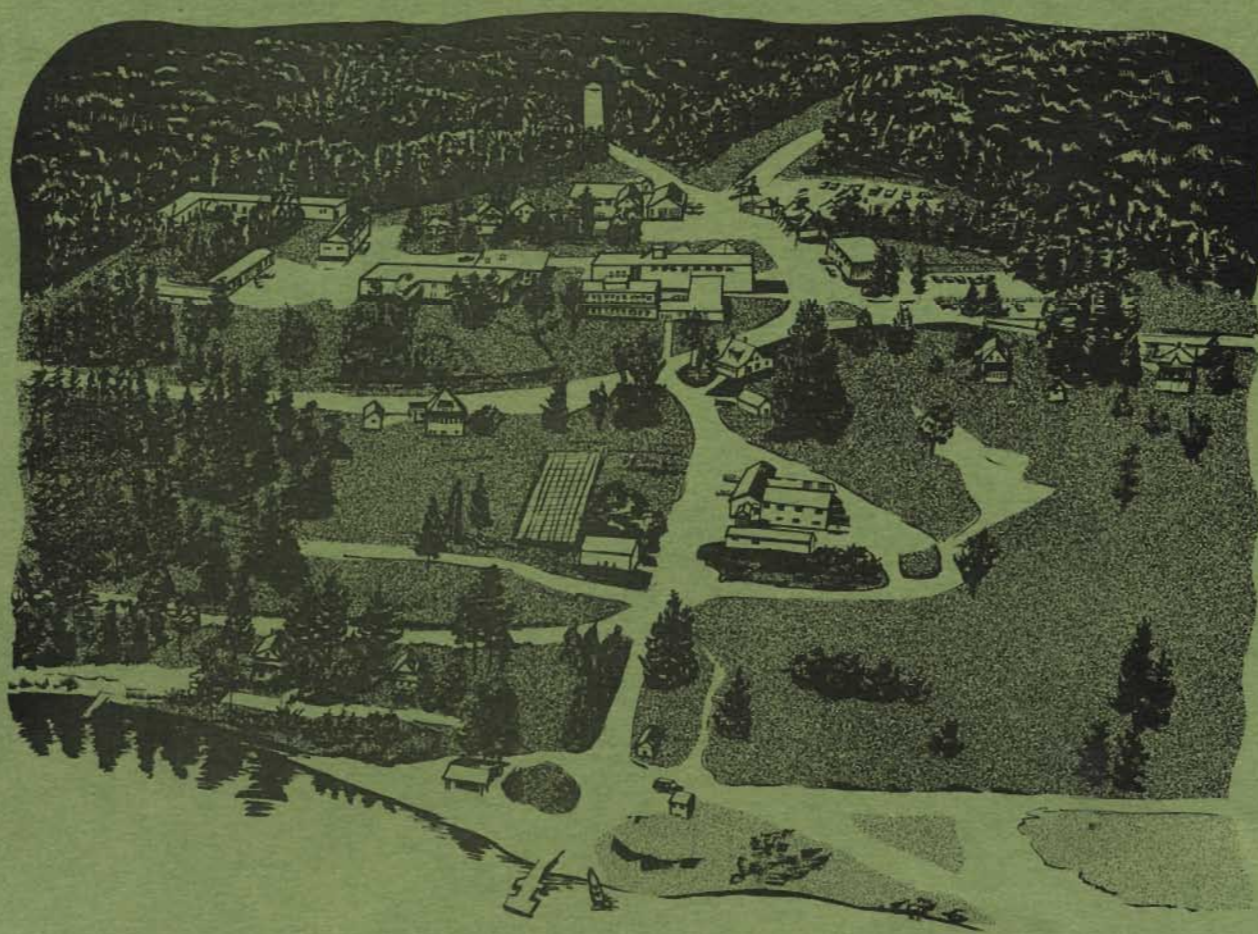4308

DEVELOPMENT OF A NUMERICAL INDEX TO QUANTIFY THE AESTHETIC IMPACT OF FOREST MANAGEMENT PRACTICES

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ABSTRACT

Develops a simplified numerical index to quantify the aesthetic impact of forest practices on particular stands or operating units, by hypothesizing the idealised normal observer on the basis of a common empathy, and the dominance of the visual response in human aesthetic relations with the natural environment. The index is constructed from six aesthetic variables which are assigned equal value in the form of arbitrary units, and which are selected on the basis of stated requirements and constraints. These variables or index components are: (i) species diversity or variety, (ii) structural complexity, (iii) forest view, (iv) slash visibility, (v) pattern, and (vi) boundary form.

