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Aesthetic Quality of Northern Ontario Riparian Landscapes

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by

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Table of Contents

Page

List of Tables

List of Maps

List of Figures

List of Appendices

EXECUTIVE SUMMARY

Effective forest management requires recognition of the full range of benefits, including aesthetics that individuals receive from forested environments. Rigorous statistical analysis aids in measuring the aesthetic quality of forested environments. In this study we used the psychophysical approach (specifically the Scenic Beauty Estimation method) from landscape perception research to measure the aesthetic value of riparian (i.e. shoreline) forested sites with different biophysical characteristics.

The sites were located throughout northwestern Ontario and to a lesser extent northeastern Ontario. Slides were taken from offshore vantage points and were presented to different groups of subjects throughout northwestern, northeastern, and southcentral Ontario. The sampled individuals were not a statistically representative sample of Ontario's population. However, results from previous research and the consistency of ratings by the various subgroups within our sample suggest that the predictive models reported here reflect the aesthetic values of Ontario's public.

In all, 454 individuals rated subsets of 128 slides each, of the total of 202 sites used for this study. By carefully identifying baseline slides and randomly inserting the other sites into the overall sets, aesthetic evaluations were derived for all 202 sites. The scenic beauty estimate for each site was determined through standard transformations of the 10 point ratings that respondents provided.

Various models that predict scenic beauty were developed to assess the following research objectives:

1. Predict the aesthetic quality of undisturbed riparian forests;
2. Determine the effects of anthropogenic (i.e. human-induced) disturbances on aesthetic quality; and
3. Determine the effects of natural disturbances on aesthetic quality.

Below, we summarize the key findings from these analyses.

Aesthetic quality of undisturbed forest types

- Forests with high aesthetic value included red pine (*Pinus resinosa* Ait.) and white pine (*Pinus Strobus* L.) forests, hardwood forests, and eastern white cedar forests (*Thuja occidentalis* L.).
- Forests with low aesthetic value include black spruce (*Picea mariana* (Mill.) BSP.) forests, white spruce (*Picea glauca* (Moench) A. Voss)/ balsam fir (*Abies balsamea* (L.) Mill.) forests, and black spruce bog forests.
- The important factors linked to aesthetics included: large sized trees, low tree mortality rates, steeply sloped lands, presence of conifer shrubs, high tree density, and presence of hardwood forests.
- Three predictive models were developed that differed by the amount of *a priori* information that was required to estimate the models.

Effects of anthropogenic disturbances on aesthetic quality

- Most logging disturbances detract from forest aesthetics (e.g. cut to shore sites and sites with reserves separating the shoreline from areas with clear cut logging).
- Sites with intermediate sized reserves (30 to 220 metres) had significantly greater aesthetic quality than sites with reserves of 10 metres or less.

- Reserve size for the intermediate sites was directly related to aesthetic quality, although the relationship was stronger for jack pine (*Pinus banksiana* Lamb.) than jack pine and black spruce or white spruce/balsam fir forested sites.
- Bushy trees (i.e. when the crown height is much greater than the stem height) within the first 13 metres of the shore mitigate poor aesthetics associated with intermediate width reserves.

Effects of natural disturbances on aesthetic quality

- Severe fires impair aesthetics.
- Severe wind induced tree blow down may not impair aesthetics.

Overall Messages

- Disturbances definitely impact the aesthetic appearance of forested landscapes in riparian areas.
- Riparian forest management should consider the affect of forest succession aesthetics.
- Shoreline aesthetics are only one component of forest management.

1.0 Introduction

Forested environments provide benefits beyond resource extraction, harvesting, and the opportunities to participate in outdoor recreation activities. From a human perspective, these benefits specifically relate to the psychological or emotive outcomes from experiences in forested settings (e.g. providing opportunities for achieving nature appreciation, solitude, escape, introspection, and spirituality outcomes). The achievements of such psychological outcomes are the reasons that individuals pursue outdoor recreation activities at all (Driver and Tocher 1970, Driver and Brown 1978).

Aesthetic quality is another seemingly intangible benefit that individuals receive from forested environments. Although aesthetics are important, the apparent difficulty in understanding, determining, and predicting aesthetics makes this benefit an elusive ideal in most forest management planning exercises. As an intangible, forest aesthetics remains as an external input to decision-making that only serves to influence public support for or against particular management actions. Indeed, preservationists have long extolled the aesthetic virtues of giant trees as rallying points for individuals and organizations concerned with the effects of logging on forested environments (Chase 1995).

Researchers have developed several methods to understand and quantify forest aesthetic values in objective and scientific manners. Most of this research has focused on the established paradigm of landscape perception in environmental psychology. In anticipation of needs within the United States, the research has focused on aesthetic quality of sites viewed from in-stand (near view), road, or scenic vista locations. These studies have demonstrated the possibility of both using scientific rigour to study forest aesthetics and providing credible results to resource managers. Many resource management agencies now employ these research methods to assist their efforts at protecting or enhancing forest aesthetics (see Daniel *et al.* 1989).

Ontario also views the protection of aesthetic values as an important aspect of forest management planning (Ontario Ministry of Natural Resources (OMNR) 1987). Impacts on aesthetics are important sources of conflict between the forest industry and resource-based tourism operators (Environmental and Social Systems Analysts 1988, Hunt *et al.* 2000a), recreationists (Hunt *et al.* 2000b), and environmental organizations. Despite the importance of the issue, little guidance or information is available to planning teams or local citizen's committees that are charged with the task of considering forest aesthetics in forest management planning exercises. Aesthetics around water bodies are usually protected by guidelines designed to protect water quality and fish habitat (OMNR 1988) or district land use guidelines. Although any of these measures may be sufficient to protect aesthetics, we simply do not know the extent of impacts that forest management has on aesthetic values in Northern Ontario.

This research was conducted to generate an understanding of aesthetic values relevant to forest management planning around riparian[1] zones (i.e. shorelines). Past research has consistently shown that most popular outdoor recreation activities in Ontario occur around water (Twynam and Robinson 1997). Similarly, the majority of resource-based tourists visiting Northern

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[1]We use the term riparian zone to denote both the vegetation immediately around water bodies and the forested upland areas that are visible from water bodies.

Ontario place greatest emphasis on settings with waterbodies, especially for fishing activities. Thus, the areas where recreationists or tourists may view alterations to forest aesthetics from logging will most likely occur around riparian zones[2]. Despite the fact that many outdoor recreationists and resource based tourists view forests from offshore vantage points, little research anywhere has focused on the aesthetics of forested shorelines.

Water based recreationists view the riparian forests as important backdrops to their activity but rarely explore these shoreline forests on foot. Therefore, a near-vista view was deemed as most appropriate for this study. The near-vista view represents an observer's view of the forest from the outside, but still sufficiently close for detailed bio-physical sampling of the study area. The methods section provides greater information relating to sampling and the choice of sites.

Formally, this research provides information on:

1. the effects of typical features found in the boreal forest, such as forest stand composition and site specific characteristics, on forest aesthetic values;
2. the effects of forest management on forest aesthetic values; and
3. the effects of natural disturbances on forest aesthetic values.

The first research objective is important since we need to recognize that many non-disturbance factors can impact forest aesthetics. Understanding these factors linked to forest aesthetic quality allows us to generate models that predict the aesthetic quality of many undisturbed, forested stands. Such predictive models could assist forest management planning by identifying the forest types that may deserve special consideration in planning efforts due to their high aesthetic value.

Understanding the effects of forest operations on aesthetic values is not only relevant to forest management in Ontario, but it is also a legal issue (i.e. Term and Conditions 24 and 80 (tourism) in the *Class Environmental Assessment by the Ministry of Natural Resources for Timber Management on Crown Lands in Ontario* (Ontario Ministry of the Environment 1994). Furthermore, a general model of shoreline forest aesthetics for the boreal forest can also be used for temporal views of forest vegetation dynamics. Simply put, researchers must consider forest aesthetic impacts over the long-term rather than myopically examining short-term impacts only. Researchers in landscape perception have long been aware of this temporal instability of aesthetics (e.g. Benson and Ullrich 1981, Hull and Buhyoff 1986).

It is equally important to understand the effects of natural disturbances on forest aesthetics as many forests in Ontario regenerate from large-scale disturbances. If the effects from logging disturbances on forest aesthetics do not differ from the effects of natural disturbances, from a purely aesthetic viewpoint, there should be relatively little concern over the impact of logging on aesthetics. If, however, logging has greater impacts than natural disturbances on forest aesthetics, forest management planning should consider the increased impact to forest aesthetics from logging disturbances.

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[2]However, fly-in based tourism establishments also have forestry impacts on aesthetics from aerial (oblique) vantage points. This topic has been the focus of previous research in Ontario (see Haider *et al.* 1998, Hunt and Haider 1999).

2.0 Methods

Although the field of landscape perception offers a variety of approaches for studying aesthetics, only the expert and psychophysical approaches (Zube *et al.* 1982) have found wide application in forest management (Ribe 1990). Whereas the expert approach discounts the importance of laypersons' perceptions of aesthetics, the psychophysical approach embraces these same perceptions. We chose to employ the psychophysical approach that relates psychometric evaluations by the public for different sites to external landscape properties (i.e. biophysical data) (Zube *et al.* 1982, Buhyoff *et al.* 1982, Daniel and Vining 1983, Hull *et al.* 1984, Shroeder and Brown 1983). Within the psychophysical approach, we employed the scenic beauty estimation (SBE) method (Daniel and Boster 1976).

The SBE method consists of a series of steps including collecting field data (both site inventories and photographs), gathering aesthetic evaluations for the sites, and jointly modeling these two sets of data. The technique has been frequently employed in landscape aesthetic research over the past 30 years (for a review see Haider and Hetherington in press). The technique relates public evaluations of landscape colour slides to the biophysical information. Numerous studies (Daniel and Boster 1976, Jackson and Hudman 1978, Buhyoff and Wellman 1979, Shuttleworth 1980, Kellomaki and Savolainen 1984, Stewart *et al.* 1984, Trent *et al.* 1987) have shown that aesthetic evaluations at on-site locations do not differ from those obtained through presentation of colour slides (i.e. a photographic transparency). Additionally, Vining and Orland (1989) found no significant difference between responses to video clips and photographs, and Hull and Buhyoff (1981) found that respondents who rated photographs for scenic beauty had few intransitivities. These studies support our decision to collect a variety of colour slides and biophysical data at each site.

