The Geometry of Form: A preference study

by

Carolyn Joan Kennedy

BA (hons) Simon Fraser University, 1996

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Landscape Architecture

in

THE FACULTY OF GRADUATE STUDIES

(Department of Agricultural Sciences; School of; Landscape Architecture)

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
April 2003

Department of LANDSCAPE ARCHITECTURE (AGSCI)

The University of British Columbia
Vancouver, Canada

Date April 24/03

The Geometry of Form: *A Preference Study.* cjkennedy

Abstract

This study attempts to determine whether the general public prefer curved edges over angular edges in urban park settings. Additionally, the construct validity of the information processing theory is called into doubt because of the difficulty in drawing sound conclusions when using compound constructs. It is posited that some of the results from the information processing experiments may be explained using simple concepts such as preference for curvilinear form. An experiment was conducted using four sets of images- two water features, one path and one combined planter and path which were manipulated into twenty different images that vary in degrees of angularity to curvilinearity. One group of images contained the entire scene (contextual condition) while the other set had most of the background blocked from the scene (non-contextual condition). Eighty participants from the Vancouver Aquatic Centre completed a balanced paired comparison task with 40 image comparison slides. Findings include strong correlations between curvilinearity and number of wins in seven of the eight image sets. The results of one water image set differed between the contextual and non-contextual groups. The primary conclusion is that the general public prefers landscape objects that have curved edges over those with angular edges. Additionally, the results provide grounds to question previous findings which claim that preference of s-curved paths are due to mystery because of a promise of new information. The third purpose of this study was the exploration of developing theories derived from quantitative research that are applicable to the practice of landscape architecture. A design application at Kitsilano Beach is explored to investigate the utility of the current study. It is concluded that it is possible to use quantitative research to develop practical design theories and future research using varied methodologies is suggested.

Table of contents

List of tables

List of figures

Acknowledgements

I would like to express my appreciation to the employees of the Vancouver Parks Board for giving me base maps, photographs and allowing me to gather data at the Vancouver Aquatic Centre. Thanks are also due to Doug Paterson for allowing me to explore a curiosity while keeping me in reign. Especially helpful was Ray Koopmen who led me to a shovel and told me where to dig. To my advisers, Will Marsh, Stephen Sheppard, Michael Mietner and Rob Barnes, I would like to express my gratitude for their confidence, understanding and constructive comments. And finally to my loved ones, who provided me a shoulder when I needed it, laughed with me or at me when I needed it and generally believed in me until I believed in myself - thank you!

When you start on your journey to Ithaca,
Then pray that the road is long,
Full of adventure, full of knowledge,...
...That the summer mornings are many,
That you will enter ports seen for the first time
With such pleasure, with such joy!

(from *Ithaca*, C.P. Cavafy)

Chapter 1. Introduction

Figure 1. David Lam park, Vancouver. Aesthetically pleasing curved path runs beside sloped lawn area.

This study attempts to determine whether landscape preference can be influenced by design elements of form such as angularity or curvilinearity. Objects found in urban design, such as water features, paths and planter edges will be the focus of the current study. Environmental aesthetics and, more recently landscape preference studies, have been topics of debate for many years. Many of these studies have attempted to delineate what aspects or characteristics of landscape contribute towards human perception of landscape aesthetics and landscape preference, how these features come together to influence our preference and why they influence our perception of landscape at all.

There have been a few key hypotheses put forth that have inspired a litany of landscape preference studies as well as research regarding the validity and reliability of the techniques used in those studies. After reviewing the recent literature, it has become apparent that the majority of current landscape perception research has been prepared in response to forestry regulations. This may be due to the forestry requirements regarding the inclusion of economic management of scenic beauty and visual resources (Daniel, 1990). As a result, most of the studies have been conducted using forested settings while very few consider urban landscape. However, the authors of the Information Processing Theory have suggested that their findings can be applied to landscape architecture design in areas such as parks, corporate grounds and backyard gardens in addition to forests (Kaplan et al., 1998). It is argued in this paper that the information processing concept may be flawed in that the findings of the research may be attributed to a more parsimonious theory. In other words, certain images may have been preferred due to their form rather than the complex explanations that were posited.

The current study employs a cognitive explanation to support a visual preference study which attempts to identify the influence of specific elements that may effect human preference of urban landscape features. It is important to define and understand aesthetics, human perception and the basic methods used to examine landscape preference so that the goals and methods used in this paper can be understood.

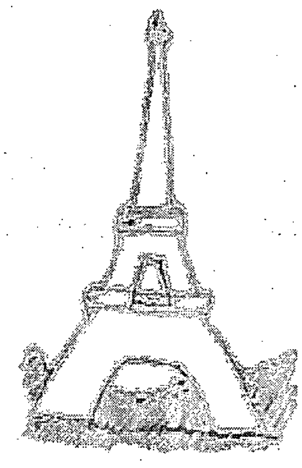


Figure 2. The Eiffel tower has become an identifiable landmark of Paris.

Definitions

What is aesthetics?

Aesthetics has historically been a problem of philosophy. The construct 'aesthetics' deals with qualities that can be perceived through any sense: olfactory, kinesthetic, tactile, auditory or visual. Aesthetics does not always imply beauty (Bourassa, 1991), however this is often the focus of philosophical debates regarding aesthetics. Visual sensory data allow one to discern light, colour, shape, patterns, movement and distance, all of which are fundamental to landscape architecture. When applied to landscape, as it is in this study, aesthetics contribute to the character and identity of a place. A place of high aesthetic value often becomes a landmark and thus becomes integral in cognitive maps of areas

(Heath, 1988). As creating a sense of place is often one of the salient goals of a landscape architect, aesthetics should be important to the designer.

What is environmental perception?

Perception can be defined as the act or effect of becoming sensorily aware of environmental stimuli. Ittelson (1973) expands on this dictionary definition by including not only the reception but the processing of information from the environment. Perception does not require one to attend to one's sensory awareness, it is possible to be sensorily aware but not cognizant of this awareness.

Environmental perception means sensory awareness of surroundings.

Perception is a sensory awareness that, if translated into conscious awareness, is filtered through cognitive processes (Berleant, 1992). Perception through one sense may be associated with other sensory data as well as memories and emotions. It will be assumed throughout this study that through past experience, one can associate various visual data with other sensory data (kinesthetic or olfactory) and thus visual perception alone is sufficient to provide enough data for one to judge preference of environment or objects in environment

Berleant (1992) claims that environmental perception is the precondition for everything else. One thing to be sure, environmental perception is a precondition to the study of landscape aesthetics; however, this leads to a discussion of what the construct "environment" means. Environment has been described as everything outside of oneself, surrounding and enfolding oneself which is all encompassing where one can not be isolated or separated from it; alternately, it can be defined as what is within ones visual spectrum (Berleant, 1992).

It is vital for a landscape architect to be aware of not only the landscape environment but one's reactions and opinions regarding the surrounding environment in order to create effective landscape designs. Additionally, the landscape architect should be sensitive to the reactions and preferences of the general population so that he or she can design places that people find attractive and inviting to use. In order to do so, the designer should have a good understanding of what people consider to be aesthetically pleasing environments, how they perceive existing landscape environments and what aspects of the environment people prefer.

A common study method:

Preference studies are common amongst psychophysical and cognitive paradigms of landscape perception (Taylor et al., 1987). During typical preference studies the participants, who are usually members or representative of members of the general public,

Landscape preference studies determine a rating or ranking to give a hierarchical value to the landscapes in question.

are asked to identify one landscape scene as being superior over another. There is some variation amongst methods in preference studies that will be discussed later.

There have been many environmental preference studies done. Through these studies evidence supports that people prefer waterscapes (Herzog, 1985) and natural or rural settings (Orland, 1988; Kaplan, 1998). An example of an urban preference study can be found in Herzog's work (1989), where he came to the conclusion that of the categories examined: older buildings, concealed foreground, tended nature, and contemporary buildings, the most preferred was 'tended nature' while the least preferred was 'older buildings'.

Figure 3. The stairs at David Lam Park (Vancouver, BC) *have strong geometrical patterns in the paving and in form.*

Additionally, the theoretical underpinnings of preference studies varies, where some studies attempt to simply identify characteristics while others attempt to find and explain the commonalities among the preferred scenes. An example of this can be found in the study where Herzog concluded that the older building category may have been the least preferred not only because of the age of the buildings but because of the grounds looking unkept. Another example is found in the Kaplan's information processing theory where preferred environments are assumed to be the environments that are more likely to enable us to meet our future needs or increase our fitness. Unlike this evolutionary explanation, other researchers (Kroh and Gimblett, 1992 as cited in Scott, 1997) posit that preferences exist within the context of values, beliefs and experiences.

The current neglect of aesthetics

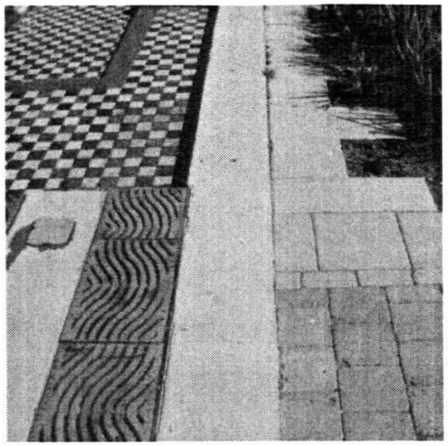


Figure 4. The mixed paving at Hastings Park *or other interesting sensory stimuli increases engagement with one's surroundings.*

Applying concepts of beauty appreciation and sublimity to environment motivates one to rethink basic assumptions about what constitutes appreciation and human experience in general (Berleant, 1992). Thus the study of visual landscape aesthetics allows researchers and designers to distinguish factors that contribute to the adaptive functioning of organisms (Ittleson, 1973). By delineating features that are determined to be aesthetically preferred features in the landscape, designers (landscape architects and architects) may use this information to not only design a more functional environment but also an aesthetically pleasing one.

Current practice of urban landscape architecture often abandons the goal of making well functioning and aesthetically pleasing spaces and instead attempts to infuse meaning into the site through historic artefacts or narratives. Olin (1988) claims that urban culture today is housed in crisp Euclidian geometries and surrounded by an excess of machined surfaces and as a result, people living in these environments are becoming attracted to blurry, compounded biomorphic shapes of nature. He goes on to say that regular geometrical forms that recall classic Greece and Rome have been drained of energy because of overuse.

Porteous (1982) claims that increasing the burden of awareness is one of the roles of an aesthetically pleasing environment. This statement parallels that of Litton (1982) who states that decreasing inattention of passing landscape and surroundings is of vital importance. Something of great beauty demands the attention and engagement of the passerby. It can be argued that by learning what forms are considered beautiful or aesthetically pleasing, one can learn how to design and build places that encourage such experiences and thus wake up a culture of disengaged people moving about in a trancelike state through a disengaging homogenous environment.

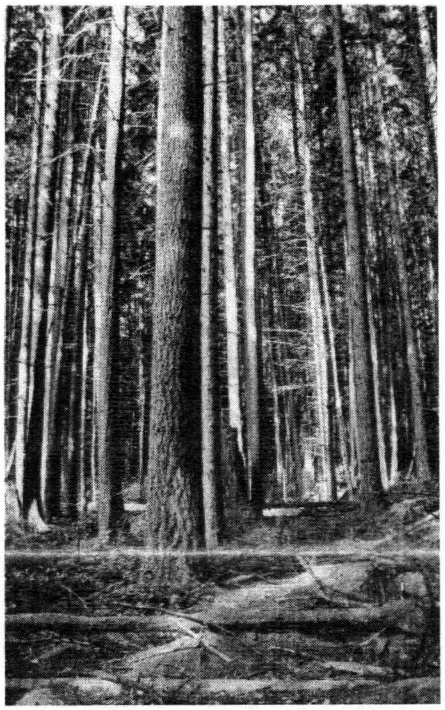


Figure 5. Pacific Spirit Forest Park. Before the Age of Enlightenment, beauty was seen as an intrinsic quality of nature that reflected the beauty of God.

Berleant (1992) argues that an environment with a full range of sensory cues can serve to guide human activities enabling comfortable movement, a sense of security, as well as interest and excitement. He goes further to identify that the tactile sensation of a road or a walk, the auditory stimulation of a drone of traffic or roar of machinery, and the olfactory sensation of decay and fuel combustion, and the kinesthetic awareness in driving or sitting does not represent a wide enough range of experiences for what humans require to maintain engagement. He calls the American culture (which could be extended to Canadian culture) an insensitive one because of the limited range of available sensory stimuli. He goes on to say that since people are capable of shaping environment as well as adapting to it, areas of cultural experience need to be identified and available.

These points confirm the need to identify characteristics and qualities that people find compelling in the landscape. By distinguishing aesthetically engaging sensory cues, enhanced awareness and attention to ones environment could be encouraged through better landscape design. The North American culture can transform from one of monotonous surroundings that allows the inhabitant to maintain an state of disengagement into a fascinating environment that stimulates the inhabitant.

Historical background of landscape aesthetic theory

Environmental aesthetics have not always been viewed as being open to subjective judgement. Historically, factors involved in landscape aesthetics were considered to be objective, intrinsic characteristics of landscape. The objective paradigm posits that landscape has inherent qualities that can be used to classify the area. This ideal is often held by geographers or planners in exercises where landforms are classified and mapped. This theory has was founded on the ancient philosophy of Socrates and Plato (approximately 400 BC) who believed that beauty was connected with morality and love of good (Bourassa, 1991). It was thought that certain intrinsically aesthetic qualities, if they were present , would be identified in the landscape. Up until the eighteenth century, landscape was considered to be reflective of God (Lothian, 1999). The reasoning went that since God is beauty and God created landscape then Landscape reflected God and thus was beautiful (Lothian, 1999). 'Nature' was viewed as revealing evidence of design through order and purpose where beauty in nature was regarded as an expression of order harmony and regularity (Lothian, 1999). This view, however, did not change until after the

Nature was historically viewed as a reflection of God.

seventeenth and eighteenth century when physico-theology, a theology founded on the evidence of God through design found in nature, fell out of favour (Lothian, 1999).

A fundamental error in reasoning behind the objective approach is the assumption that humans can identify and assess a purely objective characteristic. This paradoxically resides in subjectivity and thus subjectivity is being presented as objectivity (Lothian, 1999). The objective view of aesthetics declined when Darwin's evolution theory became popular as it was no longer necessary to regard beauty in nature as evidence of God.

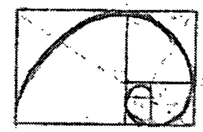


Figure 6. The golden section or mean *is formed when the proportion of two divisions of a plane figure is such that the smaller is to the larger as the larger is to the sum of the two. If the sides of a rectangle are in the form of the golden mean, and a square is placed in the shorter side, the remaining rectangle will also have the same proportion. (Oxford English Dictionary)*

Greek ideas of beauty were seen re-emerging in the Renaissance through characteristics of order, symmetry, balance and regularity as can be seen in the focus of design using the golden mean. The golden mean or the golden section rectangle is a prominent formalist theory that is concerned with proportion (Bourrassa, 1991). The rectangle can be broken down to create further rectangles of the same proportion once the square is removed from the shortest side. While this is a valid attempt at an aesthetic rule to describe ideal architectural ratio of form, the theory can not solve the problem of the form (building) being seen from many angles and thus changing the proportions and thus destroying the harmony. The same criticism can be applied to other formal theories of landscape aesthetics such as unity, complexity and symmetry (Bourrassa, 1991). The British empiricists, one of whom was William Hogarth, lead a subsequent search for aesthetic ideals. Hogarth believed that linear beauty was produced by qualities of fitness, variety, uniformity, simplicity, intricacy and quantity while the wavy line was the line of beauty (as cited in Lothian, 1999).

Hume, another empiricist, believed that beauty resides in the mind not the object, for beauty, as all else, could only be known if perceived by the senses (Lothian, 1999). Kant (eighteenth century German philosopher) who developed a framework that claimed that beauty is wholly subjective, disengaged and a symbol of the moral (Bourrassa, 1991) founded the subjective paradigm. The main tenant of the subjective paradigm of aesthetics is that beauty (and thus landscape quality) is derived from the eye of the beholder (Lothian, 1999). The subjective paradigm, posits that landscape quality and thus aesthetic quality is subjective in that it may not be absolute and may vary across cultures.

Current theories maintain the subjective qualities of aesthetics, however, due to regulatory necessities, there still remains an attempt to quantify and objectify aesthetic qualities. This study combines the ideas of objective and subjective beauty by assuming that there is some commonality among subjective ideals of beauty. It is interesting that images considered to be intrinsically beautiful are not as affected by detracting labels (Anderson, 1981). Further research into the sublime may aid in the understanding of this finding.

Current aesthetic landscape theory assumes that although beauty is subjective, people have some common perception that allows us to assume objective-like characteristics can be identified.

Current ideas have been further divided into four schools of thought by Taylor, Zube and Sell (1987). The four paradigms identified in this paper are: expert, psychophysical, experiential and cognitive. Taylor et al. (1987) suggest that future research move towards integrated approaches utilizing more than one of the identified paradigms for a more complete approach. The aforementioned paradigms will be discussed below using examples wherever possible.

Expert paradigm

The expert paradigm as set out by Taylor et al (1987) is derived from fine arts and design as well as ecology and resource management. This paradigm is the most like the historical objective aesthetics paradigm in that beauty is seen as being a property of landscape for which identification requires someone trained for the task. Often the valued criteria is identified based on the purpose of the study. For example, the study may involve a visual aesthetics study of views near forest cut blocks and the criteria being used to assess the value of the view could be edges, plant cover, plant variety, presence of water and such. The study would require someone who has been trained in such areas (an expert) to assess the area for the criteria and come up with a conclusion. The expert is assumed to have superior skills at identifying the characteristics in question because of his or her training. Laurie (1976) has gone so far as to say that aesthetics judgement is an acquired skill which can only be taught to people who are naturally receptive by people who have shown that they too are in the possession of these skills. It is unclear how it is initially determined who does or does not have the skills except Laurie seems to imply a superior innate skill that

The expert paradigm assumes that a trained person can better identify aesthetic characteristics than a lay-person.

one simply knows one has. It would follow from this description that not just anyone can learn to be an expert with expert opinions. From Laurie's point of view, a study such as the current one would be invalid since it draws from the opinions of people who may not only not have this innate quality but also have not been taught by someone who equally possesses this gift. While this idea represents an extreme position in the expert paradigm, it represents the way in which landscape architects carry out much of urban landscape design in that the expert opinion (whether it be the designer or the design panel) is often the only one considered.