A method for incorporating the index into a total economic-aesthetic evaluation is also presented.

RÉSUMÉ

Mise au point d'un indice numérique simplifié pour quantifier l'impact esthétique des pratiques forestières sur des peuplements particuliers ou des unités d'opérations, ce en créant par hypothèses l'observateur normal idéalisé sur la foi d'une empathie commune et la dominance de la réaction visuelle dans les relations esthétiques de l'homme avec l'environnement naturel. L'indice est fondé sur six varibles esthétiques de valeur égale sous forme d'unités arbitraires et choisies selon des conditions requises et limites données. Voici ces six variables: (i) diversité des espèces, (ii) complexité structurale, (iii) vue panoramique de la forêt, (iv) visibilité des rémanents, (v) apparence naturelle et (vi) forme des limites.

Les auteurs fournissent une méthode d'incorporer l'indice dans une évaluation totale, économique et esthétique.

Development of a Numerical Index to Quantify the Aesthetic Impact
of Forest Management Practices

Introduction

Increasing recreational pressure on industrial forest lands is a fact
of life (Eidsvik 1969, Place 1968), which demands that forest land managers
take into account values other than those of timber alone. Twiss (1968) has
called for co-operation between managers and designers, while Shafer (1967)
has coined the phrase "timber-aesthetic management". One of the continent's
leading social commentators and economists has even gone so far as to proclaim
that economic goals should be subordinated to aesthetic goals (Galbraith 1967).

Within the context of recreation, land needs to be assessed by essentially
two criteria; its visual or aesthetic attributes and its ability to support
recreational activity (Hamill 1971). The purpose of this paper is to develop
a quantitative methodology with which to compare the aesthetic impact of alternative
forest practices.

A large amount of work has been done in the last few years on analysing
and quantifying the aesthetic and visual qualities of forest landscapes (Hamill
1971, Krest'yashina and Arno 1971, Litton 1968, Shafer and Mietz 1970), particularly
from roads (Streeby 1970), but much less appears to have been done on a more
basic level as represented by Litton's (1968) "canopied landscape" or by the
operating unit or stand of timber management.

Assessments of the aesthetic quality of individual stands and trees
have been made on the basis of interviewee preferences (Cook 1972, Rutherford
and Shafer 1969), while an economic-aesthetic evaluation of timber management
alternatives was devised by Rickard et al (1967). The former however were strictly
qualitative while the latter was based largely on subjective judgements of
relative values and presumptions about good decisions. A need exists therefore
for an objective quantitative index based on generally accepted concepts of
visual attractiveness with which to measure the aesthetic impact of various forest
management techniques and harvesting methods.

The following development then is a preliminary attempt which hopefully
will provoke critical and constructive discussion about both the need and its
satisfaction.

Approach

The major problem in devising an aesthetic evaluation lies in the com-
plexity and intangible qualities of the subject. The aesthetic experience (AE)
for example has been equated to the sum of the relationship between the perceived
object or landscape (PO), the characteristics of the perceiver (CP), and the en-
vironmental conditions or circumstances (EC) at the time of exposure;

$$AE = PO + CP + EC, (Munro\ 1956\ in\ Newby\ 1967).$$

Each of these equation components involves not only a large number of characteristics and qualities but many of them vary with time and circumstance.

Without denying the complexity involved in the aesthetic experience however it is proposed that, in the case of the natural environment in general and the forest scene in particular, there exists a common and simplifying thread, the empathy of the percipient, the human organism, with the perceived object or in this case space, the forest scene. This points up an important difference, which is often ignored, between the "artistic" or creative products of man, with which little empathy appears to exist unless there is a strong literal representation or reflection of nature involved, and the natural environment. A consequence of this empathy of course is that any signs of man-caused disturbance, such as is involved in harvesting operations, will tend to elicit a negative aesthetic response, regardless of the ecological soundness of the practice.

