APPLICATION OF A NUMERICAL INDEX TO QUANTIFY THE AESTHETIC IMPACT OF AN IMPROVEMENT CUT IN PINE MIXEDWOODS

J. H. SMYTH and I. R. METHVEN[1]

GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

REPORT O-X-270

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

JANUARY 1978

Copies of this report may be obtained from

*Information Office,
Great Lakes Forest Research Centre,
Canadian Forestry Service,
Department of the Environment,
Box 490, Sault Ste. Marie, Ontario.
P6A 5M7*

[1]*Petawawa Forest Experiment Station,
Canadian Forestry Service,
Department of the Environment,
Chalk River, Ontario.*

ABSTRACT

In 1971, a 127 ha commercial timber harvesting operation was carried out in pine mixedwood forests at the Petawawa Forest Experiment Station near Chalk River, Ontario. The purpose of the operation was to apply improvement cutting to initiate shelterwood silviculture. A complementary objective was to preserve amenity uses and values of the stands being harvested.

In 1976, five years after the harvest, a numerical index developed by Methven (1974) to quantify the aesthetic impact of forest management practices on particular stands or operating units was applied to the harvested area. The results showed that improvement cutting had a minimal effect on aesthetic values in single-storied and two-storied stands, and that strip cutting had a significant negative impact, largely because of linearity.

RÉSUMÉ

En 1971, on a effectué une coupe commerciale sur une superficie de 127 ha dans les peuplements mixtes de Pins de la Forêt expérimentale de Petawawa, près de Chalk River, Ontario. Le but de cette opération était la mise en application des coupes d'amélioration afin de créer une méthode de sylviculture par coupes progressives. Comme but secondaire, on s'était proposé de préserver la valeur tant esthétique que commerciale des peuplements destinés à la coupe.

Cinq ans plus tard, en 1976, on a appliqué à l'aire de coupe un indice numérique mis au point par Methven (1974) afin de mesurer quantitativement l'impact de l'aménagement de peuplements particuliers ou d'unités d'opération sur l'esthétique. Les résultats ont montré qu'une coupe d'amélioration influence très légèrement la valeur esthétique des peuplements à un ou deux étages, et qu'une coupe par bandes influence cette valeur significativement d'une manière négative, surtout à cause de la linéarité.

TABLE OF CONTENTS

Cover photo: A partially cut single-storied pine mixedwood stand five years after harvesting.

INTRODUCTION

Greater affluence and increased leisure time have provided urban dwellers with opportunities to move more frequently from the urban environment into rural and forested regions for the enjoyment of recreation opportunities and the scenic beauty of the landscape. For the general public, the most immediate and direct impact of forest land management is visual. It is not surprising, then, that much of the reaction to public land management practices concerns aesthetics (Daniel and Boster 1976). Visual appearance is becoming increasingly important as people are coming to expect better living conditions in the home, office or factory, better design of cities and highways, and environments that satisfy their needs for comfort, shelter, and recreation (Twiss 1969).

Partly in response to this public concern, which in Ontario is reflected in legislation such as the Environmental Assessment Act (Anon. 1975), numerous techniques purporting to inventory and/or measure scenic quality have been developed. The proliferation of such techniques is a strong indication that guidelines for land use decisions need to be expanded to include aesthetics. A method recently developed (Methven 1974) for use by public land managers employs a model that measures the aesthetic impact of various forest management techniques and harvesting methods. The purpose of this report is to present the findings from the initial field application of the model. The area chosen to test the model was of particular interest since the choice of the silvicultural system used had protection of amenity values as an objective.

THE METHVEN MODEL

The Methven model evaluates the impact of harvesting practices on the aesthetic values of a forest stand and is described in two parts: 1) a numerical index which quantifies the aesthetic impact of forest management practices, and 2) an aesthetic-economic evaluation. This report deals with the first part only; the second part will be reported on at a later date.

Description

The numerical index involves the measurement of eight variables based on generally accepted concepts of visual attractiveness (or unattractiveness) of a forest landscape. Features of the forest landscape selected as aesthetic variables are described below.

1. *Understory species diversity:* a combination of the variety or richness of the vegetation and the relative abundance of the constituent species. The index is calculated from the relative frequencies of occurrence of all species under 3 m high on twenty 1 m^2 quadrats per stand.

