

VISUAL QUALITY IN A ROCKY MOUNTAIN ENVIRONMENT

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ABSTRACT

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The benefits of a mountain landscape touch people physically, emotionally and psychologically. Often overlooked are the aesthetic benefits mountain landscape features provide us. This thesis explores the physical landscape of a mountain environment in Aspen, Colorado and the positive effect mountain landscape features have on the visual quality of the research area. Utilizing the predictive visual quality equation developed by Dr. Jon Bryan Burley (J. B. Burley, 1997) and Professor Kendall's coefficient of concordance statistical test (Brown & Daniel, 1987) the study proves the positive influence of mountain landscape features on the visual quality score of the rocky mountain environment.

Key Words: Visual Quality, Landscape Architecture, Mountain Aesthetics

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TABLE OF CONTENTS

LIST OF TABLES	v
LIST OF FIGURES	vi
CHAPTER 1: Introduction	1
CHAPTER 2: Literature Review	4
2.1 Borrowed Scenery.....	5
2.2 Visual Quality	8
2.2.1 Shafer & Colleagues	8
2.2.2 Taylor & Colleagues	13
2.2.3 Burley & Colleagues.....	16
2.3 Mountain Aesthetics	21
2.4 Viewshed Protection	23
CHAPTER 3: Method.....	25
3.1 Purpose of Study	25
3.2 Research Area	26
3.3 Data Collection	29
3.4 Analysis Techniques	32
CHAPTER 4: Results	38
CHAPTER 5: Discussion.....	41
CHAPTER 6: Conclusion.....	52
APPENDIX.....	54
BIBLIOGRAPHY	61

LIST OF TABLES

Table 1: Independent Variables (J.B. Burley, 1997)	34
Table 2: Environmental Quality Index (J. B. Burley, 1997).....	35
Table 3: Visual Quality Score by Zoning District	38
Table 4: Visual Quality Score and Mountain Area Comparison	39
Table 5: Average Visual Quality and Area of Mountain by District	45
Table 6: Percent of Pavement	47

LIST OF FIGURES

Figure 1: Colorado State	26
Figure 2: City of Aspen, Roaring Fork River Valley, Colorado.....	27
Figure 3: Downtown Aspen Photograph Locations by Zoning District	30
Figure 4: Mixed Use West	33
Figure 5: Lodge West – Full Enclosure	43
Figure 6: Commercial Core East – Threshold of Enclosure	43
Figure 7: Commercial Core West – Minimum Enclosure	44
Figure 8: Mixed Use South – Loss of Enclosure	44
Figure 9: Residential South.....	48
Figure 10: Residential West.....	49
Figure 11: Mixed Use West	50
Figure 12: Commercial Core East.....	51
Figure 13: Commercial Core East.....	55
Figure 14: Commercial Core South	55
Figure 15: Commercial Core North	55
Figure 16: Commercial Core West	56
Figure 17: Lodge East.....	56
Figure 18: Lodge South	56
Figure 19: Lodge West.....	57
Figure 20: Lodge North	57
Figure 21: Mixed Use East	57

Figure 22: Mixed Use South	58
Figure 23: Mixed Used West	58
Figure 24: Mixed Use North	58
Figure 25: Residential East	59
Figure 26: Residential North.....	59
Figure 27: Residential West.....	59
Figure 28: Residential North.....	60

CHAPTER 1: Introduction

Value in the Rocky Mountain Environment is often measured by the successful interaction between the natural and built environments. The natural wonders that are the Rocky Mountains, stand as sights people work very hard to incorporate into their everyday lives. In the heart of the Rockies, Colorado, these iconic landforms have stood for thousands of years and are considered to be treasured entities. The city of Aspen, Colorado is known to be a tourist hotspot, with approximately 300 historic landmarks. These include buildings, structures, parks, cemeteries, and bridges; the city of Aspen is one full of culture and spirit. The popularity of this tourist destination is derived from its historical background and surrounding landscape scenery. The town thrives on the recreational and scenic opportunities that are present thanks to the natural environment. As time continues and expansion occurs, the matter of preserving these natural resources becomes ever more pressing. How does a historic place such as Aspen, Colorado balance preservation of the mountain views with the booming growth of the city itself? The line of preservation and expansion incorporates many delicate factors. The beautiful natural landscape and historic entities often stand to be threatened by expansion.

Why exactly do we want to preserve the mountain landscape and possibly restrict further human expansion? Aside from the obvious physical benefits that are associated with mountain activities, there is a distinct value in their visual appearance. Often overlooked is the aesthetic value which is not only concerned with what we see, but what emotions are evoked when we experience these vast landscapes. Small viewsheds here and there throughout a city can encourage a feeling of serenity for pedestrians within the hustle and bustle of an urban environment. Other times there are vast views to the mountain landscape, which can strongly connect and draw people to nature. The mixture of different views brings a dynamic touch to the

structure and layout of the city. When contemplating future development in an environmentally sensitive area it is important to incorporate these various visual links and view corridors to the natural world, as well as protect them. As new development encroaches upon the physical mountain landscape, it threatens to diminish its visual value. This thesis focuses on the aesthetic value of viewsheds in a Rocky Mountain environment. A viewshed is made up of the areas of land, water, and other environmental elements that can be seen from a fixed vantage point (Li et al., 2012). In a city, such as Aspen, viewsheds should be very carefully considered throughout all stages of development. There has been some recognition, however there needs to be an increased emphasis on the importance of these viewsheds.

The natural landscape has been appreciated for thousands of years; dating back to early Chinese and Japanese civilizations assessment of the landscape has been a topic of conversation. There are many different views on how to manipulate natural and built structures to exist in a cohesive manner that benefits both humans and the environment. Theories have evolved over time and methods have advanced using technology, however there has always been an underlying theme in respect to the natural environment.

Research studying the physical benefits of the environment has been vast, however until recent years the visual benefits were difficult to properly assess. Putting a quantitative value on how people aesthetically appreciate the landscape has limitations due to fact that the visual quality of landscape is often intangible (Lu, 2011). Opinions on how to accurately evaluate the landscape reach towards the same goal, yet are derived from different theories or combinations of theories.

Governmental agencies, psychologists, landscape architects, environmental planners and many more professionals have worked towards developing a concise method to evaluate and

predict the visual and ecological quality of the natural environment (J. B. Burley, 1997). Their methods have ranged from public surveys to psychological evaluations assessing natural and photographed landscapes. The varying tools used to evaluate human perception on the natural landscape have generated four universally recognized paradigms. The expert paradigm, psychophysical paradigm, experiential paradigm, and the cognitive paradigm. The four models for assessing visual quality of the landscape each contain strengths and weaknesses when it comes to complete assessment. These four paradigms have led to positive advancements concerning visual quality. The research has been able to quantify the aesthetic value of our natural landscape, and prove there is a need to enhance and protect the viewsheds that overlook the environment. With focus on the research of Dr. Jon Bryan Burley, who has studied respondents across South America and has developed a model concerning visual quality, this thesis studies the aesthetic value of Rocky Mountain viewsheds.

CHAPTER 2: Literature Review

As humans, we benefit from the natural environment physically, psychologically and even visually. The aesthetic value of a landscape is a complicated topic that relies on several variables. Historically, the landscape has been appreciated and respected as humans have settled and manipulated the land for their benefit. Early theories and techniques have been developed which are still relied upon today in landscape design and land planning. These theories and techniques balance the relationship between the natural and built environments to create the most pleasing surroundings both physically and visually. Early practices now act as the fundamentals for design. As landscape architecture and environmental planning have become more and more established, research within the field has evolved from how to practice to how to improve the practice. This research specifically focuses on the improvement of visual quality; how to properly assess and design to achieve optimal visual quality within the landscape.

The visual aspect of the landscape is an often overlooked element when it comes to design. However recently, within the last 50 years, there has been an increased awareness for the aesthetics of the designed environment. Specifically, the mountainous regions; the mountain landscape has been a popular location for settlement based on industrial, recreational and scenic reasoning. With the recent upswing of the economy, there has been increased settlement and development in the Rocky Mountain region. With all the newly built structures it is imperative we actively think about viewsheds during the entire design process. Utilizing views toward the natural environment creates opportunities for successful design.

2.1 Borrowed Scenery

Based upon our past experiences and personal opinions we place a certain value on the outdoor spaces we encounter. The ability to connect with our natural surroundings strengthens the value we place on the landscape. To experience a landscape consists of taking in the entirety of the scene using all senses; sound, taste, touch, smell and sight. The vast landscape we see before us, the smell of blooming flowers, sound of rushing water are all entities that contribute to our experience in a landscape. What we take in through our sensory receptors, the resultant feelings and emotions are what generate this value. Focusing on the sense of sight, various techniques to enhance the visual experience of our environment have been used throughout time. Dating back to the late Ming-period is the technique of borrowed scenery, ‘*Jienjing*’ 借景 (Kuitert, 2015). The method is first explained in a comprehensive guide to garden-making manual titled *The Craft of Gardens*, ‘*Yuan Ye*’ 園冶 (Cheng, 1988).