Accepting the above emphathetic proposition, it then becomes possible to hypothesize the aesthetic judgement of the idealized normal observer of Birkhoff (1956), and the aspects or qualities of the forest scene, i.e. the stimuli, which invoke a response. It is first necessary however to identify the senses involved in the perception of the stimuli. Here again it is possible to simplify by recognizing that man is predominantly visual in his aesthetic relations with the physical world except in specialized circumstances such as at a symphony concert where another sense may assume a dominant role in the response pattern. Thus the aesthetic experience can be related to the visual qualities of the perceived object or space alone, while recognizing that the response can be qualified by the reception of stimuli by the other senses.

It is therefore considered that a valid aesthetic index can be created on the basis of a common empathy and the visual qualities of the perceived space, the forest scene.

An aesthetic index has four requirements (i) it must contain a consensus view of what is visually attractive (or unattractive) in a forest scene, (ii) it must be easily defined and measured, (iii) it must be objective in the sense that the same value will be attained regardless of the person conducting the evaluation, and (iv) the scale or physical limits on the ground to which the index is to be applied must be defined.

The first requirement is undoubtedly the most controversial and difficult but it is by no means impossible if details are avoided, and only general or major features are considered. From the literature and discussions with different forest users it is apparent that the four most positive aspects of a forest scene are variety, naturalness, good visual penetrability, and the presence of large, healthy, good timber quality trees, and conversely the four most negative aspects are uniformity, artificiality, visual impenetrability, and a large number of small or unhealthy, poorly formed trees. The model or aesthetically superior stand would thus be a mature one composed of mixed, uneven-aged, healthy trees with a varied understory of shrub and herbaceous

species but with good access and visual penetrability. The stand should also contain a few openings, some picture-sque or "wolf" trees and some dead trees.

The second and third requirements of ease of measurement and objectivity immediately place constraints on the aesthetic features that can be considered as variables or components of an index. Based on the above model, these constraints and the requirement for minimisation of the impact of industrial operations, the following six features have been selected to serve as aesthetic variables: (i) species diversity or variety, (ii) structural complexity, (iii) forest view, (iv) slash visibility, (v) pattern, and (vi) boundary form. Each of these variables will be considered of equal importance and be assessed a maximum value of four arbitrary units. The first four variables are graded variables whose values increase proportionately with aesthetic quality, while the last two are two-alternative variables which will be accorded a value of either zero or four units.

The index to be developed here is not intended to be applied to large areas or distant landscapes but to identifiable forest communities, operating units or stands. Thus the impact of areas outside the immediate area of interest will be ignored. This is not to deny the aesthetic importance and impact of surrounding areas but merely to create a manageable and soluble problem. Once the impact on particular communities has been calculated then these can be combined and interrelated for a landscape impact or effect, so that a clearcutting alternative for example, which will have a low aesthetic value, may become compatible or even produce a beneficial effect by opening up panoramas.

If A = the aesthetic value of a stand at any time, then the aesthetic effect of a practice,

$$\Delta A = A_t - A_o$$

where A_t = the aesthetic value at any time t after the practice, and A_o = the aesthetic value at time zero (time practice is initiated).

Incorporation into a Total Economic-Aesthetic Evaluation

On industrial forest land the choice of alternatives cannot of course be based on aesthetic or intangible values alone; they must be incorporated into or made compatible with the dollar returns. Two alternatives are available to facilitate a choice between alternatives composed of dollar and intangible values; the simple betterness method and the compensation technique (Hughes 1968, Rickard et al 1967). It is proposed here to use a refinement of the latter approach which is based on "shadow prices", i.e. prices calculated from the foregone dollar value of a non-aesthetic alternative.

Once the possible alternatives have been listed it is necessary to calculate the present net worth (PNW) in dollars, derived from net stumpage values, and the aesthetic value (AV) in aesthetic units for each alternative.