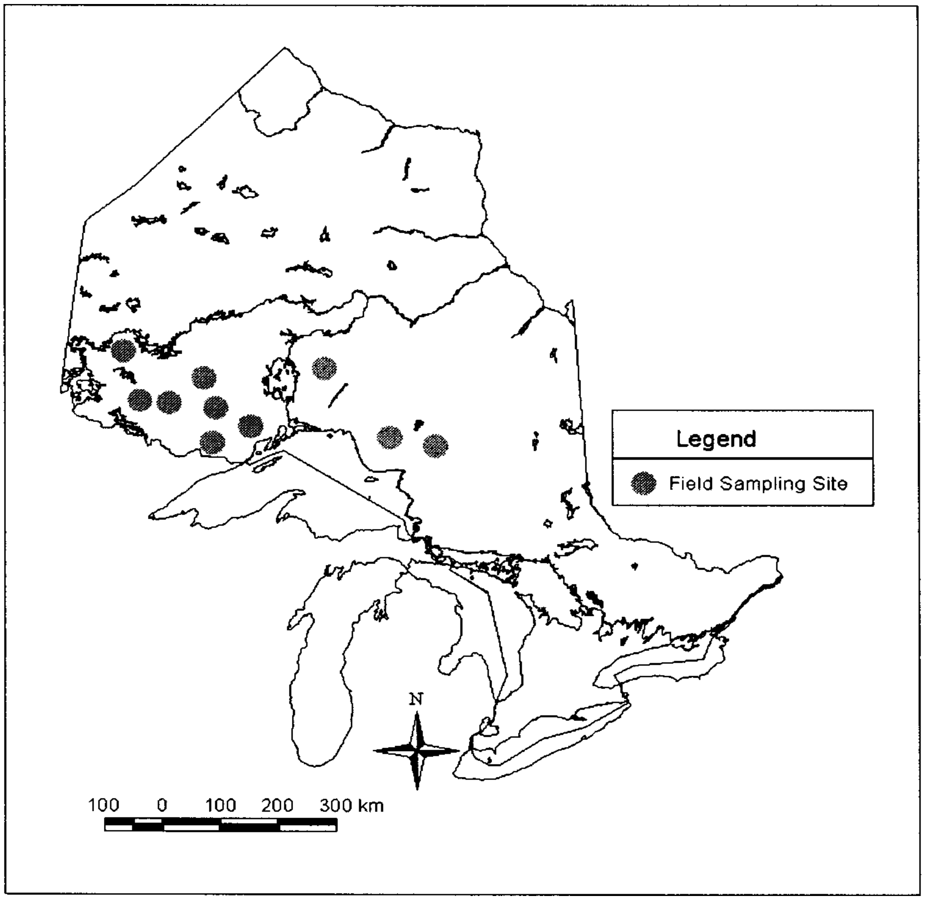
2.1 Field Data Collection Methods

Data collection in the field consisted of a biophysical and a photographic component. Although the two components are discussed separately below, in practice they are complementary.

A detailed inventory of biophysical data for the entire range of undisturbed and disturbed sites was generated following a series of steps. First, topographic maps and operation maps of the five-year Forest Management Plans were consulted to determine areas with specific elevation, vegetation, and logging activities. Discussions with Ontario Ministry of Natural Resources (OMNR) and forest industry staff assisted in obtaining information related to the presence of natural disturbances, road and access conditions, and suitable camping areas for the field staff. Most sampled sites (Map 1) were in northwestern Ontario. However, many of the forest types and topography encountered in northwestern Ontario are also representative of the boreal forest in northeastern Ontario and to a lesser extent in central Ontario.

After selecting an area, field staff chose a lake and classified the shoreline into a series of strata relating to vegetation, topography, and disturbance regimes. Field staff selected a random stratum for sampling except in cases where efforts were needed to increase sampling of underrepresented strata.

Map 1. Locations of major field sampling sites for riparian aesthetics project.



Within a selected stratum, the centre of a sampling plot was selected by a random compass bearing and an additional random correction ranging from five meters left to five metres right of the boat landing site.

Field staff marked the site centre and plots at three, 13, 28, and 43 metres along a transect perpendicular to the shoreline. Additional parallel transects were established at 20 metres left and right of the centre transect. This sampling strategy was developed after extensive pretests, which revealed that this sampling system provided the best balance between accuracy, precision, and efficiency (Trepanier and Haider unpublished manuscript). In locations with inclined shorelines, additional plots were established beyond the 43 metres, in additional 50 metre intervals. Each three metre plot adjacent to the shore also served as the centre for a six by six metre vegetation plot. For both the front and back three metres of each plot, the field staff recorded the percent ground coverage of the different herbs and shrubs. At all plots, the point-centred quarter method of sampling was employed to identify trees to sample (Cottam and Curtis 1956). The method requires the sampling of the nearest tree in each of the four plot quadrants. Information collected for each tree included its distance to plot centre, tree species, mortality, diameter at breast height (DBH) and stem, crown, and tree height. In cases where sites had two canopies, field crews collected tree information for both canopy layers.

Field staff also recorded several other site characteristics. Slope changes were recorded throughout the 43 metre transects, and the ages of typical trees in the stand were determined from increment bores[3] . Data collection at sites with logging disturbances included variables that measured the size of reserve between the shoreline and logged areas, whether forests were in a regeneration phase, and whether forests had been selectively cut. For sites with natural disturbances, characteristics collected included whether fires were highly noticeable or present, and whether significant tree blow down occurred at the sites. For sites with naturally appearing reserves, information collected included distance from shoreline to the natural clearing (e.g. peninsula width). Finally, for all sites the Forest Ecosystem Classification (FEC) vegetation type[4] of the stand was determined for plots taken from the 13 metre mark onwards, although additional vegetation types at further distances into the stand were also recorded.

For this study, we used only slides representing the near-vista views of 140 metres off shore. Since most outdoor recreationists in Northern Ontario recreate on water bodies, these near vista views provide good representations of the shoreline detail that individuals will encounter. The photographs from the 140 metre distance were taken with a Nikon F-801 35 mm camera and a 75 mm lens, capturing a 66 metre shore length image with a mix of overview and detail of the different vegetation types. The photograph was vertically centred on the middle transect, with an approximately equal amount of water and sky. In a typical scene with a slight incline in slope (15^o to 20^o), most of the vegetation in the slide is from the first 45 metres from the shore. Data from the biophysical sampling strategy contained information relating to this 45 metres of vegetation from the shore.

For the technical aspects of photography, we primarily followed the guidelines proposed by IMLAB (no date). Pictures were taken on clear days with the sun to the back of the photographer (i.e. a concentration of northeast, north, and northwest shorelines). Since Hollenhorst *et al.* (1993) found aesthetic ratings were linked to flowering vegetation, the pictures were only taken when vegetation was fully developed, thus decreasing the seasonal window of opportunity for field data collection to less than three months. Only Kodak Ectachrome 100 slide film was used and matrix metreing was turned on to ensure the correct exposure of the site in differing lighting situations. All pictures were taken with aperture priority while maintaining a shutter speed of at least one-sixtieth of a second. Buhyoff and Wellman (1979) and Buhyoff and Leuschner (1978) argued for such a rigorous approach to site photography.

2.2 Aesthetic Evaluation Pretest

Before conducting the formal slide evaluations, we conducted a pretest evaluation of the slides. The pretest with 50 Lakehead University students helped to identify important characteristics linked to aesthetic evaluations, to test for slide quality, and to determine gaps in the sample that could be addressed through subsequent data collection efforts. Although we expected

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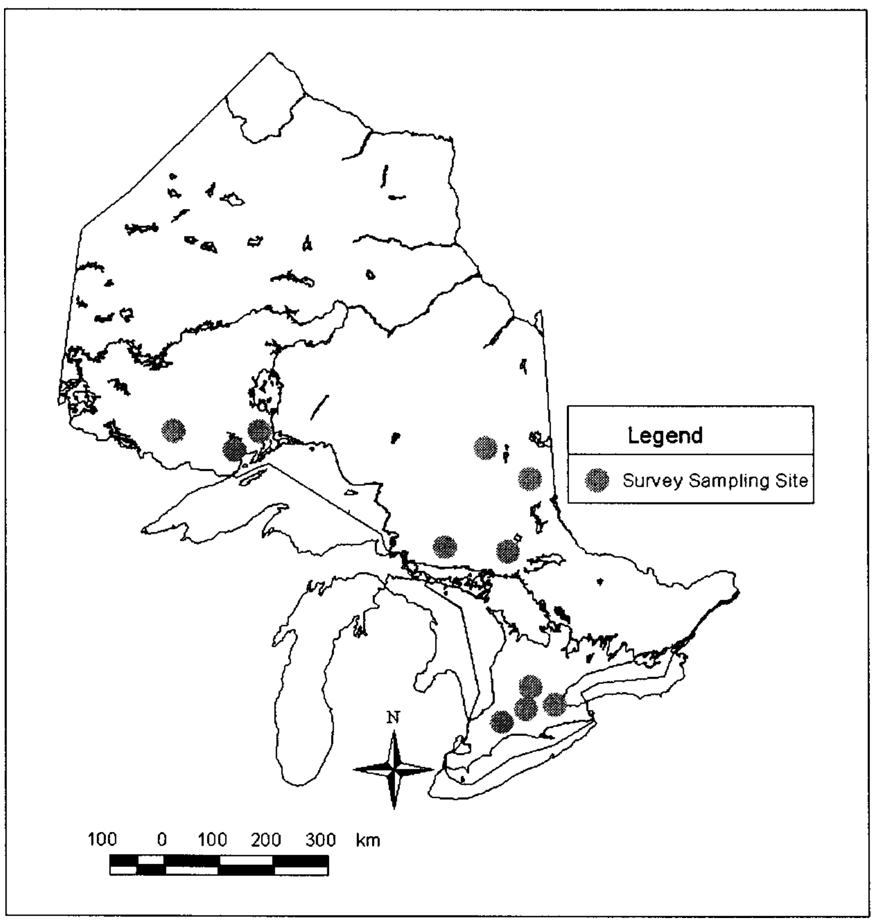
[3]Due to inconsistencies in the collection of ages from year to year, stand age was not used as a variable in any of the predictive models.
[4]The northwestern Ontario (Sims *et al.* 1997) classification was employed for both northwestern and northeastern Ontario sites.

outdoor recreation and forestry students to have extreme opposite views of the environment, we found remarkable consistency in their ratings (i.e. correlation coefficients of 0.785 for evaluations of undisturbed sites and 0.916 for evaluations of disturbed sites). However, the ratings by forestry students were consistently higher than those ratings by outdoor recreation students. The pretest demonstrated that we could address the research objectives by jointly measuring the aesthetics of undisturbed and disturbed sites. The pretest also demonstrated the need to collect more images according to vegetation types. Finally, the pretest pointed to a relationship between aesthetic quality and reserve size separating the shoreline from logged areas that needed further exploration. To fill these gaps, field crews collected additional data.

2.3 Provincial Aesthetic Evaluation Data Collection Methods

For the provincial evaluation study, we selected a convenience sample of Ontario's public. Data collection concentrated on students and not-for-profit organizations throughout Ontario. Thunder Bay and the nearby areas of Atikokan and Nipigon in northwestern Ontario were focal points for slide evaluation survey collection. However, slide evaluations were also collected from southern Ontario (Guelph, Cambridge, Hamilton, and London) and northeastern Ontario (Timmins, Kirkland Lake, Sudbury, and Elliot Lake) locales (see Map 2). These areas were chosen randomly with constraints of suitable driving distances between sites and the ability to organize sessions during a particular week. We instructed all individuals before the task that

Map 2. Locations of aesthetic evaluation sessions.



their participation was voluntary. A total of 454 individuals were surveyed from September through November of 1999.