The technique of borrowed scenery incorporates the use of distant landscape features into the foreground to appear as one cohesive environment. The illusion of expanding the outdoor space to encompass distant vistas increases the visual sensation and increases the visual value we place on the area, overall enhancing the experience. Originally descended from the Chinese, the technique did not take flight until the Japanese began using ‘*Shakkei*’ 借景 (Kuitert, 2015).

The evolution of borrowed scenery truly began in Japanese gardens, the practice reinterpreted the way the landscape was viewed. The technique created an entire composition where a distinct foreground, middleground and background worked together to create a visually pleasing environment. For a person standing in the garden, a picture was created as the garden seemingly expanded to the surrounding landscape.

The success of this design method relies on the unity of three elements; foreground, middleground and background. The foreground is represented by the garden, the area that is nearest to the observer. Often in a Japanese setting the garden would be surrounded by built structures and dense urban areas, distracting the viewer from the true beauty of the garden. Obscuring the nearby built environment allowed people to really connect with nature and enjoy the garden itself and the views it presented. In order to achieve the illusion of unison between the garden and distant landscape, the middleground worked to block out unwanted scenery by framing the desired viewsheds.

The middleground or frame is key in creating a strong relationship between the private garden and the distant landscape. This element concealed the intermediate space to bring the natural landscape scene into the confines of the garden. The use of natural and built materials framed the distant vistas horizontally and vertically (Nakase, 2015). Straight horizontal elements such as hedges or a fence masked views of human scaled objects such as roadways or built structures. Perpendicularly, vegetation worked to encapsulate the vertical frame and eliminate significantly larger gaps. Monumentally scaled entities such as suburbs or villages spanning many miles seem to disappear through the use of framing objects. These horizontal and vertical elements worked to obscure spatial depth cues to diminish the sense of distance between the garden and surrounding landscape (Kuitert, 2015).

The sought after connection to the background of the scene is what truly releases the garden from its limits. When the relationship is attained in a successful manner; the viewer can experience the full capacity of not only the garden, but the entire environment. The surrounding landscape in a Japanese garden consists of earthly features such as mountains, lakes, waterfalls, rolling hills...etc. In addition to the natural features, man-made elements such as unique

architecture, castles, temples, statues and monuments were often time the subject of the picture view desired (Kuitert, 2015). Borrowing these features gave a certain freedom to the observers, creating a limitless feeling which allowed the viewers' mind to wander through the entire landscape visually and conceptually.

An established connection through the use of borrowed scenery enables visitors to fully experience the space through a visual medium. The technique of borrowing scenery plays a significant role in not only designing a specific garden, but in planning the entire landscape area as well (Nakase, 2015). The ability to fully utilize the entirety of a landscape and allow observers to fully experience a space leads to success in terms of design. The view of the far-off landscape, for example mountains, enhances the experience the observer has, therefore denoting the importance of the mountain landscape features. Utilizing the beauty of our natural landscape in development leads to effective designs. People wish to be in spaces that function properly and are pleasing to be in whether physically or visually. The visual aspect of design has been a goal for hundreds of years, however as a priority it was placed behind functionality. General techniques such as borrowing scenery have acted as added bonuses of garden and urban design after the fundamentals of the spaces had been developed. Often an afterthought, aesthetics of the landscape was not a significant element in terms of design success. Historically, in landscape design, visually pleasing areas were not evaluated scientifically and therefore they did not signify much more than an opinion. Spaces were visually assessed in terms of "like" or "dislike". A quantitative value had not been placed on the visual quality of a landscape until roughly the 1960's (J. B. Burley, 1997).

2.2 Visual Quality

2.2.1 Shafer & Colleagues

Appreciation for the visual benefits of the outdoor landscape has been a topic for quite some time, relating back hundreds and hundreds of years. Explorers of the topic were never able to quantify the visual quality of a landscape until quite recently, within the last 50 years. Visual quality assessment has been a process based upon the opinion of users and how they feel about the landscape they are viewing, a qualitative method. Beginning in the late 1900's, the modern era of visual quality research sought to assess visual properties of the landscape in order to evaluate the impact of proposed treatments upon the landscape (J. B. Burley, 1997). Research during that time was led by Elwood Shafer and his colleagues. They explored a psychophysical approach in order to obtain a perception based evaluation of visual quality of the landscape. They worked to find the relationship between the natural environment, trees, water, mountains, etc., and what people felt about the outdoor natural environment (Shafer, Hamilton, & Schmidt, 1969).

Project leader for the United States Forest Service and a Professor at the New York State College of Forestry, Elwood L. Shafer's research aimed to provide a better basis for planning, developing and managing natural environments (Shafer, 1969). What is thought to be his greatest influence on visual quality research was his perception based predictive equation. Evolved from various studies conducted by him and his colleagues (Shafer & Thompson, 1968, Shafer et al., 1969), the predictive model determined natural landscape preferences among South American participants. American participants.

The model began as a survey conducted by Shafer in 1966. He gathered opinions of Adirondack campers in on what they felt were the most important features of various

campgrounds (Shafer, 1966). A great starting point for visual quality research the survey lead to five features important to the campers; (1) campsites near water, (2) swimming and water sport facilities, (3) landscape variability surrounding the campground, (4) campground design-campsite spacing, and vegetative screening, (5) tourist attractions nearby (Shafer, 1966). The survey acted as a platform for a later approach conducted by Shafer & Thompson in 1968. The purpose of this study was to identify a correlation between physical properties of an environment and some index of behavior within that environment (Shafer & Thompson, 1968). Building off the previous findings from 1966, they developed an equation connecting a given behavior pattern and environmental conditions of a campground.

$$Y = 3409 - [0.0183 (X1 + X2)] + [0.157 (X3^2)] + [0.0002(X4 \cdot X3^2)]$$

Where:

Y = Annual total visitor-days per campground.

X1 = Area (square feet) of land at the developed swimming beach.

X2 = Area (square feet) of water at the developed swimming beach.

X3 = Total number of campsites.

X4 = Number of islands accessible by outboard motorboat

This equation only involves four visual features in the landscape, however accounts for practically all of the variations in a campground's use intensity (Shafer, 1969). Although limited, the equation significantly explained much of how visitors were attracted to the campgrounds. Such a small study and study area, generated another great stepping stone in the research of visual quality, but opened a lot of doors for the investigators as well.

Findings from Shafer's equation demonstrated the amount of variation in a given environment increases the perceptions it can induce (Shafer, 1969). Different landscape properties within an environment generate numerous perceptions, compared to a strictly

heterogeneous landscape with limited landscape qualities. The uniqueness of an environment stems from the variation of landscape properties. The question resulting from this study was “How is the total variation of that environment distributed among its various elements?” (Shafer, 1969). Attempting to identify elements of the landscape that showed importance among recreational planning, Shafer developed nine factors that described Adirondack campground environments (Shafer, 1969). “Water-wilderness facilities; Swimming area facility; Campground-lake accessibility; White birch predominance; Supplementary lake expansiveness; Campsite picturesqueness; Tourist magnetism; Remoteness; Campsite-lake accessibility” (Shafer, 1969). These categories explained majority of the physical features outlined by campers, each factor contributed to the total variance within said environment. These factors are important because they account for a large portion of the variance and should be acknowledged during the planning process.

Desiring a mathematical reasoning to environmental perceptions, Shafer and his colleagues comprised a study. The purpose of this study was to identify quantitative variables from a photographed landscape that were related to public preference and create a predictive model. To determine useful quantitative variables that determine significant landscape features, the study examined black and white photographs. The photographs were taken by multiple photographers, half of western United States and half were eastern United States landscapes. The photographs consisted of various combinations of forests, mountains, meadows, and water. To analyze the photographs, 10 landscape zones including vegetation, nonvegetation, water and sky, were determined and studied for each landscape scene. A ¼-inch grid was placed on each of the photographs. The predominant feature of each square determined the landscape zone (Shafer et al., 1969).

Each landscape zone was then divided into four variables including; perimeter, interior, area and horizontal end-squares which in turn generated 40 variables (10 landscape zones multiplied by four variables.) In addition to the 40 variables, three tonal variables and three variables referring to the composite areas of sky, land, or water, there is a total of 46 variables. The next portion of the study was used to determine if there was a significant relationship between the quantitative variables of the photographs and the preference score.