The PNW of the alternative with the highest aesthetic value is subtracted from the PNW of the alternative with the highest dollar return to give the foregone price or the dollar value of the aesthetic difference between the two alternatives. This dollar value can then be divided by the difference between the two aesthetic values to give a maximum foregone dollar value per aesthetic unit.

$$\$/\text{aesthetic unit} = \frac{\text{PNW } (\$\text{max}) - \text{PNW } (A\text{max})}{\text{AV } (A\text{max}) - \text{AV } (\$\text{max})}$$

The aesthetic value of each alternative can then be represented in dollars, discounted to the present, and added to the present net worth dollar value to provide a total economic-aesthetic evaluation.

Measurement of Aesthetic Variables

1. Species Diversity

This is a combination measure of both the variety or richness of the vegetation plus the relative abundances of the constituent species. Probably the most useful and applicable measure of this variable is that provided by the Shannon-Weaver function,

$$D = - \Sigma \, p_i \ln p_i$$

where p_i is the probability that the next gram of plant material will belong to the ith species and equals $\frac{b_i}{B}$, where b_i equals the biomass of the ith species and B equals the total biomass.

Vegetation will be stratified into four vertical layers as follows: (i) herbaceous layer <1 meter, (ii) shrub layer 1-3 meters, (iii) sapling layer 3 meters - 8.9 centimeters Dbh, and (iv) tree layer 9.0 centimeters Dbh $<$. Separate diversity indexes will then be calculated for each stratum and summed to obtain a community index. This statification is necessary in order to avoid a bias toward relative abundance over variety in the community index.

Let initial diversity for each stratum = d_o.

Let diversity for each stratum after time t = d_t

Then change in diversity $\Delta d = d_t - d_o$

and community change in diversity $\Delta D = \Sigma \Delta d$

Diversity on the above basis is visualized most simply as probability units per gram of biomass. Each probability unit will be considered as equivalent

to one arbitrary unit since the maximum community index will be approximately four.

The quantification of this variable involves considerable sampling, even if simple diameter measurements can be converted to biomass on the basis of available regressions. It is proposed therefore that an acceptable alternative would be a determination of species variety or richness alone. Although this would result in a much weaker index it would be balanced by a considerable saving in effort, an important consideration within the context of this paper.

Vegetation would be sampled until approximate horizontality was reached in a species-area curve. The number of species counted to to this point would be divided by a factor of 25, based on a theoretical maximum of 100 species for the site, and the subsequent figure used as a variety index in place of the diversity index.

2. Structural complexity

This variable will be composed of two components; vertical stratification and age structure.

(a) Vertical stratification

Assigned units

(i)	Tree stratum	– dominants, codominants, and intermediates.	0.8
(ii)	Sapling "	– saplings and suppressed trees	0.4
(iii)	Shrub "	–	0.4
(iv)	Herb "	–	0.4
		Maximum	2.0

(b) Age structure – based on major tree species

(i)	One-aged	0.5
(ii)	Two-aged	1.0
(iii)	Multi-aged	2.0

3. Forest View

This is essentially a measure of visual penetrability and thus its value will be a function of the density of the vegetation. However after a clearcut and until a sapling layer has developed (3 meters$<$), there can be no internal forest view, so that this variable will be assigned a value of zero in such a situation.

The basic assumption will be that aesthetic value is proportional to the depth of view. This will be measured by the visibility of a stationary target, which for convenience can be another person, along two lines of sight 180° apart and at set distances from an observer.

Distance from observer at which target is visible	Assigned units
10 meters	0.1
30 "	0.4
60 "	1.0
100 "	2.0
Maximum for two lines of sight	4.0

4. <u>Slash visibility</u>

The most obvious and generally negative consequence of most harvesting methods are unsightly accumulations of logging slash over the treated area. Since the quantity of slash produced in any given situation is highly variable and dependent on a number of factors including tree species, density and size (Keays 1971), it is unrealistic to attempt to scale the impact in terms of absolute slash quantities. It is proposed therefore to rate the slash impact on a standard base for the actual situation as represented by the maximum potential slash that could be produced on the site by the particular cutting methods being used. This can be achieved by measuring the total slash per acre (TS) by the line intersect method (Van Wagner 1968), or a strip plot method, or a combination of both using the former method for material over 2cm in diameter and the latter method for material under 2cm in diameter, and multiplying this figure by the ratio of the total basal area per acre (TBA) to the basal area actually cut (CBA). This figure will be the potential slash (PS), i.e. the maximum that could be produced on the area by the cutting method being used, and defines the upper limit of the scale which in this case is four negative units.