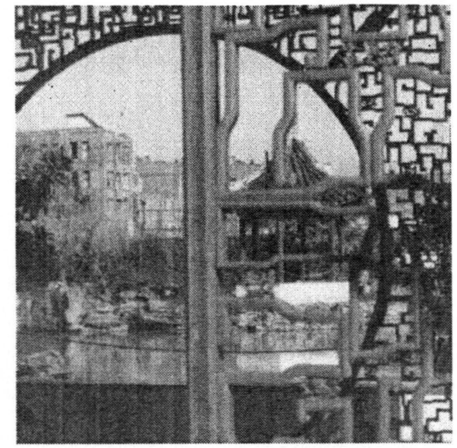


Figure 7. The moon gate at the Dr. Sun Yat-Sen Classical Chinese Garden *is placed to frame views and create harmony between the different spaces in the garden.*

Taylor (1987) tells of the U.S. Bureau of Land Management Visual Resources Management Program identifying form, line, colour and texture as being elements whose presence increases the aesthetics of landscape. An example of a popular form based theory that falls into the expert paradigm is Feng Shui. Although this theory originates in Asia, it can now be found across many cultures throughout design literature.

Expert paradigm example: Feng Shui

The direct translation of feng shui is "wind" and "water" (Rossbach, 1983) but the philosophy involves architecture, astrology and includes things such as: conservation, ecology, orientation, spatial arrangement, and form (curvilinear and angular). The philosophy is based on the goal of harmonizing the environment to capitalize on ch'i (life force). The principle of ying and yang, the complimentary forces that symbolize harmony, is central to feng shui theory. Yin is dark, passive, soft and female; while yang is light, active, sharp and male. Both yin and yang are needed to maintain balance or ch'i. Ch'i is the most important component of feng shui, "...it is the vital force that breaths life into animals and vegetation, [it] inflates the earth to form mountains, and carries water through the earth's ducts." (Rossbach, 1983 pg 21.) Ch'i is subject to weakness and decay when it is dispersed or blocked and the positive energy is drained which results in sha (life taking breath) (Xing, 1998). Sha travels down straight lines or can be directed from sharp corners or buildings or natural features. Feng shui is an extensive philosophy dealing with physical forms, juxtapositions and spirituality however, only the aspects that concern the geometry of form will be discussed here.

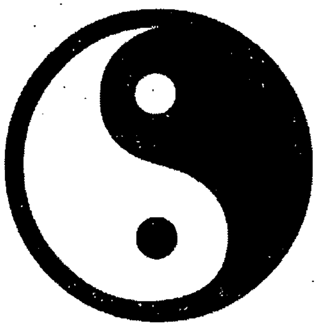


Figure 8. yin and yang *are the complimentary forces that symbolize harmony. Yin is dark, passive, soft and female; while yang is light, active, sharp and male.*

The practice of feng shui identifies forms and shapes as capitalizing on or even killing ch'i. If a river is straight and its water runs fast, it will kill ch'i. The river that follows an irregular sharply turning course is considered yin, while the river that flows evenly and meanders is considered yang and produces positive energy (Xing, 1998). Sharp bends are said to project an arrow like ch'i. Any changes to the land are done with the intention of restoring the disruption of the natural harmony. Building a straight road is avoided as it is seen to conduct ch'i too quickly, instead the road is constructed to wander slowly along the land's contours avoiding disturbance to the natural balance. However, Feng shui does not stop at linearity and curvilinearity. There are many other factors such as juxtaposition that can make a form acceptable or not; additionally, it is a balance of geometric forms and positioning that is required. The straight road may not be as detrimental as a house placed at the end of such a road, however even this deleterious arrangement can be 'cured' by feng shui. The placement of a pond between the house and the road is one solution if it includes a water wheel to lift the water out of the pond and disperse the ch'i.

Feng shui theory tells the seeker to build curvilinear garden path if possible and gives 'fixes' for the straight or angled path (Henwood, 1999; Xing, 1998). Xing (1998) explains that curves and round structures are a sign of something that is complete as well as being an indication of satisfaction and happiness. Feng shui usually requires an expert to assist in the effort to ensure the environment adheres to the chosen principles as do other expert theories and as a result, the outcomes of these types of aesthetic theories are quite subjective.

Other theories that deal with geometry form and fall into the expert paradigm are those concerning photography and picture composition. However, expert driven theories are not easily measured by validity and reliability tests in a statistical sense and thus it is difficult to know if they do indeed accomplish what they set out to accomplish and if they are repeatable (Taylor et al, 1987). Both validity and reliability are seen as requirements in scientific enquiry. The tendency for decision makers to rely on experts for the identification of components that make up scenic beauty as well as identification of areas that have these qualities leads one to wonder about the congruence between expert opinions and the opinions of the general public. Zube (1976) asks a question regarding the consensus both

The Expert paradigm is different from the psychophysical paradigm in that only one expert may be consulted for information, whereas in the psychophysical paradigm a group of participants is required to gather information.

between and within the groups of experts and lay people. Would both groups identify the same characteristics or sites as having high aesthetic qualities? A paradigm that takes the general public opinion into consideration is the psychophysical paradigm.

Psychophysical paradigm

This paradigm arises from experimental psychology (Taylor et al., 1987) where learning through scientific enquiry is of utmost importance. Typically, information is found through experiments conducted using participants or subjects assumed to be representative of the general population. This theory, when applied to landscape aesthetics, relies on the behaviourism principle of stimulus-response where landscape is seen as the stimulus and the response is what is measured. Gibson's theory of environmental perception (Taylor et al., 1987) posits the use of complex patterns of light to indicate a distinct environment (as cited in Kennedy, 2001). This theory is also used as a basis in cognitive studies because of the cognitive socio-biological themes it contains which will be discussed later. For instance, the idea of *affordances* is based on one's interpretation of a perceived stimuli as a threat or an opportunity based on one's previous experiences and provides possibilities for behaviour (Fellman, 1986).

The psychopsyical paradigm has been criticized for not explaining the results of their experiments.

Often psychophysical studies ask participants to rate or sort landscape scenes by preference and then attempt to evaluate the preferred scenes to find the commonalities and identify the factors that may lead to the scene being a preferred one. The studies range in realism and immersiveness where a subject may be simply viewing line drawings or may be in a three dimension virtual reality immersive display to view the test scene. This paradigm has been criticized for being 'theory weak' in that no explanation is sought to aid in the understanding of why the findings are found (Taylor et al., 1987) as well as for the poor applicability of the findings for use in the design field.

Figure 9. Mosaic fountain at the Vancouver Public Library *by Sincera exemplifies a beautiful sight and sound experience while one lingers in the warm toned plaza.*

Experiential paradigm

The experiential paradigm is based on the interaction of landscape and human, not just the effects of one on the other (Taylor et al., 1987). This paradigm concentrates on understanding rather than identifying aesthetic features. People are seen as participants rather than observers. This theory has also been called a holistic theory as it does not attempt to separate or delineate variables from each other but studies the interaction as a whole. John Ruskin (as cited in Relph, 1982) resisted the breaking down into elements to study as he claimed that attempts to measure environmental qualities and values outside of context will only lead to an increase in triviality and pseudo-scientific confusions. In this same vein, Tuan (as cited in Taylor et al., 1987) states that actual experience must be lived and any attempt to describe it reduces it to generalities.

Typical psychometric ideas of validity and reliability are not important to followers of this paradigm (Taylor et al., 1987). The ideas are considered valid if they have meaning to even one other person. Place theories such as those by Relph, Eliade and Bachelard are examples of experiential theories. These theories attempt to teach the reader to see rather than teach a designer how to make or design place in landscape. While the ability to detect real meaning may be great with experiential methods, it is difficult to generalize the findings to be applicable by the general population (Taylor et al., 1987).

Experiential theory originates in phenomenology in which landscape would be described in sensory terms rather than cognitively interpreted. However, as Berleant (1992) points out, it is rare that a person experiences sensory data without cognitively evaluating the information and thus phenomenology not be representative of the human experience of landscape.

Cognitive paradigm

The cognitive paradigm is similar to the psychophysical paradigm except it attempts to explain research findings with theory that is often evolutionary based.

The cognitive paradigm is similar to the psychophysical example in that the ideas are tested by using statistically valid and reliable methods, however the cognitive paradigm attempts to explain the findings in terms of evolutionary fitness. Cognitive studies assume that people do not respond passively to environment but respond to aspects that have some meaning or significance (Taylor et al., 1987). This paradigm focuses not as much on which landscapes are preferred or valued but why they are preferred.

A popular theory to explain behaviour and preferences in the cognitive school of thought is the socio-biological or evolutionary theory. The fundamental tenet of evolutionary theories is that human perception of scenic quality is founded in the goal of survival or fitness. People tend to prefer landscapes that enhance their chance of survival. Stephen Kaplan defines preferred environments as those that promise to be involving and can be easily understood (Kaplan, 1982).

A cognitive theory that is fairly well known is Appleton's prospect refuge theory. In this theory, shelter or refuge is seen as a place in which to hide in and observe while remaining unseen. This idea is similar to Gibson's notion of concealment (Kaplan, 1982). Prospect is defined as unhindered seeing. The four objectives of prospect-refuge theory were: first, to set aesthetics of the landscape within the context of biological interpretation. Second, to emphasize the need to elicit evidential support from as wide a range of human experience as possible. Third, to simplify the concepts from the evidence and lastly, to be a model that could be extended across a variety of investigations and methods (Appleton, 1988). Prospect-refuge theory explains preferences from a socio-biological standpoint where humans perceive the habitat in the same way other animals see it- as a theatre for survival (Appleton, 1988). Appleton posits that Versailles France is a symbol of prospect refuge in the straight jacket of geometric regularity while Sheffeild Park in Sussex England portrays prospect refuge through the reflecting water surfaces seen from the cozy refuge of the trees.

Appletons prospect refuge hypothesis is a cognitive theory that attempts to explain landscape preference in terms of sight advantages and feelings of safety.

While this theory has some merit, it does not explain aspects of aesthetical preferences of designed aesthetics if one were to control for prospect refuge. For instance, if seated in a safe area with a large vantage point, one could and would still prefer one aesthetic over another.

Figure 10 adapted from the Kaplan's book With People in Mind, this scene is said to show low coherency.

One of the most well known cognitive theories that deals with landscape perception serves as the inspiration behind this study. The Kaplans' Information Processing Theory of landscape preference is another example of an evolutionary based cognitive theory of landscape preference.

Figure 11. adapted from the Kaplan's book With People in Mind, This scene is said to illustrate high coherency.

Information processing

The information processing hypothesis (also known as the environmental preference hypothesis of landscape preference) attempts to identify and explain what properties the environment must have to enhance people's well-being and effectiveness (Kaplan, 1972). The researchers collected a large number of images and asked people to rate them according to their preference; the researchers then attempted to classify the images by identifying high correlations between the ratings of the images upon which they define common factors within the images that may have lead to the preferences (Kaplan, 1989). The factors identified by the Kaplans are coherence, complexity, mystery and legibility.

The preferred factors

Coherence is defined as the degree to which an environment can be organized or structured into a scene that hangs together (see figure 1). Factors that play a role in coherence are order, redundancy and grouping visual objects together so that the whole area fits together. Complexity varies depending on whether there is enough in a scene to keep one occupied and whether the scene is worthy of making a cognitive map. The visual richness (Kaplan, 1982) of a scene or number and variety of elements define the amount of complexity within a scene. There is a positive linear relationship between preference and images that contain these factors (Kaplan, 1998). Mystery is defined as a promise of more information. It is further described as the partially blocked view that will compel a person to go further into the scene to seek out the hidden information (Kaplan et al., 1998). This construct is typically measured by preference of the winding path (1998). Mystery is likened to surprise in Japanese gardens however, it differs in that new information is not presented suddenly but is implied or promised (Kaplan, 1982). The final factor in the Kaplan's preference theory is legibility. Legibility deals with the memorable or distinct components (landmarks) of a landscape that aid in a person's orientation (Kaplan et al., 1992). Legibility is closely tied with wayfinding. If the landscape is legible, one can find one's way both through the landscape and back again. In an older version of the theory, Kaplan (1972) states that a scene that is legible allows one to imagine oneself exploring without getting lost. As with the other constructs, the more legibility the greater the preference.

Figure 12. Adapted from Kaplan's book "With people in Mind" this sketch shows mystery and states that mystery can be a curving path.

The problem with compound factors

Each of these constructs could be considered a compound construct in that they are made up of many simple elements. For example, coherency is made up of the more simple constructs of form, order, grouping and repeating elements. It is difficult to verify the findings of compound constructs as there are so many variables that influence the findings. How can we be sure that it is coherence that the viewer preferred and not simply form and/or order?

Figure 13. adapted from the Kaplan's book "With People in Mind", this image shows high coherence and high complexity

Additionally, each of the features that are identified not only measure preference but attention and sometimes even more complex cognitive processing as they may have a future element to them. Is it possible that the Kaplan's findings could be attributed to something other than the compound factors as they have posited?

In a study by Stamps (2002), it was shown that the coherency or repetition and grouping between the skyline and building shapes is not preferred. Stamps tested fractal skylines of buildings (built environment) and the mountainous skyline (nature). He examined the hypothesis that people would prefer the two forms to match (theory of fractal fit) and found no evidence to support the theory. This theory is closely related to coherence as the matching skylines can be said to have order, repeating elements and are grouped so as to form a coherent scene; however, it may not have dealt with the factors in coherency that result in the preference for the construct.

Kaplan and Wendt (1972) examined Wohlwill's theory of complexity and found that it varied with the environment depicted. Complexity is a predictor of preference if it is applied to 'natural' or urban scenes when they are separated but cannot account for the difference in preference values between them. There has been some debate over complexity having a curvilinear relationship with preference where it is negative if there is either too much or too little. Where there is too much complexity it is visually distracting or unfavourable and where there is too little the scene is uninteresting (Kaplan, 1998). The environmental preference theory argues that high complexity, if grouped with construct coherence, is a desirable thing. This extra grouping though would indicate that complexity cannot stand alone but must be paired and further compounded to remain a valid indicator of preference. This idea was illustrated in figure 10, when is was stated that the low coherence scene is also an example of complexity which when combined with coherence as it is in figure 13, the scene and/or construct maintains its integrity as a preferred scene.

Mystery requires the viewer to perceive the scene and interpret the stimuli in terms of future prediction. The Kaplans define mystery as a scene that invokes the viewer to explore (Kaplan et al., 1998) and to then make inferences that one could learn more through locomotion and exploration (Kaplan, 1982). In this respect, mystery is very similar to Appleton's concept of secondary prospect where prospect is suggested but not directly experienced from where the observer is located (Appleton, 1975 as cited in Hagerhall, 2000). This idea is not consistent with the evolutionary underpinnings of the theory. If the environmental preference theory is based on the notion that people will prefer what feels safe and is easy to understand, then the presence of the nearby hidden information that is illustrated in a s-curve (mysterious) path would represent a possible threat. The Kaplans also speculate that "blocked or obstructed views can create fear and concern" (Kaplan, 1998. pg.33). These two ideas seem to contradict each other and are not enough to explain preference of nearby and distant hidden views. Furthermore, if mystery was the determining factor in preference then in the non-preferred scenes there should not by any hidden aspects or blocked views that could be interpreted as a 'promise of more information'.

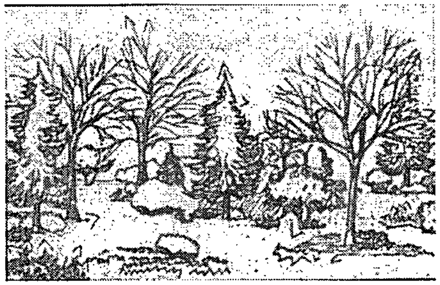


Figure 14. low coherence scene from figure 10 is more angular than the high coherency image in figure 11.

Is it possible that the preferred scenes are preferred due to form and not the named categories? Perhaps there is a more parsimonious explanation, one that does not presume future prediction and cognitive processing.

Methodological problems with the hypothesis

The environmental preference theory also has problems in terms of method. As was stated before, the theory is based on an evolutionary view which considers the quality of nature as being subjective; however, the use of the Likert scale (1-5) implies an ideal of beauty with a finite limit (Lothian, 1999). Measuring a subjective quality with a tool that implies objective qualities is a paradox.

Another problem inherent to measuring scenes using a Likert scale is the ambiguity of the rating. Is a number 1, or a "not at all", consistent with the same rating in another scene? The scenes are only being compared to one another via the ratings assigned. Would the scenes be ordered in the same way if they were directly compared to one another? Does the memory of a highly preferred place affect the rating that is given to a image during the study?

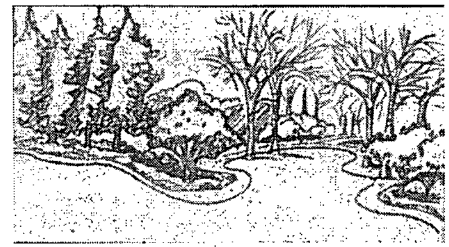


Figure 15. high coherence scene from figure 11 is more curvilinear than the low coherency image in figure 10.

The pre-selection of scenes may also bias the findings. The researcher may have chosen a certain type or preferred image thus limiting the number of possible constructs derived from the preference study. As well, the rating of different sites allows for more error in the study. Ratings of different scenes do not allow for comparison against one another. This method requires that the scenes be organized into artificial categories and assumes that any findings are due to the categorization rather than a third element that was unaccounted for. This, in combination with the fact that the constructs of this theory are complex, allows for unaccounted error where the preference of images within a category may be due to a third factor.

In a study by Scott (1997), it was found that people judge images differently when they sort them according to content than when they sort them for experience. The directions for many of the experiments conducted by the Kaplans are unavailable in the published writings. In the appendix of The Experience of Nature, it is reported that the subjects are not asked how much they like the scene, how pretty it is or how they would judge the scenic quality; however, in the 1972 article it is reported that one of the questions the subjects were asked was "how pleasing you find the slide or how much you like it?". The directions given to subjects can bias or confound the experiment. In light of the findings, that subjects judge experience and content differently, it would seem vital that the researcher understands the difference and then articulates this to the subjects. Since the underlying theory behind the Kaplan's research is evolutionary, it would seem necessary to delineate that the subjects are rating the scenes based on the experience of the scene, rather than simply how pleasing they find it or how much they like the scene, as the results may vary accordingly.

