AESTHETIC RATINGS OF NORTHERN FOREST SCENES: THE EFFECTS OF SPATIOCHROMATIC STIMULUS ATTRIBUTES IN SILVICULTURAL LANDSCAPE IMAGES

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ABSTRACT

The Environmental Impact Assessment Act, through the use of The Social Impact Assessment (SIA) established public participation in environmental decision-making. The concern for landscape aesthetics has been one among many issues, and has received special prominence in the case of timber management in Ontario's northern forests. Research on landscape perception has contributed to the debate. Typically such studies use rating methods to evaluate public perceptions of landscape quality, beauty and/or aesthetics. However, these studies did not consider whether luminance-, spatial- and/or chromatic variations influence aesthetic judgments in the natural environment. From that perspective, this study is an extension of earlier visual search studies that investigated the effects of specific spatial and chromatic properties of target stimuli into the realm of landscape perception. Based on the findings from this extensive body of work, we predicted that high levels of chromatic conspicuity and extrinsic (or unnatural) regularity in spatial patterning in a wilderness scene would have a negative impact on the public perception of forest landscapes. Three conditions representing landscape elements (targets) that simulate silvicultural practices were manipulated using Adobe Photoshop software. The targets were a checkerboard clear-cut, an irregular cut, and a roadway. The chromaticity of each target was defined by the target midtones (average across 400 pixels, or 1° subtense). The "neutral" chromaticity was equated across checkerboard and irregular patches. The chromaticity of the targets was modulated (7 steps) along red-green axes in Commission Internationale de l'Eclairage (CIE) 1931 chromaticity space. All presentations were done on a high-resolution colour monitor (CRT). Each of the targets was presented in five background conditions of oblique aerial photographs of coniferous trees with and without a lake to determine position bias and target/lake proximity effects. Each of the 16 observers per background condition (N=80) was presented 84 randomized landscapes from a total of 420 images. Data interpretation was conducted using a 4-way multifactor design with repeated measures on 3 factors (5 randomized backgrounds X 3 spatial targets X 7 target chromaticities X 4 quadrant locations). Results showed that varying the spatiochromatic properties of the silvicultural targets and their locations significantly influenced the perceived beauty of northern forest landscapes. Patches in a scene that had spatial regularity and a colour appearance that was shifted towards the "reds" were given the lowest ratings. Comparable situations can be observed in real scenes that have undergone recent harvesting operations.

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INTRODUCTION

The public perception of landscapes is increasingly recognized as an issue in the management of natural environments and wilderness regions (Crowfoot & Wondolleck, 1990). Over the last 15 years, aesthetic concerns have become an integral part of the Social Impact Assessment (SIA). Public participation became particularly prevalent since the SIA was mandated in 1979, to be included later in the Environmental Assessment Act in Ontario (Lerner, 1990). The SIA criteria for obtaining public perceptions were adapted from earlier policies, such as the 1970 American National Environmental Policy Act (NEPA). Of fundamental relevance to the management of the forested landscape of Northern Ontario is the decision of "The Class Environmental Assessment of Timber Management on Crown Land in Ontario" released in 1994 (Environmental Assessment Board, 1994). The document defines the future process for timber management and acknowledges that aesthetic concerns of the public must be considered, but no formal process about how to manage aesthetic values is recommended.

Research investigating public perceptions of landscapes is common to many disciplines including environmental psychology, social geography, forestry and landscape architecture. Typically, the method of evaluating public perceptions involves scaling designs that rate an observer's preference of various visual scenes (e.g., Lerner, 1990; Zube, 1984). The goal of scenic quality experiments, therefore, is to use a rating scale that will determine what scenic quality will positively or negatively contribute to the human, social and economic conditions (Zube, Sell & Taylor, 1982).

A general assumption about landscape evaluations is that humans share common preferences for certain types of natural landscapes (Bourassa, 1990). For this reason, researchers often attempt to establish a perceptual consensus among many landscape scenes in the hope of identifying innate population preferences (Craik & Zube, 1976). Broadly speaking, landscape perception research follows four different paradigms: (1) the expert paradigm, in which landscape quality is determined by trained observers[1]; (2) the psychophysical paradigm, in which the general public, or specific interest groups evaluate the aesthetic quality of a scene; (3) the cognitive paradigm, which searches for human meaning associated with landscape aesthetics; and (4) the experiential paradigm, which examines landscape values shaped by human interaction with the environment (Zube et al, 1982). The study presented in this thesis follows the psychophysical paradigm.

The psychophysical paradigm in environmental psychology, which differs from standard sensory psychophysics, emphasizes as the independent variables the physical attributes of landscape properties (or elements in a scene) as it relates to observer ratings. The observer's statistical ratings of the perceived aesthetics of the manipulated elements act as the dependent variables (Zube et al, 1982). Over the past 20 years the psychophysical paradigm was

[1] Several agencies such as the U.S. Forest Service and forest management in British Colombia have incorporated this approach into their management practices (Bacon, 1979; BC Environment, 1995).

characterized by three landmark developments. Prior to 1976, research applied different psychometric scaling approaches to identify the aesthetic qualities of landscapes. For example, Craik and Zube (1976) reported correlations between verbal descriptions of landscape dimensions and the observer's aesthetic expectations. These preferential measures were evaluated using 50 government parkland scenes. The most influential variables found to have an impact on observer preference were continuous trails, wide-sweeping views and the presence of clouds. Similarly, Zube (1974) reported a correlation between the perceived quality (based on a rating scale from highest to lowest scenic quality) of the Connecticut River Valley and the physical characteristics of the valley for 56 landscape sites. The physical characteristics were defined along several scenic patterns including evenness of terrain, amount of naturalness (vs. artificiality due to human intervention), "textured" grain of terrain, and type of land-use of the terrain. Brush and Shafer (1975) had campers rate mountainous terrains and identified ratings along three general pattern characteristics that positively predicted scenic quality. These characteristics were moderate proportions of water, perimeters or patterns of grassland and the framing properties of foreground terrains.

Daniel and Boster (1976) contributed a significant advancement to the psychophysical paradigm by developing a more formal, standardized scaling approach that reduced some of the subjective response tendencies associated with the traditional scaling methods.. When applied to forested landscapes, the psychophysical paradigm produced interesting and reliable results for "in-forest" scenes. Typically models would predict the effects of measurable forest characteristics on scenic quality perspectives (e.g., Daniel & Boster, 1976; Patsfall, Feimer, Buhyoff & Wellman, 1984; Ruddell, Gramann, Rudis & Westphal, 1989). However, for distant "vista views", the relevant independent variables were not controllable.

With the advent of new computer technologies in the late 1980's, the crucial elements of vista-views suddenly become manageable. For example, Orland (1987, 1988) introduced video-imaging that was applied to landscape perception research by using a process that permitted specific variables of scenic images to be manipulated (see Orland, Daniel, Hetherington & Paschke, 1993 for an application). In a recent application of video-imaging technology in the boreal forests of Northern Ontario, Orland, Daniel and Haider (1995) added one further level of complexity to the technique. They manipulated eight attributes of oblique aerial scenes by systematically following a statistical design plan (i.e. an orthogonal fractional factorial design), and then used the resulting images as visual stimuli in a choice experiment (Anderson, Williams, Haider & Louviere, 1995). The eight variables simulated typical forestry operations in Northern Ontario, and included forest roads at different distances, changes in the arrangement of residual trees (original trees left standing from cutting operations), changes in the species of forest vegetation, changes in the age of clear-cut areas and variations in the width of buffer zones (e.g., the distance between a clear-cut area and a lake shore). This technique of manipulating specific silvicultural features in a digital image permits the precise comparison of scenes with and without the respective features.

In recent years, aesthetic-rating studies on the perception of forests have identified particular physical variables unique to industrial forestry operations (e.g. Yeates, 1993; Crowfoot & Wondolleck, 1990; Willhite, Bowlus & Tarbet, 1973; Ribe, 1989). For example, the visibility of clear-cutting was found to be disruptive to other economic activities such as tourism and recreation (e.g. Craik & Zube, 1976; Rowe & Chestnut, 1983; Zube & Irwin, 1990) as well as to the moral, humanist base of many members of society (Gesler, 1992; Moser, 1989; Zube, Sell, & Taylor, 1982). Crowfoot & Wondolleck, (1990) identified two landscape dimensions important to public perception that could be identified with forestry operations: cut visibility (e.g. the magnitude of visibility of a cleared area from a lake, or roadside); and the shape of the clearing (e.g. the amount of irregularity or geometric patterning associated with logged areas). As a result, researchers have been actively studying public attitudes about the patterns of landscapes remaining after forestry operations.

In 1984, Zube established a perceptual interaction model that attempted to identify and classify all the landscape properties of "forest dimensions" that contributed to or interacted with the public perceptions of landscapes. The model categorized many factors known to influence landscape perception along several dimensions or levels of processing that influence aesthetics, including "naturalism", "scale", "complexity and gestalt", and "biological/cultural factors". The "perceptual interaction" model has been used to classify scenes by a number of U.S. Water and Land Resource Planning projects (Zube, 1984), the U.S. Forest Service (Schroeder, 1991), the Division of Water Resources, the Australian Research Centre For Water In Society (Syme, Beven, & Sumner, 1993).