To obtain a preference score (Y) of a landscape, interviews with campers from the Adirondacks in New York State were conducted. 100 photographs were randomly sorted and ranked among 25 adult participants. The photographs received a preference score which, along with the photographs was used to generate a predictive model, equation 2.

$$Y = 184.8 - [0.5436X1 - 0.009298X2] + [0.002069(X1 \cdot X3)^2] + [0.0005538(X1 \cdot X4)](2) - [0.06(X3 \cdot X5)] + [0.001634(X3 \cdot X6)] - [0.008441(X4 \cdot X6)] - [0.0004131(X4 \cdot X5)] + [0.0006666 X1^2] + [0.0001327 X5^2]$$

Where:

Y = Landscape preference.

X1 = Perimeter of immediate vegetation - section of the photo where characteristics of individual leaves and bark are easily distinguishable.

X2 = Perimeter of intermediate nonvegetation - section of the photo where nonvegetation is visible, but not in fine detail.

X3 = Perimeter of distant vegetation - section of photo where shapes of v vegetation cannot be distinguished.

X4 = Area of intermediate vegetation - section of photo where vegetation is visible, but not in fine detail.

X5 = Area of any kind of water - section of photo that includes water.

X6 = Area of distant nonvegetation - section of photo where shapes of nonvegetation cannot be distinguished

The equation proved useful to quantify aesthetic preferences, however further testing was required. The investigators designed six field tests using 8 x 10" photographs. Each test consisted

of 50 interviews of Adirondack campers. Using a quantitative scalar-value, interviewees ranked the photographs. The photographs were evaluated using the equation and a comparison was made between observed and predicted preferences. The field tests statistically related several landscape properties to the preferences of the campers. The equation was a positive step in terms of research, it indicated that predictive equations had the possibility of being an effective assessment method. However, the equation solidified the complexity of landscape perception; total perception is not the result of simple additive effect of various visual features (Shafer et al., 1969).

Over the years, Shafer's research has succumbed to criticism, specifically by Bourassa, Wienstein, and Carlson. Their criticism stemmed from the lack of formal, predictive theory to explain the relationships between the variables measured in the photographs and the preferences of respondents (J. B. Burley, 1997). The lack of theory however, does not dismiss the fact this general approach had scientific merit and seemed to perform well in predicting landscape quality ("Environmental Psychology," 1984). Although the equation has been discarded, Shafer's initial technique has been the root of modern day visual quality research.

2.2.2 Taylor & Colleagues

The expert paradigm supports the thoughts and ideas of professionalism; trained experts such as landscape planners and designers, forestry managers and ecologists (Zube, Sell, & Taylor, 1982) are the most qualified to perform and judge landscape assessments. Statistically speaking this paradigm lacks any formal theory background and is predominately based upon normative theories (J. B. Burley, 1997). Training in these fields includes the study of environmental as well as artistically based information, which are the two foundations for the expert paradigm (Taylor, Zube, & Sell, 1987). Derived from the arts and formal art theories of past centuries professionals are trained to see through principles and elements of art and design such as unity, variety, balance, scale, enclosure, form, line, color and texture (Taylor et al., 1987). The ability to understand these principles which make up a landscape scene allows professionals to assess the environment thoroughly. Complimenting the artistic background are the fundamental elements of ecology and resource management practices such as species, diversity, quality of timber, or lack of evidence of humans (Taylor et al., 1987). The expert paradigm focuses on categorizing and rating landscapes based on these two fundamental criteria. Through their studies and training, experts develop a thorough understanding of both artistic and ecological principles, in turn making them the most suitable judges for assessing visual quality of the landscape. This paradigm comes with an ease of assessment needing simple photos or site ratings and the use of a few trained persons (Lu, 2011). The weakness of the expert paradigm is the lack of public or lay person opinion. To fully understand and assess the visual quality of a landscape scenario, public preference is an essential component. The strength of the expert paradigm has led to its popularity among visual quality research studies as well as professional

planning and design decisions. The weakness of the expert approach has led to the development of various assessment techniques.

Development of the natural environment is performed by trained professionals who consider many different factors/variables and manipulate them to create functional spaces. They aim to meet the needs of users in an environmentally friendly manner. Relatively speaking, the general population, or lay person is going to be using these spaces. In terms of understanding the environment to design the landscape, it is important to understand it from the user's or public's frame of thought. The psychophysical paradigm focuses on the opinions of the public and strives to understand their perception.

The psychophysical paradigm examines the relationship of landscape variables and the public perception of said variables. Various visual treatments statistically analyze public opinions of landscape scenarios (Lu, Di., Burley, Jon., Crawford, Pat., Schutzki, Robert., & Loures, 2012). Similar to the expert paradigm, the psychophysical approach lacks theoretical support as to why specific preferences occur, however has led to the discovery of a magnitude of public preferences. The paradigm is built upon experimental psychology, carefully controlled experimental studies to measure responses. The experiments developed under the psychophysical paradigm gathered landscape assessment data from public respondents. According to Taylor and colleagues, the primary idea behind the psychophysical approach is to understand landscape as stimuli to respondents (Taylor et al., 1987). Various assessment methods including rating and comparison surveys measured public responses to photographed landscapes. Statistical techniques, regression models, and predictive models made progress towards the evaluation and assessment of visual quality.

The expert and psychophysical paradigms focus specifically on physical elements of the landscape to assess visual quality. The third paradigm recognized is the cognitive paradigm, which expands the realm of exploration addressing human-landscape interaction. According to Taylor and his colleagues, landscape quality is seen as a construct built up in the mind, people are individualists who relate to certain aspects of the landscape which have value to them. The cognitive paradigm explores the role of perception in human adaptation and evolution. Studies developed under this paradigm focus on cognitive variables rather than physical landscape features. Outlined by multiple professionals including Kaplan and Kaplan, Terry and Appleton, cognitive variables such as legibility, coherence, mystery, complexity, smoothness, density and degree of naturalness significantly contribute to visual quality. The way people perceive these elements varies due to past human experiences (Kaplan, R., 1976). Time spent in the landscape and events we experience throughout our lifetime affect the way we connect and value the environment. The cognitive paradigm focuses on human interaction with the landscape and why we perceive it the way we do. The strength with the cognitive approach is that it attempts to identify and establish a relationship between humans and the landscape. The weakness is the difficulty in measuring this relationship through cognitive variables in a quantitative manner, making it a difficult construct to establish (Lu, 2011). The cognitive paradigm lacks a validated form of measurement, however expands upon the expert and psychophysical paradigms. Information gathered through this paradigm gives experts an insight as to which landscapes are highly valued and preferred and develop future designs to meet and surpass that quality.

The fourth technique is the experiential paradigm, in this approach humans are considered “active participants in the landscape” (Taylor et al., 1987). Their experiences determine their preferences of landscape values. The experiential paradigm aims to measure

attitudes, feelings, and impressions as a person experiences the environment (Lu, Di., Burley, Jon., Crawford, Pat., Schutzki, Robert., & Loures, 2012). Similar to the cognitive approach, the experiential paradigm researches the interaction of humans and the landscape. Methods under this paradigm included psychological measurement, investigation and surveys that recorded not only visual preference but the respondents' attitude and feelings toward the landscape experiences. The studies conducted under this paradigm focused more on particular landscape values (Yu, 1987) rather than the quality of the landscape. In terms of landscape planning and management this method of research lacks in effective information (Lu, 2011). The information of this paradigm is often considered weaker than the other research methods and is not as frequently researched. However, the human-landscape interaction should be considered during the overall assessment of landscape quality.

The research from these four paradigms contains valuable information covering the scope of visual quality research. Each paradigm presents varying strengths and weaknesses, alone these paradigms reveal information suitable for a portion of visual quality research. However, to fully understand the entire topic of visual quality, researchers need to address the four paradigms as a unified approach. Studies that are developed utilizing characteristics from each of the paradigms present a more thorough approach and have the potential to understand visual quality completely.

2.2.3 Burley & Colleagues

Incorporating research techniques from various researchers, Dr. Jon Bryan Burley developed a predictive ecological and environmental quality model. The model was originally developed as a universal model across South America. The model illustrated its use for transportation planning and design; which explains 65 to 70 percent of respondent preference to

predict human preference (J. B. Burley, 1997). In addition to previous methods, Dr. Burley added an “environmental quality index” to further assess visual quality of the landscape.

His work, as much of visual quality research, derived from the work of Shafer and his colleagues. The assessment methods using photographs, gridded squares, physical variables and other environmental attributes act as the foundation for Burley’s equation. The measure of visual quality includes much more than just the visual variables; studies revealing a combination of aesthetic, cultural, economic and ecological variables contribute to visual quality. Several researchers after Shafer generated material that Burley sampled from in development of his equation; their research explored and identified these other key informational and experiential variables beyond the physical attributes of the landscape when measuring visual quality (J. B. Burley, 1997). Kaplan and colleagues investigated additional variables such as landscape legibility, coherence, mystery, and complexity. Their studies revealed significant variables which Dr. Burley adapted into his equation, those variables include openness, smoothness, and locomotion (Kaplan, R., Kaplan, S., Brown, 1989) In addition to these variables, Dr. Burley used an environmental quality index similar to the index presented by Carol Smyser (Smyser, 1982). The environmental quality index generated by Carol Smyser is somewhat a qualitative index, multiple applications over the years have shown its consistency (Jin, 2012). The index, described as the health index by Burley, references to the presence of air, water, soil resources and other natural resources. The health index states that the more positive environmental attributes the higher visual quality score.