$$\text{Potential slash (PS)} = \text{Total slash (TS)} \times \frac{\text{Total basal area} \quad \text{(TBA)}}{\text{Cut basal area} \quad \text{(CBA)}}$$

However only that slash which was easily visible or constituted an obstruction to free movement could be considered aesthetically objectionable since material lying on the ground or close to it would be shielded from view by minor vegetation easy to step over and subject to rapid decomposition. The aesthetically objectionable slash (AS) therefore could be defined as that material found above a certain height, which for this purpose will be set at 30cm (1 ft). Thus at the time of the initial slash survey to determine the total slash, material can be divided into two classes based on the 30cm division. The ratio of this value to the potential slash can then be used to adjust the maximum value of four to reflect the aesthetic impact of the slash.

$$\text{Aesthetic effect} = \frac{\text{Aesthetic slash (AS)}}{\text{Potential slash (PS)}} \times -4$$

5. Pattern

This will be a two-alternative variable composed of two components; uniformity of pattern and regularity of spacing.

(i) Uniformity   Assigned units
    Uniform e.g. strip cut   0
    Non-uniform (natural)   2.0

(ii) Regularity
     Regular spacing of trees   0
     Irregular spacing of trees   2.0

                    Maximum value 4.0

6. Boundary form

Straight boundaries and roads will be considered aesthetically negative while naturalistic boundaries which follow original stand boundaries or physiographic features will be considered positive. This again will be a two-alternative variable.

                                     Assigned units
(i) Straight   0
(ii) Naturalistic   4.0

Calculation

Let a_i be any aesthetic variable,

Then the change in any aesthetic variable,

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

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

a_{it} = value of the aesthetic variable at any time t

Thus the total aesthetic effect

$$\Delta A = \Sigma \Delta$$

Presentation

The results may be presented as a numerical index derived from the above equation, or graphically as a horizontal bar chart. The effect of alternative practices may be plotted on a line graph over time for comparative purposes.

Discussion

One effect that has been ignored is that of prescribed fire, and this is so for three reasons; (i) the effect is generally ephemeral as the area is rapidly revegetated, (ii) the negative effect of a blackened surface tends to be compensated for by the reduction of slash where this is present, and (iii) the direct effect of prescribed fire in standing timber on the visual appearance of a forest stand is not considered negative since fire is a natural agent and prescribed fire cannot be differentiated from wildfire. Apt (Smith and Mathews 1972) for example stated that the great majority of the people he interviewed did not find anything unpleasant associated with wind or fire damage, but did complain about the various manifestations of human activity.

Calculation of diversity or variety, forest view, and slash requires information which in many cases is not yet available. However by the use of measurements on similar areas to those being considered plus the experience and knowledge of forest managers about forest succession and development, it should be possible to arrive at acceptable values. Admittedly this entails a certain amount of subjective judgement but it will be based on experience of concrete events, not an assessment of intangible values.

It will be seen from the examples in the appendix that a forest practice can result in an increase in the aesthetic value of a community vis a vis the undisturbed state. Such a possibility has been confirmed by Rutherford and Shafer (1969) who found a more positive response on the part of different groups of people to 10 to 12 year old selection cuts in Adirondack softwood stands than to the undisturbed stands. Furthermore the high negative values of two of the alternatives in the appendix are largely the result of controllable factors such as pattern, boundary form and slash visibility, so that aesthetically poor alternatives can be considerably improved at relatively little cost.

The forest community is a dynamic one and thus subject to continual change. The impact of a treatment will also be subject to change. It is desirable therefore to calculate aesthetic values at different time intervals after a practice has been carried out, since a management alternative that has a high initial negative impact at time zero may be the better aesthetic alternative at a later time. Initial differences between alternatives often diminish with time.