Naturalism defines the extent that a landscape is spared development from human occupation. Generally, observers prefer undeveloped scenes over human-intervention (or developed) landscapes. Some researchers consider naturalism to be the most important predictor of scenic quality (e.g., Bourassa, 1990; Hodgson & Thayer, 1980; Zube, 1984).

Scale defines objects viewed at various distances. Scale is often associated with aerial and ground perspective. Generally, as one views a land form at greater distances, specific land patterns become less influential in the observer ratings of visual quality. This is not surprising since the subtending visual angle of each potentially invasive item gets smaller with distance, thereby reducing the spatial impact of the item over the entire scene. As the land form size decrease with distance, land patterns (i.e., textures) become more prominent in the quality ratings of a visual scene (e.g. see Zube, 1984).

Complexity or gestalt refers to the cognitive appreciation or awareness observers have about a scene (e.g. see Gester, 1992). These cognitive factors can influence the observers' perceptions before they actually view the scene. An example that demonstrates this influence can be seen in a study by Hodgson and Thayer (1980). Two identical sets of 30 scenes were described under two opposing condition labels. One condition was labeled "human-influenced" and the other "natural". The human-influenced labels described scenic elements as "irrigation patterns", "tree farms" or "roadcuts". The natural labels described scenic elements as "ponds", "forest growth" or "stream bank". In all cases, the human-influenced labels were rated lower than the natural labels.

A variation of the "complexity and gestalt" component of the physical model deals with biological or cultural-based responses to landscapes (e.g., see Bourassa, 1990). A biological/cultural component refers to biological factors such as age, or cultural factors such as ethnicity that can influence ratings of visual quality. A biological/cultural model proposed by Lawton (1980) and Zube and Evans (1983) predicted age effects on aesthetic appreciation. Zube and Evans (1983) determined that individuals who were over 65 years were not as selective in their detection of a disturbed forest landscape as were young and middle-aged adults. Lawton (1980) described that some viewing conditions of landscapes were more acceptable to elderly individuals (over the age 65) than younger viewers (age 12 to 65). Cultural influences or what Zube and Evans (1983) termed “lifespan development differences”, were considered to be a determining factor for these age differences. For example, Lawton (1980) argued that the preferences of the elderly may be less critical of settings because of socialization prior to the environmental movement. It may also be argued that the cultural experiences of the elderly with events such as the Great Depression or World War II, produced a generational attitude that is favourable to economic development and industrialization. Younger individuals exposed to environmental issues may view industrialization as seriously destructive to their present and future lifestyles. Other cultural influences on preferences of scenic quality have been demonstrated in studies examining the historical and societal attitudes towards the wilderness. Rees (1975) indicated that during the Gothic period, the wilderness was believed to be a sinister place fraught with dangers, whereas Klein (1976) indicated that during the Romantic period, many parts of society believed the wilderness to be harmoniously and spiritually connected with humankind. Zube and Pitt (1981) and Hull and Revell (1989) further noted that perceptions of the wilderness varies cross-culturally amongst the Yugoslavians, West Indians, Balinesians and Americans.

Culture, age, cognitive awareness, spatial complexity are all interactive factors that can influence our perceptions of a natural scene. In order to achieve a perceptual consensus of public ratings in an SIA, rigorous experimental controls that allow for the systematic investigation of the effects of each of these factors are needed to fully understand the impact land-use has on perceived aesthetics.

The effects of low-level visual processing of chromatic contrasts on the overall perception of landscapes have not been researched. Previously applied investigations into the principles of chromatic and luminance contrast have been used in the advertising industry to design packaging and promotions that stand out and capture the customers' attention in a commercial environment; and in military applications in such areas as camouflage and target conspicuity (e.g., Carter & Carter, 1981). There are, however, no studies that specifically address the influence of luminance and/or chromatic contrasts on landscape perception. In fact, previous landscape studies only acknowledge image contrast and brightness as an unwanted source of variance in the experimental method of rating photographed landscapes (i.e., the observation of photographs under varying room illuminances, the variation in film development techniques, and variable ephemeral effects obtained from photographs taken at different times and under different weather conditions; Craik, 1977; Dearden, 1980; Row & Chestnut, 1983; Shafer, Hamilton & Schmidt, 1969; Weinstein, 1976). The modulation of specific features (such as chromaticity) in landscape scenes were not realizable before the advent of high-speed microcomputers that were capable of generating and changing landscape simulations quickly.

The principle of contrast theory in the visual sciences states that observers will not attend to featureless, homogenous fields, but will attend to areas of chromatic and luminance (simultaneous) contrast and temporal (transient) contrast (Adams, 1961; Dawson, 1973; Engel, 1973; Teichner & Krebs, 1974); Spelke, Hirst, & Neisser, 1976; Bloomfield, 1979; Treisman & Gormican, 1988; Gerrissen, 1991). Expanding these principles to landscape quality assessment, several assumptions can be inferred about an observer's percept of a target. We can assume that conspicuous regions (i.e., extrinsic regions of high luminance and/or chromatic contrast) in a forest landscape will serve as a focal point from which ratings of unpleasantness or pleasantness are derived. These are measures based on stimulus properties that are encoded by principle processes in the visual pathway (i.e., local target parameters) prior to the complete perceptual interpretation of the scene (e.g., Zube et al, 1982). Even the cultural-based age model for scenic quality (Zube & Evans, 1983) can be reevaluated on the biological premise of age-related visual dysfunction as opposed to overall cultural interpretations of the scenes by the elderly. In other words, the elderly may not be as easily disturbed by human operations as younger observers, not because of cultural factors or higher-level cognitive percepts, but because of general sensitivity losses to chromatic and luminance contrast patterns (i.e., low-level perceptual dysfunction). For example, it is well-established that physiological mechanisms in the visual pathway selectively deteriorate with age. The clarity of the preretinal optics of the eye deteriorate resulting in a greater ocular absorption and scatter of short-wavelength energy, thus lowering the sensitivity to light in the violet and blue region of the spectrum. In addition, there is a progressive age-related loss in contrast sensitivity in the physiology of the visual pathway (e.g., Werner, Peterzell & Scheetz, 1991; Owsley, Sekuler & Siemsen, 1983). Changes in the perception of these localized stimulus parameters within a scene may be the cogent factor in defining the differences in perceived aesthetics across generations.

The idea of target conspicuity playing an important role in scenic beauty has been implicated in earlier studies that have shown that the greater the continuity of intrinsic topographical variation in a landscape, the stronger the perception of naturalness (Carruth, 1977; Klein, 1976). Variables that detract from scenic quality often involve areas of extrinsic (or unnatural) topographical inconsistencies such as hard-edged geometric patterns derived from mulched logs, or young tree stands, forest road corridors, bridges, transmission lines and cottages (Craik & Zube, 1976; Rowe & Chestnut, 1983; Schroeder & Daniel, 1980). Examining the geometric variables described above in terms of local contrast, it is likely that the topographical patterns are viewed as "inconsistent" because of the spatial and/or chromatic conspicuousness that captures the observer's focus of attention. The rating considerations and interpretations (such as the notions in Zube's perceptual interaction model) may be based on the observer's focus of attention on contrast.

As alluded to earlier, many theories of contrast and conspicuity originate from studies in visual search. Often, visual search experiments measure reaction times (RTs) to visual targets embedded in background elements. Observers typically search through background scenes that contain either alphanumeric symbols or simple geometric patterns, and are instructed to identify the target stimulus within the background as quickly as possible (see, Bloomfield, 1979 for review). In general, the closer the target stimulus characteristics (or dimensions) are to the nonessential stimuli (or elements) in the background, the longer the RT. The further apart the target dimension is from the background elements, the more discernible the targets are and therefore the faster the RT (e.g., Bloomfield, 1979; Pashler, 1987).

Past research in visual search has framed many models describing the perceptual encoding process of target contrasts. For example, serial and parallel patterns of attention in visual search have been postulated to identify target conspicuity embedded within nonessential elements (McBurney, 1984; Schneider & Shiffrin, 1977; Gerrisen, 1991; Pashler, 1987; Dykes, 1981; Anderson, 1992). This concept of conspicuity may relate to how individuals rate complex scenic patterns. For example, a focal stimulus (or target) in a landscape whose dimensions significantly deviate from those in the surrounding background may contribute to the offensiveness of that target. The magnitude of contrast between human-made targets and natural background patterns may be the qualifying determinant of scenic aesthetics. Contrast conspicuity can be defined along chromatic, spatial and/or luminance dimensions especially for forest landscapes that have undergone logging operations. Manipulations of well-defined stimulus conditions, similar to those used in psychophysical visual search studies that investigate the impact of spatial, chromatic and temporal image properties on visual target acquisition and response, may be used to ascertain some of the physical properties that are important for judging vista views of silvicultural landscapes in northern boreal forests. We intend to use the conspicuity metric as a means of defining observer perceptions of forest landscapes.