Incorporating the variables mentioned above and Shafer’s technique, Dr. Burley developed his predictive equation explaining 67 percent of the variance. The photographs were images from South America, the variables contained in the picture were: buildings, automobiles,

boats, people, wildlife, roads, fire, smoke, clouds, flowers, vegetation, and nonvegetated substrate. They were photographs of various landscape types: prairie, woodland, wetland, agricultural, urban savanna, and cliff detritus, typical aspects contained in almost all of the environment (J. B. Burley, 1997). The equation revealed two types of regressors, which opposed each other.

Per Burley, imagine if all elements are zero at the same time, the image is 100 percent natural elements. The visual quality score would be 68.30, one set of regressors is negative, the other is positive. The first set being negative, man-made elements represent the noospheric regressor. Noospheric features including vehicles, human beings, utility structure, etc. lead to negative visual quality scores. The more noospheric variables contained in an image, the higher score it would receive and the less preferred it would be, above 68.30. On the other hand, biospheric attributes including vegetation, wildlife, openness, flowers and mountains generated positive visual quality scores. The more biospheric variable present in the landscape, the lower the score it would receive and the more preferred it would be, below 68.30.

These two regressors were further studied by Burley and his colleagues in 2011. The study titled Visual and Environmental Quality Perception and Preference in the People's Republic of China, France and Portugal utilized Dr. Burley's equation to compare visual quality preference similarities and differences of those who participated in the American preference study (Mo, Cléach, Sales, Deyoung, & Burley, 2011). The study was able to link the two regressors to theoretical framework. The first theory, which Burley mentioned in his 1997 study is the "Biospheric Preference Theory." This theory postulates that respondents have a preference for biospheric surroundings and a dislike for noospheric surroundings (J. B. Burley, 1997). This theory is based off the property values of urban and rural residential properties. Rural lots

contain quiet streets with few automobiles, have relatively few people, and have fresh air and clean water (Burley, 1997). This theory states that many South American residents preferred this type of atmosphere, therefore prefer biospheric conditions.

The study analyzed the responses from the varying regions and divided the Biospheric Preference Theory three sub-theories; “Theory of Human Intrusion”, Theory of Landscape Enhancements”, and “Theory of Neutral Modifiers” (Mo et al., 2011). The first sub-theory states that intrusions are not perceived well by human subjects. Abundance of people, cars, pavement, eroding soil and related features are signs of intrusion; landscapes displaying an abundance of these attributes are not scored well. The second sub-theory, ‘landscape enhancements’ correlates to landscape elements or events that are not often experienced. The blooming of a flower only occurs in specific time periods and is appreciated when viewed, increasing the landscape value. Another example being wildlife, sighting of a wild animal can often be rare, so when they are present value is increased. Distant landscape features are also considered landscape enhancements. Mountains, buttes, and buildings are generally viewed from specific locations or directions and increase landscape value just as other enhancements. The third sub-theory pertains to ‘neutral modifiers.’ These are identified as common spatial elements found in the natural landscape: sky, clouds, green vegetation and water (Mo et. al., 2011). This theory suggests that landscapes containing a great quantity of neutral modifiers result in an average (neutral) visual quality score. Landscapes containing primarily intrusions or enhancements show extremely low or extremely high scores, displaying their significance. This theoretical framework gives validity to the study which explained that region is a significant aspect when studying visual quality. Further research over multiple regions would give insight to visual quality on a global scale. This information has the potential to increase the productivity and accuracy of design treatments as

they appeal to users. Burley continued research as it applies to design treatments on a smaller scale in 2011, *Reinventing Detroit: Reclaiming Grayfields – New Metrics in Evaluating Urban Environments*.

Similar to the formation of his equation, Burley and his colleagues developed this study to assess a design proposal for Detroit from economic, ecological, aesthetic and cultural standards (Jin, 2012). Once a booming industrial city, much of Detroit now stands as a grayfield in a state of redevelopment. The study compared ideas of Frank Lloyd Wright, old designs from the city (Old Detroit) and new design ideas for Detroit (New Detroit). “Broadacre City” was an idea proposed by Frank Lloyd Wright, never built, but not forgotten. Much beyond his architectural training Wright pulled concepts closely related to landscape architecture; the design considered site hydrology, softscape spaces, recreation, circulation and way-finding, wildlife habitat, vegetation complexes, aesthetics, socialization, cultural identity, utility corridors, multiple land-uses, and building footprints (J. Burley, Deyoung, Partin, & Rokos, 2011). “Broadacre City” was a vision for low density living environments that coexisted with agriculture and natural spaces, very different from old Detroit. The purpose of this study was to understand the predicted environmental quality of “Broadacre City” compared with Old Detroit and the ideas associated with New Detroit. The study used previous methods developed by Burley and revealed the design for “Broadacre City” and New Detroit are better environments and more preferred than the conditions of Old Detroit. This study shows that designers and planners have the opportunity to test their designs before implementation. This model has the ability to determine if and how much pleasure the public will get from a design.

Visual quality covers many aspects of a person’s opinion of an environment. The research completed in the field has come a long way since the 1960’s. The modern era of visual

quality research can change the way landscape planners and designers process their treatments. Predictive equations can assist in developing sensitive, efficient and effective landscape treatments (J. B. Burley, 1997). Being able to assess possible landscape plans gives designers the chance to alter their designs and make them the best they can possibly be.

2.3 Mountain Aesthetics

Just as taste in clothes, music, literature and art, visual perception of the landscape changes throughout time. The idea of beauty in landscapes has changed during the history of civilization (Panagopoulos, 2009). Our preferences will change and evolve as different cultural norms and values come into play as time progresses.

An on-going conflict in the design and management aspects of landscape, ecological sustainability and visual aesthetics have had opposing viewpoints concerning the care and development of our natural environment. The problem lies with the theory of ecologically sustainable environments tend to be less attractive than environments managed for aesthetics (Parsons, 1995). During stages of urban development, the aesthetics are often not considered top priority. Rapid production of urban landscapes including buildings, streets, power lines, large-scale power plants etc. have hindered or threatened landscape views. Among experts in planning, lost or damaged aesthetic qualities can be easily restored (Nohl, 2001). However, this is not the case, it is usually very difficult or near impossible to revive traditional aesthetic integrity. Treating the aesthetic issue as casual is a dangerous thought process and must be addressed. Mentioned by Nohl, a design process known as the aesthetic paradigm has the potential for a balanced method of developing landscape treatments. This paradigm focuses on the equality of natural and built landscape features. It is a way of design that respects nature in terms of land use

processes. It encourages a stability between the natural environment and an ecologically sustainable built environment. The nature-compatible land use processes will decisively improve the aesthetic situation of landscapes (Nohl, 2001). Designing a place that is environmentally and aesthetically pleasing leads to a successful place that welcomes users and sustainability. It is important we prioritize aesthetics to ensure proper design methods.

The importance of aesthetics in the environment lies beyond the obvious visual benefits. Studies conducted assessing aesthetic benefits of the landscape have revealed multiple benefits including emotional, cognitive, physical, psychosocial, and psychological. Moore (1982) and West (1985) compared health indicators of prisoners with high and low quality window views (Choudhry et al., 2015). They discovered prisoners with a view of nature had fewer stress related physical symptoms such as headaches and indigestion. Cognitive benefits were found in a 1991 study by Hartig and his colleagues. Significant improvements were shown among subjects exposed to the natural environment (Choudhry et al., 2015). In 1993, Hartig found subjects who were exposed to the natural environment tended to have greater positive and lesser negative emotional responses. The study also found that physiological measures including blood pressure and heart rate positively correlated to the natural environment (Parsons, 1995). In addition to these visual benefits, exposure to natural wildlife yields psychosocial and physiological benefits as well (Parsons, 1995). Overall, studies have found interaction with the natural environment and its components generates a positive impact on humans. It is necessary to preserve these natural elements, when new development has potentially harmful effects. The ties to nature provide a sense of belonging which contributes to the culture of a town. The character created through a connection to nature is a direct link to the neighborhood livability, variety, and quality of life. These built structures and surrounding landscapes work together in creating the character and

identity of the town, preservation is key in ensuring these resources are present for years to come.