It must be emphasized that this aesthetic evaluation is primarily designed for comparing the aesthetic impact of various management alternatives; it is not intended as a means of comparing the aesthetic appeal of various types of forest community. The danger in the latter application is two-fold; (i) stands must be considered within a landscape mosaic before their absolute or final aesthetic value can be assessed, and (ii) certain forest communities are adapted to and develop better on certain sites than other communities that may have a higher theoretical aesthetic value. Although a pure even-aged pine stand will have a lower aesthetic value than a mixed, unevenaged tolerant hardwood stand, on a dry rocky site it will have greater aesthetic appeal because of its integreation with the landscape, health of the community and tree size. Thus any final comparative assessment of different forest communities should be placed within an ecological and landscape context. In short, aesthetics cannot ignore ecological realities. However this does not obviate the need for and validity of a measure that will compare the aesthetic effect of forest management alternatives in quantitative terms, and provide a strong objective input into a total economic-aesthetic evaluation.

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APPENDIX

The following is an imaginery application of the index, based on experience and observation, to three management alternatives for red and white pine; cleaructting in large blocks followed by planting, clearcutting in alternate strips at twenty year intervals with natural regeneration, and prescribed fire followed by shelterwood cutting and natural regeneration.

An aesthetic effect will be calculated for three time intervals, $t = 2$, $t = 20$ and $t = 22$ years after the initial harvest cut, all based on the initial state at $t = 0$, which will be that of a natural, mature, even-aged red and white pine stand with a heavy to moderate understory of shrubs and tolerant saplings.

Alternative I

Clearcutting in blocks followed by planting.

			Δa

1. Time t = 2 years

    (i) Diversity - increase from 1.5 to 2.5 units due to invasion of site by new species.   **+1.0**

   (ii) Complexity -

        (a) Vertical stratification reduced by one stratum, the tree layer. Decrease from 2.0 to 1.2 units.   **-0.8**

        (b) Age structure unchanged.   **0.0**

 (iii) Forest view - Removal of all trees. Decrease from 2.0 to 0.   **-2.0**

  (iv) Pattern -

        (a) Uniformity - creation of a uniform pattern. Decrease from 2.0 to 0.   **-2.0**

        (b) Regularity - Planted stock regularly spaced. Decrease from 2.0 to 0.   **-2.0**

   (v) Boundary form   - creation of straight line boundaries. Decrease from 4.0 to 0.   **-4.0**

  (vi) Slash   **-3.0**

$$\Sigma\Delta a = \Delta A \qquad = \qquad -12.8$$

3. Time t = 22 years Δa

    (i) Diversity - closed canopy monoculture. Decrease from 1.5 to 0 units.   **-1.5**

   (ii) Complexity

        (a) Vertical stratification reduced by three strata; tree layer only present. Decrease from 2.0 to 0.8 units.   **-1.2**

        (b) Age structure unchanged.   **0.0**

(iii)   Forest view – visibility reduced.   Decrease from 2.0   –1.8
                     to 0.2 units.

 (iv)   Pattern

        (a) Uniformity – creation of a uniform pattern.   –2.0
            Decrease from 2.0 to 0 units.

        (b) Regularity – regularly spaced planted stock.   –2.0
            Decrease from 2.0 to 0 units.

  (v)   Boundary form – straight edges.   Decrease from 4.0 to   –4.0
                     0 units.

 (vi)   Slash   0.0
                                                                     ───────

                                        $\Sigma \Delta a = \wedge A$ =   –12.5

Alternative II

Clearcutting in alternate strips at 20 year intervals accompanied by natural regeneration.

1. Time t = 2 years Δa

   (i)   Diversity - increase in species due to exposure, dis-   +2.0
turbance and edge effect. Increase from
1.5 to 3.5 units.

  (ii) Complexity

      (a) Vertical stratification reduced by one stratum   -0.4
on half the area. Decrease from 2.0 to 1.6.

      (b) Age structure - two-aged if regeneration success-
ful. Increase from 0.5 to 1.0 units.   +0.5

 (iii) Forest view - removal of all trees on half the area.   -1.0
Decrease from 2.0 to 0 x 0.5 = 1.0.

  (iv) Pattern

      (a) Uniformity - creation of a uniform **pattern**.   -2.0
Decrease from 2.0 to 0 units.

      (b) Regularity - unchanged.   0.0

   (v) Boundary form - creation of straight line bound-   -4.0
aries. Decrease from 4.0 to 0.