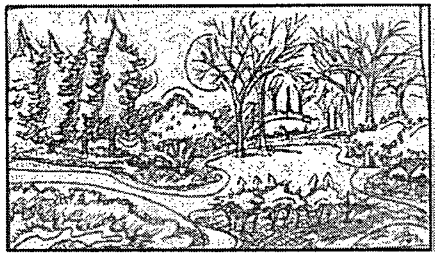


Figure 16. high coherence and complexity scene from figure 13 has a mix of form but is curvilinear dominant.

An alternate proposition

An alternate theory that may explain some of the findings from these preference studies follows. The principle of parsimony is fundamental to the following idea, thus avoiding the possible error that can be found in compound constructs.

Elemental constructs

Zajonc (1980) posits that preferences are not the result of rational calculation but rather are made so rapidly that they precede rather than follow conscious thought. Kaplan defends Zajonc's idea by using mystery as an example of evidence of interpretation- however this may encapsulate a vital error in that Kaplan assumes that it is mystery that the subjects were preferring rather than the basic geometric form of the scene. If Zajonc is correct, people may not be basing their preferences on some cognitively processed idea of exploration and hidden information but reacting to the basic elements of the image.

An example of this can be seen in the 1966 study where Guthrie and Wiener re-examined a 1959 study by Eagle (Guthrie & Wiener, 1966). The original purpose of the study was to examine subliminal research by using visual stimuli with below-threshold exposures. They took the study by Eagle and looked for possible explanations for his findings. In his study, Eagle used three pictures, one of a man with a knife attacking another man, another of the same man handing a cake to another man and the last one of the same man standing with his hands at his sides. Images adapted from the original experiment can be seen in Figure 17.

Either the benevolent picture with the two men and the cake, or the aggressive picture with the knife would be exposed briefly (enough to see and identify the picture) followed by the neutral picture with the man standing hands in pockets. At this point the experimenter would ask the subjects to assign a personality trait list to the man in the neutral picture. The resulting personality trait list would vary depending on whether it was the benevolent or the aggressive picture shown first. The results were concluded to mean that the first pictures were subliminally influencing the responses towards the second picture. However, upon further examination, it was found that the structural attributes (angularity and thickness of line) of the benevolent and the aggressive pictures varied.

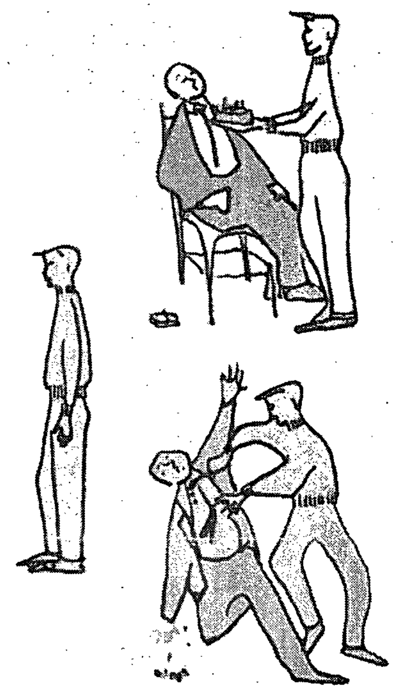


Figure 17. Adapted from Eagle experiment. After brief exposure to either stabbing image or cake image, adjectives were assigned to the image of the solitary man. The conclusion was that the first image was subliminally influencing the responses to the second picture. Later Guthrie and wiener showed it was due to angularity .

After conducting a three part investigation that concentrated on the elemental form of the images (figures 18 & 19). Guthrie and Wiener were able to conclude that:

1. People assign negative traits to angular lines and positive traits to curved lines (thickness was not a significant factor).

2. The original pictures used in the Eagle experiment were significantly rated as having different amounts of angular attributes from one another (the aggressive being more angular than the benevolent picture).

3. Guthrie and Wiener found angularity to be a greater influence on the designation of negative attributes than the presence of a gun when subjects were asked to describe the man in the image.

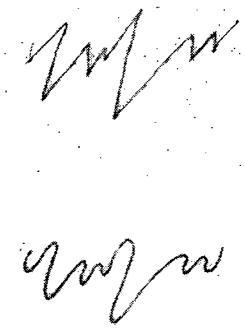


Figure 18. Adapted from Guthrie Wiener experiment. Negative attributes were assigned to the angular line while positive attributes were assigned to the curved line.

This experiment illustrates how elemental form may influence a person's judgment of preference of a more complex idea. Upon examining the images used by the Kaplans (figures 10 & 11), one can see that the difference between low and high coherency is mainly a rounding off of garden borders. There is less angularity in the high coherency (proffered image) than the low coherency. The idea of preference due to form is not a new one. William Hogarth believed that linear beauty was produced by qualities of fitness, variety, uniformity, simplicity, intricacy and quantity while the wavy line is the line of beauty (as cited in Lothian, 1999). A simple construct, such as angularity, allows for a more controlled experiment that can isolate which variables affect preference.

Figure 19. Adapted from Guthrie & Wiener experiment. *Angularity was a greater influence on the designation or attributes than was the presence or absence of a gun.*

An alternate method

In a weight elicitation study, it was determined that by having two tangible images to compare and rank, decisions are more precise than when a person is simply assigning ranks or rating the images (Xiang, 2001). By using a direct comparison method where images are rated according to preference, the arbitrariness or ambiguity of the Likert scale can be avoided. This method also avoids the assumption of an ideal as it only requires the subjects to compare one image against another.

By using one scene and manipulating only certain elements confounding factors such as lighting, background, the presence of water or people should all be held constant.

Using the same site and image while varying basic elements within the image can allow one to control for possible bias and error more easily than if two completely different images are used. Confounding factors that can positively influence preference of a site such as experience or familiarity (Balling, 1982; Zajonc, 1980) can be ruled out when both images are dealing with the same site. Another source of error, that same site comparisons control for, is the preference for a type of site rather than the image itself. In numerous studies it has been found that natural scenes are preferred over urban scenes and scenes that depict human disturbance (Hul,l 1989; Purcell, 1994). Additionally, it is suggested that the subjects be given clear direction as to whether they are comparing the scenes for their preference of being in the environment depicted or if they are merely comparing the scenes on the basis of the content of the image.

There are many elemental factors, such as lighting, symmetry or triggered memories that could influence the preference of one scene over that of another. Compound factors and categorizations are arbitrary if these simple factors have been neither examined nor held constant. It is necessary to look at the simple factors while controlling for others if the preferred variables of landscape aesthetics are to be identified. Until then, one can only conclude that the Environmental Preference Theory is an in interesting notion that contains so many opportunities for error that the conclusion does not definitively explain the experimental results.

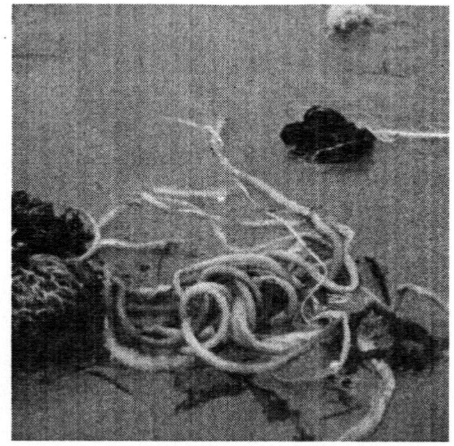


Figure 20. Seaweed from Long Beach, Tofino, B.C. illustrates the natural swirl configuration identified by Simon Bell

Integrated approach

Taylor et al. (1987) suggest that a better way of viewing landscape aesthetics may be to use an integrated approach by combining various aspects from each of the four theories (expert, psychophysical, experiential and cognitive). It is with this in view that the present study will attempt to combine cognitive theory with psychophysical elements and then apply the findings to a practical design problem.

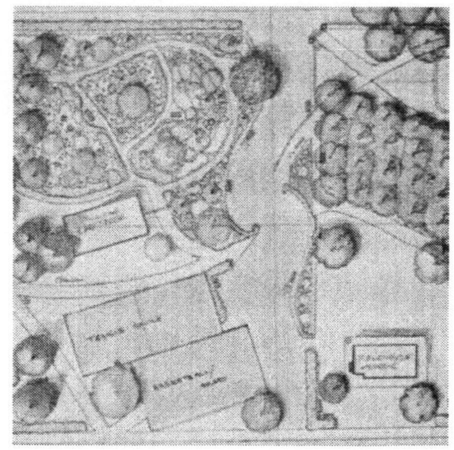


Figure 21. Park design emulates swirl pattern in agora area and stroll garden.

Curvilinearity and angularity in nature and design

Elements of form make up all of our surroundings. People may have come to associate certain forms with certain characteristics, such as meandering curves with streams or a rocky angular edges with cliffs. When the elements of form do not meet one's expectations or anticipations of the character of the object, some cognitive dissonance may occur causing one to feel uncomfortable. For instance, when a horizontal water feature has extreme angular edges one may not feel as comfortable with or like the object as much as if the edges were made up of curving organic lines. Of course this may alter when it is applied to a vertical water feature because of naturally existing water falls that hug the face of angular rocks. Bell recognizes the problem of incompatible shapes producing tension and visual conflict (1993).

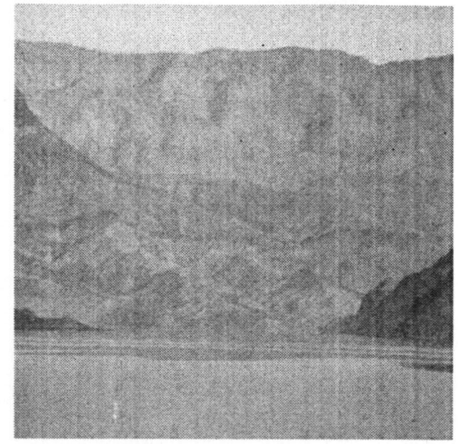


Figure 22. Nevada mountains have angular places.

The same may hold true of a path; however, depending on the purpose, one form may be preferred over another. If the path is used as a route to get somewhere rapidly then it may be the preferred form is that of a straight line; however, if the path is used as a stroll then it may be that the meandering form is preferred. Sharp or angular lines may be perceived as sharp or injurious to the body, where curved forms can not inflict as much harm and so may be preferred. Or contrastingly, it may be more appropriate at times to prefer angular edges over curved edges. The form of objects in landscape may influence one's preference for an entire area for reasons of perceived comfort. The sensory cues may be subconsciously assessed and then interpreted simply as a preference for a landscape.

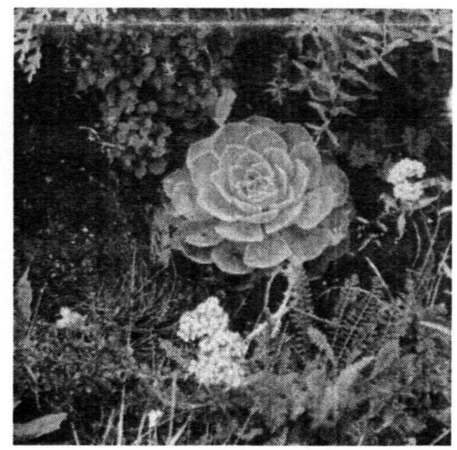


Figure 23. This Sempervivum has a swirled pattern.

Simon Bell (1993, 1999) has written about elements of visual design in landscape and identified points, lines, planes, solid volumes and open volumes as the elements that make up patterns. He has also come up with variables and organization as influencing factors. He lists shape or the variation of lines and edges of planes and volumes (he identifies form as the three-dimensional equivalent of shape) as the most important variable that effects the way surroundings are perceived as patterns. Olin (1988) writes that nature contains all forms and that discernment and abstraction is in the human imagination. Bell states that as most forms found in geography are irregularly curvilinear, designs which recognize this may be more compatible with their surrounding context than those which disregard naturally occurring form. Bell writes extensively on the importance of patterns in landscape as a means of understanding and predicting in the world (1999). This view is somewhat similar to the cognitive theories of aesthetics in that this understanding and ability to predict the future based on patterns founding landscape enable a species to increase its fitness or ability to survive.

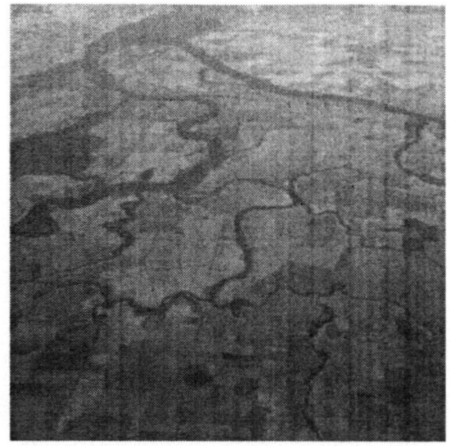


Figure 24. The Fraser River, B.C. has the meandering pattern Simon Bell identifies.

Stevens (as cited in Bell, 1999) identified basic patterns found in topological studies; he listed these as spirals, meanders, branches and explosions. These shapes are combined in many ways to create mosaics in the world. Bell then compares these patterns to ones created by people and finds that similar shapes have been replicated throughout history. The patterns in geography discussed by Stevens and Bell can be seen in figures 20, 23, 24 & 25. Often designs emulate the same patterns (figure 21 and 26). The patterns identified by Bell and Stevens are not exhaustive and one must not ignore the angular forms found in mountains and rock formations (Figure 22).

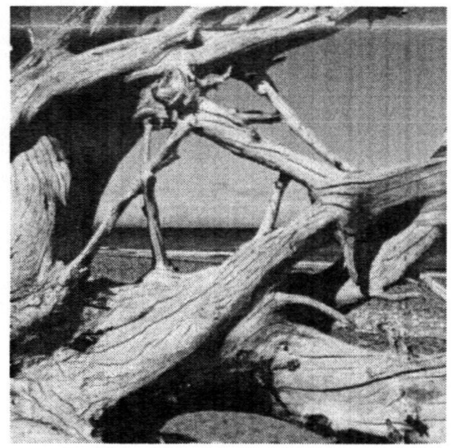


Figure 25. Drift wood in Oyster Bay, B.C. has branching pattern discussed by Simon Bell.

Hannebaum (2002) writes of ground patterns. He divides ground patterns into three categories: straight lines and angles, curved lines or arcs and tangents. He states that straight lines and angles are the easiest to use because they reflect property boundaries. The current practice of using CAD programs to design may also influence the forms used in designs. It may be easier or more efficient to draw straight lines and angles in a CAD program than to draw sinuous lines. The same author, Hannebaum (2002) goes on to state that curved line designs, if done effectively, give a sense of informality and add a calming effect that straight lines and angles do not. However, the author warns the designer of using busy squiggly lines as being distracting and unable to hold one's interest. The third category, arcs and tangents, are a combination of straight lines and curves. In a classic landscape architecture text, Simonds (1961) diagrams a variety of angular and curvilinear lines with varying frequency and gives them sometimes anthropomorphic attributes. A gentle curvilinear line is said to be tender, soft, pleasant and feminine while the sharp angular line is said to be jagged, brutal, hard, vigorous and masculine. These descriptions are similar to the ones used in feng shui. It is interesting to note the cross-cultural tendency to assign gender to the form of a line. When the frequency is increased the curved line is indirect and plodding while the angular one is excited, nervous and jittery.

Figure 26. Cave rock formations demonstrate explosion pattern.

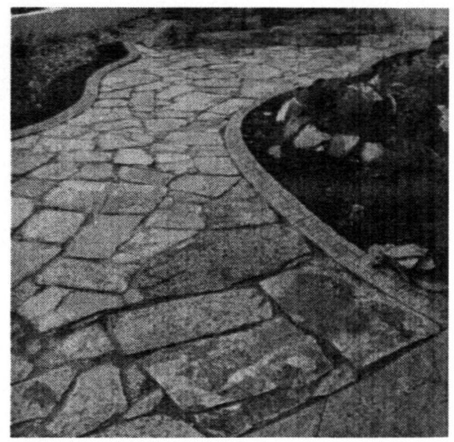


Figure 27. Residential path mimics explosive pattern in material and meander pattern in form.

An instance presenting multiple design options using the range of form in landscape architecture is seen in the Geraldton Mine Project in Geraldton, Ontario. This project began as a reclamation project of a derelict mining site. Fourteen tons of mine tailings were to be re-formed and planted to create an aesthetic as well as an economically motivated tourist friendly sight. Martha Schwartz Inc. developed two proposals which were then taken to vote in a public town meeting (figures 28 & 29). The proposals varied in the form used, one utilized vary curvilinear land forms while the other very angular. The design utilizing curvilinear form, Golden Scroll, was the one selected for construction (Kirkwood, 2001).

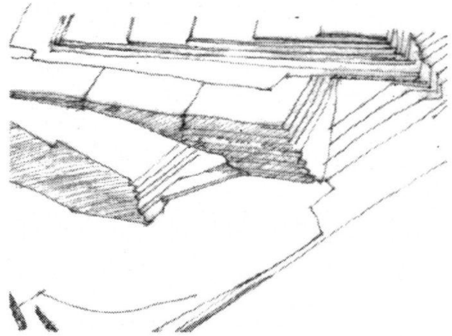


Figure 28. sketch of Golden Bar model from Martha Schwartz Inc. design.

Other authors have researched topics that either focus on form or skirt the topic. Litton (1982) examines skyline silhouettes of mountains and contrasts foothills that have sharp, granite mountains with flat-topped landforms. He looks at colour/texture and scale contrasts as well as patterns of shapes, edges and dispositions. Karjalainen and. Komulainen(1999) researched visual preference of forestry cut blocks in Finland using a variety of geometrical shapes. Most of the cut block shapes were angular and had a strong geometrical form, which have been criticized by landscape architects as being at odd with natural shapes in landscape; however, one of the tested forms was irregular in shape and had curved edges. The research found that the irregular shape was preferred over geometrical cut-block shapes.