2. *Overstory species diversity:* as above but calculated from the relative basal area of each tree species obtained from the pre- and post-cut cruise data.

3. *Overstory size class diversity:* as above but calculated from the relative basal area of each 2.54 cm DBH class obtained from the pre- and post-cut cruise data. Basal area rather than number of trees is used in this variable and in the previous one to ensure that stems are weighted according to size.

4. *Structural complexity:* includes vertical stratification and age structure, each of which is further divided into a number of sub-components.

5. *Forest view:* essentially a measure of visual penetrability of the forest landscape. The value accorded to the variable is obtained by a measurement of the visibility of a stationary target--which, for convenience, can be another person--along two lines of site 180° apart and at set distances from an observer.

6. *Slash visibility:* Unsightly accumulation of logging slash over a treated area is usually considered a negative consequence of most harvesting methods. However, only slash which is easily visible or constitutes an obstruction to free movement is considered aesthetically objectionable. For purposes of determining a value for this variable, aesthetically objectionable slash is material found 30 cm or more above the forest floor. There are two steps involved in assigning the value to the variable (see Table 1). First, the volume of slash per unit area on the site is measured by the Van Wagner (1968) line intersect method, and multiplied by the ratio of the total basal area to the cut basal area in order to yield the potential slash as a constant standard. This is assigned a maximum value of four negative units. The maximum is then adjusted down by the ratio of the aesthetically objectionable slash to the potential slash. This negative value, therefore, represents the impact of the visually objectionable slash on the area.

7. *Pattern:* a variable comprising uniformity of pattern and regularity of spacing.

8. *Boundary form:* a variable in which straight boundaries and roads are considered aesthetically negative while naturalistic boundaries, following original stand boundaries or physiographic features, are considered positive.

Each variable described above is considered to be of equal importance and is assigned a maximum value of four arbitary units. The first

Table 1. Units assigned to numerical index variables.

Variable	Component	Sub-component	Assigned unit (maximum of $\pm$ 4)	Means of calculation
Understory species diversity			0 to 4.0	$Du = -\Sigma \left(\frac{fi}{F} \ln \frac{fi}{F}\right)$ [a]
Overstory species diversity			0 to 4.0	$Do_1 = -\Sigma \left(\frac{ba_i}{BA} \ln \frac{ba_i}{BA}\right)$
Overstory size class diversity			0 to 4.0	$Do_2 = -\Sigma \left(\frac{ba_i}{BA} \ln \frac{ba_i}{BA}\right)$
Structural complexity	vertical stratification	tree stratum	0.8	
		sapling stratum	0.4	
		shrub stratum	0.4	
		herb stratum	0.4	
	age structure	one-aged	0.5	
		two-aged	1.0	
		multi-aged	2.0	
Forest view[b]	target distance	10 m	0.1	
		30 m	0.4	
		60 m	1.0	
		100 m	2.0	
Slash visibility	potential slash		-4.0	Potential slash = total slash[c] x $\frac{\text{total basal area}}{\text{cut basal area}}$
	aesthetic effect			Aesthetic effect = $\frac{\text{aesthetically objectionable slash}}{\text{potential slash}}$ x -4
Pattern	uniformity	uniform	0	
		non-uniform	2.0	
	regularity	regular spacing of trees	0	
		irregular spacing of trees	2.0	
Boundary form	straight		0	
	naturalistic		4.0	

[a] fi = individual species frequency
F = total species frequency
ba_i = individual basal area
BA = population basal area

[b] After a clearcut and until a sapling layer has developed (3 m), there is no internal forest view, so that this variable is assigned a value of zero in such a situation

[c] Total slash = $\frac{\pi^2 \Sigma d^2}{8L}$, where d = piece diameter, L = length of sample line.

six variables are graded variables whose values increase proportionally with aesthetic quality, while the remaining two are two-alternative variables that are accorded a value of either zero or four units. Values accorded to each variable are shown in Table 1.

Calculation of Aesthetic Impact

Calculation of the total aesthetic impact following specific forest management practices or timber harvesting is shown below.

Let a_i be any aesthetic variable.

Then change in any aesthetic variable is defined by:

$$\Delta a_i = a_{it} - a_{io}$$

where a_{io} = value of the aesthetic variable at time 0, the time the practice is initiated, and a_{it} = value of the aesthetic variable at any time t.