The present study focused on two stimulus dimensions that have been extensively investigated in visual search studies: spatial patterns and chromaticity (i.e., spatiochromatic properties). We presented spatial patterns that were commonly observed in silvicultural operations and modulated the chromaticities of the patterns embedded within natural forest scenes. Observers then rated these landscapes along a visual analog scale (e.g., Luria, 1975; Gift, 1989; Shillingford, 1969; Freyd, 1923). We attempted to establish a psychophysical model that may lead to new insights about how silvicultural techniques that alter the natural patterns of a scene can impact on the perceived quality of that landscape. The present study added two additional dimensions of control to video imaging as applied by Orland et al (1995): spatial pattern and chromaticity (i.e., spatiochromatic target parameters). By examining the quality of the environment as a measure of spatiochromatic conspicuity, we explicitly focus on the colour and shape of areas in landscapes that have been changed by forest-harvesting operations. The stimuli we used were a series of altered forest landscape images of Northern Ontario, generated from prior research done at the University of Illinois for the Ontario Ministry of Natural Resources (Orland et al, 1995; Daniel et al, 1995).

Calvin, Dearinger & Curtin, (1972) found the "natural force" of water to be a significant landscape element in obtaining high quality ratings for scenic beauty. In a preliminary study done by Yeates (1993), large fresh clear-cuts, shaped in regular block-like square patterns were given low scenic quality ratings, particularly when the square patterns were located near a lake at a distance of 30 to 100 m. Square patterns near a lake in the foreground apparently were the most disturbing and produced the lowest rating. The highest rating (i.e., the most preferred landscape arrangement) for the square patterns was found when the clear-cut patches were showing new growth and were located furthest from a lake at a distance of 300 m or more. These influences on scenic quality can be attributed to either general (i.e., cognitive) factors, or to a number of specific stimulus characteristics. In the former case, the cognitive awareness of human intrusion into the wilderness may be amplified when human operations occur near lakes. Lakes are recreational sites and the extent of timber-cuts may not be as apparent when operations are distanced from lakes. Obviously, lakes are an integral element of the boreal forest landscape and therefore, we presented the different spatiochromatic targets within two backgrounds: one that contained a lake and one that did not.

At a more specific stimulus level, however, a good predictor of aesthetic ratings above may be the magnitude of chromatic and/or luminance contrast the block-patterned target has with its nearby lake. Fresh harvest operations near a lake may produce patch boundaries that have high contrast conspicuity, thereby lowering aesthetic quality. With patch regrowth, the conspicuity of the contrast boundaries may be lowered, thereby improving aesthetic quality once again.[2] In general, contrast theory suggests that the greater the contrast, the less natural or appealing the regions appear.

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2 Of course for real-world situations, these effects will be only be meaningful assuming near uniform illumination and strong lightness and colour constancy processing. Issues such as heterogeneity in surface reflections, dynamic changes in context, and changes in line-of-sight perspective are always a concern when extrapolating results from controlled experimental images to real-world situations.

This is in effect, a "psychophysical" explanation that is similar to what Craik & Zube (1976), Rowe & Chestnut (1983) and Schroeder & Daniel (1980) referred to with regards to topographical inconsistencies.

Craik and Zube (1976) observed that scenic quality is positively related to the observer's line of site. This also relates to the placement of targets (e.g. either in the foreground or background). Koenderink and Richards (1992) found that background elements appear brighter than foreground elements, probably due to atmospheric light scatter and the law of darkening, in which the sky at the horizon appears darker than at the zenith. This luminance/line-of-site interaction was considered a function of observer contrast sensitivity enhancing the luminance contrast boundary between horizon and sky. For this reason, we also placed spatiochromatic targets, in either the lake or no-lake background, near the horizon and near the foreground on the computer monitor (CRT).

It is a common procedure to use rating scales in public preference evaluations of photographed environments. The ratings of scenes depend on an observer's direct perception of a scene and on the observer's judgment criteria for beauty of a particular scene. Any analysis of ratings does not rely on the direct observer perception of a scene, but on how the observers establish judgment criteria for their ratings. In general, ratings are never interpreted as direct perceptions, rather as relative indicators of the true position along the psychological dimension being studied (e.g., Brown & Daniel, 1990).

In this study, the data were analyzed in accordance to several prevailing assumptions about rating scales. One assumption deals with the problem of end-point bias. Typical scenic rating scales request the observer to assign a number, (e.g. low = 1, high = 10) to areas presented in a photograph (e.g., Brown, Daniel, Richards & King, 1988). The earliest reference establishing guidelines for rating scales originated in the Scott Company Laboratory in 1920 (Freyd, 1923). The Scott rating scale, known as the Visual Analog Scale (VAS) uses a horizontal, 100 mm line, with the low end of the scale to the left, without gradations (to increase sensitivity). The objective is to devise scales to discourage making routine judgments in all standard, pre-marked positions. This is the scale that has received the most merit for recording subjective experiences. There was the possibility, however, that observers would still rate scenes towards the midpoint of the scale (i.e., the end-point bias). We assumed that this problem could be ameliorated several ways. One was to allow observers to preview scenes that show no human intrusion and that show a considerable amount of human intrusion. These previews assisted the observers in establishing a representation of the extreme points of the VAS (e.g., Hull, Buhyoff & Daniel 1984). Another method involved using a vertical rating scale. A variation of the VAS was to use a vertical VAS, which was more sensitive to recording subjective experiences than the horizontal scale (Gift, 1989). An example of the scale used in the present study is shown in Appendix A.

METHOD

Observers

The experiment used 80 undergraduate students from Lakehead University, ranging in age from 19 to 35 years. All the observers were tested for colour deficiencies using the Ishihara colour plate test (24 Plate Edition). The observers had normal or corrected acuity. No observers with refractive errors greater than -3.00 D (spherical equivalent) or who wore tinted prescription lenses participated in the study.

Apparatus and Stimuli

A series of 420 landscape images were derived from a number of elements found in several digitized forest images. These elements were modified and standardized chromatically and spatially and pasted into a quadrant in a standard lake and no-lake background. There were six standard shapes composed of seven standard chromatic levels. The images were presented on a 17", high resolution RGB monitor (SuperMatch 17•T). The images were modified using Adobe Photoshop™ software (1991). Samples of these images are shown in Figs. 1 and 2 for backgrounds with lakes located near the horizon (Far Lakes) and close to the viewer near the bottom the scene (Near Lakes), respectively.

Three different forest treatments served as targets. The target conditions were a square checkerboard clear-cut, an irregular shaped

Figure 1: Examples of landscapes images with “far” lake backgrounds. The specific target shapes and their chromaticities are labeled under each sample scene. CHKBD, RDWY and IRR denote checkerboard, roadway and irregular shaped targets, respectively. The chromaticities are shown using nomenclature from the Adobe Photoshop application (see text for details).

Note 1: These images are reduced, second-generation colour photocopies taken from photographs of the scenes presented on the SuperMatch 17•T monitor.