2.4 Viewshed Protection

Beginning as settlement design, the art of urban planning goes as far back at 400 B.C. (Spreiregen, 1965). From Ancient Athens, to Paris, to Egyptian villages, motivation for development of urban areas has evolved throughout time. Priorities considered in terms urban design include people, administrative organization, artistic value, speculation and social welfare. Majority of these priorities are based upon function rather than aesthetics. It wasn't until the turn of the 20th century that an emphasis was placed on aesthetic beautification (Spreiregen, 1965). During this time period, the profession of Landscape Architecture began to take shape. Major contributors to the profession including Frederick Law Olmsted, Calvert Vaux, and Frederic Edwin Church depicted design with an artistic appreciation for the landscape. These individuals generated awareness and appreciation for the visual aspect of the environment through the terms of design, planning and evaluations of landscapes (Ii et al., 2012).

Ideals developed during the 1900's and into the 2000's progressed with a focus on aesthetics. Throughout history there has been little emphasis placed on the visual importance of viewsheds. Urban development originally did not take into consideration the heights of buildings, signs, towers, rooftop equipment or any other threatening factors concerning viewsheds (Ii et al., 2012). Scale and mass were often overlooked and over established which diminished many scenic entities. When compared to a structurally dominant environment, the untouched wilderness of the mountain environment generates positive emotions. Elements of the natural landscape such as the vegetation, wildlife and geological features work together in

creating a peaceful and pristine environment, which is received in a positive manner when viewed by humans. These emotions are directly linked to the beauty of the natural landscape and their positive entities decrease when built structures inhibit views to natural areas. Pedestrian oriented corridors nestled in the commercial district break up the busy streets. These inner courtyards provide an escape from all of the built infrastructure that encompasses the city. The small scale of these areas ties into the history of the space and enhances the character. The use of natural elements and viewsheds within a city connect humans to nature. It allows for a smooth transition between the natural and built environment. When designing urban areas, there needs to be an emphasis placed upon the natural world through the use and protection of viewsheds. This research explores the aesthetic benefits of viewsheds that incorporate natural mountain landscape features within an urban environment.

CHAPTER 3: Method

3.1 Purpose of Study

A region such as the Rocky Mountains attract endless visitors each year due to recreation and many other factors. In recent years, the state of Colorado has seen a constant increase in population (U.S. Department of Commerce, 2016). People are flocking to these environmentally spectacular areas seeking places where they can surround themselves with the outdoors. This increase in tourism and long term residents generates the need for new infrastructure. New development in environmentally sensitive areas such as the Rocky Mountains poses many difficulties. People want to settle and experience these areas with vast landscapes, however if numerous people wish to develop in these areas, the wildlife and landscape become threatened. It is important we consciously develop with preservation in mind. It may become simple to lose sight of the important qualities that the environment provides, when there is so much growth present.

Viewsheds in the Rocky Mountain environment are vital to the success of a city. Urban areas with beautiful surrounding sceneries are desired areas to settle, whether temporarily or permanently. People often wish to see as much of the natural landscape as possible when they are choosing locations to visit or live. The visual scenery of these specific viewsheds are often dominated by mountain landscape features. The purpose of this study is to define a specific correlation between the visual quality scores of a Rocky Mountain landscape and the area of mountain features within the landscape.

The Hypothesis for this study is:

Hypothesis 1: The predicted visual quality scores of a Rocky Mountain landscape have a high concordance with the area of mountain features within the landscape.

Null Hypothesis 1: The predicted visual quality scores of a rocky mountain landscape have a low concordance with the area of mountain features within the landscape.

These mountain features are nice to look at and people generally wish to view them, however is there a significance where these landscape features are concerned? Do the mountain landscape features have a significant positive impact the visual quality of Aspen, Colorado?