  (vi) Slash - on half the area.   -1.5

$$\Sigma\Delta\ a = \Delta A\ =\ -6.4$$

2. Time t = 20 years (before second cut)

   (i)   Diversity - small residual increase from 1.5   +0.5
to 2.0 units.

  (ii) Complexity

      (a) Vertical stratification - returned to original   0.0
situation in terms of numbers of strata.

      (b) Age structure - two-aged. Increase from 0.5   +0.5
to 1.0 units.

(iii) Forest view - reduction in visibility from the   -0.6
original 60 to 30 meters on the previously cut
strip. Decrease from 1.0 to 0.4.

 (iv) Pattern

    (a) Uniformity - uniform pattern.   -2.0

    (b) Regularity - unchanged.   0.0

 (v) Boundary form - straight line boundaries   -4.0

(vi) Slash - degraded   0.0
    ―――
    -5.6

3. **Time t = 22 years**

 (i) Diversity - increase due to exposure, disturbance,   +2.0
and edge effect. Increase from 1.5 to
3.5 units.

 (ii) Complexity

    (a) Vertical stratification - reduced by one stratum   -0.4
on half the area. Decrease from 2.0 to 1.6.

    (b) Age structure - two-aged. Increase from 0.5   +0.5
to 1.0 units.

(iii) Forest view - removal of all trees on half the area   -1.6
and a reduction in visibility on the
other half.

 (iv) Pattern

    (a) Uniformity - creation of a uniform pattern.   -2.0
Decrease from 2.0 to 0 units.

    (b) Regularity - unchanged.   0.0

 (v) Boundary form - straight line boundaries. Decrease   -4.0
from 4.0 to 0 units.

 (vi) Slash   -1.5

$$\Sigma\Delta \quad a = \Delta A \quad = \quad -7.0$$

Alternative III

Prescribed fire followed by a shelterwood cut, natural regeneration and a final harvest cut after 20 years.

1. Time t = 2 years Δ a

   (i) Diversity - increase due to more even relative abundances as a result of fire, and greater variety as a result of disturbance and increased radiation. Increase from 1.5 to 3.5 units.   +2.0

   (ii) Complexity

      (a) Vertical stratification - loss of shrub and sapling layers. Decrease from 2.0 to 1.2.   -0.8

      (b) Age structure - two-aged. Increase from 0.5 to 1.0 units.   +0.5

   (iii) Forest view - increased visibility from 2.0 to 4.0 units.   +2.0

   (iv) Pattern

      (a) Uniformity - unchanged.   0.0

      (b) Regularity-unchanged.   0.0

   (v) Boundary form - naturalistic.   0.0

   (vi) Slash   <u>-1.5</u>

$$\Sigma \Delta\ a\ =\ \Delta\Lambda\ =\ +2.2$$

2. Time t = 20 years (before final harvest cut)

   (i) Diversity - small residual increase from previous shelterwood cut. Increase from 1.5 to 2.0 units.   +0.5

   (ii) Complexity

      (a) Vertical stratification - return of shrub and sapling layers. No change.   0.0

      (b) Age structure - two-aged. Increase from 0.5 to 1.0 units.   +0.5

(iii) Forest View - increased visibility from 2.0 to   +1.0
       3.0 units.

(iv) Pattern

    (a) Uniformity - unchanged.   0.0

    (b) Regularity - unchanged.   0.0

(v) Boundary form - naturalistic   0.0

(vi) Slash - degraded   <u>0.0</u>
            +2.0

3. <u>Time t = 22 years</u>

    (i) Diversity - increase due to disturbance and   +1.8
          increased radiation. Increase from
          1.5 to 3.3 units.

    (ii) Complexity

        (a) Vertical stratification - removal of tree layer.   -0.8
           Decrease from 2.0 to 1.2 units.