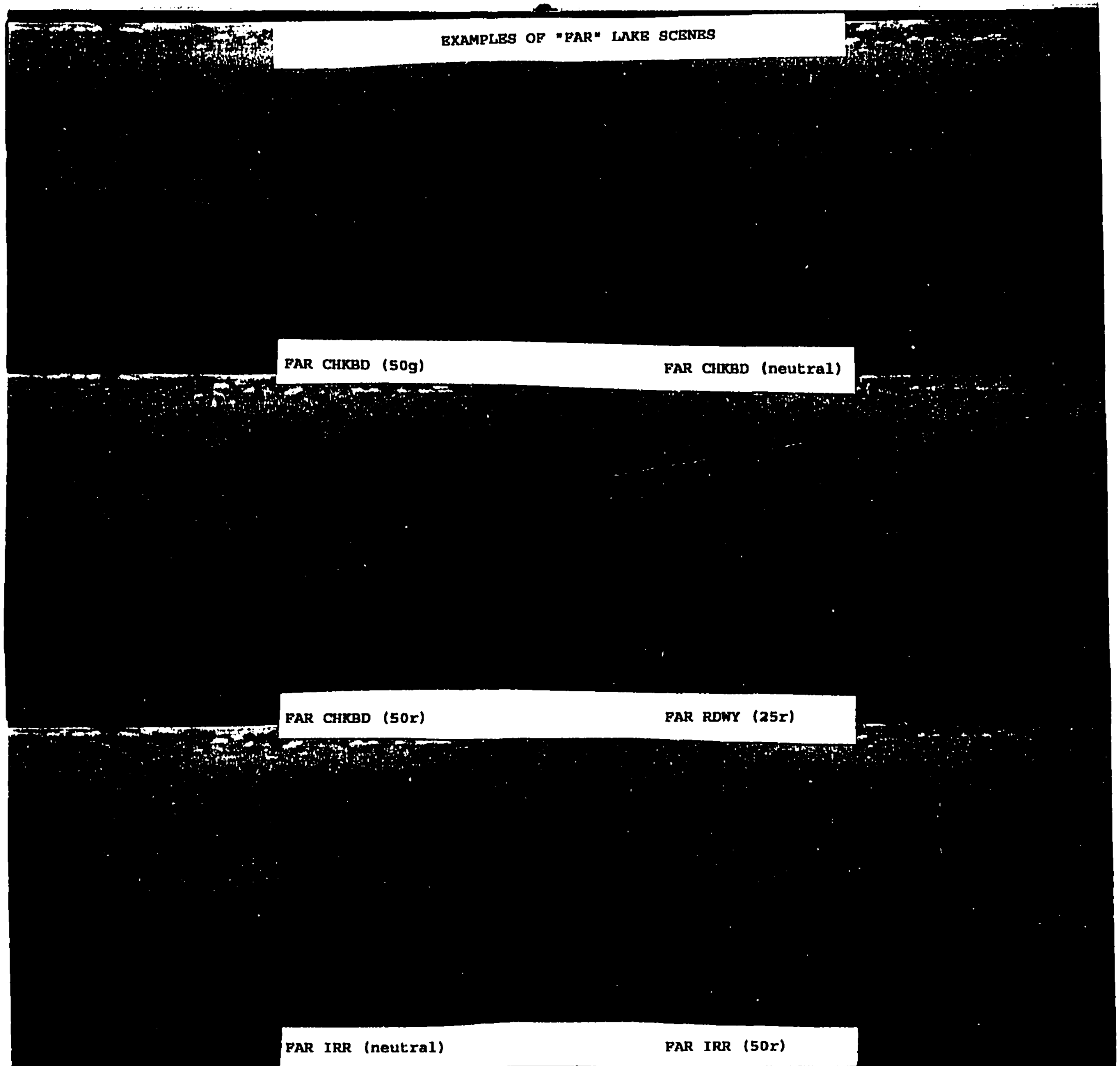
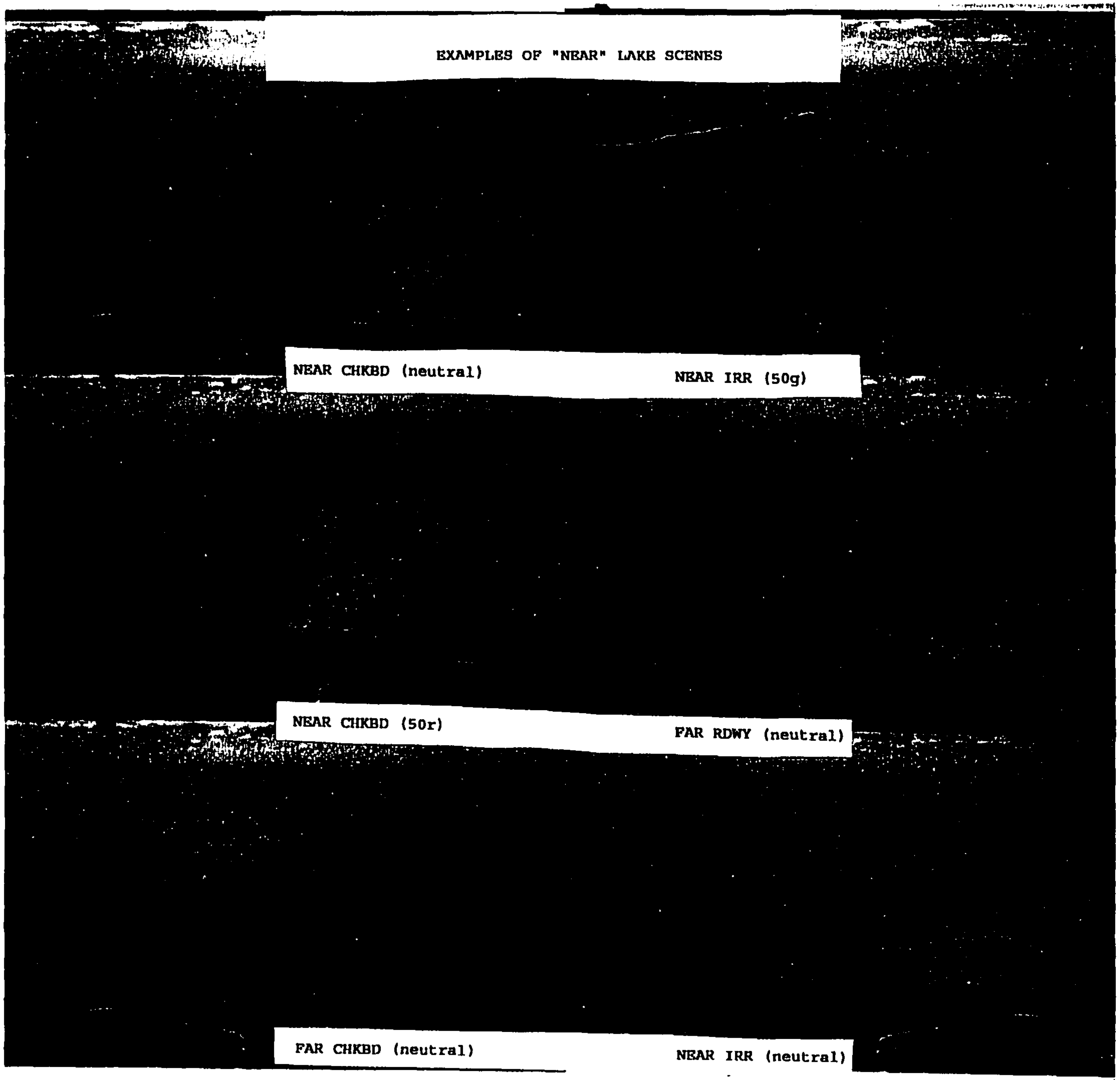

EXAMPLES OF "FAR" LAKE SCENES
FAR CHKBD (50g)
FAR CHKBD (neutral)
FAR CHKBD (50r)
FAR RDWY (25r)
FAR IRR (neutral)
FAR IRR (50r)

Figure 2: Same as Fig. 1 except target images are with "near" lake backgrounds.

Note 2: The labels in the first row are reversed with those in the second row.


EXAMPLES OF "NEAR" LAKE SCENES
NEAR CHKBD (neutral)
NEAR IRR (50g)
NEAR CHKBD (50r)
FAR RDWY (neutral)
FAR CHKBD (neutral)
NEAR IRR (neutral)

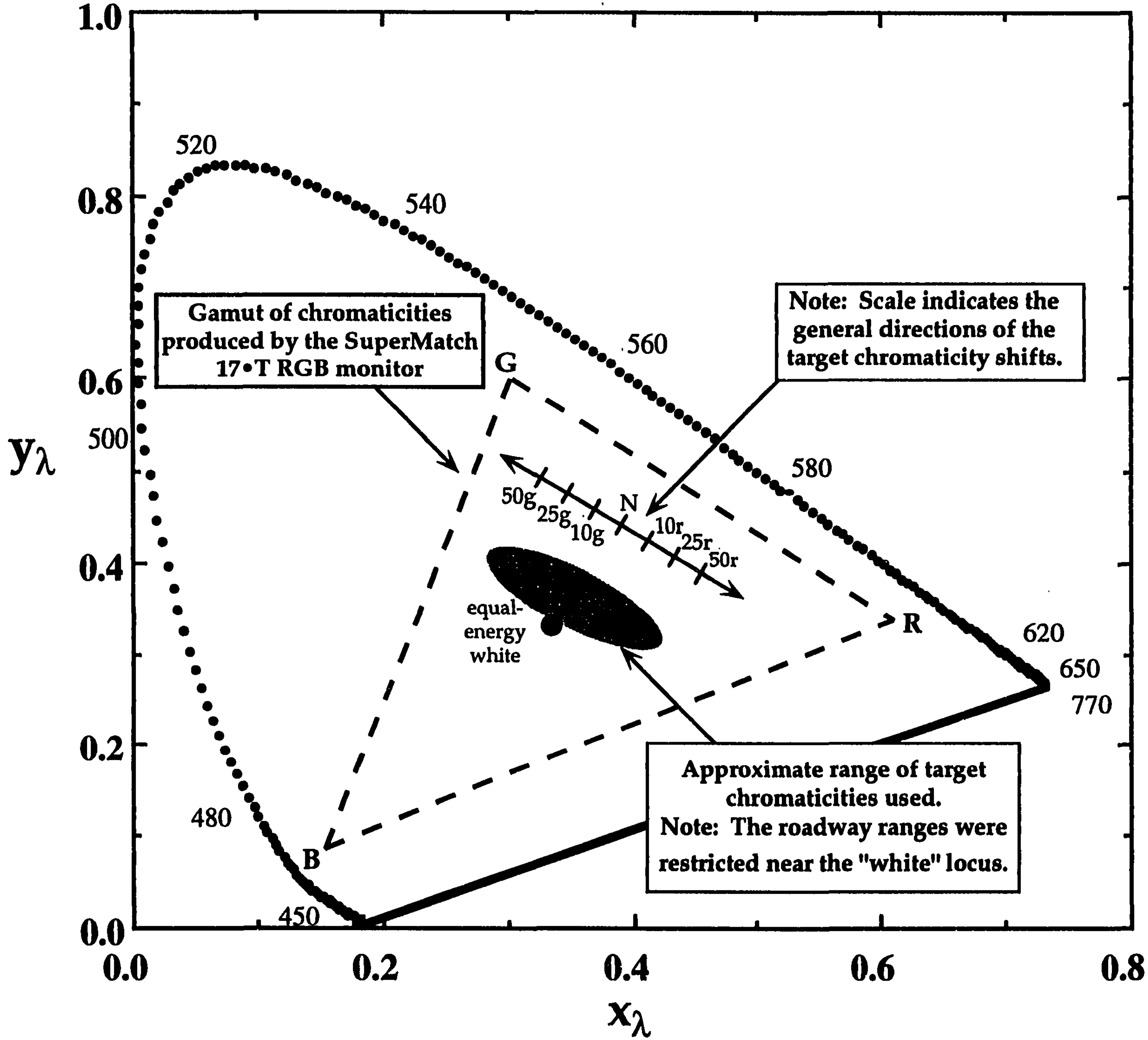
clear-cut, and a forest road. The monitor was sectioned into 4 quadrants. This was done to evaluate the effects of target distance (foreground vs. horizon locations), and whether or not there was a left or right target position bias in the observer ratings. Quadrants 1, 2, 3 and 4 represented Far/Left, Far/Right, Near/Left and Near/Right target locations within the background, respectively. The smaller "Far" target patches subtended an average visual angle of 2° and were positioned near the horizon (in Quadrants 1 or 2). The larger "Near" target patches, which subtended an average visual angle of 5°, were positioned in the foreground (in Quadrants 3 or 4). All the narrow roadway targets (both "Near" and "Far") were approximately 7° in length with a thickness of 0.25° visual angle. Thus, a total of 12 spatial images were used in the study (i.e., 3 "Far" targets in quadrant 1 or 2 (6 total) plus 3 "Near" targets in quadrant 3 or 4 (6 total).