Thus, the total aesthetic effect or impact is $\Delta AE = \Sigma \Delta a_i$.

STUDY AREA

The area selected to apply the numerical index is located in the Cartier Lake basin on the Petawawa Forest Experiment Station near Chalk River, Ontario. The area lies within the Middle Ottawa Section L·4c of the Great Lakes—St. Lawrence Forest Region (Rowe 1972), and within Site Region 5E, Brent Site District (Hills 1959). It is characterized by the Henvey, Sherborne, and Petawawa land types.

The forest on the area consists of mixed stands containing white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) associated with tolerant and intolerant hardwoods, jack pine (*Pinus banksiana* Lamb.), white spruce (*Picea glauca* [Moench] Voss), and balsam fir (*Abies balsamea* [L.] Mill.). These stands have evolved after the pine logging of the last century, which was followed closely by fire, and constitute about 50% of the forest in the area. The stands, based on the oldest components, are concentrated in the age class 60-90 years. The softwoods (except balsam fir) are generally sound, and varying amounts are currently merchantable for pulpwood, small poles, and small sawlogs. The hardwoods, particularly aspen (*Populus tremuloides* Michx. and *Populus grandidentata* Michx.) and white birch (*Betula papyrifera* Marsh.), are in various stages of decadence[2].

---

[2] Brace, L.G. 1972. Assessing silvicultural stand improvement alternatives in pine mixedwoods. 1. Costs and effects of treatments. Can. For. Serv., Chalk River, Ont. Intern. Rep. PS-27. 31 p.

In 1971 a 127 ha commercial timber harvesting operation was carried out in the area using wheeled skidders (Brace and Stewart 1974). The logging operation was conducted as a research project applying improvement cutting to initiate extensive shelterwood silviculture, with the objectives of increasing the growth and yield of residual white pine for sawlogs during the following 20-30 years and preserving amenity values. Harvesting operations occurred in both single- and two-storied stands.

The pine mixedwood forests represent a significant portion of the forests within the Great Lakes—St. Lawrence Region of eastern Canada and are centred on the fringe of urban influence where they are subjected to continuing and increasing demands for a variety of uses, particularly recreational activity. Because of this, a complementary objective of the project was to accommodate and retain amenity uses and values of the stands being harvested. To ensure that this objective was attained, additional logging costs were incurred for planning, crew training and supervision, road design, and post-logging cleanup of landings.

Because of the type of forests characteristic of the region, their growing importance for a variety of uses, and the objectives of the Cartier Lake project, the area was considered ideal for measuring changes in the scenic appearance of forest stands as a result of the silvicultural and logging systems employed. Table 2 describes the stands harvested in terms of unit area, stand age, pre-cut volume, volumes cut by product, and percent of stand cut. Measurement of the variables took place in the early fall of 1976, five years after the harvest.

Because the aesthetic index was developed after the cutting, no pre-treatment aesthetic index values were available. Therefore, as part of the present work, nearby untreated control stands were evaluated as well as cut stands to provide the basis for comparison.

RESULTS

All stands suffered a deterioration in aesthetic quality as a result of partial logging. Two common variables were largely responsible: "overstory species diversity", which was reduced as a result of the removal of hardwoods in the conversion cut, and "forest view", which was reduced by the stimulation of understory vegetation, and the prolific ingrowth of aspen suckers.

In the case of the two-storied and the single-storied stands that were subjected to an improvement cut, the negative aesthetic effect was marginal, being only -4.8 and -2.8%, respectively, on the average (Tables 3 and 4). Strip shelterwood cutting, however, had an adverse and somewhat more pronounced effect, being -16.1% on the average (Table 5). This was due largely to the linearity introduced by the uniformity of the strips, which gave a large negative value for the variable "pattern".

Table 2. Description of pine mixedwood forest areas treated to establish shelterwood silviculture, Cartier Lake, 1971.