3.2 Research Area

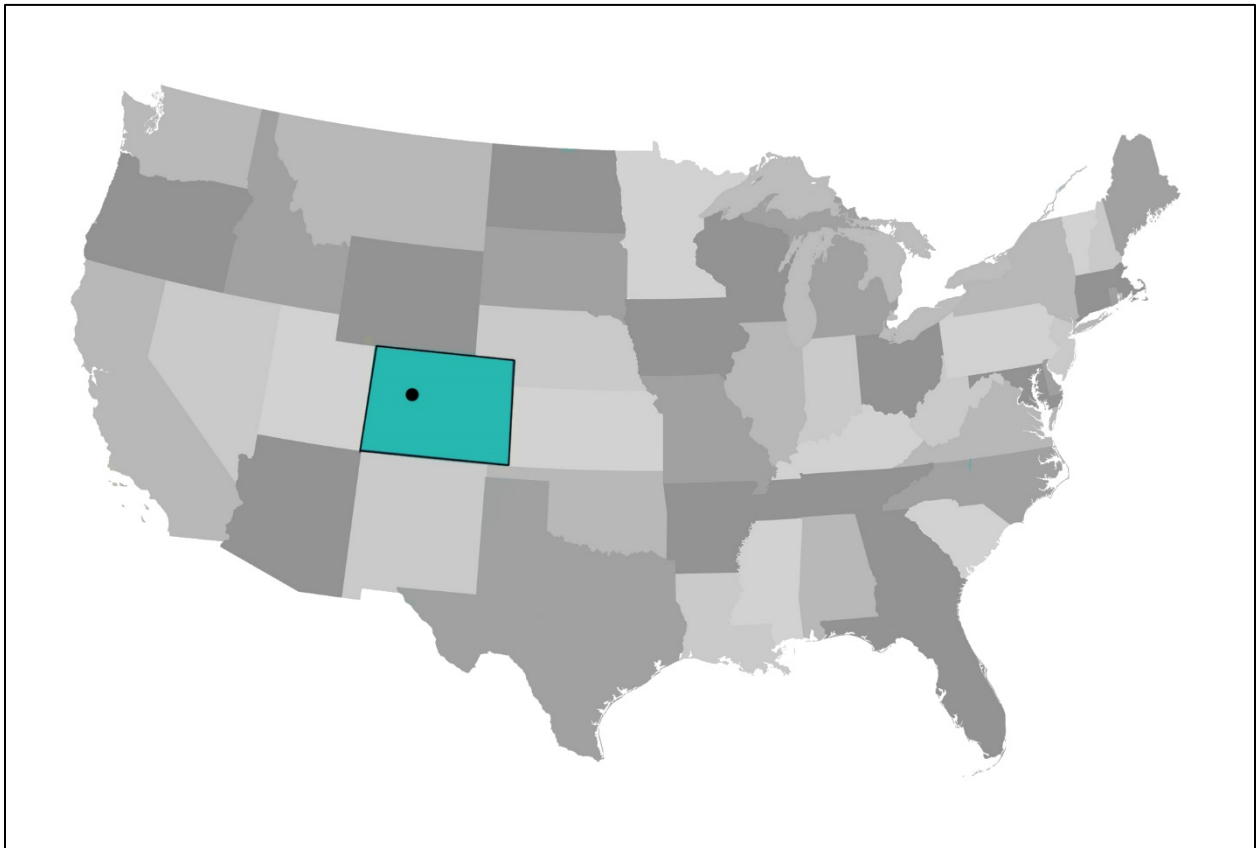


Figure 1: Colorado State

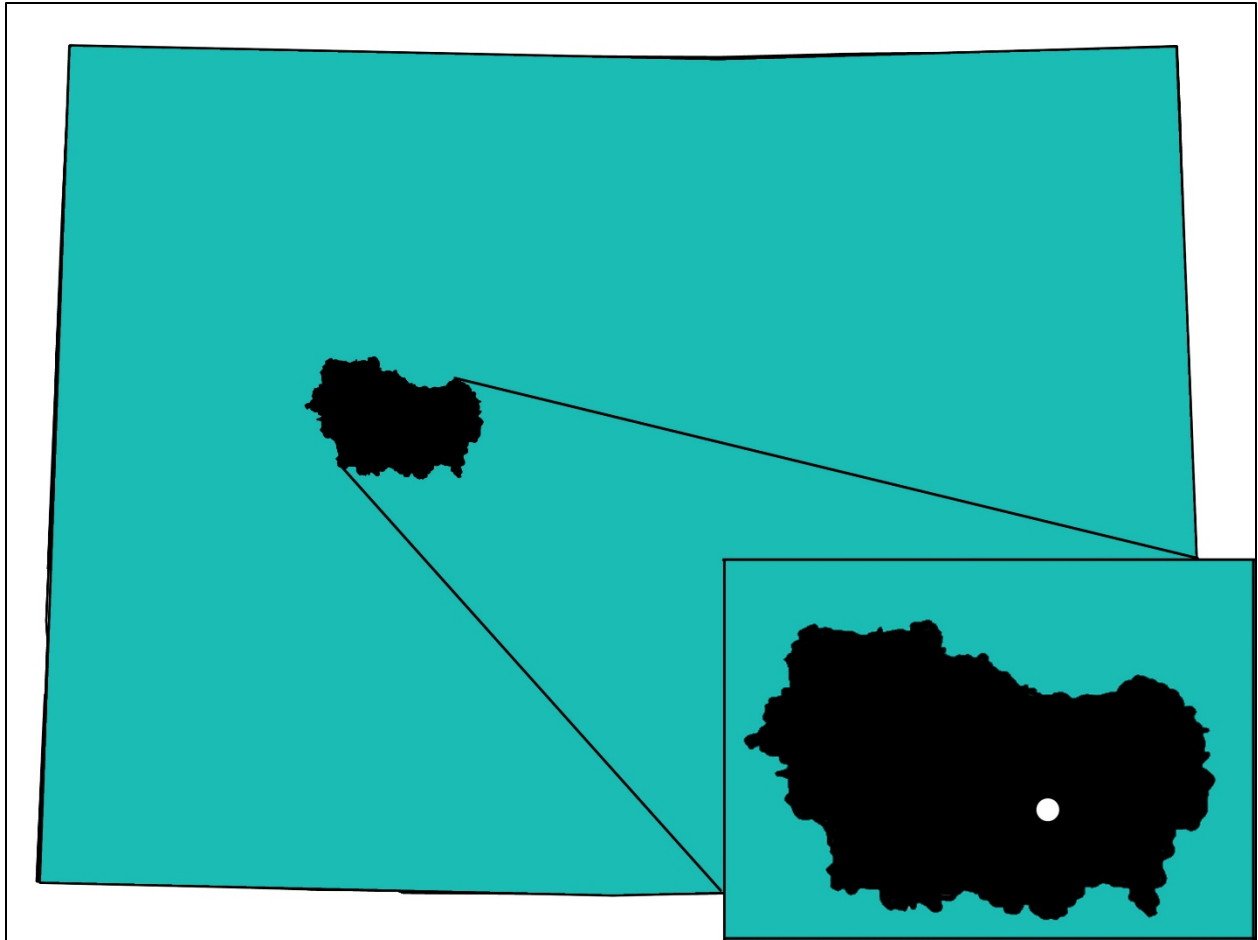


Figure 2: City of Aspen, Roaring Fork River Valley, Colorado

Located in the heart of Colorado's Rocky Mountains is one of the state's most historic and popular tourist destinations. In the picturesque Roaring Fork River Valley is Aspen, Colorado, an attractive year-round site full of beautiful mountain scenery, endless recreational activities, historic amenities and high-end retail and restaurants. The town started as a settlement of the silver mining boom during the 1800's and gave way to many historical landmarks that are still standing today. The town became a skier's dream in the latter half of the 1900's when the town hosted the FIS World Alpine Championship ("History," 2008). The mix of recreational activities has been complemented by designer boutiques and classy restaurants and has become a popular second home to many celebrities. The vast array of activities appeals to a wide range of

people, triggering the tourist population. The natural landscape is to thank for that; the mountains provide recreational opportunities, increase property values and contribute natural resources for the popular town.

Aspen, Colorado was chosen for this research for various reasons. The first reason is the establishment of the city, it has been successful for over 100 years and includes many historically significant elements as well as new construction. The second is population, according to the 2010 census the population of Aspen hovers around 6,000 full time residents (U.S. Department of Commerce, 2016). Permanent residents of the area are extremely passionate about the preservation of the mountain viewsheds. The City of Aspen is very concerned with the people that call the town home. Input from the members of the community is strongly encouraged and community forums are often held to gather input. Citizens are invited to meet with the city officials to express their opinion on developmental decisions for the city. Input from community members is vital in any city, especially one with such strong historical ties. In 2012 the community gathered to discuss height limitations for the commercial core of the city. The public strongly disliked the use of three story buildings because they obstruct so much of the mountain viewsheds. The city planning committee then altered the rule according to the opinions expressed in this forum and the height restriction was placed at a lower height (Supino, 2012). Community involvement is vital for the prosperity of the town. People who are unhappy are likely to leave and not return. If the city is able to successfully incorporate the community opinion in the design of the town, people are more likely to develop a relationship with the city and want to stick around.

The community has a strong core of full time residents however, the number of inhabitants increases dramatically during the ski season and the popular summer season. To

accommodate the tourist population, infrastructure has been a need in the past and will be a necessity in the future. This tourist population strongly relies on the mountainous views which leads to the third reason for selection; the geographic make-up of Aspen. Since the town is located in the Roaring Fork River Valley the potential for mountain views is increased compared to a town in the mountains with obstructed views. The grid pattern that Aspen was designed upon accentuates these mountain views. The streets strictly run North-South and East-West giving visitors distinct views of the nearby landscape and multiple opportunities for visual quality research.

3.3 Data Collection

The data used in this research is gathered from photographs taken of downtown Aspen by myself. The pictures were collected in August 2015; the use of summer photographs ensures the proper count for vegetation. The visual quality scores would show a variety with a sample from different seasons. The photographed locations were documented by hand and translated into an Adobe Photoshop map. Using the City of Aspen zoning map 46 photographs were collected in four districts; Commercial Core, Lodge, Mixed Use, and Residential.

service character. The district also permits a mix of retail, office, lodging, affordable housing, free-market housing and short term vacation rental uses. The next district is defined as Mixed Use: variety of lodging, short term vacation rentals, multi-family, single-family and mixed-use buildings with commercial uses serving the daily or frequent needs of the surrounding neighborhood, to provide a transition between the commercial core and surrounding residential neighborhoods and to provide a variety of building sizes compatible with the character of the Main Street Historic District. The third district known as the Lodge: encourages construction, renovation and operation of lodges, tourist-oriented multi-family buildings through short term vacation rentals, high occupancy timeshare facilities and ancillary uses compatible with lodging to support and enhance the City's resort economy. The City encourages high occupancy lodging development in this zone district. The final district sampled from is defined as Medium Density Residential: provide areas for long-term residential purposes, short term vacation rentals, and customary accessory uses. Recreational and institutional uses customarily found in proximity to residential uses are included as conditional uses. Lands are generally limited to the original Aspen Townsite contain relatively dense settlements of predominantly detached and duplex residences and are within walking distance of the center of the City. The photographs taken in the sampled districts defined by the city of Aspen cover a wide range of building uses, which is utilized by a large range of users including temporary and permanent residents.

The photographs were taken with an iPhone 5S, using the panorama 180° feature. Two pictures were taken from each location to create a 360° viewshed. The pictures were taken from the viewpoint of a person standing on the ground. The focus of each picture was to capture a view of the mountain from each location. Other landscape attributes including vehicles, buildings, people and vegetation were often present in the photographs.

A total of 46 pictures were gathered from the four districts. One sample picture from each district was selected to be analyzed. Each 360° picture was divided into four 8 x 11” photos pertaining to directional views. Each of the districts had four pictures that were labeled according to their direction, for example Residential North, Residential South, Residential East and Residential West. A total of 16 pictures were sampled from and analyzed.

3.4 Analysis Techniques

The photographs were analyzed using Burley’s equation based upon physical variables and environmental quality developed in 1997. It has been regarded as a universal predictive equation concerning South American landscapes and has been used in various studies. The predictive model explores the landscape including total area of noospheric features and total area of motorized vehicles; presence of humans, wildlife, utility structures, and foreground flowers; total area of distant nonvegetation landscape features such as mountains and buttes; perimeter of intermediate nonvegetation; total area of foreground vegetation; and openness, mystery, and environmental quality index; with an overall p-value for the equation <0.0001 and a p-value <0.05 for all regressors (J. B. Burley, 1997).

Landscape variables are measured by overlaying a grid on the picture, each 1 x 1 square grid is recorded as one unit (Figure 4). The numbers used in the equation are obtained by counting areas or perimeters (J. B. Burley, 1997). The variables (Table 1) in addition to Carol Smyser’s environmental quality index (Table 2) are implemented into the equation.