The chromaticity of a target midtone varied by a total of 3 incremental and 3 decremental steps along a red-green axis in colour space (i.e., a total of 7 chromatic steps). The highlights and shadows of the target and background were kept constant, as was the overall luminance of the targets. The target chromaticity of the patches was equated at a predetermined midtone "neutral point" except for the roadways which had a different "neutral point". The most saturated "red" and "green" target levels were double the distance from the "neutral point" in Commission Internationale de l'Eclairage (CIE) 1931 space than the average chromatic discrimination threshold distance established from visual search tasks (Nagy & Sanchez, 1990). We were only interested in measuring the effects of location and chromaticity of the targets on perceived aesthetics; therefore, the luminance of each spatial target remained constant. Since the background consisted of a complex pattern of shadows and highlights, the reference "neutral" midtone chromaticity for the targets was an average of all the RGB values of each pixel within a 1° subtending area (comprising of approximately 400 pixels). This 1° sample size appeared to best represent the midtone chromaticities for each target. The reference chromaticities for each of the target configurations are plotted in CIE 1931 (x,y) coordinate space along with the range of six realizable chromaticities used in all the scenes (Wyszecki & Stiles, 1982, See Fig. 3). The red-green chromatic steps used in the experiment are shown adjacent to the complete range of target chromaticities to illustrate the approximate axial directions in CIE space taken when changing the chromaticities of the target from a neutral point towards redness or greenness. The neutral point is indicated as N. Increasing the midtones of the targets towards redness or greenness is represented in the figure as the arbitrary values 50g and 50r, respectively. These values were derived from the Adobe™ program which changes selected chromaticities along different phosphor intensities. These values are also used in Figs. 4 and 5.

Each of the targets was presented in two background templates. One background simulated an aerial photograph of coniferous trees with few natural clear patches (i.e., swamp regions). The second background was the same as the first except there was a

FIGURE 3: CIE 1931 (x,y) chromaticity diagram showing gamut of chromaticities produced by the SuperMatch 17•T RGB monitor and approximate range of target chromaticities used. The scale indicates the general direction of the chromaticity shifts from green (50g, 25g, 10g) to red (10r, 25r, 50r). "N" denotes neutrality of the midtone chromaticity. This was equated for the checkerboard and irregular shaped targets. The roadway targets had an "N" that was nearly equal-energy "white" and the chromaticity range 50g to 50r were truncated near this locus.

CIE 1931 (x,y) CHROMATICITY DIAGRAM



lake positioned in one of the 4 quadrants on the CRT. The position of the background "Far" lake was at the top left (Quadrant 1) or the top right (Quadrant 2) of the CRT screen, and subtended a 4° visual angle. The position of the foreground "Near" lake was at the bottom left (Quadrant 3) or bottom right (Quadrant 4) and subtended approximately 10° visual angle. The background templates were divided into five background conditions. Five groups of 16 observers were randomly assigned to each background condition. Each observer participated in only one background condition and rated 84 images. The total number of stimulus conditions was 420 (3 spatial targets X 7 target chromaticities X 4 quadrant locations X 5 randomized background templates). The ratings of the 420 images produced a total of 6,720 observations.

Procedure

Prior to entering the laboratory, the observers were told that they would rate the beauty of remote wilderness scenes as viewed from a low-flying aircraft. The background templates with and without the lake were presented to all observers (without the target conditions) before they were designated into one of the five background conditions to begin rating the 84 scenes. Thus, only the spatiochromatic properties of the target varied with each presentation; not the background. Observers rated all target configurations in their background condition during one single session. Interleaved within the session, two background scenes without targets were presented to see if the backgrounds alone were similarly rated. The scenes were randomly presented for each observer for four sec intervals. A signal indicated the next presentation. The experimenter recorded the numerical order that each scene randomly appeared for each observer according to a code presented at the bottom, right corner of the CRT. The analysis was a 4-way multifactor design with repeated measures on three factors.

In order to reduce variations in responses of the ratings, we requested observers to rate the beauty of a scene using a 100 mm vertical axis where the top denoted most beautiful and the base of the vertical line denoted least beautiful. In this way, we asked observers to rate each scene individually instead of requiring the observers to make comparative judgments across scenes (Craik & Zube, 1976).

The observers were also allowed to make qualifying statements at the end of the rating session. This allowed the observers to describe their strategies for rating the scenes the way they did. Owens (1988) suggested that including a provision for qualifying statements enables researchers to identify values that are consistently important to the public. Also Schroeder and Hebert (1991) noted that landscape ratings are much more informative in conjunction with an open-ended debriefing of the observers' thoughts and feelings about particular scenes. Following those researchers' recommendations, debriefing all observers as a check of preference frequencies with the rating data was conducted to bring further insight to our findings.

RESULTS

The purpose of the study was to determine whether physical parameters such as target shape, chromaticity or distance from the viewer are factors that influence aesthetic judgments in the natural environment. The study is a 4-way multifactor design with repeated measures on three factors. The specific dimensions we manipulated were a lake in four quadrants and one no-lake condition (5 randomized backgrounds), target or shape (3 spatial patterns), chromaticity (7 intervals), and position or distance (4 quadrant locations). The analysis was conducted using one group of 16 observers each assigned to one background condition (presenting 84 randomized targets).

We found that varying the spatiochromatic properties and the locations of the silvicultural targets significantly influenced the perceived beauty of the landscapes. Fig. 4 shows the main effects from the analysis. For all three within factors, the assumptions on sphericity were not met. The degrees of freedom of all tests were therefore adjusted with Greenhouse Geisser epsilons (ε). The sphericity condition is an assumption of ANOVA that has to be satisfied. It is equivalent to the equal variance assumptions in linear regression analysis. If the sphericity condition is not met, the ANOVA model can be adjusted by applying the Greenhouse Geisser epsilons.

Overall, spatial patterns were found to have a significant influence in landscape beauty, with significantly different mean

FIGURE 4: Mean ratings of the main target and background effects. Ordinate values are measured (in mm) from the bottom of a vertical analog scale that represents a “least” to “most beautiful” rating. The probabilities of the significant main effects are shown in the appropriate panels.