From a set of 220 sites with photographs, 202 final sites were selected for evaluation. Poor quality of slides, usually in terms of lighting, was the primary reason for removal of sites. The 202 selected sites were catalogued according to undisturbed, undisturbed forests with a reserve appearance, anthropogenic disturbance, and natural disturbance themes. Within each theme, vegetation and disturbance types further divided the sites. Results of the pretest study with Lakehead University students found these further divisions to be important predictors of aesthetic quality. We selected 54 baseline slides from the 202 total slides in proportion to the frequency of all slides within each site classification.

In the slide shows, every survey participant rated these baseline slides along with an additional 74 slides that were randomly selected from the remaining 148 sites. To ensure that individuals recorded information correctly, every fifth slide was a number that referred to the following slide number, which enabled respondents to keep track of their ratings. The placement of the baseline, non-baseline, and numbered slides was held constant between all presentations, but the order of the baseline slides was randomly changed between sessions. Russell and Lanius (1984) and Brown and Daniel (1987) suggest that reordering slides can remove any effect from the previous slides on evaluations. Additionally, each respondent was shown five "warm-up" slides that contained the typical range of images to assist individuals in setting anchors for their aesthetic ratings (McCool *et al.* 1986). Each slide was shown for six seconds and, as much as possible, room lighting, image size, and noise were held constant for all sessions. A brief questionnaire elicited some sociodemographic background information and outdoor recreation activity participation levels from each survey participant. The entire task of slide evaluations and questionnaire completion took less than 25 minutes.

Respondents rated the aesthetics of each site on a ten-point rating scale that ranged from "very poor aesthetic quality" to "excellent aesthetic quality". These ratings were then transformed into scenic beauty evaluations, using the "by slide method" (Daniel and Boster 1976) that produces an aesthetic score for each site (referred to as the SBE score below). Due to the statistical standardization, these SBE scores for all sites are directly comparable on an interval scale, which by its very nature contains an arbitrary zero-point[5] .

3.0 Data Preparation

This section provides descriptive information about both the field and questionnaire data. First, the results from the questionnaire are analyzed and reported. Second, the biophysical site information is described and transformed to a suitable input for the development of predictive models.

[5]Other researchers argue that the SBE transformation should not be made and that the rating task should include a rating indicating neutrality or acceptability (Brunson 1996, Paquet and Belanger 1997). However, without a transformation of the scale, it is not known whether an individual's ratings are truly interval, and no tests have been conducted to determine if the acceptability point is related to the types of photographs shown.

3.1 Description of Survey Respondents

Each respondent completed a brief questionnaire about their sociodemographic characteristics and past outdoor recreation activity participation. These questions were asked since many sources have shown that these aspects are linked to the opinions that individuals have towards logging practices (Levine and Langeneau 1979, McLaughlin and Paradice 1980, Langeneau *et al.* 1980, Wilman 1984, Jackson 1986, Paquet and Belanger 1997, and Hunt *et al.* 2000b).

Table 3.1.1 details the sociodemographic characteristics of the sample. In this sample, females, young individuals, and college and university students were over represented, while their counterparts and individuals from northeastern Ontario were underrepresented. Clearly, these biases reflected the necessity of conducting the sampling in a cost efficient manner by organizing sessions primarily with university students and church groups. Individuals from the church groups tended to be older and more often female. The percentage of respondents engaged in environmental and outdoor recreation clubs may be higher than that in the population because of the high number of students in the sample. Although some may believe that these biases weaken our results, previous research on landscape perception has shown that students and members of church groups represent the general public well (Daniel and Boster 1976, Buhyoff and Leuschner 1978, Shuttleworth 1980, Schroeder and Daniel 1981, Buhyoff *et al.* 1982, Brown and Daniel 1984, Kellomaki and Savolainen 1984, Brown and Daniel 1988, and Daniel *et al.* 1989). Additionally, we formally tested the agreement in aesthetic evaluations among the different segments created by sociodemographic characteristics and activity interest.

Table 3.1.1. Sociodemographic characteristics of respondents.

Gender (n = 451)	**Percentage**	**Region (n=429)***	**Percentage**
male	40.6	Southcentral	47.3
female	59.4	Northwestern	34.0
		Northeastern	15.2
Residence (n = 452)		Other Canadian	2.1
rural	11.1	International	1.4
small community (< 5,000 people)	12.6		
town (5,000 – 50,000 people)	21.2	**Highest Education (n = 451)**	
urban (> 50,001 people)	55.1	primary school or less	1.5
		some high school	4.9
Age (n = 452)		completed high school	10.0
24 years or younger	47.6	some college or university	51.2
25 – 29 years	5.1	college/university diploma/degree	22.0
30 – 34 years	2.9	post graduate degree	6.4
35 – 39 years	5.3	trade or vocational	4.0
40 – 44 years	5.3		
45 – 49 years	4.4	**Membership in Outdoor Club (n = 446)**	
50 – 54 years	4.6	Yes	19.1
55 – 59 years	5.1	No	80.9
60 – 64 years	7.1		
65 – 69 years	4.2	**Membership in Environmental Club (n = 444)**	
70 years or older	8.4	Yes	14.6
		No	85.4

* following the Ontario Ministry of Natural Resources regions for Ontario.

A further question on the survey asked individuals to state their previous year's participation levels, i.e. 1998, for many popular outdoor recreation activities. Table 3.1.2 summarizes these results and shows that respondents participated in day hiking/nature walking and wildlife viewing/bird watching activities with the greatest frequency. This finding was expected, as individuals require no special gear to conduct these activities and they can pursue these activities in combination with other interests. In fact, individuals can conduct forms of wildlife viewing and bird watching from their own home, thus increasing the participation rates among more sedentary individuals. The high frequency of participation for mountain biking, canoeing, and back packing activities reflects both the increasing demand for these nonconsumptive activities (Twynam and Robinson 1997*,* Development Consulting Limited 1991*,* Marshall, Macklin, and Monoghan 1991) and the higher interest amongst younger individuals for these physically demanding activities (Hunt *et al.* 2000b*,* Twynam and Robinson 1997). Motor boating and fishing in open water occur in similar settings and thus many people would spend some time on an outdoor recreation trip pursuing both, but the other consumptive and motorized activities were much less frequently cited. Although rock climbing, kayaking, and snow shoeing activities were less popular than the previously mentioned nonconsumptive activities, they were very important to a minority of respondents. A few respondents had even participated in the unique activity of dog sledding. Finally, it is interesting to note that 78.6 percent of respondents had pursued some form of water-based recreation in 1998.

Table 3.1.2. Participation rates of respondents for various outdoor recreation activities.

	Individual Participation in 1998 (%)				
Activity	**Never**	**1-4 times**	**5-9 times**	**10-24 times**	**25+ time**
day hiking and nature walking	13.1	22.0	19.8	20.9	24.1
wildlife viewing/bird watching	29.2	33.3	15.3	9.0	13.3
mountain biking	55.5	20.0	7.9	7.0	9.7
canoeing	40.6	32.1	13.2	8.0	6.0
motor boating (no fishing)	45.6	31.0	11.0	4.7	7.6
back packing	53.6	23.0	11.7	5.6	6.1
fishing (open water)	54.9	28.3	7.4	4.0	5.4
cross country ski	58.6	26.1	6.2	4.9	4.2
mountain/rock climbing	64.7	22.9	5.8	3.6	2.9
kayaking	74.9	15.9	4.3	1.8	3.1
all terrain vehicle driving	77.5	13.2	4.0	2.9	2.5
snowshoeing	71.5	21.2	2.9	3.6	0.9
snowmobiling	77.5	15.4	3.3	2.7	1.1
hunting	90.6	5.6	1.6	1.1	1.1
ice fishing	85.9	11.7	1.3	0.7	0.4
dog sledding	95.8	3.8	0.0	0.4	0.0

To assess how participation rates for recreation activities relate to aesthetic evaluations, we grouped individuals with similar participation rates for the activities through a principal component and cluster analysis. First, the participation frequencies for the different activities were subjected to a principal component analysis (PCA), which attempts to reproduce the activity by activity participation correlation matrix by using only a subset of activity themes. One can view these themes as important distinguishing aspects that combine similar activities into one new variable. With PCA one can also calculate regression estimated scores for each new component and each individual. These regression estimated scores can be subsequently used for a cluster analysis to identify segments of individuals with similar activity participation patterns.

Effective principal component analysis requires good correlation coefficients among the different variables (activities). To test the suitability of conducting a PCA, we computed a Kaiser-Meyer-Olkin (KMO) test. Kaiser (1974) stated that a KMO value of less than 0.50 would be unacceptable. The test produced a coefficient of 0.850, which Kaiser (1974) described as “meritorious” for conducting a PCA.

Based on examination of slope breaks in the plot of eigenvalues (i.e. explanatory power of the components), four components with eigenvalues greater than one were selected, accounting for 58.8 percent of the data set variation. Table 3.1.3 shows these components, labeled as themes, and the associated component loadings that each activity has with the theme after varimax rotation. The component loadings are the correlation coefficients between the theme and any given activity’s participation rate, and the higher the correlation coefficient, the better the theme is at accounting for that activity. Activities that are highly correlated with a respective component facilitated the labeling of that component. The four themes represent *active* nonconsumptive *activities*, *passive* nonconsumptive *activities*, *consumptive or motorized activities*, and *winter* nonconsumptive *activities*. PCA also allows computation of a component score for each respondent and each theme.

Table 3.1.3. Principal component analysis of outdoor recreation activity participation rates.

Active nonconsumptive	**Loading**	**Consumptive or Motorized**	**Loading**
kayaking	0.787	ice fishing	0.748
canoeing	0.753	open water fishing	0.736
rock climbing	0.717	hunting	0.711
back packing	0.716	snowmobiling	0.673
mountain biking	0.713	all-terrain vehicle driving	0.644
cross-country skiing	0.414	motor boating	0.515
Passive nonconsumptive	**Loading**	**Winter nonconsumptive**	**Loading**
wildlife viewing	0.876	dog sledding	0.771
hiking/walking	0.712	snowshoeing	0.545

The component scores were then subjected to a cluster analysis to group together individuals with similar activity participation patterns. A Ward’s clustering algorithm was chosen with squared-Euclidean distance calculations. A five-group solution was chosen because of a large change in the distance measurement for merging the five groups to four groups. A comparison of the different activity component means for each group facilitated segment labeling, see Figure 3.1.1. It is important to stress that these means only show participation differences for one activity theme among the groups, and they do not permit comparisons of participation rates across activity themes. That is, the component scores for each theme have been standardized to a mean of zero and standard deviation of one, which masks overall participation differences among the activity themes. For example, the mean of the component scores for *winter* nonconsumptive *activities* is equal to that for passive nonconsumptive *activities* despite the fact that the former activities were pursued with much less frequency than were the latter activities.