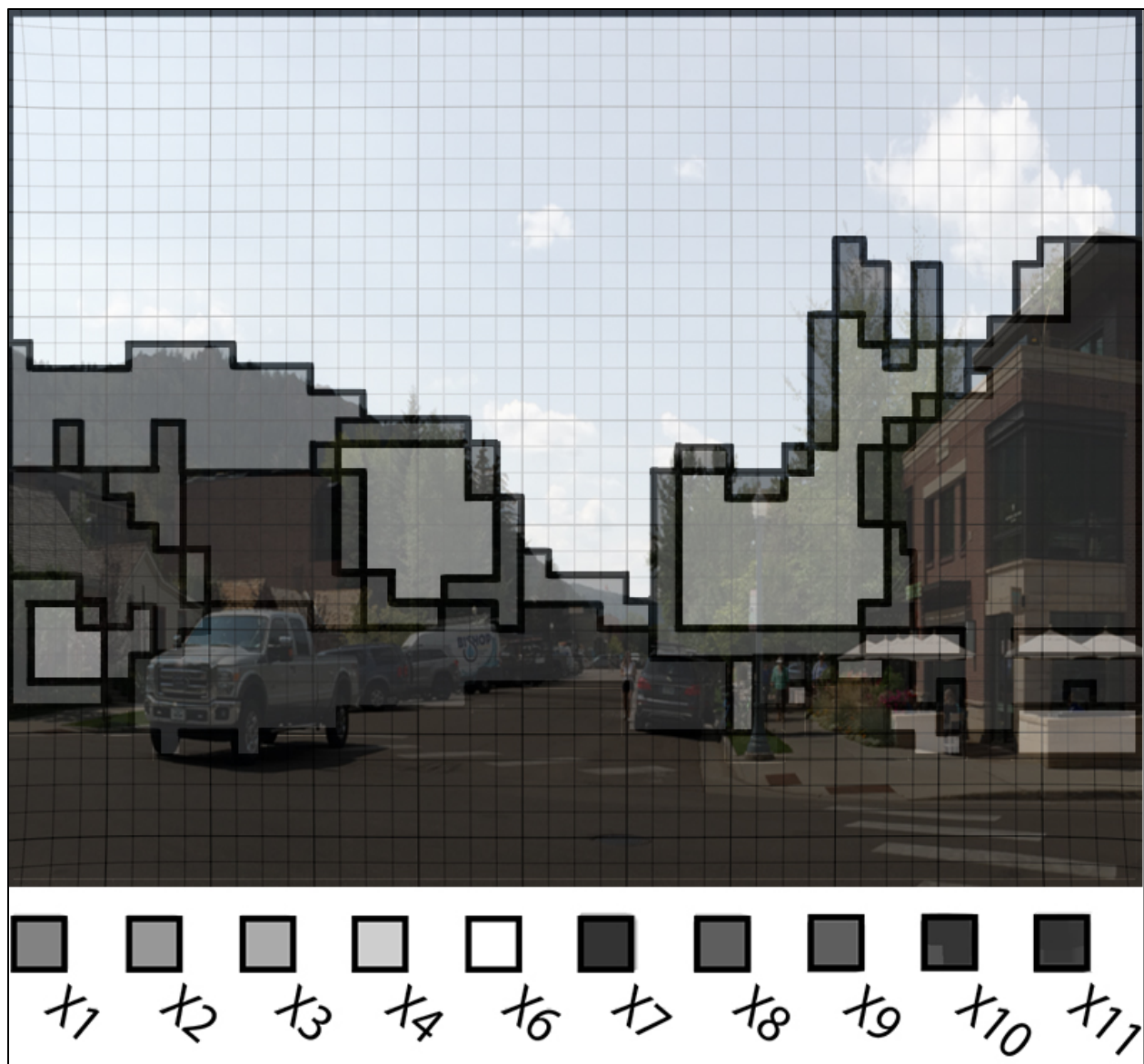


Figure 4: Mixed Use West

Independent Variables	
HEALTH	Environmental quality index (Table 2)
X1	perimeter of immediate vegetation
X2	perimeter of intermediate non-vegetation
X3	perimeter of distant vegetation
X4	area of intermediate vegetation
X6	area of distant non-vegetation
X7	area of pavement
X8	area of building
X9	area of vehicle
X10	area of humans
X13	area of herbaceous foreground material
X14	area of wildflowers in foreground
X15	area of utilities
X16	area of boats
X17	area of dead foreground vegetation
X19	area of wildlife
$X30 = X2 + X4 + (2 * (X3 + X6))$	open landscapes
$X31 = X2 + X4 + (2 * (X1 + X17))$	closed landscapes
$X32 = X30 - X31$	openness
$X34 = X30 * X1 * X7 / 1140$	mystery
$X52 = X7 + X8 + X9 + X15 + X16$	noosphericness

Table 1: Independent Variables (J.B. Burley, 1997)

Environmental Quality Index	
Variable	Score
A. Purifies Air	+1 0 -1
B. Purifies Water	+1 0 -1
C. Builds Soil Resources	+1 0 -1
D. Promotes Human Cultural Diversity	+1 0 -1
E. Preserves Natural Resources	+1 0 -1
F. Limits Use of Fossil Fuels	+1 0 -1
G. Minimizes Radioactive Contamination	+1 0 -1
H. Promotes Biological Diversity	+1 0 -1
I. Provides Food	+1 0 -1
J. Ameliorates Wind	+1 0 -1
K. Prevents Soil Erosion	+1 0 -1
L. Provides Shade	+1 0 -1
M. Presents Pleasant Smells	+1 0 -1
N. Presents Pleasant Sounds	+1 0 -1
O. Does not Contribute to Global Warming	+1 0 -1
P. Contributes to the World Economy	+1 0 -1
Q. Accommodates Recycling	+1 0 -1
R. Multiple Use	+1 0 -1
S. Accommodates Low Maintenance	+1 0 -1
T. Visually Pleasing	+1 0 -1
Total	_____

Table 2: Environmental Quality Index (J. B. Burley, 1997)

The visual quality score is obtained through measuring variables and implementing them into the equation. The lower “Y” scores, the better visual quality of the landscape.

$$\begin{aligned}
Y = & 68.30 - (1.878 * HEALTH) - (0.131 * X1) - (0.064 * X6) + (0.020 * X9) \\
& + (0.036 * X10) + (0.129 * X15) - (0.129 * X19) - (0.006 * X32) \\
& + (0.00003 * X34) + (0.032 * X52) + (0.0008 * X1 * X1) + (0.00006 \\
& * X6 * X6) - (0.0003 * X15 * X15) + (0.0002 * X19 * X19) - (0.0009 \\
& * X2 * X14) - (0.00003 * X52 * X52) - (0.0000001 * X52 * X34)
\end{aligned}$$

To identify if the amount of mountainous landscape affects the visual quality score, area of mountain was recorded among the photographs. Using the variable identified in Dr. Burley’s equation, the total area of mountain landscape in each picture was recorded. The pictures were ranked according to visual quality score and area mountain to compare the relationship. In order to scientifically prove a significant relationship between the visual quality scores and the area of mountain of each picture, the two columns of ranks were compared using Kendall’s Coefficient of Concordance (W) (Brown & Daniel, 1987) a nonparametric test which is quite flexible in use and application (Lu et. Al., 2012). Score i is the given rank $r_{i,j}$ by judge number, j , where there are in total n (16) scores and m (2) judges. The total rank given to score i is

$$R_i = \sum_{j=1}^m r_{i,j},$$

The mean value of these total ranks is

$$\bar{R} = \frac{1}{2}m(n + 1)$$

The sum of squared deviations, S , is defined as

$$S = \sum_{i=1}^n (R_i - \bar{R})^2$$

Then Kendall's W is defined as

$$W = \frac{12S}{m^2(n^3 - n)}$$

The test statistic W is between 0 and 1. If W is 0, there is no overall trend of agreement between the two sets of rankings. If W is 1, the responses may be regarded as random. Intermediate values of W suggest a degree of concordance among the responses. W will be used to test the agreement between the visual quality ranking and the area of mountain ranking. Chi-square distribution will be analyzed by consulting a chi-square table. If W is greater than the Chi-square number, the results are in accordance with the p-values for that Chi-square number.

CHAPTER 4: Results

The visual quality scores were recorded for each location within the zoning districts. The four sampled pictures from the Mixed Use district scored: 44.08495, 25.8621, 31.7065, and 34.7153. The Commercial Core scored: 43.6106, 31.5029, 120.809, 35.5721. The Lodge district scored: 71.8002, 58.2552, 52.1498, and 36.3071. The Residential scored: 48.1308, 36.6581, 42.1958, and 33.9858. The mean scores of each zoning district is represented below (Table 3). The lower the score, the better visual quality for that area. The Mixed Use zone scored the best visual quality and the commercial score had the lowest visual quality. Scores in the 30's and 40's signify highly desirable landscapes. For an urban area such as Aspen, scores in the 50's are highly favored and still indicate a preferred landscape. However, according to Burley's equation the results dictate Mixed Use district to be the most preferred landscape. The Commercial Core is shown to be the least preferred landscape for this research area.