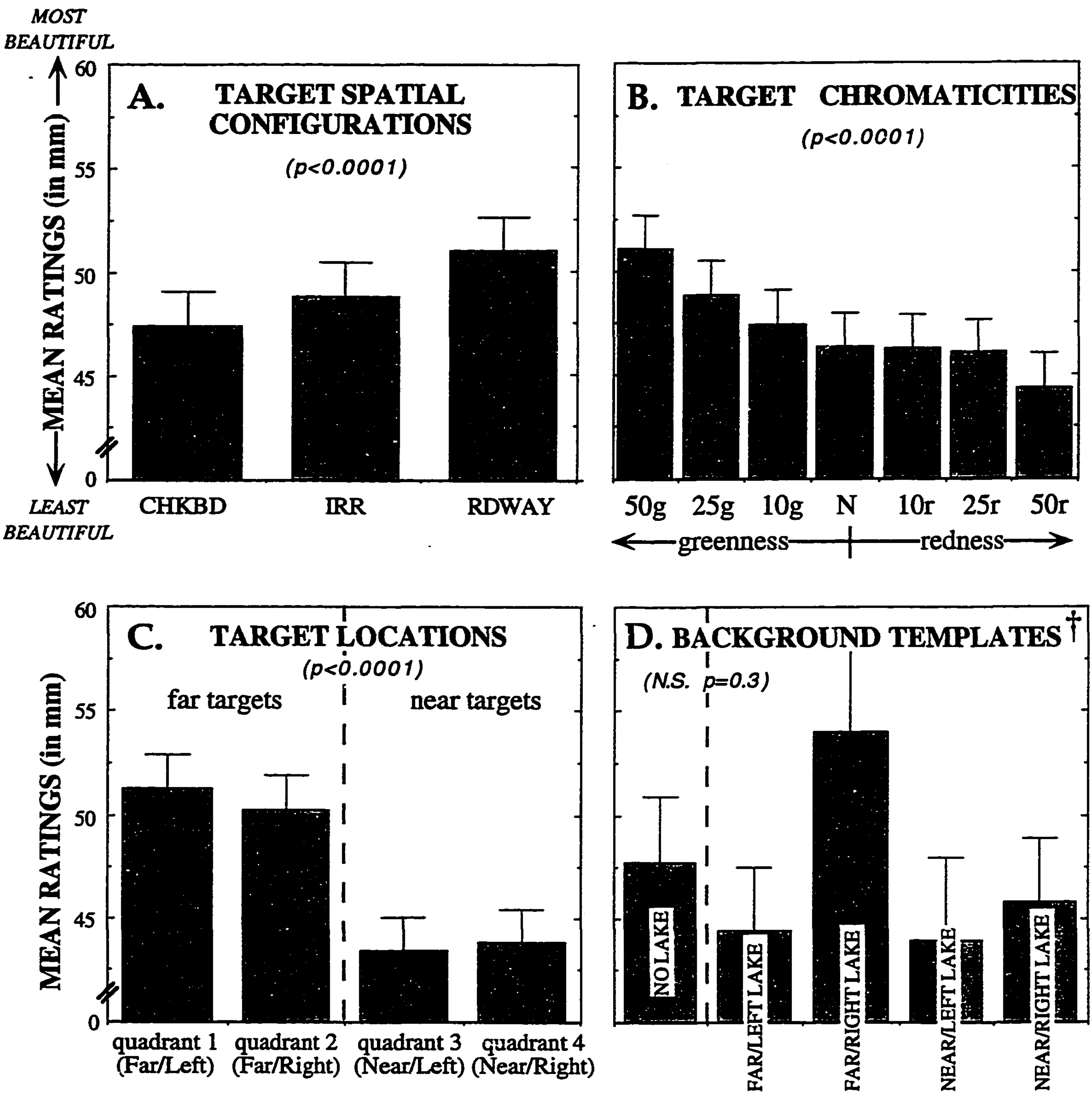
Panel A: Main effects of target spatial configuration (or shape)

Panel B: Main effects of target chromaticity. Chromaticity values on the abscissa are the labels derived from the Adobe™ program (See text for details).

Panel C: Main effects of target location. Each of the quadrant means are shown. The Far and Near targets are also separated by a vertical dashed line.

Panel D: Main effects of background templates. Targets are presented either without a lake (to the left of vertical dashed line) or with a lake positioned in one of four quadrant locations.

MAIN EFFECTS



† Background was the only randomly applied treatment (N=16).

NOTE: Error bars denote SEMs.

ratings found for the three patterns (roadway, irregular, checkerboard; $F(1.18, 88.47)=108.19$, $p<0.01$; $\varepsilon=0.589$). Overall, the scenes with roadways were rated the highest in terms of beauty.. The checkerboard clearcuts were rated less favorably than the irregular targets. These main effects can be seen in Fig. 4A. Assuming univariance amongst the independent variables, we conducted a posthoc mulivariate Helmut and Difference Bonferroni contrast of the 95% confidence intervals. Bonferroni test statistics are a method of testing the statistical significance of multiple comparisons of treatment effects. After rejecting the null hypothesis, this test statistic identifies significantly different pairs of means. The means for the roadways were found to be significantly different from the irregular and checkerboard means (Helmut: $t_{0.05}=-11.70$, $p<0.0001$; Difference: $t_{0.05}=8.12$, $p<0.0001$).

A significant chromaticity main effect was also found $F(4.96, 372.20)=29.11$, $p<0.001$; $\varepsilon=0.827$). The greenish appearing targets (towards 50g) were rated higher in terms of beauty than the reddish targets (towards 50r). The roadway chromaticities had no effect, probably due to the truncated chromatic range of the roadway towards the centralized "white" locus (see Fig. 3). A Bonferroni posthoc Helmut multiple comparison revealed that the extreme greenish target (50g) had significantly higher mean ratings than the neutral and reddish targets (Helmut: $t_{0.05}=3.78$, $p<0.001$). The error bars in Fig. 4B illustrate this. Although the Bonferronni operations compared 95% confidence intervals, the figures show standard error of the means (SEMs) for clarity. The trends, however, can still be seen with SEMs. The overlapping SEMs indicate areas where there are small differences between the chromatic levels. The SEMs for the extreme greenish targets (i.e., 50g) were the only error bars that did not overlap with other target chromaticities, namely the neutral and reddish targets. It is important to note, however, that the level of greenness was restricted to values at or below an arbitrary 50g label. Targets with an average midtone of 50g "greenness" are located towards the top-left portion of the chromatic range, as indicated by the gray oval in the CIE 1931 space (Fig. 3). It is likely that tweaking the target midtones beyond 50g would produce a less appealing scene (i.e., going beyond a greenness that is natural in appearance). The same holds true for the reddish targets towards the lower-right portion of the chromatic range. In fact, preliminary runs delineated the present range as the best representation for natural-occurring colouration. Moving beyond this range was perceived by observers as being too artificial in colour appearance.

Target distance from the observer was found to be an important factor of landscape beauty. Targets located in the "Far" quadrants (Quadrants 1 and 2) were given better ratings overall than the "Near" targets (Quadrants 3 and 4). Fig. 4C shows that the main effect for quadrants was significant [$F(1.91, 140.99)=108.56$, $p<0.001$; $\varepsilon=0.636$]. Bonferroni Difference multiple comparison across collapsed Quadrants 3 and 4 (Near) and Quadrants 1 and 2 (Far) show a significant difference ($t_{0.05} = -2.30$, $p<0.02$) between Near and Far targets. To see if there was a bias towards the Left or Right target position, a bonferroni Helmut multiple comparison was conducted for collapsed Near and Far quadrants. The Left versus Right "Near" were not significantly different ($t_{0.05}$ = -1.60, p=0.11), however, the "Far" targets did show a significant difference between left and right target position ($t_{0.05}$ = -2.35, p<0.02) with left targets receiving a lower rating.

In order to reduce rating variability, the mean and standard deviation of each observer's 84 ratings were converted into a standardized score. A standardized (or "ipsatized") score reflected the observers' ratings of a scene relative to their ratings of other scenes. Ipsatization controls for variation among observers in their use of the rating scale (e.g.. for variations in range, or for preferred locations of the rating scale). Since preliminary computations for Z-scores of the results produced no notable difference in the means for each observer and between observers, the original ratings were maintained in the analysis.

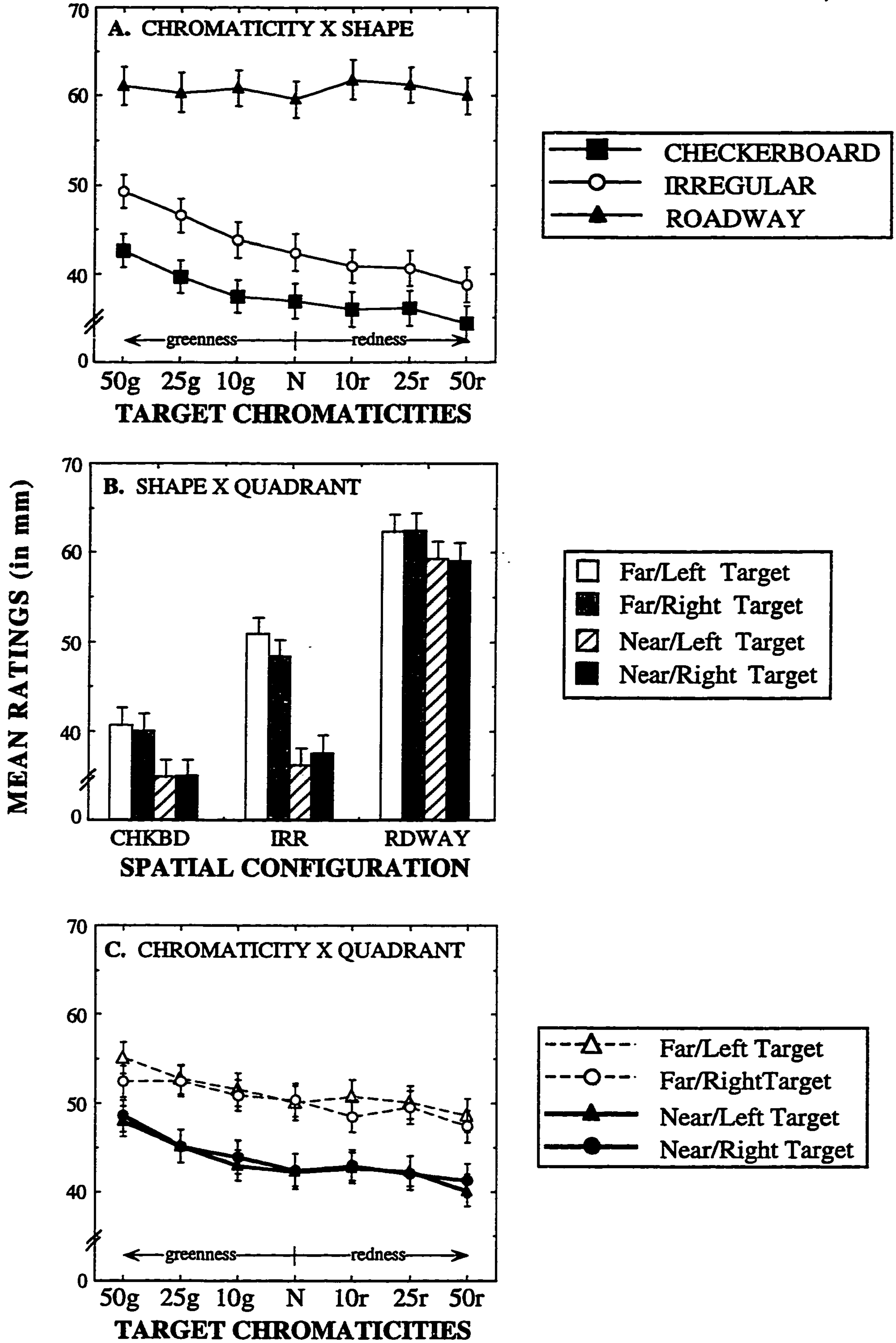
The interactions between target chromaticity and shape, shape and quadrant, and chromaticity and quadrant are shown in Fig 5, panels A, B and C, respectively. The interaction between target chromaticity and shape was found to be significant [F(8.86, 664.55)=8.96, p<0.001; ε=0.738]. Greenish checkerboard and irregular targets were viewed more favorably than reddish checkerboard and irregular targets in backgrounds with Far/Left, and with foreground lakes. However, chromaticity had very little effect on roadways (compare solid triangles to squares and circles in Fig. 5A). As discussed previously, this was probably due to the limited range of roadway chromaticities used in the study.