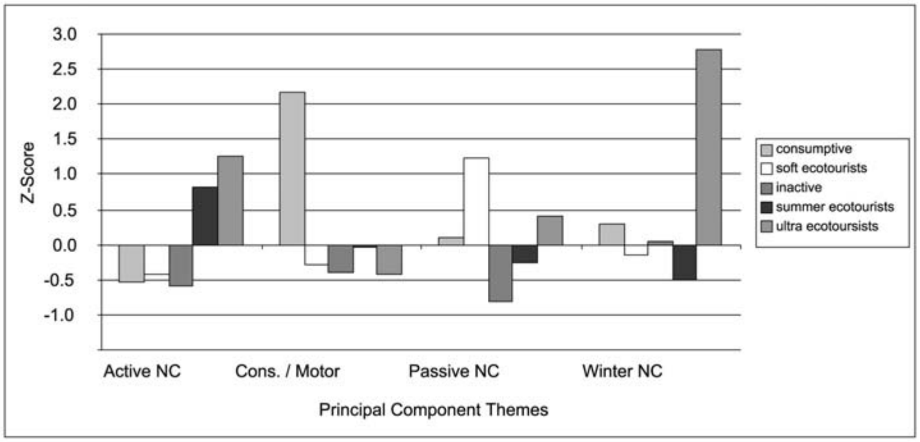


Figure 3.1.1. Standardized mean importance of activities by segments.

The first group was labeled *consumptive/motorized users* since this group pursues the consumptive/motorized activities much more than any other group. The second group was labeled *soft* nonconsumptive *users* since these individuals placed greatest relative importance on the passive nonconsumptive theme. Third, an *inactive group* was identified since these people tended to have below average participation rates for all the activity themes. Because of the relatively higher importance that individuals placed on active nonconsumptive activities that were summer related, the fourth group was labeled *summer* nonconsumptive *users*. The final group was named *ultra* nonconsumptive *users* since this group had the highest participation rates for active nonconsumptive and winter nonconsumptive activities.

3.2 Comparison of Aesthetic Evaluation Consistency Among Segments

To test for possible effects of sampling biases, correlation coefficients were calculated among segments for the SBE aesthetic evaluations of the sites. Many other researchers have employed this technique to comment on the consistency of responses (e.g. Buhyoff *et al.* 1982, Brown and Daniel 1988). Presence of high positive correlation coefficients would lessen suspicions that sampling biases would noticeably affect the results. Before computing the results, we simplified the structure of some sociodemographic variables used for segmentation (i.e. age categories were formed for less than 25 years, 25 to 54 years, and 55+ year-levels, and education was grouped into those without college or university experience and those with college or university experience).

Table 3.2.1 shows that almost all correlation coefficients of scenic beauty evaluations between various groups of respondents were between 1.00 and 0.90, except for the ones involving *ultra* nonconsumptive *users* (who have the smallest sample size, n = 23). However, even for this segment, the lowest correlation coefficient was 0.84. The results of the correlation coefficient tests do not imply that all individuals viewed all riparian forested settings identically. Rather, the results suggest that people were consistent in their relative evaluation of scenic quality between the different sites (i.e. some people may have viewed aesthetics of all sites as consistently lower than did other individuals). Further analyses involving segments of the population are beyond the scope of this report.

Table 3.2.1. Relationships between scenic beauty estimates and selected segments (correlation coefficient).

Sex	Correlation Coefficient	Education	Correlation Coefficient	Activity Segment*	Correlation Coefficient
male & female	0.964	coll./univ. & other	0.942	consum. & soft nc.	0.952
				consum. & inactive	0.939
Region		Age (years)		consum. & sum. nc.	0.948
NW & NE	0.959	< 24 & 25-54	0.950	consum. & ultra nc.	0.858
NW & SC	0.931	< 24 & 55+	0.917	soft nc. & inactive	0.956
NE & SC	0.929	25-54 & 55+	0.959	soft nc. & sum. nc.	0.964
				soft nc. & ultra nc.	0.863
Residence		Recreation Club		inactive & sum. nc.	0.948
rural & community	0.933	yes & no	0.945	inactive & ultra nc.	0.840
rural & town	0.947			sum. nc. & ultra nc.	0.918
rural & urban	0.937	Environmental Club			
community & town	0.956	yes & no	0.954		
community & urban	0.928				
town & urban	0.959				

* consum. = nonconsumptive/motorized users; soft nc. = nonconsumptive users; sum nc. = summer nonconsumptive users; inactive = inactive group; ultra nc. = ultra nonconsumptive users.

3.3 Preparation of the Biophysical Field Data

Just as a PCA reduced the activity participation questions into themes, the biophysical data were also analyzed by a PCA. However, before the PCA was conducted, the data had to be summarized in a manner that would allow comparisons between sites with much different vegetation.

For each site, data from the three transects were aggregated into one array that would provide information at a given distance from the shore. Also information collected from the 28 metre plots, 43 metre plots, and where applicable up to the 93 metre plots were all aggregated together. These aggregations resulted in measurements for three different distances from the shore (i.e. three, 13, and more than 28 metres). Basic information was tabulated for each distance relating to the percentage of hardwood trees, the average height of trees, the average diameter of trees at breast height, the percentage of dead trees, the number of different tree species, the density of trees, and the percentage of shoreline shrub cover by hardwood and conifer species. Although the field data collection permits finer statistics for each tree species, this summary allowed for meaningful comparisons between sites with very different stand characteristics.

A KMO test on the correlation matrix indicated that the data was about "middling" (Kaiser 1974) for a PCA (KMO = 0.692). The PCA yielded six components that accounted for 76.4 percent of the variation. Table 3.3.1 shows the six components and their component loadings after varimax rotation. Not surprisingly, most components simply summarized a statistic across the three different distances from the shoreline. The first component related to *tree size* both in terms of tree diameter and height. The second component related to the degree of *hardwood cover* of the site for both trees and the shoreline shrubs. *Tree mortality* measured the extent of dead trees in a stand. *Species variability* was the fourth component, which summarized the number of different tree species in the stand. The fifth component related to the *tree density*. Finally, the amount of *conifer shrubs* on the shoreline was the last component. Appendix 1 provides a weighting matrix that readers could use to calculate component scores for new field sites.

Table 3.3.1. Principal component analysis of biophysical field data.

Tree Size (" = 0.939)	**Load.**	**Hardwood (" = 0.894**)**	**Load.**	**Tree Mortality (" = 0.874)**	**Load.**
Height (13 metre)	0.905	Hardwood (3 metre)	0.916	Mortality (3 metre)	0.911
DBH (13 metre)	0.903	Hardwood (13 metre)	0.907	Mortality (13 metre)	0.856
Height (3 metre)	0.897	Hardwood (28+ metre)	0.804	Mortality (28+ metre)	0.842
DBH (3 metre)	0.880	Hardwood Shrub (shoreline)	0.535		
Height (28+ metre)	0.877				
DBH (28+ metre)	0.877				
Species Variety (" = 0.740)	**Load.**	**Density (" = 0.651)**	**Load.**	**Conifer Shrub (NA)**	**Load.**
Species Variety (3 metre)	0.840	Density (3 metre)	0.818	Conifer Shrub (shoreline)	0.877
Species Variety (13 metre)	0.807	Density (13 metre)	0.777		
Species Variety (28+ metre)	0.786	Density (28+ metre)	0.678		

** based on the hardwood tree measurements only.

Component scores were calculated for each site and were used to explain aesthetic evaluations in later analyses. Although masking some important stand specific information, these themes represent many important elements that describe the biophysical information of each stand. One additional advantage of using components, rather than raw data is that they are completely uncorrelated among each other. This fact eliminates problems of multicollinearity that frequently plagues models of aesthetic quality that are based on original measurements.

3.4 Considerations for Model Selections

The next step following the preparation of the biophysical and forest aesthetic evaluation data was to determine if site characteristics explain the variation in forest aesthetic evaluations. For these analyses, generalized analysis of variance (ANOVA), analysis of covariance (ANCOVA), and multiple regression based models were employed with scenic beauty evaluations related to a classification of vegetation types or themes describing biophysical data. However, the ANOVA and ANCOVA models were simply employed as convenient forms of regression based models that assist in predicting mean aesthetic values for different sites.

The total number of sites did not permit a detailed analysis of the scenic beauty evaluations by all 38 FEC vegetation types. Consideration of gross visible characteristics and sample size led us to use eight groups. Inspection of the homogeneity of scenic beauty evaluations within the eight groups led us to separate eastern white cedar and eastern white cedar mixedwood forests into their own group. Table 3.4.1 shows the number of sites in the nine final groups with their associated vegetation types and a miscellaneous category.

For the remainder of this document, we have shortened some of these forest grouping names from Table 3.4.1 to enhance the readability of this report. In accordance with Table 3.4.1, the mixedwood and conifer portions of the names have been dropped (e.g. red pine and white pine conifer and mixedwood forests becomes red and white pine forests). The two black spruce forest groups were also renamed: black spruce forests for black spruce/wet organic and black spruce bogs for black spruce/leatherleaf/ sphagnum.

Table 3.4.1. Sampling sites by modified FEC overview groupings and FEC vegetation types.

Modified FEC Overview Groupings	NW FEC V-types	Sites
Hardwood species	1 through 11	20
Red Pine (*Pinus resinosa* Ait.) or White Pine (*Pinus Strobus* L.) Conifer and Mixedwood	12, 13, 26, 27	16
Balsam Fir (*Abies balsamea* (L.) Mill.) - White Spruce (*Picea glauca* (Moench) A. Voss) Mixedwood and Conifer	14, 15, 16, 24, 25	31
Jack Pine (*Pinus banksiana* Lamb.) Conifer and Mixedwood	17, 18, 28, 29	40
Black Spruce (*Picea mariana* (Mill.) BSP.) & Jack Pine Conifer and Mixedwood	19, 20, 30, 31, 32, 33	52
Black Spruce / Wet Organic	23, 34, 35, 36, 37	13
Black Spruce / Leatherleaf / Sphagnum	38	10
Eastern White Cedar (*Thuja occidentalis* L.)	21, 22	18
Other (burns, cut to shore, etc.)		2*

* includes one burnt site and one site logged to the shoreline; in both cases, the former vegetation type (working group) was indeterminable.

4.0 Predictive Models of Aesthetics for Undisturbed Forests

In this section, we predict the scenic quality of undisturbed sites through three separate model forms determined by different types of biophysical and vegetation classification information. Although the term "undisturbed" may be inappropriate for many of the sites, a site was considered undisturbed if it consisted of a mature stand of trees with no anthropogenic disturbances (logging within 350 m of the waterbody) or evidence of a recent severe natural disturbance (including fire and significant tree blow down) at the time the photograph was taken.