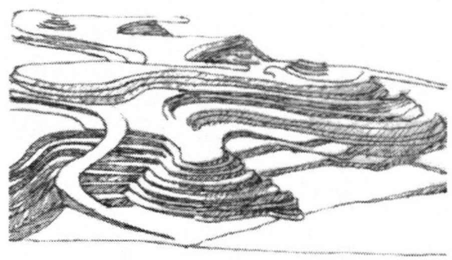


Figure 29. sketch of Golden Scroll model from Martha Schwartz Inc. design.

Many designs use natural forms as an image to either create an atmosphere or indicate a function. Examples of this can be seen in the mid-campus park at the University of British Columbia (figure 30). This park features a stormwater run-off swale that is imaged after a dry stream bed. The curving stream bed design implies the water collection and transportation function of the park. Another example can be seen in the Andy Livingstone park in Vancouver where the water features resembles a stream.

At the opposite side of the spectrum is design that uses contrasting form. One of these designs can be found in North Vancouver at the RCMP plaza. This plaza utilizes very strong geometrical forms in the square planters and the sharply angular water feature. The flowing water feature seems to be at odds with the angular form of the edges of the pond. Two images from this site were used in this study.

Figure 30. UBC mid campus park run-off swale imitates a natural stream meander pattern.

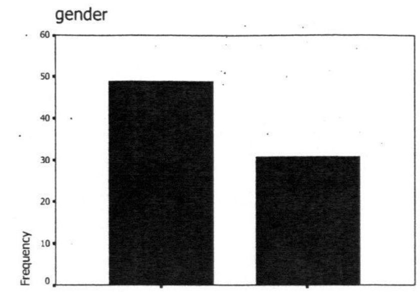
Description of present experiment

The present study was designed to examine the effect of angular and curvilinear edged forms on preference for landscape designs. By applying the idea that form may impact preference for landscape design, it is hoped that this variable can either be eliminated from the collection of possible explanations for previous preference findings or it may become clear that this aspect needs to be examined more extensively. The scenes used in this study have been limited to urban park settings focusing in particular on paths, water features and other well defined edges. The reasons for this are that it aids in the applicability of the findings to the specific park design component of this research and secondly, it helps define the applicability of the findings.

Chapter 2. Method

Participants

A flyer was posted at the centre for approximately one month prior to the data collection canvassing for volunteers to participate in the present study. During the testing phase, the researcher sat at a table in the lobby area over four days at varying times and durations. The participants were offered a can of soda for their efforts.



A total of 80 Volunteer participants were gathered from the Vancouver Aquatic Centre, a local public swimming pool. The participants include 49 men and 31 women. Nineteen of the participants fell within the 19-30 year age category, 39 were within the 31-50 age range, and 22 were 51 years of age or older. The sample included many ethnicities and cultural backgrounds. Two participants were wheelchair bound and another two used supportive walking devices. It is assumed this sample represents a cross-section of the general public likely to use urban parks and that there is no reason to suspect biases that would unduly influence the research findings.

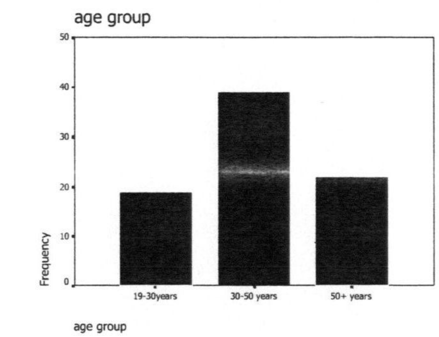


Figure 32. Age distribution of participants 19-30, 30-50, 50+

Materials

Photographic images were used to test landscape preference as they have been generally accepted as surrogates for actual landscapes and have been shown to have good reliability and validity when tested against actual on-site ratings (Daniel, 2001). Four photographs from two urban parks were manipulated into five variations, ranging in angularity to

Figure 33. Test image: Lam path 1 (most angular).

curvilinearity, resulting in twenty different images. Two different sites from different parts of the city were used to control for any possible familiarity effects that could happen if the participants were familiar with the test sites. Familiarity effects may cause judgements to be less dependant on immediate information and be influenced by the participant's memory instead (Kaplan, 1982). Familiarity also gives rise to cognitive maps which may interfere with preference judgements based on cognitive map instead of what is seen in the pictures. The photographs contained water features, paths and planter edges and were chosen because the landscape objects or features had strong geometrical forms that could be manipulated to have a range of angled and curved edges. The images used depict scenes with similar season to the seasonal features during the testing (Brown and Daniel, 1987 as cited in Scott, 1997).

Figure 34. Test image: Lam path 2

The four sets of images were manipulated using Adobe Photoshop each to gradually change a central design form from curvilinear to angular forms in five roughly equal steps (see figures 33-54 (except 47). The design features in the images were then assessed for number of elements or edges that change in direction. The number of elements within each set of images were kept constant throughout the manipulations with the exception of the path image set. The images were then imported into AutoCAD and polygons traced on top of the manipulated feature (see figure 47). The perimeter and area of each feature were measured to ensure a fairly constant perimeter to area ratio within each set of images. It was decided that a reasonable variability of perimeter area ratio within each set

Figure 35. Test image: Lam path 3

Figure 36. Test image: Lam path 5 (most curved).

was within one percent and thus the images were adjusted until they met this criteria. Three of the sets were below the 1% area/perimeter ratio while one image set fell just above the allowable one percent range at 1.02% (Appendix A: table 2.)


Figure 37. Test image Lam planter 1

Questionnaire design.

The questionnaire was printed in black ink on white bond paper. The participant was asked to circle gender, age group (19-30 years, 30-50 years, or 50 and above), if they live in British Columbia, for how long and where else they had lived. The later questions were asked so that information regarding the participants experience with varied geography (e.g. angular mountains versus rolling mountains and hill or flat prairie land) could be compared with results. This information was often incomplete and thus was not used in any data comparisons. The next section of the questionnaire had image codes followed by a short line where the participant or researcher could place a mark in the column locating the preferred image. No names were attached to the images as it has been shown that preconceived notions are often attached to 'labels/names' which affect perceived beauty (Andersen, 1981). The questionnaire can be seen in Appendix A.

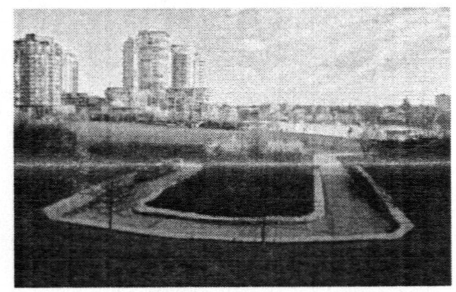


Figure 38. Test image Lam planter 2

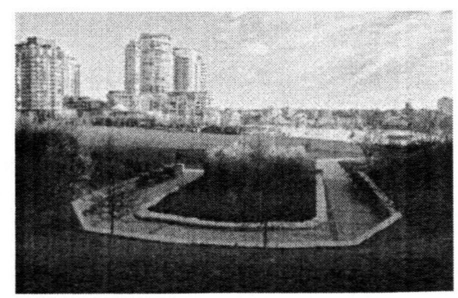


Figure 39. Test image Lam planter 3

Procedure

A balanced paired comparison method (Garner, 1989) was used to determine rank order of preference for the test images. To create the paired comparison task, a PowerPoint slide show was made to include all forty comparisons. On each of the forty slides two images were placed side by side with the question "Which landscape scene do you prefer?" at the bottom of the slide. The slides were shuffled in a semi-random style so that there was no apparent order, then further shuffled so that there were no consecutive comparisons from any one set of images. Three more pseudo-random shuffles were made to reduce any possible order effect yielding a total of four possible orders for each of the two groups. The PowerPoint slide transition was set to change slides every seven seconds without effects.

Figure 40. Test image Lam planter 4

The twenty original images were duplicated and edited into a second group of slides and called the no-context group. These images were edited to delete the part of the image just above the horizon line in order to reduce contextual data that may influence the preference of the image. The same four orders used for the contextual slides were used for the non-contextual slide show. It was decided that an additional sample would be run using the non-contextual images after the data from the contextual images were collected.

Figure 41. Test image Lam planter 5.

The contextual group data was run first. The researcher set up a laptop on a table in the lobby of the Vancouver Aquatic Centre and began to collect data at various times covering a time period from eight in the morning to nine at night over the course of four days.
Participants were asked if they would like to participate in the experiment when they approached the table. If a participant expressed interest in participating, s/he was asked to have a seat and was given instructions. The instructions were preceded with an explanation of what was expected of them, namely, that they would be requested to view

Figure 42. Test image RCMP Plaza waterfall 1.

forty pairs of images and choose the preferred landscape image between the two. The instructions directed the participants to judge the images on the basis of the scene rather than on the basis of the experience of the scene in an attempt to keep the judgements of images constant. This was done because it has been shown that people conceptualize the content of images differently than they evaluate "place" experientially given the same images (Scott, 1997). This idea was followed by Purcell (1998) when the directions given in a study explicitly stated that the judgements were to be made from the participant's experience of the outdoors and not confined within the range of the scenes shown in the landscape. These type of instructions emphasize the landscape tested as a type and not 'the' particular scene shown. It was felt that in order to assess the subtle changes within the image the participant should be instructed to attend to the landscape scene in particular.

The instructions read to the participants were:

"Please watch the computer and look at the two images on the screen. Each slide will be presented for 7 seconds only, there are 40 slides in total. Without thinking, choose which landscape scene you prefer- the one on the left or the one on the right. You can either record your preferences yourself on the questionnaire provided, by placing a mark in the column that corresponds to the image or you can verbalize which landscape scene you prefer and I will record it. There is no 'correct' answer.

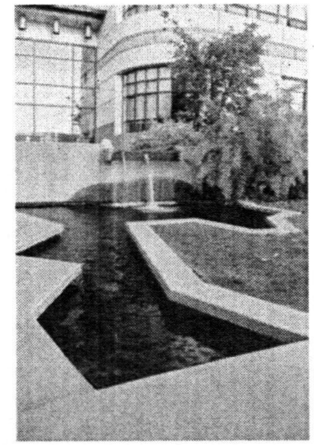


Figure 43. Test image RCMP Plaza waterfall 2 (close to as is).

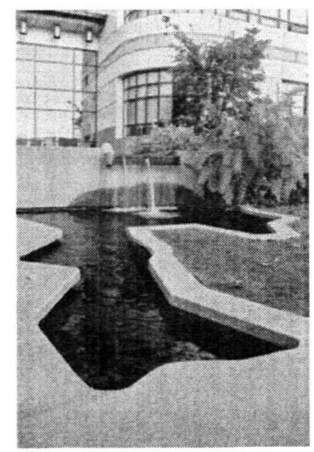


Figure 44. Test image RCMP Plaza waterfall 3.

Some of the scenes will look very similar to one another or you may not particularly like either scene, but please just do your best and choose which scene you prefer over the other. If you have any further questions please ask me.

You will first view a demonstration so that you can practice.

Thank you. You may also ask questions after you have completed the task."

The images were viewed on a laptop computer with a 35.56 cm LCD display using 1024 x 768 pixels. The participants viewed the screen from a distance of approximately 30-75cm. After reading the instructions to the participants, a timed demonstration (using the same seven second timing) was given using paired shapes that had been subtly altered. At this point, the researcher asked if there were any further questions before beginning the preference study and asked if they were going to fill out the questionnaire on their own or if they required assistance. Approximately half of the participants chose to record their own preferences. Participants were assigned to various slide presentation orders within one group (context or no-context) consecutively until there were 10 participants in each order. Upon collecting data from 40 participants for the contextual images, the procedure was repeated for the non-contextual group of images. The result of each presentation was a matrix that assigned a score of 1 to each "win" or preferred image and a 0 to each "loss" or non-preferred image from each comparison. An image could score between 0 and 4 per participant and a range of 0 to 160 per group. The number of wins per image within each set of images were tallied in order to assign rank order to the images to gage order of preference.

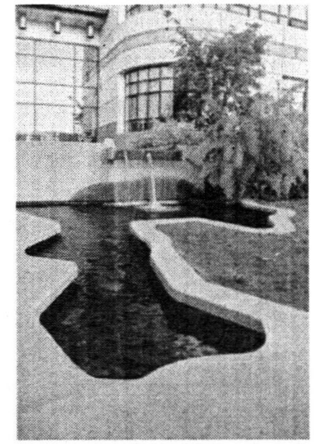


Figure 45. Test image RCMP Plaza waterfall 4.

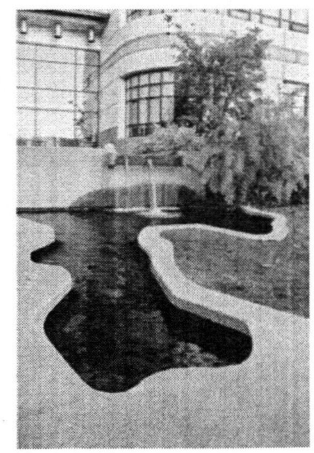


Figure 46. Test image RCMP Plaza waterfall 5.

Chapter 3. Results

The data from the paired comparisons reflect a tournament matrix in that ranking is a result of the outcome of games between every player determined by summing the number of wins per image comparison (Garner, 2000). Each image was compared against all other images within the set. This amounted to 10 comparisons within each set of images to total 40 paired comparisons in all. An overall trend can be seen between the number of wins and angularity. Images that are more curved had a larger number of wins than the more angular image. In most image sets, the context and no context groups did not differ greatly; the exception to this finding appeared in one of the water sets (rwa1-5).

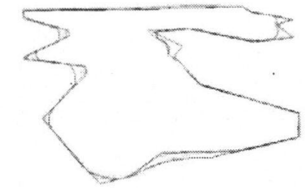


Figure 47. CAD perimeter area comparison of RCMP Plaza waterfall image set.

Images from each group were correlated with angularity as well as with each other between groups. Kendall's tau b was used as it is a nonparametric statistic due to the non-random image use as well as it being a conservative measure that is sensitive to ties in ranked data. Kendall's tau b uses the ordinal properties of data and gives a value between + 1 and –1. Tau is based on the idea of pairwise agreements and disagreements in ordering. In a perfect correlation using Kendall's tau b, one would not expect to see any inversions of rank (Howell, 1992). A way of graphically illustrating tau b and the easiest way to calculate this statistic (Howell 1992) is to graph the two variables and then count the number of intersections of lines where:

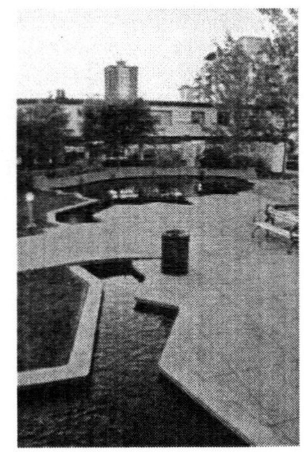


Figure 48. Test image RCMP water 1.

$$\tau = 1 - \frac{2(\text{number of inversions})}{\text{Number of pairs of objects}}$$

The correlation results were computed using a one-tailed test of significance and Kendall's tau b. Although table 1 shows the data as having significant relationships, the results will not be discussed in these terms as standard error has not been identified.

The path image set (figures 33-36) appears to have the greatest variance within number of wins across the variations in angularity. The numbers of wins in the contextual group range from 24 wins for the most angular image and 142 wins for the most curved image (a spread of 118). For the same image set in the non-contextual group, the image with the least number of wins (27) was the second most angular image and 136 wins for the most curved image (a spread of 109). The only preference by angularity reversal was in the non-contextual group between the most angular image (53 wins) and the second most angular image (27 wins); the rest of the path images followed a linear relationship with the number of wins increasing with the curvilinearity.

The correlation between curvilinearity and number of wins in the contextual image set is $\tau=1$, while the correlation between curvilinearity and number of wins in the non-contextual group is $\tau=.80$. The correlation between the contextual and non-contextual groups within the image set is $\tau=.80$. These statistics indicate a very strong positive relationship between curvilinear form and preference.

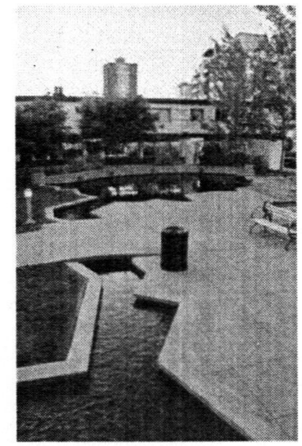


Figure 49. Test image RCMP water 2.

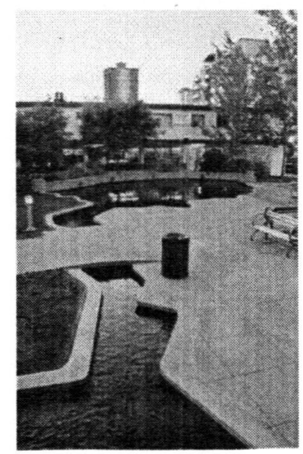


Figure 50. Test image RCMP water 3.

The planter image set (figures 37-41) has the second most variability within number of wins between angularity in the contextual group and the least variability within the non-contextual group. The contextual image with the least number (44) of wins was the most angular while the one with the most (128) was the most curvilinear image. The non-contextual image set was consistent with the contextual set in that the planter showing the least number of wins (49) was also the most angular and the most curvilinear image obtained the highest number of wins (108). Both groups show a reversal preference between the second and third image (figures 38 & 39) where the second image, which was more angular, was more preferred having 11 and 10 (contextual and non-contextual respectively) more wins than the third image.

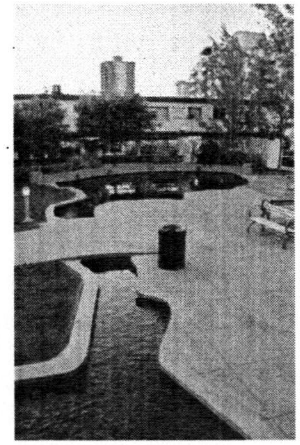


Figure 51. Test image RCMP water 4.

Both the contextual and non-contextual planter image set have a τ=.8 correlation between curvilinearity and preference. The correlation between the contextual and non-contextual planter image groups is τ=1. These statistics indicate a strong relationship between preference and curvilinear form in addition to the very strong relationship between the contextual and non-contextual groups.

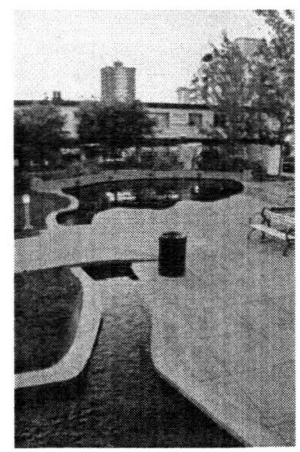


Figure 52. Test image RCMP water 5.