FIGURE 5: Within observer interactions. Mean ratings are measured (in mm) from the bottom of a vertical analog scale that represents a "least" to "most beautiful" rating. See legend to the right of each figure for symbol denotation.

Panel A: Interaction effects of target chromaticity by shape.

Panel B: Interaction effects of target shape by quadrant. Symbols connected by thick (thin) lines denote Near (Far) targets.

Panel C: Interaction effects of target chromaticity by quadrant. Symbols connected by thick (thin) lines denote Near (Far) targets.


A. CHROMATICITY X SHAPE
CHECKERBOARD
IRREGULAR
ROADWAY
greenness
redness
50g 25g 10g N 10r 25r 50r
TARGET CHROMATICITIES
MEAN RATINGS (in mm)
B. SHAPE X QUADRANT
Far/Left Target
Far/Right Target
Near/Left Target
Near/Right Target
CHKBD
IRR
RDWAY
SPATIAL CONFIGURATION
C. CHROMATICITY X QUADRANT
Far/Left Target
Far/RightTarget
Near/Left Target
Near/Right Target
TARGET CHROMATICITIES

The interaction between shape and quadrant was significant [$F(4.38, 328.39)=22.86$, $p<0.001$; $\varepsilon=0.730$]. The roadway (checkerboard) targets consistently showed the highest (lowest) ratings for all target locations. Also, the scenes containing the Far targets were always given higher ratings than the scenes containing the Near targets; however significant differences between the Near and Far targets were found for only the checkerboard and irregular targets and not the roadways (cf. solid and dashed lines in Fig. 5B; $t_{0.05}=7.46$, $p<0.0001$).

The interaction between target chromaticity and position (Fig. 5C), and the three-way interaction between chromaticity, shape, and distance were not significant. Interactions between background and all remaining factors were not significant except for Background X Shape X Chromaticity [$F(35.44, 664.55) = 1.67$, $p<0.01$; $\varepsilon=0.563$].. Whether the observers viewed the silvicultural targets with or without a lake did not appear to influence overall ratings, although observers did report being more disturbed by viewing a silvicultural target with a lake than without one. The background templates were the only randomly assigned treatment conditions used in the study. The interobserver ratings showed considerably more variation than the intraobserver ratings. It is therefore not surprising that the background conditions showed no significant main effects. Because Background X Shape X Chromaticity was significant, the interaction effect of Shape X Chromaticity was reevaluated for each of the five levels of background. There were no sphericity problems, nor were there significant Shape X Chromaticity interactions for the No-Lake Background [F(18, 270)=1.13, N.S.]. For the Backgrounds with a lake in Quadrant 1 (Far/Left Lake), there was a significant Shape X Chromaticity interaction [F(4.04, 60.00)=3.96, p<0.01; ε=0.207). For the Backgrounds with a lake in Quadrant 2 (Far/Right Lake), there was no significant Shape X Chromaticity interaction [F(3.91, 58.68)=2.16, N.S.]. For the Backgrounds with a lake in Quadrant 3 (Near/Right Lake), there was a sphericity problem and there was a significant Shape X Chromaticity interaction [F(12, 180)=2.45, p=0.006. Finally, for the backgrounds with a lake in Quadrant 4 (Near/Left Lake), there was a significant Shape X Chromaticity interaction [F(5.13, 77.01)=4.55, p<0.001; ε=0.428].

DISCUSSION

This study showed that physical target dimensions that simulate silvicultural operations have an important influence on scenic beauty. These results support those of Yeates (1993) who found a negative relationship between human-designed targets and beauty estimates of natural scenes. We initially suggested that changes at the local stimulus level may be a good predictor of aesthetics, where the magnitude of chromatic contrast (or conspicuity) will define aesthetic quality. In fact, our findings suggest that all the target dimensions we manipulated in the study (i.e., shape, chromaticity and location) influence scenic beauty. Overall, the lowest means were for reddish (at 50r on the chromaticity axis) checkerboard shapes, located in a Near/Left

Quadrant (mean=30.23). The highest overall means were for roadways located in the Far/Right Quadrant (mean=63.50). Chromaticity was not a factor in the high ratings of the roadway scenes (See Fig. 5A).

The importance of physical dimensions on the perceived beauty of silvicultural targets were also supported by the qualifying comments made by the observers after they rated the scenes. For example, observers commented consistently about how spatial patterns (targets) were a major determining factor in how they rated the scenes. Seventy-five percent of the respondents commented on the checkerboard targets, and of these, 85% gave negative comments saying that they looked unnatural and human-made. Sixty-three percent of the observers commented about the irregular targets. Of these, 54% indicated that they preferred the irregular shape over the checkerboard because they looked more natural (i.e., a patch from a forest fire or insect infestation). The roadways appeared to have little impact on scenic beauty. Of the 55% of the respondents who commented on the roadways, 95% stated that they viewed the roads as "belonging to" the scene. Only 5% of the remaining respondents disapproved of the roadways.

A possible explanation for these "spatial pattern/target" rating responses is that even though a checkerboard is a common visual pattern in farm regions, it is an extremely uncommon sight to see in a forest. Interestingly, Baum, Fleming, Israel & O'Keeffe (1991) and Ellis, Greenberg, Murphy & Reusser (1992) state that on protected lands, the public is more tolerant of naturally occurring influences than human influences because there is no perception of control for a natural occurring event but there is a strong perception of control over human behavior. Relating this argument to the present study, the perceived naturally occurring event that created the irregular patch exemplifies a lack of control and is therefore rated as more beautiful than the regular, checkerboard patch.

The importance of target chromaticity on scenic beauty was demonstrated by the high ratings for "green" targets and by the post-rating observer comments. According to many observers, chromaticity had a major influence on their ratings of beauty. Sixty-six percent of the respondents commented on the targets that appeared reddish. Of these, 88% disapproved of the targets. Typical comments were that the reddish targets appeared to represent a dying forest, recently destroyed by human hand. However, of the 73% of the respondents who commented on the greenness of a target, 97% approved of the "green" patterns saying they appeared as natural regrowth. Only 3% of the observers specifically disapproved of the "green" saying the targets had an unnatural and inappropriate look about it.

The present study's target-location (Quadrant) findings support Yeates (1993) preliminary conclusions that foreground interruptions in a scene are often rated lower than interruptions in the distance. However, in an earlier study, Patsfall et al, (1984) argued that the background was the focal point of interest in scenic beauty, not the foreground. Also, Craik and Zube (1976) noted that scenic qualities were related to the observer's line of sight and not necessarily target position. The present study, however, shows that obstructing background vegetation by placing foreground targets significantly lowers the public ratings of scenic beauty. This was also evident in the observers' post-rating comments. All of the 33% of the respondents who commented on foreground (Near) cuts strongly disapproved of the closer patches. Apparently, foreground composition is highly relevant in perceiving scenic quality. All of the 35% of the respondents who specifically commented on the background (Far) targets noted that their ratings for distanced targets were more tolerable than near targets. Several physical features that distinguish near from far targets could account for this difference in opinion. The first, and most obvious distinction, is the difference in size. Each potentially invasive item gets smaller with distance, thereby reducing the spatial impact that item has over the entire scene. For example, the subtending visual angles between the Near and Far checkerboard patterns differed by 3 degrees. Second, given that the visual resolution of the Far targets are much lower than Near targets, much of the detail and texture in the Far target is lost. It is possible that the grain and texture of a silvicultural pattern increases its potential for disturbing a surrounding scene. However, this is unlikely since there was no chromaticity by target location interaction. Chromaticity is closely linked to spatial texture (i.e., midtone chromaticities make a larger percent contribution to Far-target colour than Near-target colour), yet the approval ratings for greenish targets changed little with distance (see Fig. 5C).