The models presented below contain different independent variables. The first model provides a convenient field guide for forest aesthetics by only requiring that the modified FEC overview groupings be known about sites. Appendix 2 provides photographic examples of these groups. The second model includes, in addition to these overview groupings, readily available information about slope of the land and tree mortality estimates. The third model requires detailed site specific information to estimate aesthetic quality.

4.1 Aesthetic Quality Prediction from Modified FEC Overview Groupings

A generalized Analysis of Variance (ANOVA) was fit on the SBE scores for the 95 undisturbed sites. Only the modified FEC overview grouping factor was included in the model. Table 4.1.1 shows that the ANOVA model was significant ($F=13.66$, $df = 7, 87$, $p<0.001$) and explained 48.5 percent of data set variation. Both the intercept ($F=31.88$, $df = 1$, $p <0.001$) and the vegetation type factor were also significant ($F=13.66$, $df = 7$, $p<0.001$). A nonsignificant Levene's test of equality of error variances ($F=1.14$, $df = 7, 87$, $p = 0.346$) provided evidence that assumption of homogeneity of variances between the groups was met.

Several of the pairwise Bonferroni tests yielded significant aesthetic rating differences between pairs of modified FEC groups[6] (Table 4.1.2). Black spruce bog forests were significantly least preferred with the exception of closely related black spruce forests (and even here the statistical probability that the two site types have identical mean SBEs was quite small). Hardwood species forests and red and white pine forests both had significantly higher SBE means than balsam fir/white spruce and black spruce forests; also, the eastern white cedar forests were significantly more preferred to balsam fir/white spruce forests. Despite the lack of significance between the pairwise tests, the results below are sorted by their sample SBE means and Figure 4.1.1 shows box and stem plots for each group.

Table 4.1.1. ANOVA summary table for aesthetics and modified FEC overview groupings.

	SS	df	MS	F	Sig	η^2
Corrected Model	160860.58	7	22980.08	13.659	<0.001	0.524
Intercept	53629.62	1	53629.62	31.877	<0.001	0.268
Modified FEC groups	160860.58	7	22980.08	13.659	<0.001	0.524
Error	146368.76	87	1682.40			
Total	385329.63	95				
Corrected Total	307229.34	94				

				95% Confidence Interval		
Contrasts*	Estimate	Std. Err.	Sig.	Lower	Upper	Pairwise**
Red & White Pine (RWP)	50.903	10.79	<0.001	29.459	72.347	WSBF, BS, BSB
Hardwood Species (HS)	45.489	10.46	<0.001	24.693	66.284	WSBF, BS, BSB
Eastern White Cedar (EWC)	25.759	NA	NA	NA	NA	WSBF, BSB
Jack Pine (JP)	15.053	12.06	0.215	-8.924	39.030	BSB
Jack Pine & Black Spruce (JPBS)	7.377	9.46	0.437	-11.420	26.174	BSB
Black Spruce (BS)	-23.503	14.13	0.100	-51.583	4.578	
White Spruce / Balsam Fir (WSBF)	-32.388	10.17	0.002	-52.605	-12.171	BSB
Black Spruce Bog (BSB)	-88.690	12.63	<0.001	-113.795	-63.584	all but BS

* to predict SBE for each group 28.672 must be added to the contrast values (that is 28.672 is the average SBE for all the sites).
** based on Bonderroni adjusted t-tests of pairwise differences at a 95 percent confidence level.

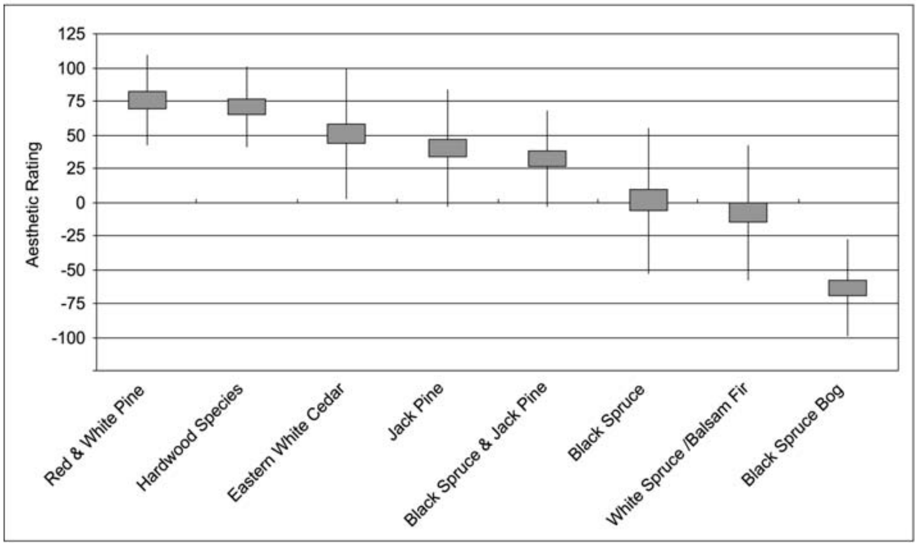
Table 4.1.2. Aesthetic quality contrast estimates and pairwise comparisons between the modified FEC overview groupings.

Figure 4.1.1 shows that red and white pine stands had the highest sample mean aesthetic value. The preference for these forests, no doubt, arises from the fact that pines are the largest trees in Northern Ontario. These trees have also been the subject of past near-view aesthetic work in Ontario (Haider 1992), and the OMNR has devised a conservation strategy for these trees (OMNR 1996).

Hardwood dominated forests were rated a close second in the aesthetic by our sample. We suggest that the illumination quality of hardwood tree species increased the aesthetic ratings along with the richness and fullness of the vegetation associated with these stands. The slopes of hardwood stands in riparian zones are typically steeper than the slopes of many other forests types. Both of these factors contribute to their high aesthetic evaluations.

[6]It should be noted that the 28 different pairwise comparisons exacerbates the probability of making a type II error (i.e. the above presentation is highly conservative about differences between groups).

Figure 4.1.1. Box and stem plots* of aesthetic ratings for the modified FEC overview groupings.



* boxes represent one standard error above and below the mean; stems represent one standard deviation above and below the mean.

Eastern white cedar and jack pine forests were next in order of aesthetic quality. Although the cedar sites were on considerably flatter lands than the jack pine forests, the cedar forests usually had a very high density of cedar trees within the first five metres of the shoreline. This front row of vegetation appeared to be aesthetically important for people when viewing riparian zones from near-vista views. Jack pine forests provided a uniform view of the forests since they usually occur as even aged stands with few additional tree species. These stands also are normally located on steeper lands than many of the other forests.

Following closely behind the above sites in aesthetic quality were black spruce and jack pine dominated forests. These sites typically consist of uneven aged stands with a two-tiered vegetation appearance. These sites in the field sample also occurred on slightly flatter lands than the pure jack pine sites.

Next in aesthetic quality were sites characterized by black spruce and balsam fir/white spruce forests. The black spruce forests provide an even aged stand, but appear on much flatter lands than jack pine forests. As with the black spruce and jack pine forests, balsam fir/white spruce forests consist of very uneven aged tree stands. The sites contain abundant diversity of tree species and occur on slightly flatter lands than do the black spruce and jack pine forested sites.

Black spruce bogs were the least preferred vegetation type. These forests are predominately characterized by stunted trees that are widely dispersed through very flat lands. The small tree heights and low elevation can provide an illusion that the offshore photographic distance exceeds 140 metres (see Appendix 2).

4.2 Aesthetic Quality Prediction from Modified FEC Overview Groupings with Slope and Tree Mortality Covariates

The predictive power of the above model can be enhanced by including two covariates along with the factor of modified FEC overview groupings. The two covariates are stand mortality ($F=7.98$, $df = 1$, $p=0.006$, $\eta^2= 0.084$)

and slope (F=5.27, df=1, p=0.024, η^2 =0.058). For mortality, as the presence of dead trees becomes more prominent, the aesthetic quality of the site declines. This is a consistent finding in the aesthetic literature (Brunson 1996). Increases to slope increase aesthetic ratings for the sites. The final Analysis of Covariance (ANCOVA) model is significant (F=13.35, df = 7, 2, 85, p <0.001), see Table 4.2.1, and the explanatory power of this model improves to 54.2 percent of data set variation. Again, Levene's test of equality of error variances (F=1.27, df = 7, 87, p =0.276) showed no significant difference in variation between the modified FEC overview groupings.

Table 4.2.1. ANCOVA summary table for aesthetics and modified FEC overview grouping with covariates.

	SS	df	MS	F	Sig.	η^2
Corrected Model	179920.48	9	19991.16	13.347	<0.001	0.586
Intercept	1948.53	1	1948.53	1.301	0.257	0.015
Vegetation Factor	60142.79	7	8591.83	5.736	<0.001	0.321
Tree Mortality	11678.58	1	11678.58	7.797	0.006	0.084
Slope	7899.87	1	7899.87	5.274	0.024	0.058
Error	127308.86	85	1497.75			
Total	385329.63	95				
Corrected Total	307229.34	94				

The modified FEC overview grouping factor remains as a significant (F=5.74, p<0.001, η^2 = 0.321) explanatory factor of variation in aesthetic ratings. For the most part, the importance of the respective vegetation types remained independent of the inclusion of the covariates. The only exception was that the black spruce bog forests increased slightly in relative value, since these sites are located on very flat lands with many dead trees.

Table 4.2.2 shows the parameter estimates for the aesthetics model. To estimate the aesthetic quality for any site, an individual needs to know the extent of tree mortality at the site, the slope of the land for the first 50 metres from the shoreline, and the vegetation type of the forested land. Although determining slope and mortality require greater efforts than identifying the modified FEC overview grouping, the predictability of the model increases with the provision of such information.

Table 4.2.2. Aesthetic quality parameter estimates for the modified FEC groups and covariates.

					95% Confidence Interval		
Estimates	**B**	**Std. Err.**	**t**	**Sig.**	**Lower**	**Upper**	η^2
Intercept	26.57	15.61	1.70	0.092	-4.47	57.61	0.033
Red & White Pine	19.21	16.87	1.14	0.258	-14.33	52.74	0.015
Hardwood Species	19.12	16.66	1.15	0.254	-14.00	52.25	0.015
Eastern White Cedar	0.00	NA	NA	NA	NA	NA	NA
Jack Pine	-5.16	17.86	-0.29	0.773	-40.68	30.35	0.001
Jack Pine & Black Spruce	-16.33	16.07	-1.02	0.312	-48.27	15.61	0.012
Black Spruce	-37.56	20.74	-1.81	0.074	-78.79	3.68	0.037
White Spruce/Balsam Fir	-41.57	17.09	-2.43	0.017	-75.54	-7.59	0.065
Black Spruce Bog	-84.13	20.33	-4.14	<0.001	-124.56	-43.71	0.168
Tree Mortality	-16.52	5.91	-2.79	0.006	-28.27	-4.76	0.084
Slope	12.11	5.27	2.30	0.024	1.63	22.59	0.058

Finally, Table 4.2.3 shows the contrast elements of the aesthetic comparison. Again, the contrasts compare the effect of any vegetation type to the average effect of vegetation. The same previous footnoted discussion of inflated type II errors applies to the table.