The waterfall image set (figures 42-46) has a linear relationship between curvilinearity and preference in the contextual group. In the contextual group the most angular image tallied 44 wins while the most curvilinear image received 108. In the non-contextual group the most angular image obtained 47 wins while the most curvilinear image received 104. In the non-contextual group image 4 received 4 more wins than did image 5 indicating a slight reversal in preference of form from the other images.

The correlation relationship between number of wins and curvilinearity in the contextual waterfall image set is $\tau=1$, while the correlation between number of wins and curvilinearity in the non-contextual image set is $\tau=.8$. The correlation between the contextual and non-contextual waterfall groups is $\tau=.8$. These statistics indicate a very strong relationship between preference and curvilinear form with little variance between the contextual and non-contextual groups data.

The only image set that did not show a strong relationship between curvilinearity and number of wins was the water image set (figures 48-52) in the contextual group. The ranking of images within the non-contextual group shows similar results to the other image sets where the angular images did not receive as many wins as did the more curved images. The water image with the most wins in the contextual set was the third image (figure 50) with 100 wins. The most angular image (figure 48) in the same image set and group had 50 wins which was the least number of wins within this contextual image set. In the non-contextual group within this image set, the most preferred image was the fourth image (figure 51) with 109 wins and the least preferred image was the most angular (40 wins). Possible explanation for this result are discussed later. It is interesting that this image set had the least between image wins variability among all sets meaning that image set did not always score a wide spread in the number of wins per comparison.

The correlation between the number of wins and curvilinearity in the contextual water image set is τ=.4 while the correlation between the number of wins and curvilinearity in the non-contextual image set is τ=.8. These statistics indicate a substantial difference between the way the contextual image set was being judged from the non-contextual water image set. The two image sets correlated at τ=.6 to one another. This image set consistently obtained the lowest correlations within all image sets.

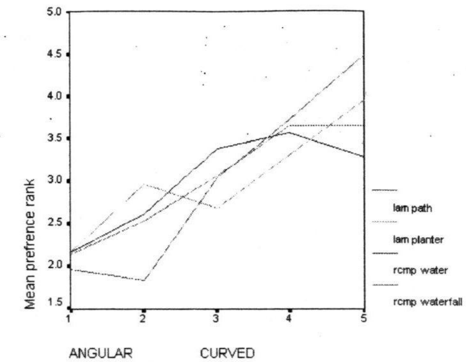


Figure 53. Graph showing each image by number of wins, contextual and non-contextual groups collapsed together. Image get progressively less angular and more curved as they move to the right of the graph.

Correlations

			curvilinearity	context path	no context path	context planter	no context planter	context water	no context water	context waterfal	no context watfal
Kendall's tau_b	curvilinearity	Correlation Coefficient	1.000	1.000**	.800*	.800*	.800*	.400	.800*	1.000**	.800*
		Sig. (1-tailed)	.	.	.025	.025	.025	.164	.025	.	.025
		N	5	5	5	5	5	5	5	5	5
	context path	Correlation Coefficient	1.000**	1.000	.800*	.800*	.800*	.400	.800*	1.000**	.800*
		Sig. (1-tailed)	.	.	.025	.025	.025	.164	.025	.	.025
		N	5	5	5	5	5	5	5	5	5
	no context path	Correlation Coefficient	.800*	.800*	1.000	.600	.600	.200	.600	.800*	.600
		Sig. (1-tailed)	.025	.025	.	.071	.071	.312	.071	.025	.071
		N	5	5	5	5	5	5	5	5	5
	context planter	Correlation Coefficient	.800*	.800*	.600	1.000	1.000**	.200	.600	.800*	.600
		Sig. (1-tailed)	.025	.025	.071	.	.	.312	.071	.025	.071
		N	5	5	5	5	5	5	5	5	5
	no context planter	Correlation Coefficient	.800*	.800*	.600	1.000**	1.000	.200	.600	.800*	.600
		Sig. (1-tailed)	.025	.025	.071	.	.	.312	.071	.025	.071
		N	5	5	5	5	5	5	5	5	5
	context water	Correlation Coefficient	.400	.400	.200	.200	.200	1.000	.600	.400	.600
		Sig. (1-tailed)	.164	.164	.312	.312	.312	.	.071	.164	.071
		N	5	5	5	5	5	5	5	5	5
	no context water	Correlation Coefficient	.800*	.800*	.600	.600	.600	.600	1.000	.800*	1.000**
		Sig. (1-tailed)	.025	.025	.071	.071	.071	.071	.	.025	.
		N	5	5	5	5	5	5	5	5	5
	context waterfal	Correlation Coefficient	1.000**	1.000**	.800*	.800*	.800*	.400	.800*	1.000	.800*
		Sig. (1-tailed)	.	.	.025	.025	.025	.164	.025	.	.025
		N	5	5	5	5	5	5	5	5	5
	no context watfal	Correlation Coefficient	.800*	.800*	.600	.600	.600	.600	1.000**	.800*	1.000
		Sig. (1-tailed)	.025	.025	.071	.071	.071	.071	.	.025	.
		N	5	5	5	5	5	5	5	5	5

**. Correlation is significant at the .01 level (1-tailed).

*. Correlation is significant at the .05 level (1-tailed).

Table 1. Kendall's tau b correlation between number of wins per image set and curvilinearity, and image set to image set

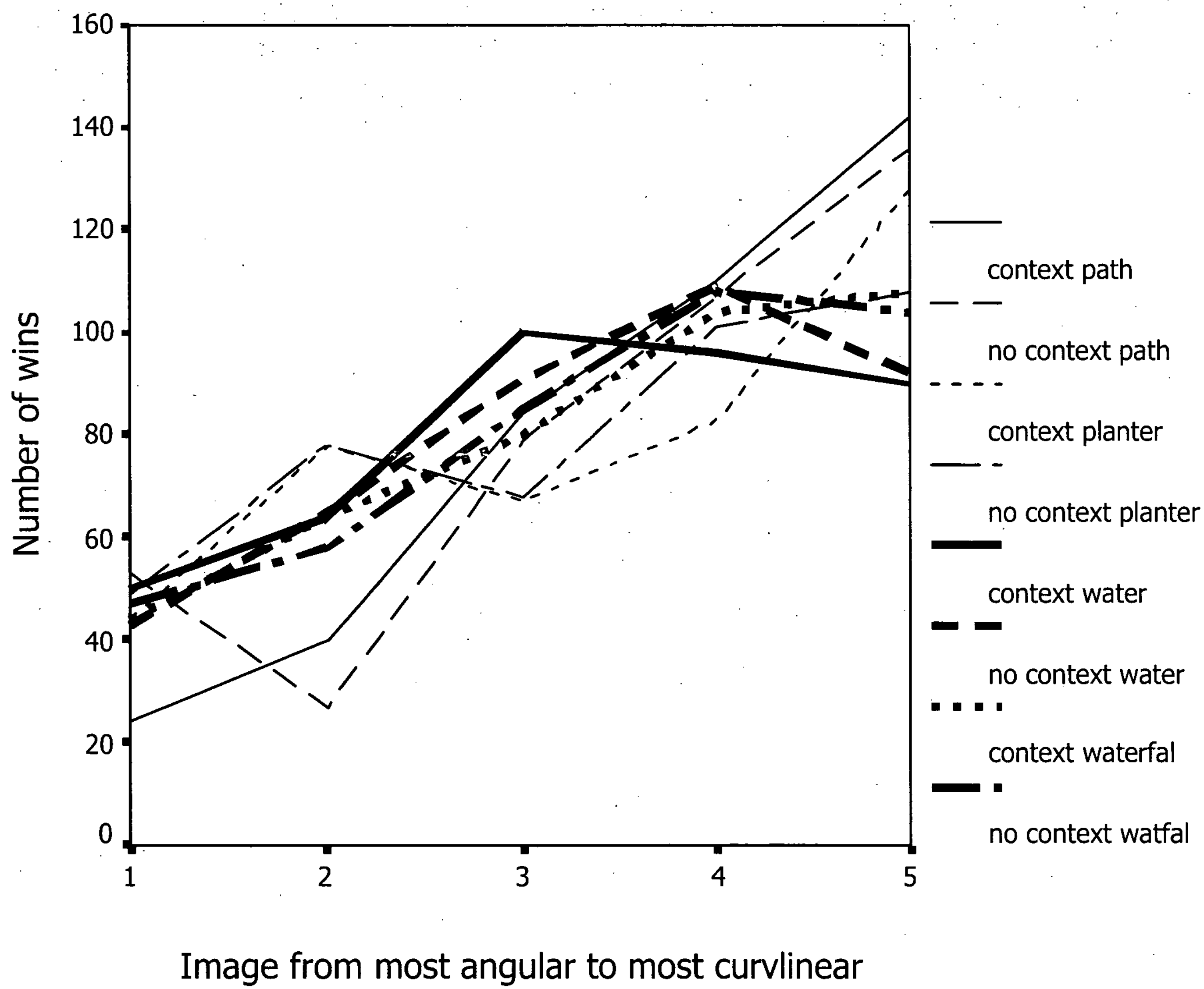


Figure 54. Graph showing each image per group by number of wins.

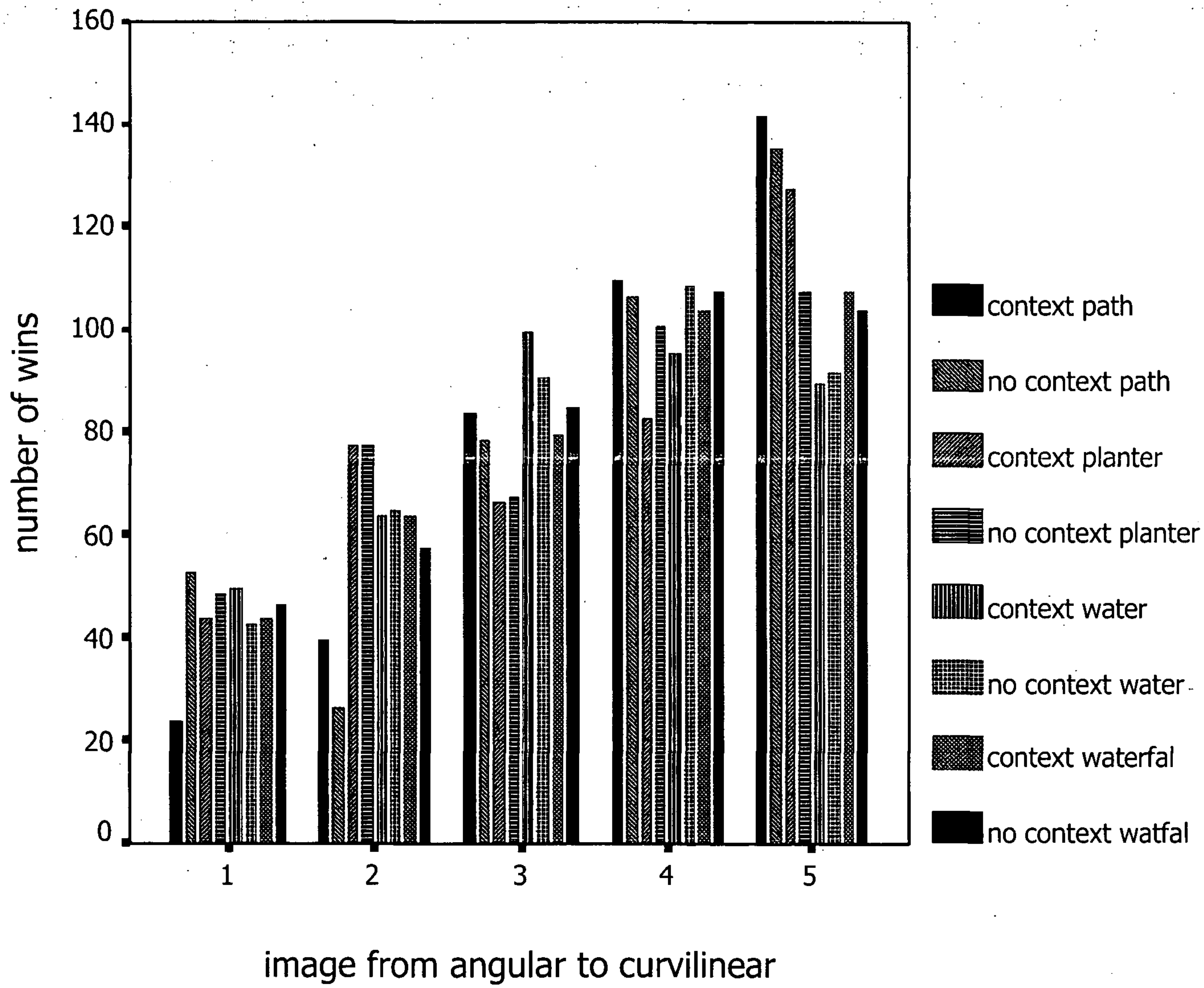


Figure 55. Bar graph showing each image per group by number of wins.
1 is the most angular and 5 is the most curvilinear.

Chapter 4. Discussion

The general upward trend across all images would confirm the original hypothesis that people prefer curved forms over that of angular forms when in the context of urban park objects.

The large variance associated with angularity found in the path data would suggest that this image set was more clearly ranked from least preferred to most preferred across many participants. The s-curved path clearly had the most number of wins over the other path forms. Additionally, the s-curved path had the most wins of any of the image sets. It was also observed that during testing, decisions involving comparisons with the s-curved path were made more quickly that other comparisons which may indicate the depth of the preference for this form.

It is interesting that this is the form used by the Kaplan's Information Processing Theory to illustrate the construct "mystery". In this experiment, because of the use of one constant path that has been manipulated only in form, it is possible to say that movement along the s-curve path offers no more possible information than do the other more angular paths. This could lead one to the conclusion that preference for an s-curved path is not due to the mysterious nature of the path but to the curved form itself. At the very least, this finding should encourage further research to delineate the key factors influencing previous findings attributed to mystery.

It was noted that the participants confined to wheelchairs also preferred the s-curve path even though it could be a more difficult path to traverse. It is not clear whether this indicates a high preference for the path or if it illustrates Scott and Cantor's (1997) finding that due to the instructions given, the landscape scene was being evaluated differently than it would have been had the participant been evaluating the scene on the basis of imagined experience of that landscape.

When context was removed from the image, the most angular path is preferred over the next angular (image lpa1 over image lpa2). This may be due to the image containing more elements than the less angled straight path. The elements or changes in direction, may create more interest than the straight path lines or edges in landscape features. It is also noted that both the s-curved and the s-angled paths contain forms that are friendly to the path that eye movement often takes. It has been noted that natural pictorial eye movement (this applies to western cultures) reads a picture from left to right and tends to be pulled downward with gravity (Arnheim, 1974). The s-curved path allows a viewer to view horizontally while shifting downwards in the image and thus may feel more comfortable to view. Comfort, in this case, may be interpreted as preference. The contextual group was fairly highly correlated with the non-contextual group indicating that the form of the path was being consistently evaluated regardless of the surrounding contextual information.

The most preferred shape of the planter image set was the curved horseshoe shape. This is consistent with the general trend that the most curved form was also the most preferred form. The second most angular planter (figure 38) image was more preferred than the third image (figure 39) in both groups and the fourth in the contextual set. This could be due to the 45-degree angles seen in the planter in figure 38. The diagonal line has been singled out by picture theory as being a strong and energetic line (Arnheim, 1982). This energetic angle may attract more interest than other angles and could account for the preference reversal seen in this experiment.

The contextual image set correlates completely with the non-contextual image set (r=1) indicating that the two image sets were evaluated in the same way and that the contextual background information did not alter the way in which participants evaluated the form of the planter. When compared to other image sets, the planter shows a high correlation to the contextual path (r=.8) and the contextual waterfall (r=.8) . This suggests that these image sets were being evaluated in a similar manner and the contextual information in the photograph did not change the way the object was assessed.

The contextual waterfall images are linear in progression showing no image reversals. A reversal in preference can be seen in the non-contextual waterfall image with the fourth and fifth image. However, the reversal was very slight (image 4 received 108 wins while image 5 received 104 wins) and so it did not have a large impact on the outcome thus the correlation of r=.8 between the groups. It can be concluded that contextual information did not change the way in which the image was being evaluated. In both groups, the fifth image was reversed from the expected order. The contextual group ordered the third image (figure 44) as the most preferred, the fourth image (figure 45) as the second most preferred and the fifth image (figure 46) in third place. This pattern is very similar to the non-contextual set where the third and fifth image almost tied at 91 and 92 wins respectively while the fourth image obtained the most preferred ranking with 109 wins.

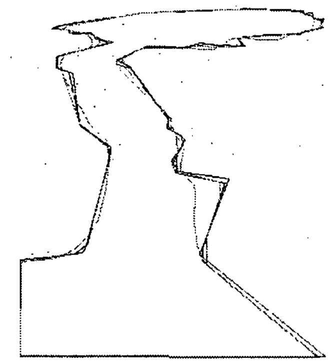


Figure 56. CAD lines showing perimeter area comparison of RCMP water image set. Error that may have influenced results can be seen in large form variance between light grey line and darker lines on the lower left hand side.

It is postulated that the unexpected results may be due to error in the Photoshop manipulation of the fifth image in that the first curve on the right hand side of the image was changed too drastically and thus destroyed the flow or continuum in the range of angled to curved edges. It was noted that some of the participants commented that the 'arm' and 'neck' of the water feature were too skinny. This response may also reflect the concept of the form-function relationship where form should follow the basic function of the landscape (Marsh, 1998). To further this, the data can be explained by the possible desire to see a water feature that emulates a stream have the natural flowing form of a meander and not angular jagged or straight edges. The image could exemplify a form which is incompatible with the implied meander function because of it being too skinny and too straight, which in effect may cause an intuitive discomfort with the image.

The only image set which did not correlate highly with angularity was the contextual water image set. This group of images show the narrowest range or spread of wins and losses between images indicating that it was not being ranked consistently.