        (b) Age structure - unchanged.   0.0

  (iii) Forest view - unchanged.   0.0

    (iv) Pattern

        (a) Uniformity - unchanged.   0.0

        (b) Regularity - unchanged.   0.0

    (v) Boundary form - naturalistic.   0.0

    (vi) Slash   <u>-3.0</u>

$\sum \Delta a = \Delta A =$ -2.0

Summary

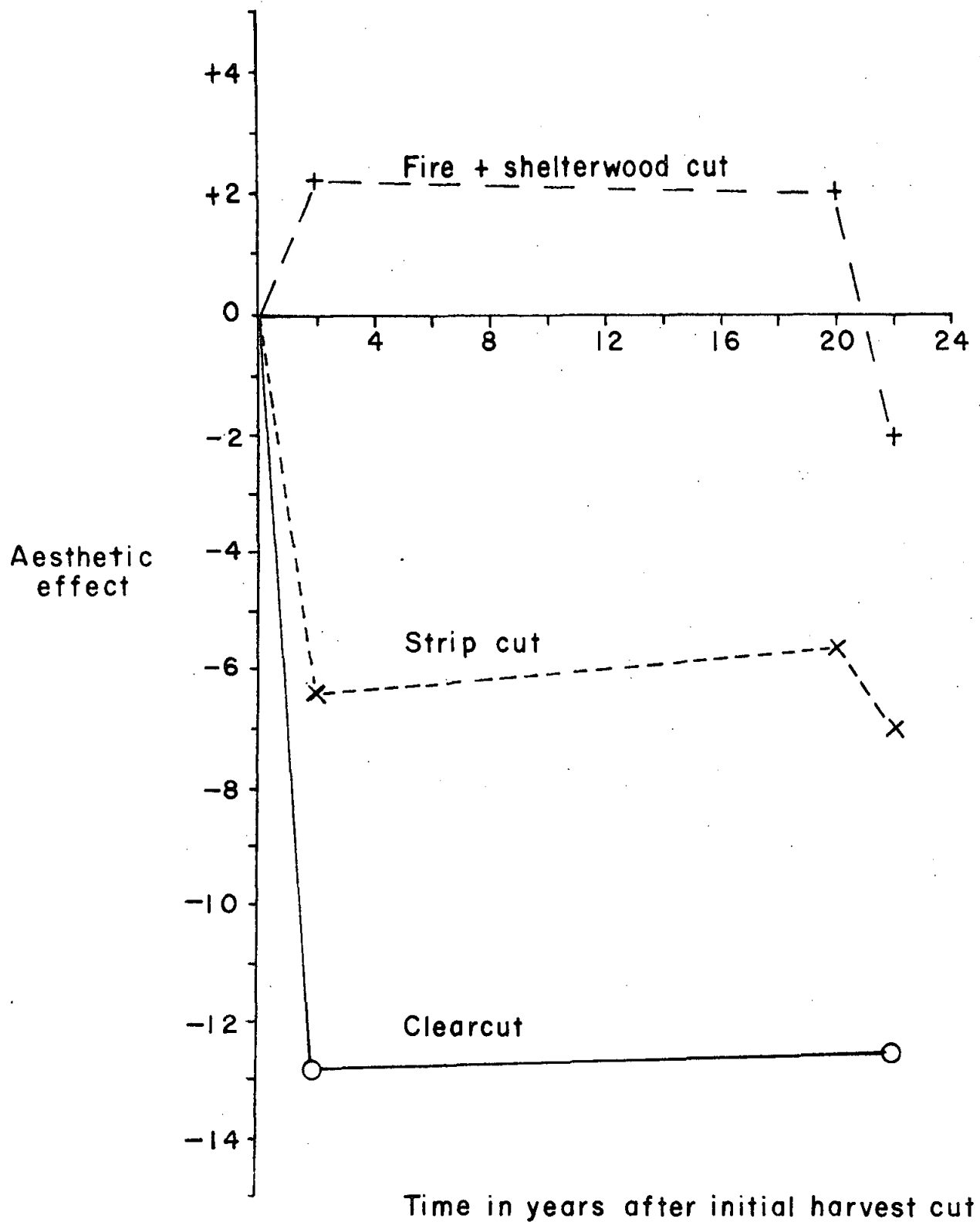| Forest Practice	Time t in years	Aesthetic effect ΔA
Clearcut	2	-12.8
"	22	-12.5
Strip cut	2	- 6.4
"	20	- 5.6
"	22	- 7.0
Fire + shelterwood cut	2	+ 2.2
" " "	20	+ 2.0
" " "	22.	- 2.0

Fig. 1. Graphical display of the aesthetic effect of three management alternatives in red and white pine.