Stand no.	Area (ha)	Total age[a]	Volume		% of Cut			% Stand cut
			Pre-cut (m^3/ha)	Cut (m^3/ha)	Hdwd pulp	Swd pulp	Sawlog	
				Two-storied[b] (uniform shelterwood)				
101	19.2	60-85	256.8	141.3	64.2	13.0	22.8	55
102	9.8	60-80	223.2	152.5	44.3	20.8	34.9	68
129	3.4	50-75	213.4	100.1	69.8	11.3	18.9	47
201	10.9	50-80	210.6	155.3	85.8	8.9	5.3	74
202	13.8	50-83	153.9	105.0	85.9	4.3	9.8	68
205	10.1	60-85	205.7	123.9	80.0	8.8	11.2	60
208	3.2	60-85	156.7	114.8	64.9	25.6	9.5	73
209	5.3	55-90	238.6	148.3	82.6	14.2	3.3	62
301	3.8	55-80	188.2	113.4	67.5	11.6	20.9	60
				Single-storied (uniform shelterwood)				
128	13.4	80	249.1	127.3	29.3	22.0	48.7	51
204	8.7	70	213.4	102.2	39.5	30.1	30.4	48
302	7.9	75	198.0	109.2	17.0	34.2	48.8	55
				Single-storied (strip shelterwood)				
123	8.5	75	218.3	72.8	17.3	45.3	37.4	33
207	2.8	80	251.9	84.0	22.6	23.7	53.7	33
346	5.9	75	254.0	84.7	12.0	45.8	42.2	33

[a] First of two figures is age (in years) of understory softwood, second figure is age of overstory hardwood.

[b] Characterized by white pine and varying amounts of red pine and white spruce occurring in an understory aged 30-70 years, 4.9 to 18.3 m tall, 10.2 to 30.5 cm DBH and 25 to 50% live crown.

Source: Brace and Stewart (1974).

Table 3. Aesthetic effect of an improvement cut on a two-storied pine mixedwood forest five years after harvest.

Stand no.		Understory species	Overstory species	Overstory size class	Structural complexity: Vert. strat.	Structural complexity: Age struc.	Forest view	Pattern: Unif.	Pattern: Reg.	Boundary form	Slash[a]	Total Δ value	% Change
		numerical value											
101	Control	3.0	1.5	2.8	2.0	1.0	1.1	2.0	2.0	4.0	0.0		
	Cut	3.1	0.8	2.7	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	+0.1	-0.7	-0.1	0.0	0.0	-0.9	0.0	0.0	0.0	0.0	-1.6	-6.8
102	Control	3.3	1.3	2.8	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.4	0.8	2.7	2.0	1.0	0.5	2.0	2.0	4.0	0.0		
	Δ value	+0.1	-0.5	-0.1	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	-0.8	-3.5
129[b]	Control	3.1	1.5	2.6	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.4	1.0	2.5	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	+0.3	-0.5	-0.1	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	-0.9	-3.9
201[b]	Control	3.1	1.5	2.6	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.2	0.9	2.6	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	+0.1	-0.6	0.0	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	-1.1	-4.8
202	Control	3.1	1.5	2.5	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.2	1.1	2.5	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	+0.1	-0.4	0.0	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	-0.9	-3.9
205	Control	3.3	1.7	2.6	2.0	1.0	0.5	2.0	2.0	4.0	0.0		
	Cut	3.4	1.1	2.5	2.0	0.5	0.2	2.0	2.0	4.0	0.0		
	Δ value	+0.1	-0.6	-0.1	0.0	-0.5	-0.3	0.0	0.0	0.0	0.0	-1.4	-6.1
208	Control	3.2	1.8	2.6	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.2	1.4	2.5	2.0	0.5	0.4	2.0	2.0	4.0	0.0		
	Δ value	0.0	-0.4	-0.1	0.0	-0.5	-0.4	0.0	0.0	0.0	0.0	-1.4	-6.0
209[b]	Control	3.1	1.5	2.5	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.1	1.2	2.5	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	0.0	-0.3	0.0	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	-0.9	-3.9
301	Control	3.1	1.5	2.5	2.0	1.0	0.8	2.0	2.0	4.0	0.0		
	Cut	3.1	1.0	2.4	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Δ value	0.0	-0.5	-0.1	-0.4	-0.5	+0.6	0.0	0.0	0.0	0.0	-0.9	-3.9
	$\bar{x}$												-4.8

[a] In order to calculate a percent change for the variable "slash", the value of 4 was assigned to the control stand even though, in fact, its value is zero. Zero cannot be the base for a percent change calculation.

[b] No control plot established; stand 202 used as control.

Table 4. Aesthetic effect of an improvement cut on a single-storied pine mixedwood forest five years after harvest.