It is suggested that due to a general dislike of the image, ranking may have been a difficult task to perform. This is somewhat supported by the anecdotal evidence concerning the length of time taken to choose one image over the other during test phase. Frequently, the slide would time-out and advance to the next comparison before the participant had made a selection which may have caused him/her to randomly choose one image over the other. Interestingly, when the contextual information is removed from the image, the relationship to angularity is vastly improved. This suggests that the contextual information alters the way that these images were evaluated even though no significant main effect of context was supported by the data. The removal of context may have prohibited the integration of form from its 'total context' and thus have caused the form to be evaluated differently (Sadler, 1982). It is unclear whether this is due to distracting features in the contextual background, such as the single high-rise mid-frame or the red coloured tree to the side or if it is suggestive of the contextual information providing the impression of mis-fitness between the design and the surroundings.

At the end of the questionnaire the participants were asked if they could identify the park where the images were taken. Only a couple of the participants in the contextual group

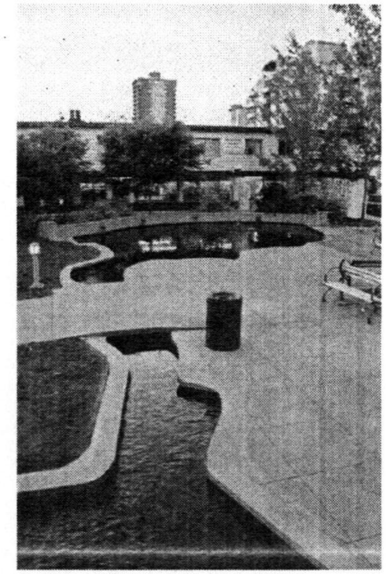


Figure 57. RCMP water 4 with context- single building in middle or red tree at side may have been distracting.

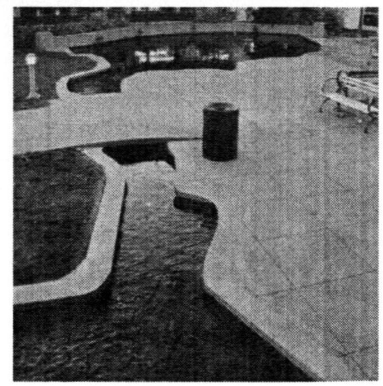


Figure 58. RCMP 4 without context. Indicates contextual information alters preference relationship.

could indicate the general park area. It was decided that the contextual information was the distinguishing factor and not the identifiability of the landscape objects themselves. Although preconceived ideas may affect judgment of beauty (Andersen, 1981), when preparing an experiment of this nature it is easy to fall into the assumption of the 'stimuli environment' as though it were in a vacuum rather than being affected by past experience. Due to the poor response in the identification of test sites, it can be concluded that familiarity did not play a major role in the results of this study.

Another factor which may be worthy of further research is the effect of frequency. Preference of form may vary within angular forms or curved form depending on the frequency of curves or angles, thus showing that the elements of form may be broken down even further than was done in this paper. An s-curved path may only be preferred while the frequency of the curves is within certain boundaries. The low frequency curved path may not be curved enough to be preferred while the high frequency path may be too curved to feel comfortable or functional.

Other interesting responses included a verbalized preference for "order" and "interesting geometry that makes sense". Upon investigation, it was further clarified that a predictable pattern was desired. A further valuable observation concerns the apparent excitement the participants exhibited when they at first thought that the study pertained to the development taking place across the street from the test site. Many participants expressed the desire to convey their opinions and to have an influence on local development. This may indicate a dissatisfaction with current designs and may further suggest the failing of the expert paradigm of landscape design.

Perhaps one trained individual cannot represent the needs of the general population, which implies the need for increased public consultation regarding designs for their communities. However, with this said, a caveat must also be expressed, namely that public consultation must be divorced from market research surveys such as the one by Vitaly Komar and Alex Melamid 'Most Wanted and Least Wanted Paintings' (Ross, 1995). The artists attempted to apply aesthetic preference and a survey regarding taste in paintings to find out what true people's art would look like. A survey was conducted where people responded to questions that asked about preferred content and styles of paintings. The project questions the democratic consumer idea that attempts to please the greatest number of people; however the amalgamation of all preferences may not result in anything (painting or design) that represents of any one person's preferences. Additionally, designs created this was would most likely not be suitable for the site. With this in mind it must be stressed that 'form making' without due attention to the context such as can be seen in some postmodernist land-art is a risky exploit even if one is using public preference input. Ultimately, urban landscape design should attend to locally distinctive (or critical regional) features and limit the use of arbitrary form making. However, the design may arrive at a point where the contextual surroundings, regional or site specific, do not inform the actual shape of an

What does " normal" mean anyway? Except the average of all abnormal.

object. It is in this case that the designer may attend to findings from studies such as this one to decide upon the form of a path, planter or water feature.

However, the methodology of the current study is not without limitations. Ittelson (1973) points out a difference between *objects* and *environment* by listing vital characteristics that an environment possesses that an object does not (peripheral stimulation, the presence of too much information and the multi-modal property). He states that an object is the result from laboratory experiments where the item of study is separated from its context and as a consequence, the findings of studies such as these may not be extended beyond objects. This notion supports the holistic paradigm in that isolated elements may change simply due to the isolation. This may be part of the difference seen between the water contextual and non-contextual image sets.

Object vs environment

There is a discrepancy between static and serial vision that may affect the validity of laboratory landscape aesthetic research. Static images may not portray life experience of constant changing views as one moves through landscape where angled edges themselves may even change in appearance as one moves through the landscape. Cullen (1961 in Porteous, 1982) posits the idea of serial vision which concerns urban aesthetics and the sequence of views gained by turning corners, changing views as one enters one area and leaves another. Assessing landscape aesthetics while incorporating serial views is difficult to test in the lab situation unless using an interactive simulation. A possible future research

Static vision vs. serial vision

project may include looking at the effect of serial vision on landscape preference of curvilinear and angular form.

The current study only brushes the surface of elements that combine to form aesthetically pleasing environments. There are so many possible elements and combinations of elements that some authors believe that the task of finding consensus about what is beautiful should be abandoned and that it may be an easier task to identify what people consider ugly (Kates, 1962 as cited in Eaton, 1989). It may be interesting to continue along this line and 'select out' rather than 'select in' characteristics and objects that are preferred. To study this, one may select urban scenes and ask participants to apply a Q-sort technique to various components of the scene. After the initial Q-sort is done, the scenes may be manipulated to only include the objects that were not labelled with negative terms and then ask a second group to do a labelled rating task on the scenes. It would also be interesting to further examine the implications of scale on form preference by testing the preference of a meandering roads or curvilinear forestry cut blocks over that of the typical square cleared areas.

Selecting out instead of selecting in

The second focus of this study was further investigation into the explanations offered by the Kaplans to explain the data they collected in their preference studies. To follow this line of inquiry, a number of further investigations could be done. One such investigation could take one of the methodologies used by Guthrie and Wiener (1966) where the original images used in the Kaplan experiments could be categorized by participants applying adjectives, such as angular or curvilinear, to the images. This may either refute or further support the claims made in this paper, namely that the preference may be due to form rather than the complicated constructs that were posited. Style and trends are also relevant to this line of enquiry. Some research may indicate that as trends change back and forth so does preference, where people indicate a preference for the exotic or 'different'. Eskimo subjects were found to have a preference for exotic landscape scenes or merely landscapes that were different from familiar landscapes (Sonnenfeld 1967). However, if it were only novelty that were influencing preference, one would expect to find higher preference for forms that do not fit their function, which was not the case in this paper.

A layering of methodologies may lead to a richer theory.

Another suggestion for further investigation may include using varied methodologies to study the same phenomenon. This process may support the ideas expressed by Taylor et al. (1987) in that a more eclectic and perhaps richer theory could result by coalescing the strengths of various paradigms. For example, one could phenomenologically examine the relationship between experiential sensory data and urban aesthetics, and based upon the conclusions, develop a quantitative study to support or refute the findings. By combining holistic and Cartesian models of research, a more significant and utilitarian theory may be developed. The work of Christopher Alexander (1977) exemplifies this idea in his development of the concept of pattern language. In his work, Alexander states that although patterns have been formed and tested quantitatively, they can not be used as isolated entities; he states that the patterns for town and building development only exist while they are supported by surrounding and embedded patterns.

Our current narrow view of evaluating landscape scene by means of visual preference has been questioned. Steinitz (2001) compared the typical findings of naturalized, distant views, the presence of water and mystery with scenes that he finds 'memorable', with the conclusion that they are dissimilar. The images he finds memorable are a collection of photographs and paintings that are judged as such for a number of reasons, not all of which are aesthetic. He points out that some of the most memorable scenes are ugly. Why do we study only visual aesthetics when there are so many facets involved in making a place preferred or memorable? It could be that designers are preparing the canvas for the art of experience and memory and thus aiding in place making.

Perhaps a more aesthetically pleasing scene will attract more inhabitants to thus manifest the burgeoning place. There is a need for more research that is applicable to urban design aesthetics and can aid the designer in his/her attempts to create well-liked spaces. Not only is there a need for applicable urban landscape design research, there is a need for research driven design. Design can be used as a tool to practically assess the relevance and worth of information generated from quantitative research and then in turn the design can guide new research questions.

Chapter 5. Applying the research to design

One challenge of quantitative research in landscape design is the difficulty of generating a relevant hypothesis, one that is both pertinent and applicable to the field of landscape architecture. The latent question investigated throughout this thesis can be stated as: "Is it possible to generate significant and usable theory for landscape architecture through quantitative research methods?" This research, by itself, is not enough to determine a sound answer. In order to answer the question, a number of research questions should be generated and answered in conjunction with practical design work. This research needs to be set within a larger series of studies to increase the reliability to determine the applicability of quantitative research in design.

The ideas posited in this paper are the result of an attempt to examine the conjectures of an existing theory as well as the effort to develop a practical design guideline. It is intended that the findings be applicable to urban park or plaza design problems. However, with this said, it must be clarified that the author does not condone the application of such guidelines without due attention to programming and contextual information. Instead the information derived from this study should be used in combination with information that typically informs a landscape design. To illustrate how this information could be used, a small area of a local urban park will be redesigned. The design interventions will focus on edges of paths and objects that are pertinent to the research in this paper.

Kitsilano park, Vancouver British Columbia.

Kitsilano park is located between Trafalgar Street and Maple Street north of Cornwall Avenue. It is approximately 12.6 hectares. The park is dog-leg in shape and lies along the English Bay of the Pacific Ocean. The park is a highly popular destination for not only the immediate neighbourhood but the district as well. One of the main attractions of Kitsilano Park is a large outdoor pool (137.5 m long) that is filled with heated, filtered salt water. The Kitsilano Showboat is a stage for amateur performances that adjoins the pool. The park also has a sea wall that connects to and beyond Granville island, a long sandy beach, large unprogrammed fields, tennis courts, basketball courts, beach volleyball, a children's playground, two concession stands and two grove-like sections and nearby cafes and restaurants. There are two lost streams that feed into the park.

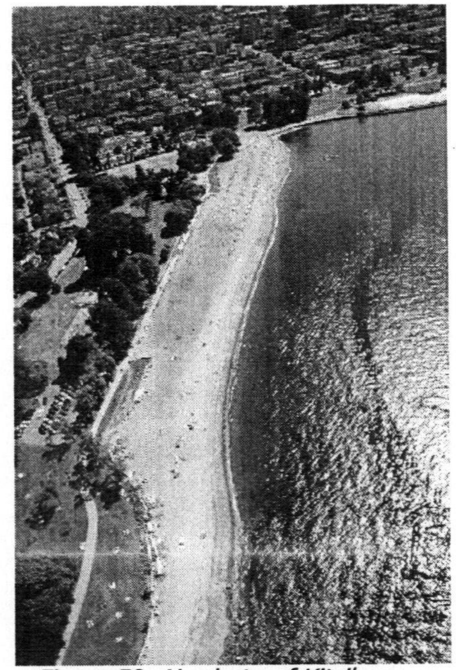


Figure 59. Air photo of Kitsilano Beach Park. Photographer: Cliff Lemire.

Kitsilano Park was chosen for the design because it is an urban park that is flexible enough to handle either a design fastened on the angular grid of the surrounding streets or the flowing curved shoreline. In addition to it's flexibility, the park does not currently incorporate strong geometric shapes in the design. Kitsilano Park is easily accessible for site visits during the design phase. The author has worked at Kitsilano Pool during summer months and used the park year-around and as a result is familiar with park usage issues and concerns. The design issues in Kitsilano Park range from problems of weak programming, weak or non-existent form, user conflict, improper scale and physical problems.

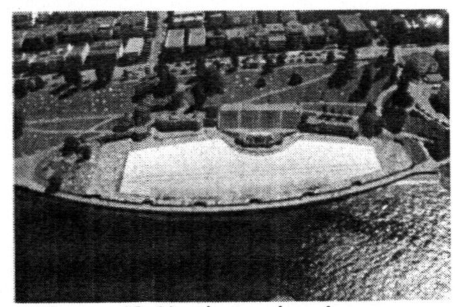


Figure 60 Air photo showing Kitsilano Outdoor Pool. Photographer: Cliff Lemire.

Site History

Kitsilano Park was named in 1905 after Squamish Chief of Khahtsahlanough, prior to this it was known as Greer's Beach after squatter, Sam Greer. In 1884, the Canadian Pacific Railway made a claim that they owned the land and Sam Greer was sent to jail after shooting the sheriff that had been sent to evict him (Vogel & Wyse 1993). The beach became a summer destination for tent campers and a bathhouse and playground were soon built. In 1931 the first Kitsilano pool was excavated and built. Soon afterwards, in 1935, the Kitsilano showboat was built. The pool was rebuilt in 1979.

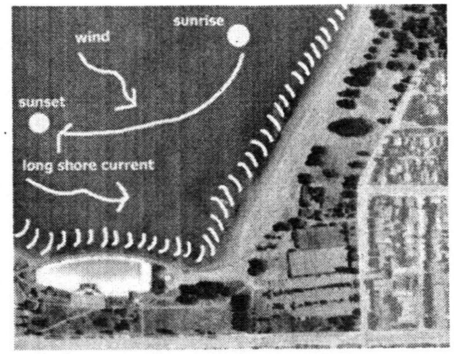


Figure 61. Natural processes

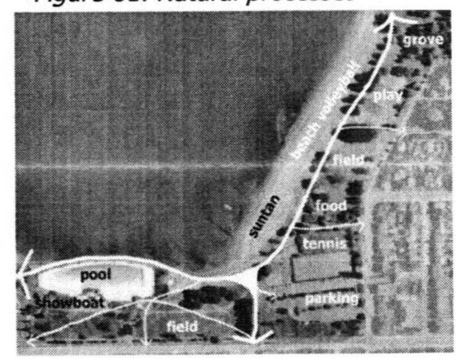


Figure 62. Site structure

Site structure

Kitsilano Park is not just a park for play it is also a prime viewing park. The park provides opportunities for external views to the mountains or the city skyline and internal viewing to the other park users. It is the park to use to either watch or be watched. The park also provides a scenic route for walkers, joggers or neighbouring commuters. As a result of the variety of user groups, activities and the circulation routes, the park has a distinct spine that divides, intersects and joins various spaces. It is the central space where the north side of the park is divided from the south side and the east half from the west half that is the *heart* of Kitsilano park and will be the central focus of the design and research application.

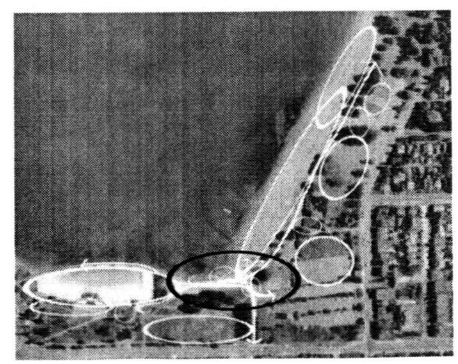


Figure 63. Site use

The current layout of Kitsilano Park is shown in figure 65. Through the process of site inventory and ground truthing, several design problems have become apparent. Some of these can be easily identified through observation such as user conflicts between bicycles and cars and pedestrians, or performances and joggers or walkers, or basketball court users and the nearby residents. Other design problems can be seen by walking around in the park. An example of this is the muddy soil beside the Yew Street entrance and the same soil that prohibits the use of the field to the north east of the bathhouse for days after rain. The form related issues are visible once the park is scrutinized in terms of why spaces are not being used at all or as much as they could be. The design issues can be broken in to categories that deal with programming, form, user conflicts and scale.

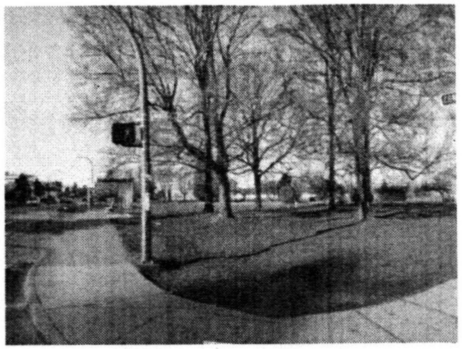


Figure 64. Photo taken from corner of Cornwall Ave. and Arbutus St. showing lack of south east entrance and weak park edge.

Solutions were developed through programming and design explorations. Once the problem was identified, a number of design responses were generated and then evaluated in terms of the success of dealing with the issue. For instance the problem of weak edges resulted from an observation of a lack of use of the eastern edge of the park along Cornwall Avenue. After identifying the area as being not used, it was possible to recognize that the space felt very exposed to traffic and uncomfortable. It is bound by street traffic on one side and a parking lot on the other. Upon this further discovery it is possible to conclude that it currently has weak edges that need to be strengthened. From this point a number of solutions that could separate the field from the traffic and parking. Four design solutions for the central heart area were that met the basic program requirements while applying the research findings were developed and then evaluated. Only one of these was explored in more detail.