Contrasts*	B	Std. Err.	Sig.	95% Confidence Interval Lower	Upper
Red & White Pine	37.509	11.00	0.001	15.649	59.369
Hardwood Species	37.420	510.13	<0.001	17.288	57.562
Eastern White Cedar	18.303	NA	NA	NA	NA
Jack Pine	13.139	11.69	0.264	-10.104	36.383
Jack Pine and Black Spruce	1.974	9.10	0.829	-16.112	20.061
Black Spruce	-19.256	14.06	0.174	-47.205	8.693
White Spruce/Balsam Fir	-23.260	49.93	0.022	-43.012	-3.515
Black Spruce Bog	-65.830	13.56	<0.001	-92.799	-38.862

* to predict SBE for each group 28.672 must be added to the contrast values (that is 28.672 is the average SBE for all the sites)

Table 4.2.3. Aesthetic quality contrast estimates for the modified FEC overview groupings (ANCOVA Model).

4.3 Aesthetic Quality Prediction from Site Specific Biophysical Measures

The ANCOVA model presented above provides an adequate explanation of the differences in aesthetic evaluations. However, additional biophysical data could supplant the modified FEC overview groupings factor in a multiple regression model. Such a regression model could provide a more precise description of the important aspects to forest aesthetics. The major drawback of using biophysical data is that this type of information is rarely available and needs to be collected through intensive field work.

A final regression model ($F= 24.69$, $df=7, 88$, $p < 0.001$) was selected that explained 60.2 percent of data set variation. This improved model contained five of the six biophysical components (see Section 3.3) along with slope and an intercept value (Table 4.3.1). Again, using the principal component scores rather than raw measures removed the multicollinearity from the data. Additional tests between the component scores and slope revealed that only one of the five relationships was significant (slope and tree size $r_p = 0.328$, $df = 101$, $p = 0.001$), but this small correlation coefficient should not greatly influence the parameter estimates for tree size and slope.

Table 4.3.1. Regression summary table for aesthetics and site specific biophysical field data.

	SS	df	MS	F	Sig	R^2
Regression	192733.91	6	32122.32	24.69	<0.001	0.627
Residual	14495.43	88	1301.08		adj R^2	(0.602)
Total	307229.34	94				

The only component that was not significant in this regression model was the tree species diversity component ($t=-0.24$, $df=1$, $p=0.810$). This insignificance may have arisen since diversity measured only the actual number of different tree species at the three distances from the shoreline combined, and not the dominance of each different species. As well, whereas unpopular black spruce bogs had few different tree species, other less preferable balsam fir/white spruce forests could be very diverse. The effect of having these two less popular forest types on polar ends of the diversity scale, no doubt led to the insignificant finding. Another plausible explanation could relate to the fact that people do not view very cluttered landscapes as aesthetically appealing.

The component relating to tree size was positively related to aesthetics (t=6.01, df=1, p<0.001) and was the most important explanatory variable in the model (Beta = 0.421) (Table 4.3.2). Thus, as trees in forests become taller and wider, aesthetic ratings improve. The highly preferred red and white pine forests contained the tallest trees in the data set, whereas the less popular black spruce bog sites would have negative values for the tree size component. Many of the hardwood forests sampled also were of large size, especially for tree diameter.

Table 4.3.2. Aesthetic quality parameter estimates for site specific biophysical field data.

	Unstandardized Coefficients					95% Confidence Interval for B	
	B	**Std. Error**	**Beta**	**t**	**Sign.**	**Lower**	**Upper**
Intercept	-8.404	6.27		-1.34	0.184	-20.87	4.06
Tree Size	20.224	3.37	0.421	6.01	<0.001	13.53	26.92
Slope	21.131	4.27	0.338	4.95	<0.001	12.64	29.62
Tree Mortality	-22.398	5.12	-0.298	-4.38	<0.001	-32.57	-12.23
Conifer Shrubs	-17.500	5.49	-0.214	-3.19	0.002	-28.40	-6.59
Tree Density	11.080	3.58	0.209	3.10	0.003	3.97	18.19
Hardwood Species	8.290	3.27	0.173	2.53	0.013	1.78	14.79

Slope, which was previously explained, was next in importance and was positively related to aesthetic quality (t=4.27, df=1, p<0.001, Beta = 0.338). Third was the tree mortality component, which was negatively related to aesthetics (t=-4.38, df=1, p<0.001, Beta = -0.298). Although the higher mortality rates of trees in black spruce bogs than other places may partially explain this relationship, the relationship does make intuitive sense in other instances. As more trees die in a forested stand, the aesthetic ratings for that site should decrease. This would especially hold true for sites where dead trees would provide sharp contrast in coloration, as with most conifer species.

The component relating to conifer shrub was significant and negatively related to aesthetics (t= -3.18, df=1, p=0.002, Beta = -0.214). Since hardwood stands predictably had the least amount of conifer shrubs in the front 13 metres, the estimate is negative. Many of the rocky shores holding pine forests also were devoid of shrubs of any type.

Next, stand density was positively related to aesthetics (t=3.10, df=1, p=0.002, Beta = 0.209). Again the sparse black spruce bog densities would push this variable towards significance, but larger tree species in two-tiered forests would be found at lower densities in the upper canopy, which was the basis for all measurements. Eastern white cedar forests had the densest stands of trees, especially for the front 20 metres. This suggests that tree density is important to provide an opaque look that assists in preventing visual penetration further into the forest stand.

Finally, the regression model detected a significant positive relationship between aesthetic quality and the component measuring hardwood abundance (t=2.53, df=1, p=0.013, Beta = 0.173). This relationship follows from the high aesthetic appeal of hardwood forests, but lower ratings given to balsam fir/white spruce forests, which usually occurred with many hardwood species, tempered the strength of this relationship.

This model formulation is still basic as it employs aggregated site specific biophysical data to predict evaluations. It may be possible to predict aesthetic evaluations better for each separate forest type. However, no significant interactions between the biophysical components and the modified FEC overview grouping were statistically related to forest aesthetic evaluations. Presumably, a larger number of sites within each vegetation type would be required to identify significant differences.

5.0 Aesthetic Predictive Models for Disturbed Forests

The previous models provide good explanatory power for estimating the aesthetic quality of sites that are "undisturbed" or pristine. Although these models can identify areas of high aesthetic value, the question remains as to whether disturbances impact aesthetic quality of riparian forests. This section addresses that question by formally examining sites representing a suite of different disturbances in forests, and comparing these to undisturbed forested sites.

To understand the different analyses conducted in this section, a few issues about the selection of sites need to be discussed. First, although forest companies may harvest within 30 metres of the shore around warm water lakes, the additional costs faced by forest companies for field inspections leaves most *de facto* harvests at a minimum of 30 metres from the shoreline. Therefore, the number of sites that contain harvests within 30 metres of lakes is severely limited, and for this study we primarily inventoried these sites from a set that was part of an experiment to test the efficacy of the "fisheries guidelines" for coldwater lakes. Therefore, most of our sites representing logging to within 10 metres of the shore come from locations with very similar topography and vegetation. Consequently, our sample of disturbed sites may somewhat violate the assumption that sites are selected randomly and independently from each other. Second, it was difficult to obtain over the life of the field data collection efforts a large sample of sites with natural disturbances. The small number of sites within these groups should also caution us about interpreting insignificant results too literally.

5.1 Aesthetic Quality Prediction from Various Forest Disturbances

An ANOVA model was employed to test for the effects of a treatment variable on aesthetic evaluations. Specifically, we examined the effects of four different forest disturbances to the control group of undisturbed forests. These four disturbances include sites with: severe fires; wind induced blow-down; intermediate sized reserves (30–225 m); and no reserves (10 m or less). Again, the number of sites representing each treatment was highly dependent on our ability to find sites with each disturbance type occurring around lake shores. Appendix 3 provides photographic examples of these types of forest disturbances.

To identify a more homogeneous set of sites to test for possible effects of the respective disturbances, we removed all sites representing the modified FEC overview groupings of hardwood species, red or white pine forests, eastern white cedar and black spruce bogs, along with regenerating sites, selective logged sites, and one outlier that had a large buffer (230 m) and high slope for two reasons. First, the earlier ANOVA and ANCOVA models for undisturbed forests showed that the aesthetic quality of these sites differed significantly from the remaining sites, while the pairwise comparisons of the remaining forest types were not statistically different in aesthetic evaluations. Second, many of the excluded forest types contained too few plots for proper statistical analysis, see Table 5.1.1.

Table 5.1.1. Distribution of sites by disturbance types and modified FEC overview groupings.

	Type of Disturbance				
Modified FEC Group	**Undisturbed**	**Intermediate Reserves**	**Cut to Shore**	**Severe Fires**	**Wind-Induced Blowdown**
Hardwood Species	14	3	1	2	0
Red & White Pine	13	2	0	0	0
Eastern White Cedar	9	6	0	2	0
Jack Pine	10	16	4	3	2
Jack Pine & Black Spruce	18	20	2	3	4
Black Spruce	6	4	0	1	0
Balsam Fir/White Spruce	15	10	0	0	3
Black Spruce Bog	9	0	0	0	0
Miscellaneous	0	0	1	1	0
Total exlcuded	*45*	*11*	*1*	*4*	*0*
Total included	*49*	*50*	*7*	*8*	*9*

This reduction in the data set left 49 undisturbed sites for the subsequent analysis. Also remaining in this analysis were: seven sites that had logging present within the first 10 metres of the shoreline; 51 sites that had logging present from 30 to 225 metres[7] of the shoreline; eight sites with severe fires; and seven sites with wind induced tree blow down. The final ANOVA model explained 46.5 percent of data set variation ($F=27.56$, $df = 4,118$, $p < 0.001$) (Table 5.1.2). A test for equality of variances between the groups showed no significant differences ($F= 0.508$, $df = 4, 118$, $p = 0.730$). Table 5.1.3 displays the parameter estimates and associated significance of the various levels of the broad classification of sites.

Table 5.1.2. ANOVA summary table for aesthetics and a general forest disturbance type factor.

	SS	df	MS	F	Sig	η^2
Corrected Model	262121.99	4	65530.50	27.557	<0.001	0.483
Intercept	209432.63	1	209432.63	88.070	<0.001	0.427
Disturbance Factor	262121.99	4	65530.50	27.557	<0.001	0.483
Error	280606.51	118	2378.02			
Total	599720.91	123				
Corrected Total	542728.50	122				

Contrasts*	Estimate	Std. Err.	Sig.	Lower	Upper	Pairwise**
Undisturbed Forests (U)	0.000	NA	NA	NA	NA	IR, F, CR
Tree Blow-Down (BD)	-39.836	17.685	0.03	-74.857	-4.815	F, CR
Intermediate Reserves (IR)	-43.519	9.803	<0.01	-62.931	-24.107	U, F, CR
Fire (F)	-122.728	18.595	<0.01	-159.552	-85.905	U, BD, IR
< 10 m Reserve (CR)	-175.541	19.704	<0.01	-214.560	-136.522	U,BD, IR

* to predict SBE for each group 17.052 must be added to the contrast values (that is 17.052 is the average SBE for these undisturbed (control) sites)
** based on Hochberg GT2 post hoc tests with an overall 95% confidence level

Table 5.1.3. Aesthetic quality contrast estimates and pairwise comparisons between forest disturbance types.