The ratings were consistent across the Left/Right quadrants for the Near targets, but unfortunately they were found to be significantly different for the Far/Left and Far/Right Quadrants. It could be argued that the lower ratings for the Far/Left Quadrants are a manifestation of our cultural bias towards the upper left corner (i.e., the starting location for reading a page). However, these significant differences were only found for the far, roadway targets Examining just the irregular and checkerboard ratings, we found no bias towards the left Quadrants. Also, there were no post-rating responses dealing with Left/Right target locations preferences.

We found no differences for most of the background conditions. Background with Far/Left, Near/Left and Near/Right Lakes were the three background conditions that did show significance. As discussed earlier, this was probably due to the high variance found across observers. Idiosyncratic differences in rating schemes is discussed in the literature (e.g., Daniel & Boster, 1976), and this was one of the reasons why the target conditions were part of a within design. The study could have been implemented as a 4-way within design, but unfortunately this would have required the observers to rate over 420 images. Thus, the 80 observers were divided into the 5 separate background conditions. The fact that the four Lakes and No-Lake conditions did not show significant differences is in disagreement with previous research that showed a higher quality rating for scenes that contained lakes (Calvin, Dearinger & Curtin, 1972; Haider, 1994). In the post-rating comments, only 23% of the respondents commented about the lakes. Of these, 15% indicated that the cuts near the lake were offensive. Interestingly, 7% of the respondents actually described the targets near the lakes as having a beautifying effect because they appeared to represent recreational beach sites.

There are several issues with the present study that need to be addressed. First, given the high interobserver ratings variability, we believe that within-measures of the background templates would be a better analysis of the background lake effects. Unfortunately, as mentioned earlier, the logistics of running such an experiment with the same number of target characteristics was prohibitive and was therefore not included as a within variable. Second, the observers were all university students who are not representative of the population at large. We assumed similarity between them without pre- and post-tests which may have resulted in some rating bias. Therefore the analysis is generalized only to the observers in the study and not the entire population. Third, there may have been a fatigue effect even though we reduced the number of scenes to 84. Preliminary analysis of the time effects for each individual's ratings did not support such an effect, however. Mean ratings were essentially the same over the 15 minute time period it took for the observers to rate the scenes.

A future research agenda with this study requires a cross-validation of these findings to other types of scenes and with other groups of observers. For example, the roads could be examined further by varying their lengths and widths into the forest to meet the applied interests of major harvesting corporations. In addition, studies should modify target variables to accommodate the specific recommendations and requirements made by forest management.

There is economic value to conducting research on the impact of land-use. Landscape research can be included in cost-benefit analysis and for assessing alternate directions in silviculture operations. The main goal of landscape perception research is to develop effective regulations that will improve silvicultural management. The present study hopefully begins to establish standards that may be incorporated into future silvicultural land-uses that will assist in maintaining the natural beauty of the northern forests.

In terms of SIA, a focused empirical rating-survey in environmental assessments will provide a means of accurately assessing the public perceptions of landscapes. The intention of the SIA is to provide a document for review before a forest operation proceeds, or before a decision is made on the direction that the operation should take. Wise management decisions are made when the public awareness is considered with the decision-making process. Hopefully the approach taken with this study will help to achieve that objective.

SUMMARY

Our research is an extension of earlier visual search studies that investigated the effects of specific spatial and chromatic properties of target stimuli. Based on the findings from this extensive body of work, we predicted that high levels of chromatic conspicuity and extrinsic (or unnatural) regularity in spatial patterning in a forest scene would have a negative impact on the public perception of forest landscapes. Indeed results showed that varying the spatiochromatic properties of the silvicultural targets in forest scenes did significantly influence their perceived beauty. Generally, patches in a scene that had spatial regularity and a colour appearance that were notably shifted towards the "reds" were given the lowest ratings overall. Although the above study manipulated stimulus variables on a CRT under well-controlled experimental conditions, it is tempting to generalize these findings to real life situations. Similar spatiochromatic properties can be viewed aerially in forest regions that underwent recent logging operations. It is possible that the local stimulus properties such as color or shape within a particular region of a scene may play a decided role in the overall perceived beauty of the scene. Evidence in the present study supports this view. However, it is important to note that with any scenic rating study, until researchers develop experimental methods that allow observers to view real scenes (which may not be possible), any generalizations from rating data to real situations are tentative at best.

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VERY BEAUTIFUL

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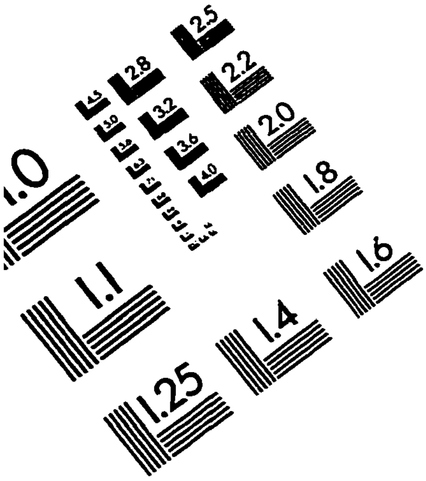
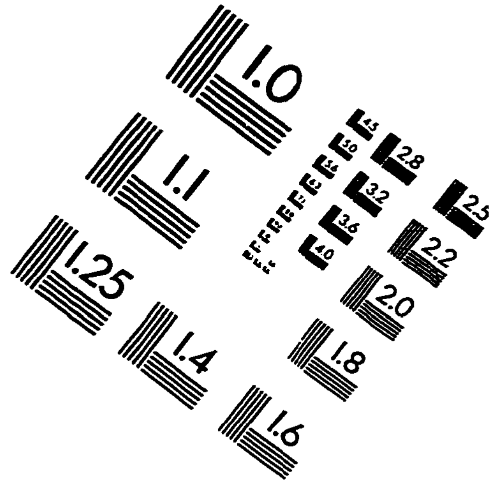
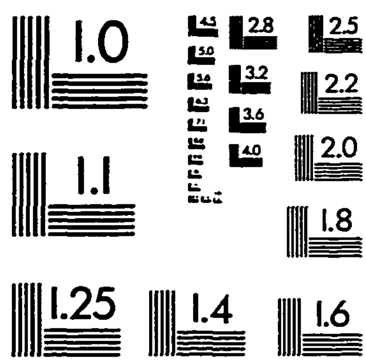
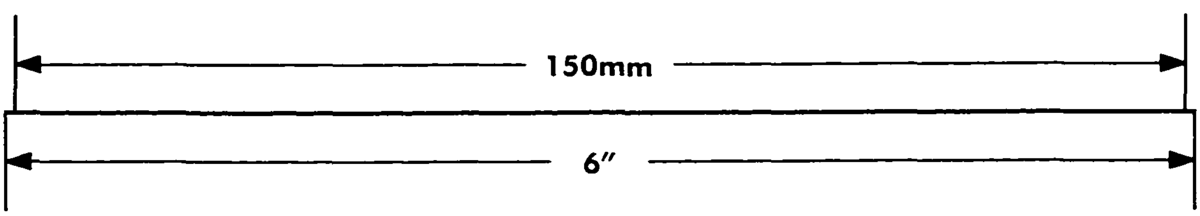
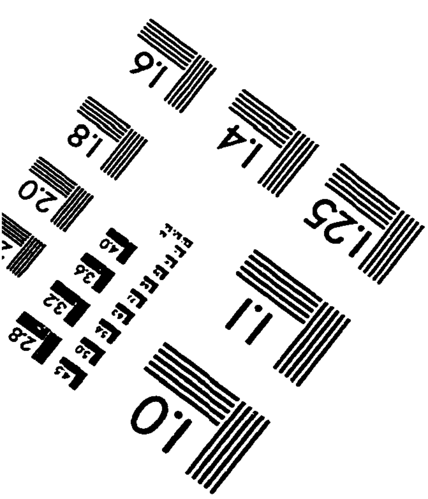
IMAGE EVALUATION TEST TARGET (QA-3)

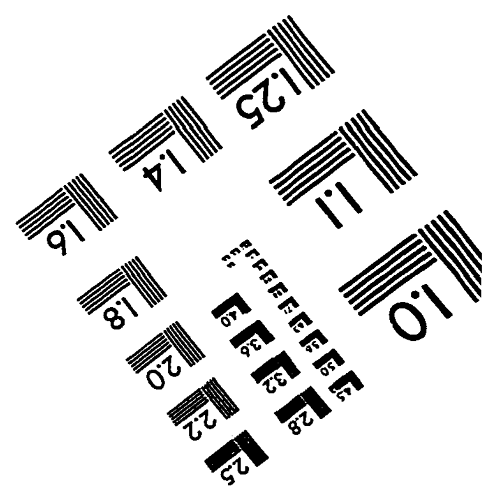












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