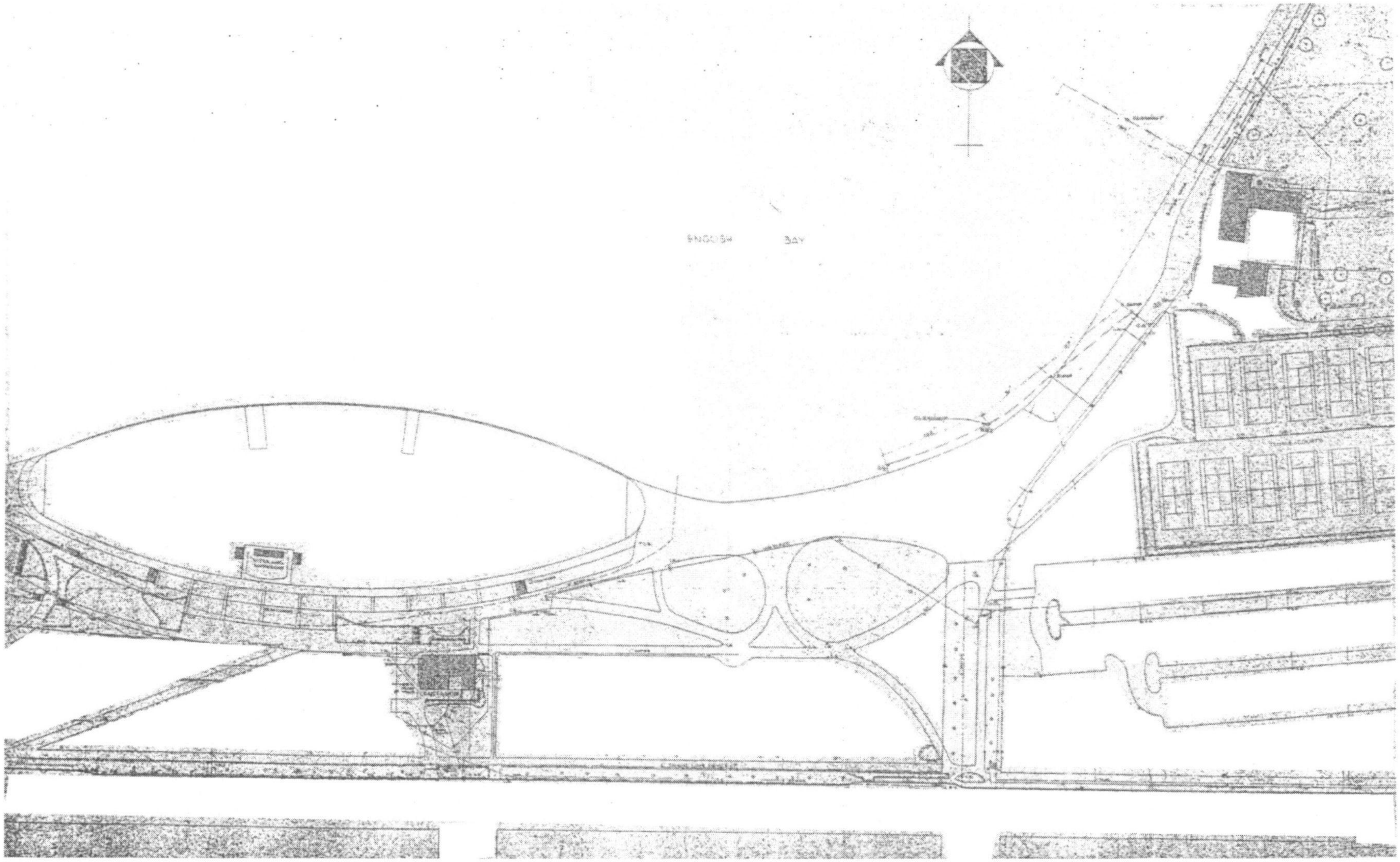


Figure 65. Blue print image of Kitsilano Park as it is today with the exception of pool renovation. Cornwall Avenue runs east west along the bottom of the image.

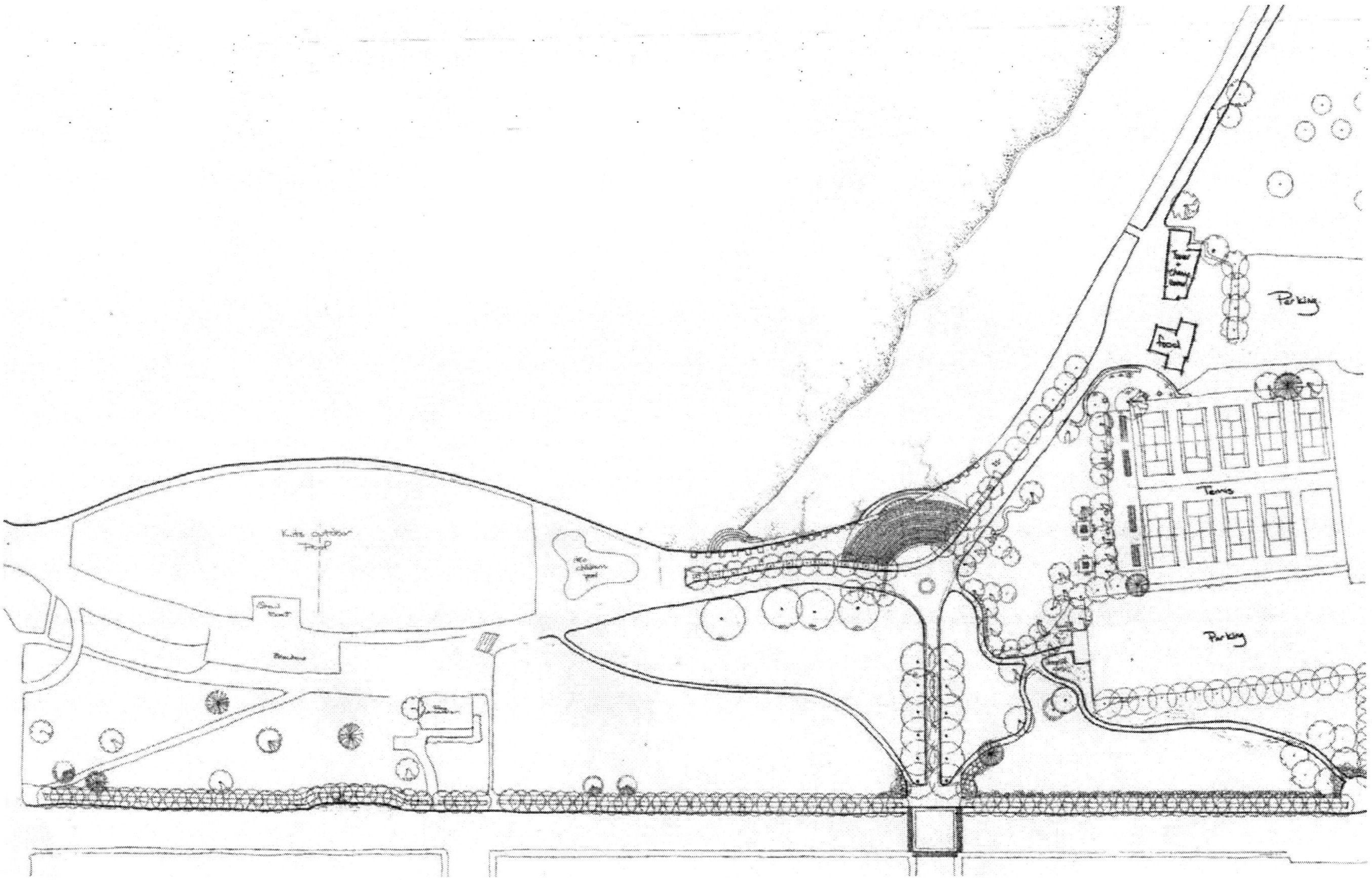


Figure 66. Design proposal for Kitsilano Park. Some of the interventions that can be seen in this image are, bike lane, Yew St. entrance, central plaza area, tennis viewing and quiet activity area, thicker park edges, parking rearranged, and new paths.

	Issue/problem	Design Intervention
Programming:		
	-parking takes up prime park area -no-mans land (behind concession and east side along Cornwall) -not enough space for adolescents -no space to view tennis -lack of quiet activity programming	-Parking redistributed -parking and drop off for proposed restaurant -youth skate park -tennis viewing opportunities -area for quiet play
Form:	-no main entrance	-Entrances at Yew and Arbutus -Gardens at entrances
	-lack of distinct gathering place	-Central gathering area -Seats to view and visit
	-weak edges	-Tree lined edges of the Park -Field along south-east edge
	-weak area for children in pool -weak playground for children	-Children's pool -Distinct children's play area
User conflicts:	-user conflict at edges between bus, cars, bicycles	-Bike path along south edge
Scale:	-path too narrow in spots	-new path system
Physical:	-mucky fields	-field built up and improved drainage to reduce mud or paths built up

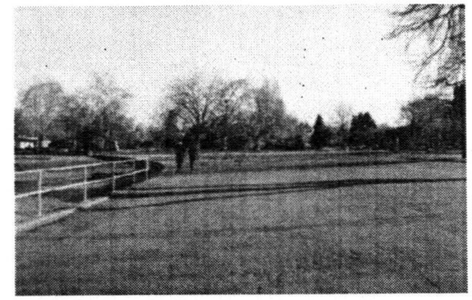


Figure 67. Looking east in the central plaza area as it is today, this area does not function well as a gathering place and lacks a distinct form.

When diagrammed, many of the design issues in the park converge at the central area in the park that was already identified as the heart of Kitsilano Park. This area is currently a transitional zone as well as being used a performance area, an area to visit and view.

While an overall master plan was developed that addressed the design problems that were identified, the area identified as the heart of the park was the location of more in-depth design interventions and research application. This area was selected because of the central location and the diversity of use of this area.

As was mentioned in the above issues and interventions list, an central gathering area that is separated from the paths and that can be used to view, entertain or visit is needed. This intervention requires a physically distinctive area that feels separated from the main promenade while remains accessible and inviting, maintains a compatible aesthetic appearance to the existing design elements in the park, and applies the findings of the research. Four design options were produced that met the above requirements to varying degrees. In all cases the design considers the context of the park as having priority over blindly using the findings of the research. These options can be evaluated by test criteria to select the more successful design solution. The test criteria used to evaluate the designs were:

- Does the design fulfill the program requirements?
- Is the design harmonious with the surroundings?
- Is the design efficient and functional?
- Is it aesthetically engaging?
- Is the scale correct?
- Does the design reflect the preferred edge form (curvilinear)?

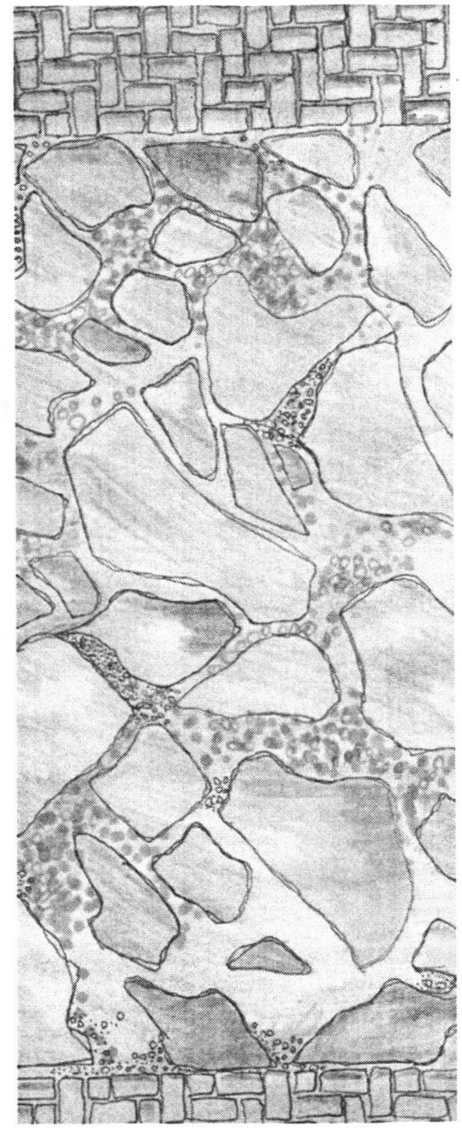


Figure 68. Paving option for Yew street entrance

Three of the designs developed for the central plaza or heart area are shown in sketches below.

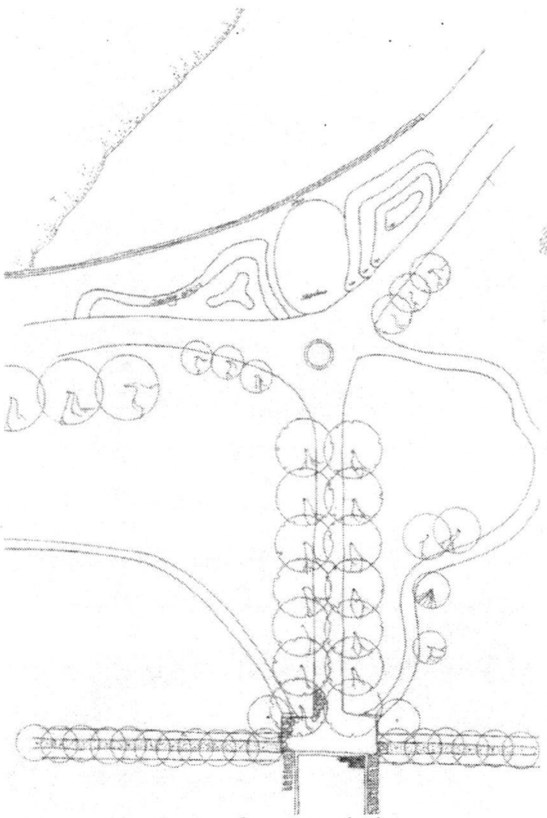


Figure 69. Option for central plaza area. This option has wide curved stairs that create a creating area for viewing into or out of the park. The centre area steps down to create a performance space. This design option does fulfill the requirement of applying the research results; however, this option is a bit large and out of scale as well as restricting movement.

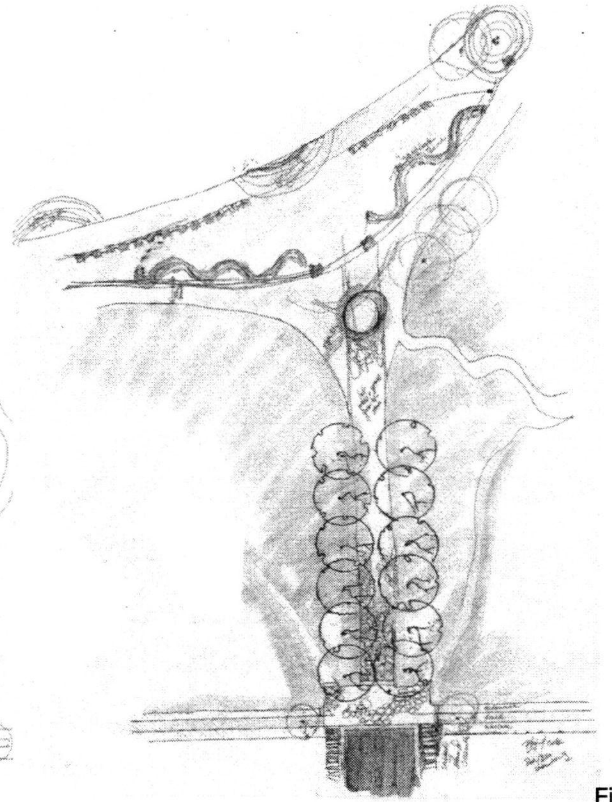


Figure 70. Option for central plaza area. This option provide a separation of space by using s-curved benches along the perimeter and allows a greater amount of movement behind and along the front edges. This design is not as harmonious with the current design aesthetic but does fulfill the requirement of application of research results.

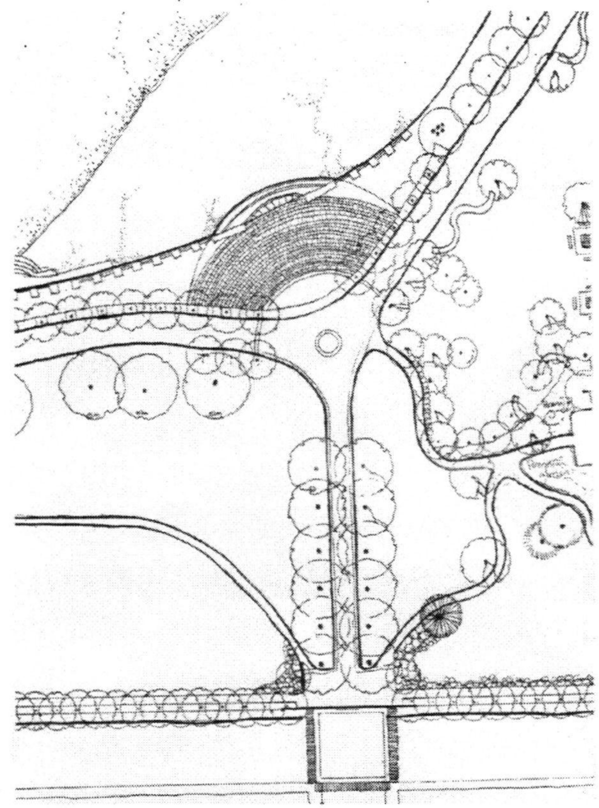
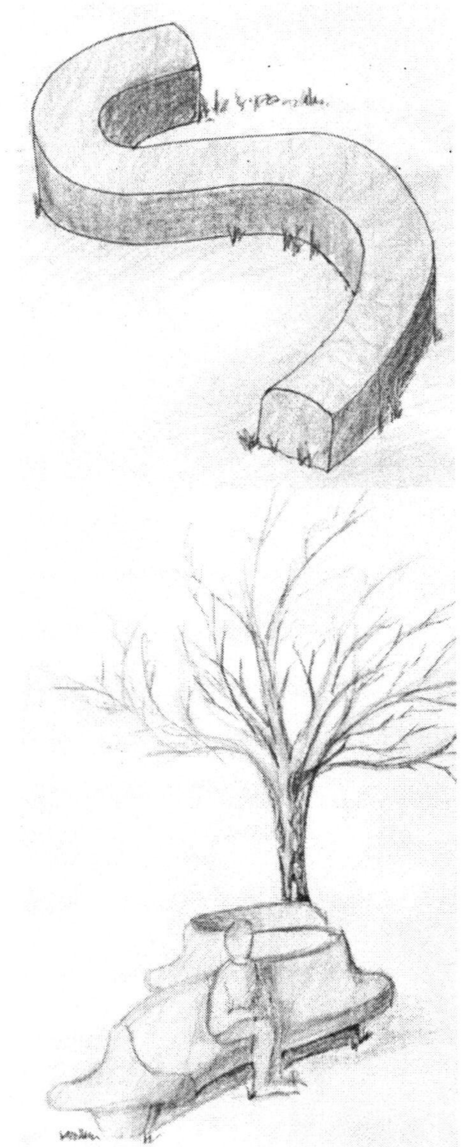


Figure 71. Successful option for central plaza area. This option utilizes paving, trees and benches to divide the pedestrian space from the gather space and does not restrict movement in and out of the area. The design is harmonious to the current design aesthetic and applies the research findings through a curved edge delineating the area. Further design exploration resulted in paving patterns, public art, quiet area to the east where curved garden edges, paths and benches were utilized.