[7] This group was first separated into 30 to 59 metre reserves and greater than 60 metre reserves, but no statistically significant difference between the aesthetics ratings were observed based on these two categories ($t = -1.57$, $df = 49$, $p = 0.123$). Therefore, the two groups were aggregated for the ANOVA model. Subsequent analyses examine the importance of the reserve size to aesthetics.

A Hochberg GT2 post hoc test was used for pairwise comparisons because of the greatly different sample sizes among the different groups (Toothaker 1993). Again, the relatively large number of pairwise comparisons (i.e. 10) increases the likelihood of type II errors occurring among the comparisons.

With this point in mind, the following conclusions are drawn from these tests. First, the undisturbed sites had greater aesthetic ratings than any disturbed sites, except for sites with wind-induced tree blowdown (p=0.229). These results clearly show that fire and anthropogenic disturbances both negatively impact the attainment of aesthetic quality in riparian areas. Second, sites with logging within 10 metres of the shoreline were significantly less preferred than any other sites with the exception of sites with severe fires (p=0.320). The results also showed that the sites with reserves of 30 metres or more were significantly preferred to sites with reserves of less than 10 metres. Third, we see that undisturbed sites were preferred to sites with intermediate reserves. Therefore, it should be possible to determine a functional form for reserve size and aesthetic quality. Fourth, sites with presence of forest fires were significantly less preferred to sites with either wind-induced tree blow down or intermediate reserve distances (30 to 225 metres). No statistical difference existed between aesthetic ratings for sites with wind induced tree blow down and sites with intermediate reserve distances.

The results show that disturbances impact the aesthetic quality of sites. In the case of natural disturbances, sites with wind induced tree blow downs were much more aesthetically pleasing than were sites with severe forest fires. Although sites with wind induced tree blow down were preferred to sites with logging within 10 metres of the shoreline, no statistically significant difference existed between comparisons of means for wind induced tree blow down and intermediate sized reserve sites or logged to within 10 metres and severe fire sites.

5.2 Aesthetic Quality and Sites with Intermediate Reserve Sizes

The previous analysis provided substantial evidence that the size of a reserve strongly impacts the aesthetic quality of a site. The analysis showed that aesthetic ratings were lowest for sites with less than 10 metre reserves and highest for sites that were undisturbed. This suggests that a functional form for reserve size and aesthetic quality exists and is likely non-linear[8]. Instead of modeling the relationship between reserve size and aesthetics with all sites, we only employed those sites with intermediate reserve distances (i.e. 30 to 225 metres) for several reasons. First, the above analysis already showed that undisturbed sites were most preferred, and any reserve distance we apply to the undisturbed sites for this analysis would be arbitrary. Second, the above analysis has shown that sites with less than 10 metre reserves were least preferred, and inclusion of these sites would anchor the slope of this relationship. Finally, the *de facto* minimum reserve size around most

[8]It is doubtful that undisturbed sites will have greater aesthetic ratings than sites with very large sized reserves. Indeed, we defined undisturbed as sites that had no logging within 350 metres of the shore.

lakes is 30 metres. Therefore, modeling the effects of reserve beyond this 30 metre threshold provides the most useful information to the forest management planning process.

To identify this relationship, we selected only sites with 30 to 225 metre reserves between the shoreline and cutovers. As in the previous analysis, we selected only those sites that had similar aesthetic ratings for undisturbed cases (i.e. we eliminated sites with hardwood species forests, red and white pine forests, eastern white cedar forests and black spruce bogs). However, based on these criteria, another 11 of the 62 sites were removed from analysis.

After discovering a non-linear relationship between reserve distance (from shoreline to the logged area) and scenic beauty, the reserve distance variable was transformed through a natural logarithm. The natural logarithmic transformation makes intuitive sense as an increase from a 30 to 50 metre reserve should improve aesthetic ratings more than an increase from 200 to 220 metre reserve.

The number of sites with these intermediate reserve sizes varied for each vegetation types (see Table 5.1.1). The sample sizes for black spruce forests and miscellaneous types were not sufficient to test for interactions between vegetation type and reserve size. The sample sizes for the three other vegetation types were sufficient, but an ANCOVA test for the interaction between reserve size and vegetation type was insignificant ($F=2.51$, $df = 2$, $p=0.094$). However, since ANCOVA assumes that the regression slopes of the covariates are identical within the different treatment groups (Huitema 1980), a low probability such as 0.09 should caution us about the general ability of the aggregate results to summarize the relationship.

With the insignificant interaction between vegetation type and reserve size, a regression model was specified that only included the transformed reserve size and average ratio of the tree crown to stem height as an explanatory variable for aesthetic ratings. The final model was significant ($F=6.14$, $df=2, 47$, $p=0.004$), but was poor in explaining data set variation (adjusted $R^2 = 0.17$), see Table 5.2.1.

Table 5.2.1. Regression summary table for aesthetics and anthropogenic reserve sizes.

	SS	df	MS	F	Sig	R^2
Regression	23508.74	2	11754.372	6.142	0.004	0.207
Residual	89940.05	47	1913.618		adj R2	(0.173)
Total	113448.79	49				

Table 5.2.2 shows that the logarithmic transformation of reserve size was significant and positive ($t=2.54$, $df = 1$, $p= 0.014$, $Beta = 0.335$) with a coefficient of 28.548. This suggests that aesthetic quality does improve as the size of reserves is increased between 30 and 225 metres. Because of its logarithmic form, the relationship suggests that additions to reserve size increases aesthetic evaluations faster for sites with 30 metre reserves than sites with 200 metres.

Table 5.2.2. Aesthetic quality parameter estimates for intermediate reserve sizes.

	Unstandardized Coefficients					95% Confidence Interval for B	
	B	Std. Error	Beta	t	Sign.	Lower	Upper
Intercept	-172.12	50.21		-3.43	0.001	-273.12	-71.12
crown to stem height ratio	28.57	4.43	0.370	2.81	0.007	3.53	21.36
reserve size (natural logarithm)	12.45	11.23	0.335	2.54	0.014	5.96	51.13

The second significant variable in the regression equation was the ratio of crown to stem height for trees in the front 13 metres of the forested stand. The coefficient was positive (12.370) and significant (t=2.81, df = 1, p= 0.007, Beta = 0.370). The sign of the coefficient follows intuition. As trees become bushier (i.e. the crown height is greater than the stem height) the aesthetic ratings of sites with intermediate reserves increases. Thus, the bushier trees help to mitigate and hide the disturbances at greater distances in the stand. Further credence to this argument for the relationship between reserve size and bushy trees is found since this same variable was not significantly related to the aesthetic evaluations of undisturbed sites (r_p=0.227, df = 55, p = 0.093). Finally, the intercept for the model was negative (-172.118) and significant (t=-3.43, df = 1, p= 0.001). Although the model shows a relationship between intermediate reserve size and aesthetic quality, the poor predictive power of the model demonstrates the great degree of site variation that tempers this relationship.

One of these tempering factors may be the vegetation type of the forest. Despite the insignificant interaction between vegetation type and reserve size, other evidence hints at differences between the effects of reserve size and aesthetic quality. A series of correlation coefficients were calculated between reserve size and aesthetic ratings for the three different vegetation types. For both balsam fir/white spruce and black spruce and jack pine forests the relationship between the logarithm of reserve size and aesthetics was not significantly different from zero (r_p=0.01, df = 8, p=0.980 and r_p=-0.05, df = 18, p=0.821, respectively). However, for jack pine forests the correlation between reserve size and aesthetics was significantly different from zero and positive (r_p=0.549, df = 14, p=0.028). These analyses suggest that the effect of vegetation type on the reserve and aesthetic relationship may be important and deserves further investigation.

5.3 Aesthetic Quality and Undisturbed Forests with a Reserve Appearance

Although the above analysis demonstrates that reserve size is related to aesthetic quality, one may question whether the effect arises from the presence of logging behind the reserve or simply the width of the reserve. It could be entirely possible that undisturbed sites with naturally appearing reserves (e.g. peninsulas and islands) may have a similar relationship between aesthetic quality and reserve distance as do logged sites. Therefore, a final examination of the data involved an evaluation of sites with reserves versus undisturbed sites with a reserve appearance.

The eight sites with naturally appearing reserve-like features occurring on the same reduced set of forest types used in Section 5.2 ranged from 30 to 170 metres in distance, but did not contribute to explaining the variation of forest aesthetic evaluations (t=1.30, p=0.201). This result suggests that the public may view undisturbed sites with a reserve appearance differently than sites with anthropogenic reserves, but no direct test between these two treatments was possible with the small sample sizes.

6.0 Summary

The rationale for this study was to predict the aesthetic evaluations of shorelines in the boreal forest by biophysical and/or classification variables. The predictive models included different forms for undisturbed sites and anthropogenic disturbed sites.

The first objective of the report was to determine how typical biophysical and vegetation classification variables impacted forest aesthetic values. Three different models were calibrated that explain the aesthetic evaluations of undisturbed forested sites. One model explained scenic beauty from the modified FEC overview groupings. A second model built on the first by adding two easily measurable covariates (i.e. slope and tree mortality) to predict aesthetic quality. The final model explained aesthetic quality from site specific biophysical information. The ability of the models to explain data set variation was inversely related to the ease of obtaining the respective input data. For the site specific model, the explanatory power was very good, but the model requires biophysical characteristics of detailed stand level measurements to predict aesthetics. For the model employing the modified FEC overview groupings, the explanatory power was lower than the formerly mentioned model, but the information needed to predict aesthetic quality is readily available.

The same conclusions can be derived from all three models. Large trees were by far the most important factor in determining aesthetic quality. This should not be surprising, as large trees are often a source of wonderment to individuals as evidenced by efforts to save “old-growth” forests. The large trees in Northern Ontario are dominated by red and white pine species, but may also include old-growth jack pine, white spruce, and trembling aspen stands. The affinity towards these older large trees appears to constitute an important, albeit well known, message to forest management planning: at any one time, some forest stands with large trees should exist. This is not to say that all large treed forests must be preserved. Rather, some of these forests need preservation, as do forests representing various younger age groups that will ensure old growth and tall tree conditions in the future. Again, temporal stability of age classes for trees on a landscape should supersede any tendency to impose a myopic protection strategy for only the existing large treed forests.