Stand no.		Understory species	Overstory species	Overstory size classes[a]	Structural complexity: Vert. strat.	Structural complexity: Age struc.	Forest view	Pattern: Unif.	Pattern: Reg.	Boundary form	Slash[b]	Total Δ value	% Change
		numerical value											
128	Control	3.2	1.0	-	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Cut	3.2	1.0[c]	-	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	0.0	0.0	-	+0.4	+0.5	-1.2	0.0	0.0	0.0	0.0	-0.3	-1.5
204	Control	3.2	1.7	-	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Cut	3.0	1.0[c]	-	2.0	1.0	0.2	2.0	2.0	4.0	0.0		
	Δ value	-0.2	-0.6	-	+0.4	+0.5	-1.2	0.0	0.0	0.0	0.0	-1.1	-5.4
302	Control	3.2	1.3	-	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Cut	3.2	1.0[c]	-	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Δ value	0.0	-0.3	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-1.5
$\bar{x}$													-2.8

[a] Data not available, but from data of other partially cut stands this variable shows little or no change.

[b] In order to calculate a percent change for the variable "slash", the value of 4 was assigned to the control stand even though, in fact, its value is zero. Zero cannot be the base for a percent change calculation.

[c] Not actual stand value but mean of nine other pine mixedwood stands.

Table 5. Aesthetic effect of a strip shelterwood cut on a single-storied pine mixedwood forest five years after harvest.

Stand no.		Under-story species	Over-story species	Over-story size classes	Structural complexity: Vert. strat.	Structural complexity: Age struc.	Forest view	Pattern: Unif.	Pattern: Reg.	Boundary form	Slash[a]	Total Δ value	% Change
		-----	-----	-----	-----	numerical value	-----	-----	-----	-----	-----		
123	Control	3.3	1.4	2.6	1.6	0.5	1.4	2.0	2.0	4.0	0.0		
	Cut	3.2	0.0	0.0	1.6	1.0	0.2	0.0	2.0	4.0	0.0		
	Δ value[b]	-0.03	-0.46	-0.86	0.0	+0.17	-0.4	-2.0	0.0	0.0	0.0	-3.6	**-15.8**
207	Control	3.0	1.7	2.6[c]	1.6	0.5	0.5	2.0	2.0	4.0	0.0		
	Cut	2.7	0.0	0.0	1.6	0.5	0.2	0.0	2.0	4.0	0.0		
	Δ value[b]	-0.1	-0.56	-0.86	0.0	0.0	-0.1	-2.0	0.0	0.0	0.0	-3.6	**-16.4**
346	Control	3.2	1.1	2.6[c]	1.6	0.5	1.2	2.0	2.0	4.0	0.0		
	Cut	2.9	0.0	0.0	1.6	0.5	0.3	0.0	2.0	4.0	0.0		
	Δ value[b]	-0.1	-0.36	-0.86	0.0	0.0	-0.3	-2.0	0.0	0.0	0.0	-3.6	**-16.2**
	$\bar{x}$												**-16.1**

[a] In order to calculate a percent change for the variable "slash", the value of 4 was assigned to the control stand even though, in fact, its value is zero. Zero cannot be the base for a percent change calculation.

[b] Since one third of the area of each stand was strip shelterwood cut, the value given represents one third of the total Δ value for all variables except pattern and boundary form, which apply to the entire area.

[c] Mean value of 10 pine mixedwood stands was used since no diameter measurements were taken on the control stands. Data for these stands were based on prism cruises only.

Appendices A, B and C show the appearance of control and cut stands harvested at Cartier Lake.

DISCUSSION AND CONCLUSIONS

The Cartier Lake Silviculture Project carried out at the Petawawa Forest Experiment Station offered an excellent opportunity to evaluate the aesthetic impact of improvement cutting in pine mixedwood stands when one of the objectives was to preserve the amenity value of the forest as much as possible.

The method developed by Methven (1974) results in a numerical index designed specifically to measure changes in the aesthetic value of the same stand as a result of treatment; it is neither intended nor suited for comparing different stands at the same time, or for application to large areas or distant landscapes. These limitations are important and should be kept in mind.

Furthermore, although each variable has an inner logic, the choice and equal rating of these variables inevitably contain a subjective element. Nevertheless, the combination arrived at represents, in our opinion, a reasonable one, and results in a standard evaluation of aesthetic change.