Specific examples of landscape objects that reflect the research findings were s-curved paths, benches, garden edges and paving edges (figures 72-74). These objects were designed to fulfill the basic requirements of the park issues while responding to surrounding context and the research findings. Of particular interest, the paths vary in the degree of curvilinearity from completely without curves to the preferred s-curve used in the study. The main axial path that leads one into the park from Yew street was kept straight. It was felt that despite the findings of the study, the axial view to the extended scenery was more important than having a winding path. It is here that the need for more research is identified. Does the preferred s-curve path form vary depending on the use and location? Is a less curved path preferred when the path is used as a means of transportation and the end point is a destination rather than as an intrinsic experience unto itself or journey. Does the view at the end of the path influence the preferred form?

The decision to maintain a straight edged pathway was a result of deference to the expert paradigm in that it was felt that the features of view beyond the park and function of the path took precedent over the experimental results. Is this the correct design? If more research was conducted and indicated it was the incorrect decision, what are the ramifications to landscape architecture? Despite the possible deleterious conclusions that quantitative research could lead to, it is felt that this research is important to the evolution of landscape architecture. The public opinion is an important one when the continued goal of landscape architecture is to make liveable spaces.



Figures 72. Single sided and double sided curved benches

The current research would benefit from a process similar to grounded theory research where additional questions arise through design explorations that may be even more salient than the original questions. These new research questions could be answered through a variety of methodologies and then be applied again to design scrutiny where the research questions may be further refined and made more pertinent and applicable to design issues.

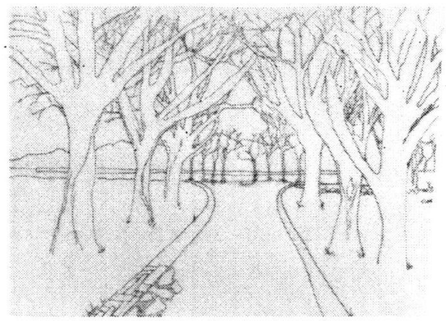


Figure 73. curved paving path edged corners between the Yew Street entrance and the central pedestrian spine.

In conclusion, while the data from this research project supported the idea that preference of urban landscape may increase when curved forms are used over angular forms, further research is needed to verify the statistical significance this finding. Additionally, this research supports the idea that preference for the curving path known to represent 'mystery' may be related to its curved form; however, it cannot yet be concluded that preference is only due to the curved form. It can also be suggested that when a landscape architect is faced with the decision to place an object into the urban park landscape he/she should consider not only the context of the site but features, such as curved edges, that public prefer.

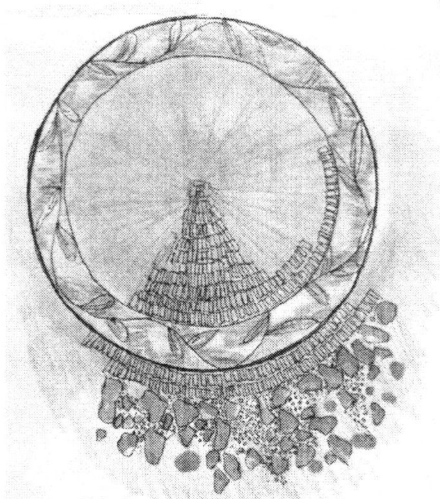


Figure 74. Public art circle acts as a ground plane focal point. Art to be flush with paving and to change seasonally celebrating various events.

The third question explored in this paper, namely whether quantitative research can be usable in landscape architecture was also substantiated. Through the re-design of Kitsilano Beach Park design, it has been shown that the findings of the research can be applied to edges and objects in urban park design. Quantitative research can indeed play a role in applied landscape architecture designs.

Works Cited

Alexander C., Ishikawa S., Silverstein M., Jacobson M., Fiksdahl-King I., & Angel S. (1977). A Pattern Language: Towns Buildings Construction. Oxford University Press. New York.

Anderson, L. (1981). Land Use Designations Affect Perception of Scenic Beauty in Forested Landscapes. Forest Science. Vol. 27, No 2. 392-400.

Appleton, J. (1988). Prospects and Refuges Revisited. In Jack Nasar (Ed.) Environmental Aesthetics: Theory, Research and Applications. (pp27-44). Cambridge University Press. New York.

Arnheim, R. (1974). Art and Visual Perception: A Psychology of the creative eye. University of California Press. Berkley.

Arnheim, R. (1982). The power of the Center: A Study of Composition in the Visual Arts. University of California Press. Berkley.

Auclair, D., Barczi .J, Borne F. & Etienne, M. (2001). Assessing the Visual Impact of Agroforestry Management with Landscape Design Software. Landscape Research. Vol. 26(4). 397-406.

Bell, S. (1999). Landscape: Pattern, Perception and Process. E&FN Spon. London.

Bell, S. (1993). Elements of Visual Design in the Landscape. E&FN Spon. London.

Berleant, A. (1992). The Aesthetics of Environment. Temple University Press. Philadelphia.

Bourassa, S. (1991). The Aesthetics of Landscape. Belhaven Press. London.

Daniel, T. C. (2001). Whither scenic beauty? Visual landscape quality assessment in the 21st Century. Landscape and Urban Planning. Vol. 54. 267-281.

Daniel, T.C. (1990). Measuring the quality of the natural environment: A psychophysical approach. American Psychologist. Vol.45(5). 633-637.

Eaton M.M. (1989). Aesthetics and the Good Life. Associated University Presses, Inc. New Jersey.

Fellman, J.P. (1986). Visual Physiology. In Smardon, R.C., Palmer, J.F., and Fellman J.P. Foundation for Visual Project Analysis. John Wiley & Sons. New York. 40-54.

Garner, M. & Engelhard, G. Jr. (1989). Rasch measurement theory, the method of paired comparisons and graph theory. In Wilson, M & Engelhard G. Jr. Objective Measurement: Theory into Practice. Vol. 5. Connecticut. Ablex Publishing Corporation.

Guthrie, G. & Wiener, M. (1966). Subliminal Perception or Perception of Partial Cue with Pictorial Stimuli. Journal of Personality and Social Psychology. Vol. 3 (6). 619-628.

Hagerhall, C.M. (2000). Clustering Predictors of Landscape Preference in the Traditional Swedish Cultural Landscape: Prospect-Refuge, Mystery, Age and Management. Journal of Environmental Psychology. Vol. 20(1). 83-90.

Hannebaum, L.G. (2002). Landscape Design: A Practical Approach fifth edition. Prentice Hall. New Jersey.

Henwood, B. 1999. Feng shui. Raincoast books. Vancouver.
Heath, T.F.(1988). Behavioral and Perceptual Aspects of the Aesthetics of Urban Environments. In Jack Nasar (Ed.) Environmental Aesthetics: Theory, Research and Applications. (pp6-10). Cambridge University Press. New York.
Herzog, T. (1985). A Cognitive Analysis of Preference for Waterscapes. Journal of Environmental Psychology. Vol. 5. 225-241.
Herzog, T. (1989). A Cognitive Analysis of Preference for Urban Nature. Journal of Environmental Psychology. Vol. 9. 27-43.
Howell, D.C. (1992). Statistical Methods for Psychology. Duxbury Press. Belmont California.
Hull, R. B. IV & Revel, G. (1989). Cross-Cultural Comparison of Landscape Scenic Beauty Evaluations: A Case Study in Bali. Journal of Environmental Psychology. Vol. 9. 177-191.
Ittelson, W. (1973). Environment perception and contemporary perceptual theory. In W.H. Ittelson (Ed.) Environment and Cognition (pp141-154). Seminar Press. New York.
Kaplan, R. (1975). Some Methods and Strategies in the Prediction of Preference. In Ervin Zube (Ed.) Landscape Assessment: Values, Perceptions, and Resources. Dowden, Hutshinson & Ross Inc. Pennsylvania.
Kaplan, R., Kaplan, S. & Ryan, R. (1998) With People in Mind. Island Press. Washington DC.
Kaplan, S. (1988). Where cognition and affect meet: a theoretical analysis of preference. In Jack Nasar (Ed.) Environmental Aesthetics: Theory, Research and Applications. (pp56-63). Cambridge University Press. New York.
Kaplan, S. & Kaplan, R. (1972). Rated Preference and Complexity for Natural and Urban Visual Material. Perception and Psychophysics. Vol12 (4).353-356.
Kaplan, S. & Kaplan, R. (1978). The Experience of the Environment. Man-Environment Systems. Vol. 7 (6). 300-305.
Kaplan, S. & Kaplan, R. (1982). Cognition and Environment: Functioning in the Environment. Praeger. New York. USA.
Karjalainen, E. &. Komulainen, M (1999). The visual effect of felling on small and medium-scale landscapes in north-eastern Finland. Journal of Environmental Management 55, 167–181
Kennedy, J. (2001). Smart Geometry! ?" in Looking at Looking : An introduction to the intelligence of Vision. Ed. Theodore Parks. Sage Publications. London.
Kirkwood, N. (2001) Manufactured Sites: Rethinking the Post-Industrial Landscape. Spon Press. London.
Laurie, I. C. (1976). Visual Aspects of Landscape Evaluation. In Appleton (Ed.) The Aesthetics of Landscape. Rural Planning Services Ltd. Oxford.
Litton, R.B.Jr (1982). Visual Assessment of Natural Landscapes. In: Environmental Aesthetics: Essays in Interpretation. Western Geographical Series vol. 20. University of Victoria. Victoria.
Lothian, A. (1999). Landscape and the Philosophy of Aesthetics: is Landscape Quality Inherent in the Landscape of in the Eye of the Beholder? Landscape and Urban Planning. Vol. 44. 177-198.
Marsh, W.M. (1998). Landscape Planning Environmental Applications. Third Edition. John Wiley & Sons, Inc. New York.
Olin, L. (1988) Form, meaning, and expression in landscape architecture. Landscape Journal. Vol. 7. 149-168.

Orland, B. (1988). Aesthetic preference for rural landscapes: some resident and visitor differences. In Jack Nasar (Ed.) Environmental Aesthetics: Theory, Research and Applications. (pp364-378). Cambridge University Press. New York.

Porteous J.D. (1982). Urban Environmental Aesthetics. Environmental Aesthetics: Essays in Interpretation. Western Geographical Series vol. 20. University of Victoria. Victoria.

Purcell, A. T., Lamb, R. J. (1998). Preference and naturalness: An Ecological Approach. Landscape and Urban Planning. Vol. 42. 57-66.

Purcell, A.T., Lamb RJ., Mainardi Peron, E., Falchero, S. (1994). Preference or Preferences for Landscape? Journal of Environmental Psychology. Vol.14. 195-209.

Rock, I. (2001). "Stupid Perceptions?" in Looking at Looking : An introduction to the intelligence of Vision. Ed. Theodore Parks. Sage Publications. London.

Ross, A. (1995). Poll stars. ArtForum, Vol 109. 72-77.

Rossbach, S. (1983). Feng Shui: The Chinese Art of Placement. Penguin. New York.

Sadler, B. & Carlson, A. (1982). Environmental aesthetics in interdisciplinary perspective. Environmental Aesthetics: Essays in Interpretation. Western Geographical Series vol. 20. University of Victoria. Victoria.

Scott, MJ, & Canter DV. (1997). Picture or Place? A Multiple Sorting Study of Landscape. Journal of Environmental Psychology. Vol. 17. 263-281.

Simonds, J.O. (1961). Landscape Architecture: The Shaping of Man's Natural Environment. McGraw-Hill book company, Inc.. New York.

Sonnenfeld, J. (1967). Environmental perception and adaptation level in the Arctic. Environmental Perception and Behavior. University of Chicago. Chicago.

Stamp, A. E. (2002). Fractals, skylines, nature and beauty. Landscape and Urban Planning. Vol. 60. 163-184.

Steinitz, C. (2001). Visual Evaluation Models: Some Complicating Questions Regarding Memorable Scenes. Landscape and Urban Planning. Vol. 54. 283-287

Strumse, E. (1994). Environmental Attributes and the Predictions of Visual Preferences for Agrarian Landscapes in Western Norway. Journal of Environmental Psychology. Vol. 14. 293-303.

Taylor J.G., Zube, E.H. & Sell, J.L. (1987). Landscape assessment and perception research methods. In R.B. Bechtel & R.W. Marans (Eds.). Methods in Environmental and Behavioral Research. New York. Nostrand Reinhold. 361-393.

Van Den Berg, A., Vlek, C.& Coeterier, F. (1998). Group Differences in the Aesthetic Evaluation of Nature Development Plans: a Multilevel Approach. Journal of Environmental Psychology. Vol. 18 (2). 141-157.

Vogel, A. & Wyse, D. (1993). Vancouver: A History in Photographs. Altitude Publishing. Vancouver.

Xiang, Wei-Ning. (2001). Weighting-by-Choosing: a Weight Elicitation Method for Map Overlays. Landscape and Urban Planning. Vol.56. 61-73.

Xing, Wu. (1998). The Feng Shui Workbook. Tuttle. Tokyo.
Zajonc, R.B. (1980). Feeling and thinking: Preferences need no inferences. American Psychologist. Vol. 35 (2). 151-175.
Zube, E., (1976). Landscape Aesthetics: Policy and Planning in the U.S. in J. Appleton (Ed.) The Aesthetics of Landscape. Rural Planning Services Ltd. Oxford.
Zube, E., Simcoe David, Law Charles. (1987). Perceptual Landscape Simulations: History and Prospect. Landscape Journal. Vol. 6(1). 62-79.

Appendix

Questionnaire used in study: (format changed to fit page)

Geometry of Form 01c

A. Subject information:

Gender   Male   Female

Age range   19-30   31-50   50+

Do you live in British Columbia?   Yes   no

If yes for how long? ______________________________

Where else have you lived?

____

B. preference information: preferred=1   not preferred=0

Image comparison:

	left	right
1.	rwf4______	rwf3 ______
2.	lpa0______	lpa1 ______
3.	Lpl5______	lpl2 ______
4.	Lpa3______	lpa0 ______
5.	rwf0______	rwf3 ______
6.	rwa1______	rwa4 ______
7.	Lpl5______	lpl3 ______
8.	Lpa2______	lpa1 ______
9.	rwf2______	rwf4______

image comparison:

	left	right
10.	Lpl1______	lpl5 ______
11.	Lpa4______	lpa1 ______
12.	rwa3______	rwa1______
13.	Lpa2______	lpa3______
14.	rwf1______	rwf4______
15.	Lpa3______	lpa4 ______
16.	rwa4______	rwa2______
17.	Lpl1______	lpl2 ______
18.	rwf0______	rwf2______

image comparison

19.	rwa2______	rwa1______
20.	Lpl3______	lpl1 ______
21.	Lpa4______	lpa2______
22.	rwf3______	rwf2______
23.	rwa3______	rwa5______
24.	Lpa0______	lpa2______
25.	Lpl2______	lpl3 ______
26.	rwf1______	rwf3 ______
27.	rwa2______	rwa3______

28. Lpl2______ lpl4 ______

29. rwf4______ rwf0______

30. Lpl4______ lpl3 ______

31. rwa5______rwa1______

32. Lpl4______ lpl5 ______

33. Lpa4______ lpa0______

34. rwa2______ rwa5______

35. rwf0______ rwf1______

36. rwa4______ rwa3______

37. Lpa1______ lpa3______

38. rwf2______ rwf1______

39. Lpl1______ lpl4 ______

40. rwa5______rwa4______

C. Extra information:

1.do you know where these pictures were taken?

path yes/ no planter yes/ no waterfall yes /no water yes/ no

Table 2.

CAD area perimeter measurements for images

RCMP water feature without fall

	Area		Perimeter		
image	1.5551		5.1103		
	Area		Perimeter		A/P
rw1	0.3900	100.0%	5.0214	100.0%	7.77%
rw2	0.3843	98.5%	4.9460	98.5%	7.77%
rw3	0.3822	98.0%	4.5356	90.3%	8.43%
rw4	0.3814	97.8%	4.7813	95.2%	7.98%
rw5	0.3677	94.3%	4.3596	86.8%	8.43%
variance		5.7%		13.2%	0.66%

David Lam park planter

	Area		Perimeter		
image	0.639		3.278		
	Area		Perimeter		A/P
lpl5	0.1144	100.0%	1.6703	100.0%	6.85%
lpl4	0.1078	94.2%	1.5927	95.4%	6.77%
lpl3	0.1205	105.3%	1.8134	108.6%	6.64%
lpl2	0.1116	97.6%	1.6503	98.8%	6.76%
lpl1	0.1204	105.2%	1.9193	114.9%	6.27%
variance		2.4%		1.2%	0.58%

RCMP water feature with fall

	Area		Perimeter		
image	1.4925		4.9851		
	Area		Perimeter		A/P
rfw0	0.3751	100.0%	4.3624	100.0%	8.60%
rfw1	0.3854	102.7%	4.3202	99.0%	8.92%
rfw2	0.3749	99.9%	4.2770	98.0%	8.77%
r2w3	0.3798	101.3%	4.0754	93.4%	9.32%
rfw4	0.3760	100.2%	3.9104	89.6%	9.62%
variance		2.8%		10.4%	1.02%

David Lam park path

	Area		Perimeter		
image	0.6576		3.3153		
	Area		Perimeter		A/P
lpa0	0.1280	100.0%	2.2839	100.0%	5.60%
lpa1	0.1132	88.4%	2.2197	97.2%	5.10%
lpa2	0.1155	90.2%	2.2078	96.7%	5.23%
lpa3	0.1201	93.8%	2.3260	101.8%	5.16%
lpa4	0.1114	87.0%	2.2136	96.9%	5.03%
variance		13.0%		3.3%	0.57%

***allowable variance in area perimeter ratio within set of images 1%.