Another resonant characteristic was the influence of hardwood species on aesthetic quality. One simple explanation for the high aesthetic ratings of hardwood forests was that many of the sites sampled with hardwood forests had large trees. Besides that obvious explanation, during the summer, when our images were captured, hardwood forests provide a lush appearance of vegetation. The stands typically were on medium to steeply sloped lands, which further increased the aesthetic quality of these sites. Finally, although this study found hardwood forests to have strong aesthetic qualities in summer, it is more than likely that the aesthetics of these stands increase dramatically during the fall when the deciduous leaves change colour.

Sites with eastern white cedar forests were also viewed as aesthetically pleasing by the respondents. Although these sites were typically located on flatter lands than were hardwood or red and white pine forests, the aesthetic evaluations still remained high. It is possible that the dense front 10 metres of these stands with an assortment of cedar trees and shrubs provide a unique backdrop for these sites. The cedar trees also differ from the other tree species in their texture, which may also account for their aesthetic appeal.

Although black spruce bogs were lowest in aesthetic quality, of course, we advocate that forest management planning processes treat these sites with careful attention. The small, and frequently dispersed trees in these stands, convey the appearance of a distance further than the 140 metres offshore. The lack of slope enhances this appearance further. For one, these forests provide contrast opportunities to other forested settings when individuals enjoy water based recreation activities. These forests may also provide many other functions beyond forest aesthetics that deserve recognition and consideration. They definitely represent value as complements to the overall boreal ecosystem, and they may provide suitable wildlife habitat or may house rare plant species. Even from a purely anthropocentric view, these environments may be important areas that humans demand for wildlife and plant viewing.

Other important variables relating to aesthetics at "undisturbed" sites included slope, mortality, and density. Sites with steep gradients were preferred to sites with lower slopes. Furthermore, sites with increasing tree mortality were less preferred to sites with live trees. Again, most literature supports this finding (Haider 1994, Benson and Ullrich 1981, Ribe 1990, Schroeder and Daniel 1981) although Hollenhorst *et al.* (1993) identified a quadratic relationship that actually increased aesthetic evaluations until stands reached about 30 percent tree mortality. Finally, increasingly dense sites were preferred to less dense sites. At first the result seems to contradict previous research findings (Buhyoff *et al.* 1982, Haider 1994, Brown and Daniel 1984, Hull and Buhyoff 1986), but Brown (1987) did find increased aesthetics with an increasingly dense forest. That difference may have arisen since all the previously mentioned studies examined aesthetics from a near-view perspective, while this study looked at near-vista views, in which a denser forest may provide a richer and fuller appearing scene.

The finding that aesthetic evaluations for jack pine, jack pine and black spruce, black spruce, and balsam fir/white spruce forests were not significantly different from each other allowed us to use all these sites from these forest types to examine the effects of anthropogenic and natural disturbances on aesthetics.

The second objective related to determining the effects of forest management on aesthetic values. Sites with cuts to within 10 metres of the shoreline were significantly less desirable in aesthetics than any other sites except for those with severe fires. Sites with intermediate sized reserves were given aesthetic ratings in between the sites with logging within 10 metres of the shore and undisturbed sites. The analysis of the relationship between aesthetics and reserve size showed that a functional form for the effect of reserve size on aesthetics was significant, albeit at a low level of explanatory power. Although the vegetation type and reserve size interaction was insignificant, further correlation tests suggest that reserve size may be more important for increasing aesthetics in jack pine forested sites than for black spruce and jack pine and balsam fir/white spruce forested sites. Further comparisons showed that undisturbed sites with a reserve appearance (e.g. peninsulas) had no significant effect on aesthetic ratings, compared to the significant effect from anthropogenic reserves on aesthetics. Although the finding that the clear felling forest management method negatively impacts forest aesthetics is expected, our analysis also revealed relationships between reserve size and aesthetics, which must be regarded as a significant insight to a difficult issue.

The final objective of the study was to determine the effects of natural disturbances on forest aesthetics. The results are somewhat muddled. Fire negatively impacted the forest aesthetics at sites, and these sites had lower aesthetic ratings than sites with intermediate reserves or wind induced disturbances. The sites with wind induced disturbances were significantly more preferred to sites with fire disturbances, but no statistical difference in aesthetics between undisturbed and wind induced disturbance sites was found.

6.1 Management Considerations

Forest aesthetics are constantly changing and evolving. Forest managers should ensure that forest aesthetics are protected and enhanced over a long time period rather than at a single point in time. Therefore, calls for the protection of certain stands, the suppression of natural disturbances and the prohibition of anthropogenic disturbances must be considered over a long-term planning horizon rather than a single point in time. It could well be that relatively short lived negative impacts to forest aesthetics due to disturbance may actually lead to greater aesthetic quality of those sites over a long-term planning phase.

This is not to say that those current demands and desires from forest users for forest aesthetics should be of no concern. There are risks and uncertainties for long-term planning that may increase the need to maximize present aesthetic benefits. Just as fixation on short-term benefits may be too myopic, fixation on long-term benefits may prove to be too elusive. Therefore, we must consider the importance of providing aesthetic quality today in addition to tomorrow. As well, we must recognize that aesthetic preferences of the public can be dynamic and change over time.

Understanding, quantifying, and predicting aesthetic values of shoreline sites will become increasingly important for resource management in Ontario. Currently, guidelines designed to protect fish habitat and water quality provide some *de facto* protection for aesthetic values in shoreline areas of Ontario. These guidelines are subject to change, and recent evidence suggests that forested shoreline reserves may not be necessary to protect fish habitat/water quality (Steedman 2000). If the guidelines are revised to permit shoreline forestry, riparian reserves may only be needed if it is demonstrated that they protect non-fish/water quality values (e.g. aesthetics). This report has provided such information on the impacts of forest management on aesthetic values of near-vista views of riparian forests.

As with any study, our results are contingent on the criteria chosen for the data collection. Particularly, the view of the forested setting (i.e. distance of the photograph) may influence the evaluations of the sites. The 140 metre picture was chosen since the riparian forest is seen as only a backdrop to water based recreation activities. But photographs from 300 metres, 500 metres, or one kilometre from offshore may have provided slightly different results. At one site, it is known that the 140 metre photograph effectively hides a bare hill that becomes visible from more than 250 metres from the shore. Clearly, in this case the aesthetics for that site would dramatically change if different distances for that site were used for the photograph. As well, near forest views from 10 metres and 15 metres offshore and in-stand photographs may also provide different results. We do have a catalogue of photographs that contain some of these different vantage points for the sites, but we emphasized the 140 metres offshore photographs. Additionally, although field crews attempted to take photographs with consistent conditions, the variability of weather may introduce some noise in the data. Although cloud cover, sky colour, water colour and waves were not found to be significant explanatory factors of aesthetic variations, these elements, no doubt, add noise that lessens the precision of predicting aesthetics.

As much as these findings offer answers, further questions are raised. First, the additional slides that were taken at each site could be used to conduct different analyses. These analyses could focus on the evaluation of a site described by a combination of offshore and in-stand photographs, as mentioned above. Buyhoff *et al.* (1982) suggest that the distance between the photographer and scene impacts aesthetic ratings. Second, additional experimental work could be conducted with the impacts to aesthetics from natural and anthropogenic disturbances including the role of selection cuts. Only two sites from our current sample have selection cuts, which is not of sufficient size to permit statistical analyses. However, these two sites appear to be higher in aesthetic quality than comparable sites with reserves and clear-cutting operations. Third, the effects of regeneration on aesthetics should be determined for both natural and anthropogenic disturbances. A continuing aspect of this research project is to monitor a series of sites with these disturbances for a future analysis of aesthetic quality.

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Appendix 1.

Weighting matrix and inputs needed to produce biophysical component scores.

Variable	Tree Size	Hardwood	Mortality	Variety	Density	Conifer Shrubs
Conifer Shrubs (% cover 0-6 m)	-0.022	0.013	-0.030	-0.026	0.017	0.752
Hardwood Shrubs (% cover 0-6 m)	-0.035	0.237	-0.001	-0.119	-0.011	0.270
Tree Density (from 3 m)	0.086	0.008	0.119	-0.035	0.461	0.155
Tree Density (from 13 m)	0.042	0.000	0.028	-0.012	0.448	0.002
Tree Density (from 28+ m)	0.004	-0.001	-0.019	0.037	0.348	-0.161
# of Tree Species (3 m)	0.003	0.004	0.010	0.357	-0.013	0.115
# of Tree Species (13 m)	0.024	-0.044	-0.035	0.404	0.037	0.032
# of Tree Species (28+ m)	0.018	-0.89	-0.036	0.443	-0.039	-0.273
% of Hardwood Trees (3 m)	-0.019	0.350	0.032	-0.062	-0.011	-0.051
% of Hardwood Trees (13 m)	-0.015	0.353	-0.008	-0.044	0.026	-0.007
% of Hardwood Trees (28+ m)	0.018	0.282	0.042	0.085	0.002	-0.095
Average Tree Height (3 m)	0.194	-0.009	0.024	0.002	0.038	-0.047
Average Tree Height (13 m)	0.213	-0.006	0.032	0.001	0.143	-0.072
Average Tree Height (28+ m)	0.205	-0.005	0.029	0.022	0.108	-0.144
Average DBH (3 m)	0.187	-0.038	0.054	0.006	-0.029	-0.003
Average DBH (13 m)	0.183	-0.013	0.036	0.022	-0.044	0.053
Average DBH (28+ m)	0.182	0.005	0.056	0.018	-0.024	0.106
% of Dead Trees (3 m)	0.057	-0.048	0.378	0.018	0.067	-0.200
% of Dead Trees (13 m)	0.050	-0.007	0.397	0.022	0.019	-0.037
% of Dead Trees (28+ m)	0.050	0.050	0.378	-0.025	0.055	0.147

() – field plot location

Appendix 2.

Examples of modified FEC overview working groups.

Red and White Pine Forest
(Northern Lights Lake, SBE = 97.77)

Hardwood Species Group
(Whitefish Lake, SBE = 116.23)

Appendix 2. (continued)

Eastern White Cedar Group (Rogers Lake, SBE = 68.69)

Jack Pine Forest (Icarus Lake, SBE = 87.74)

Appendix 2. (continued)

Black Spruce / Jack Pine Forest (Lake #26 (Atikokan), SBE = 34.25)

Black Spruce Forest (Alley Lake, SBE = -13.00)

Appendix 2. (continued)

Balsam Fir/White Spruce Forest (BareTent Lake, SBE = 4.07)

Black Spruce Bog (Savanne Lake, SBE = 61.57)

Appendix 3.

Examples of disturbance groups.

Wind-induced Tree Blowdown
(Long Legged Lake, SBE = -102.49)

Intermediate Sized Reserve
(Burrows Lake, SBE = -86.64)

Appendix 3. (continued)

Severe Forest Fire (Northern Lights Lake, SBE = -117.25)

Cut to within 10 metres of shore (Lake #42 (Atilokan), SBE = -132.49)

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