Because the forest community is a dynamic one and subject to continual change, the impact of a treatment will also be subject to change. Consequently, it is necessary to evaluate aesthetic values periodically throughout a rotation. A management alternative that has a high negative impact at time zero may be the better aesthetic alternative at a later date. The measurements taken at the Cartier Lake project area are the first of such measurements and constitute the five-year evaluation.

To the authors' knowledge, the Cartier Lake project represents the first time the Methven methodology has been applied and reported on. In addition to evaluating the impact of a management practice on the aesthetics of forest stands, it provided the opportunity to evaluate the technique itself.

"Overstory species diversity" and "forest view" contributed most towards a decrease in the aesthetic value of most stands. The former was an inevitable result of the objective of the cutting operation, namely conversion of pine mixedwood to pine in order to increase the growth and yield of white pine for sawlogs. The latter variable, on the other hand, if persistent in its negative impact, can be corrected through several possible management steps such as prescribed fire, herbicides, and manual cleaning. However, where the major culprit is aspen suckers, the species is not expected to survive the closure of the pine canopy in the denser residual stands, and in this way the depth of view into the forest will be improved by natural means.

In addition, the variable "pattern" contributed most to the decrease in the post-cut aesthetic value of strip shelterwood cut stands as a result of the linearity introduced by the uniform strips, which clashed with the natural contours of the land. When aesthetic appearance is considered important, but a form of clearcutting is considered necessary, then the alternative of irregular patch clearcutting would be preferable to strip cutting.

It is difficult to state specifically to what extent the additional planning and supervision of logging operations kept amenity losses minimal since the only variable affected that was measured was logging slash. Other amenity factors considered for the project, i.e., road design and location, landing orientation and cleanup, are extraneous to the forest stand and common to all management systems and, therefore, should be measured within a landscape context.

The method itself was found to be simple to apply, and provided a standard means by which to assess the visual impact of a forest management practice after the fact. However, the method is also useful to the knowledgeable forest manager in the planning stages of any operation, since it is based largely on the specifics of visual quality over which he has control. Thus it can be used in both the planning process and the post-operation assessment.

REFERENCES

Anon. 1975. The Environmental Assessment Act. Statutes of Ontario, 1975. Chapter 69.

Brace, L. G. and D. J. Stewart. 1974. Careful thinning can preserve amenities and increase yield. Pulp Pap. Mag. Can., Aug. 1974. p. 36-42.

Daniel, T. C. and R. S. Boster. 1976. Measuring landscape esthetics: the scenic beauty estimation method. USDA For. Serv., Rocky Mtn. For. Rge. Exp. Stn., Res. Pap. RM-167. 66 p.

Hills, G. A. 1959. A ready reference to the description of the land of Ontario and its productivity. Ont. Dep. Lands For., Div. Res. 142 p.

Methven, I. R. 1974. Development of a numerical index to quantify the aesthetic impact of forest management practices. Can. For. Serv., Chalk River, Ont. Inf. Rep. PS-X-51. 19 p.

Rowe, J. S. 1972. Forest regions of Canada. Can. For. Serv., Ottawa, Ont. Publ. 1300. 172 p.

Twiss, R. H. 1969. Conflicts in forest landscape management - the need for environmental design. J. For. 67(1): 19-22.

Van Wagner, C. E. 1968. The line intersect method in forest fuel sampling. For. Sci. 14(1): 20-26.

APPENDICES

APPENDIX A

TWO-STORIED PINE MIXEDWOOD FOREST

Control

Cut

Note the negative change in aesthetic value due to 1) the reduction of overstory species diversity resulting from the removal of birch and 2) the reduction in forest view resulting from the stimulation of understory growth.

APPENDIX B

SINGLE-STORIED PINE MIXEDWOOD FOREST

Control

Cut

As in the two-storied stand, a negative change in aesthetic value resulted due to 1) the reduction of overstory species diversity resulting from the removal of birch and 2) the reduction in forest view resulting from the stimulation of understory growth.

APPENDIX C

STRIP-SHELTERWOOD CUT ON A SINGLE-STORIED PINE MIXEDWOOD FOREST

Control

Cut

Clear-cut strips resulted in a reduction of overstory species and size class diversities. Note also the explosion of undergrowth resulting in a decline of forest view. Though it is not obvious from this photograph, linearity due to clear-cut strips is a significant negative feature to an on-site observer.