Visual Quality Mean Scores by Zoning District				
District	Mixed Use	Residential	Commercial Core	Lodge
	44.84948	48.13082	43.61061	71.80002
	25.86215	36.65814	31.50291	52.14977
	34.71527	42.19577	120.8086	58.25522
	31.7065	33.98584	35.57213	36.30715
Average	34.28335	40.242643	57.8735625	54.62804

Table 3: Visual Quality Score by Zoning District

Picture	Visual Quality Score	Visual Quality Rank	Area Mountain	Area Mountain Rank
Mixed Use South	31.7065	3	177	1
Residential North	33.9858	4	57	2
Mixed Use West	25.8621	1	55	3
Lodge North	36.3071	7	45	4
Commercial Core West	31.5026	2	36	5
Residential South	42.1958	9	36	6
Mixed Use North	34.7153	5	33	7
Mixed Use East	44.8495	11	17	8
Commercial Core East	43.6106	10	16	9
Commercial Core South	120.809	16	15	10
Residential East	48.1308	12	14	11
Commercial Core North	35.5721	6	13	12
Lodge South	52.1498	13	6	13
Lodge West	58.2552	14	4	14
Residential West	36.6581	8	3	15
Lodge East	71.8002	15	2	16

Table 4: Visual Quality Score and Mountain Area Comparison

In Table 4 the pictures are ranked low to high based upon their visual quality scores 120.809 being the highest score and 25.8621 the lowest. The number of squares containing mountain features of each photograph was recorded in the area mountain column. The visual quality score and area mountain were assigned an associated rank. In Kendall's Coefficient of Concordance, a W value 0.870588 was generated. A corresponding Chi-Square table was consulted to determine if the derived value for Chi-Square was significant ($p \leq 0.05$) at fifteen degrees of freedom (Brown & Daniel, 1987). Since the derived value of Chi-square 26.11765 is greater than the table value of 24.996, the null hypothesis was rejected and the hypothesis that the two sets of numbers are in concordance ($p \leq 0.05$) was accepted. It was determined, through statistical analysis, that the relationship of visual quality scores and the area of mountain features are in concordance and significant to a high (95%) confidence level. In other words, statistical analysis has proven the mountain features of a landscape relate to the visual quality scores of that landscape. Mountain features are significantly important in high visual quality scores.

CHAPTER 5: Discussion

The results for this research agree with previous findings which generally state that humans prefer biospheric (natural-like) landscape environments compared to urban, man-made (noospheric) environments (J. B. Burley, 1997). The study area samples demonstrate four different districts with four diverse urban constructs. The urban makeup of the districts represents a majority of the land use that is present in not only Aspen, Colorado, but most urban domains. Therefore, this research could potentially be applicable for other similar environmental regions such as the Alps of Europe or the Andes of North America. Mountain ranges across the globe are tourist hotspots and face many of the same developmental restrictions and challenges as those in the North American Rockies.

In an area such as Aspen, Colorado the mountains play a significant role in everyday life, they provide physical benefits, recreational opportunities and proven from this research, visual benefits. The objective of this study was to prove mountain landscape features positively affect visual quality scores in viewsheds of a Rocky Mountain environment. The study used a combination of Dr. Burley's predictive equation and Professor Kendall's Coefficient of Concordance and suggests a strong relationship between the area of mountain landscape features and the visual quality of a landscape with a p-value of $p \leq 0.05$. The results proved the area of mountain features present in a photograph demonstrate a lower visual quality score, which means the area is more visually pleasing to a confidence level of 95%.

The study area for this research was positioned in a valley with surrounding mountain features on all sides. The grid layout of the city streets was designed to achieve optimal viewsheds in nearly all directions. The photographs assessed in the study display various amounts of mountain features. The composition of urban elements in the different districts result

in varying levels of enclosure. Throughout the districts there are examples which display each of the four levels of enclosure; full, threshold, minimal and loss of enclosure (Spreiregen, 1965).

Full enclosure is defined as a ratio of 1:1, one unit of distance away from an enclosing object which is one unit in height. The upper limit of a person's field of view is noted as a 45° viewing angle to the top of the enclosing element. Details of the scene are registered, rather than the view as a whole. Threshold of enclosure is recognized as a 30° viewing angle with a ratio of 1:2.

Objects are seen as a whole composition; this level is known as the lower limit of enclosure. The next level is minimum enclosure defined as a viewing angle of 18° and ratio of 1:3. Viewers perceive the prominent object beyond the space just as much as the space itself. Objects are viewed as in a relationship to its surroundings. The final level is defined as a loss of enclosure which is a 14° viewing angle and a ratio of 1:4. Objects in the scene are viewed as urban edges, the space loses its containing quality. Structural elements that are in the peripheral zone also function as edges in the viewshed. It is important in urban planning to keep enclosure in mind.

Dynamics of a city rely on the various levels of enclosure to create intricate spaces that appeal to users. According to Spreiregen as a rule of thumb; for an urban area, the ratio must not exceed 1:3 which falls into the category of minimum enclosure. Plazas that exceed this ratio often lose their sense of place, it is noted that the space "leaks out" and the plaza loses its general significance.



Figure 5: Lodge West – Full Enclosure



Figure 6: Commercial Core East – Threshold of Enclosure



Figure 7: Commercial Core West – Minimum Enclosure



Figure 8: Mixed Use South – Loss of Enclosure

Depicting the four levels of enclosure, the photographs generally scored better as the level of enclosure decreased. This pattern agreed with majority of the photographs, until figure 8 which displayed a loss of enclosure. The fact that figure 8 did not score better than figure 7, it is safe to assume, the area of mountain landscape features generates positive scores to a certain point. It also establishes that enclosure is important when considering design where viewsheds are highly valued.

Figure: District	Visual Quality Score	Area of Mountain
5: Lodge	71.8002	2
6: Commercial Core	43.6106	16
7: Commercial Core	31.5209	36
8: Mixed Use	31.7065	177

Table 5: Average Visual Quality and Area of Mountain by District

Urban spaces alternate through various levels of enclosure. There are alleyways that represent full enclosure, shopping corridors that mimic threshold of enclosure and plazas that display minimum enclosure. The rule of thumb discussed regarding enclosure may correlate to the visual quality scores of these areas. It may not be true that the more mountain features present the better visual quality of an area. Aside from the views, there needs to be other features to balance the natural landscape as well as create a sense of enclosure. If there were endless amounts of open vistas containing high percentages of mountain features, the visual dynamics of a cityscape wouldn't be enjoyable and interesting. The impact that the mountain features have on the users of the space would be lessened. Present in the data was a hint of a pattern pertaining to this theory.

There is a certain point where the percentage of mountain features becomes less significant pertaining to the visual quality score. It is safe to say there is a limit on the positive effects this variable has on the visual quality score, this is referred to as diminishing returns. There seems to be a pattern as the percentage of mountain features reaches above 3% the visual quality score is not significantly impacted in a positive manner. This information can be helpful when creating design guidelines. The large open views are great to see occasionally, however if the mountains were to be omni-present, they lose their appeal and can become less significant. Knowing that it only takes roughly 2-3% mountain features in a given frame to increase visual quality scores creates more opportunities for developers. Design professionals are free to create dynamic spaces with this information, there is much more room for higher levels of enclosure within the 0-3% visible mountain feature range. A flow of smaller spaces with minimal mountain views builds up an anticipation when a person is traveling through an environment. The sequence of spaces can be heavily weighted with developed structures and when an open view does present itself, it will be valued higher. This value will register in the minds of the inhabitants, the mountains will remain significant and protected. Future development will not need to expand into the wilderness, however will be intelligently expanded through denser cityscapes.

In addition to levels of enclosure the data was studied was based on viewshed direction. Rather than focusing on urban makeup, this method for analyzation does not rely on which district of the city the viewshed is in. This allows the sample to be assessed as a whole rather than by district. It also allows for another variable, rather than mountain features to be the prime focus. Originally, the city of Aspen was designed based on a grid system of streets. The streets are aligned South to North and East to West to achieve ideal views of the surrounding

mountains. The grid layout of the city was designed to optimize viewsheds, and the data respects that grid. In addition to the positive features of the landscape, the negative variables were also investigated. One individual landscape entity that seemed to have an impact on the visual quality scores was the amount of pavement. The measurement was computed based on area of pavement in terms of a percent of the entire landscape scene. The pavement variable includes any hardscape material; concrete, pavers, stone, etc. These elements are assessed in a negative manner due to the fact they generally do not improve the natural environment or contribute positively to human health. To assess the negative impact, I looked at the mean visual quality scores and the average percentage of pavement for each of the four view directions. The results are as follows:

Direction	Visual Quality Score	Pavement Percentage
South	61.71528	41.49%
East	52.09778	34.01%
West	38.0695	26.51%
North	35.14508	26.94%

Table 6: Percent of Pavement

The higher average visual quality scores seem to have a correlation to the percentage of pavement found in each directional viewshed. This is a rather small sample to gather information from, but it seems that 30% pavement and below produces more visually pleasing landscapes.

Figure 9 below displays a viewshed with a higher percentage of pavement.



Figure 9: Residential South

The percent of pavement pictured above is 40.04%, percent of mountain features is 2.4% and the visual quality score is 42.19. Figure 10 below happens to be in the same district, however displays a lower percentage of pavement. The percent of pavement pictured below is 27.14%, percent of mountain features is .2% and the visual quality score is 36.67. Comparing these two viewsheds signifies that even with minimal mountain visibility, a desired viewshed can still be obtained if the pavement is kept to a minimum.



Figure 10: Residential West

Based on the way the city is laid out, generally speaking the West viewshed has very minimal, if any visible mountain features. Overall the Westward viewsheds displayed the lowest numbers of mountain area. This is important because the West showed the second best average visual quality scores in the data sampled. Therefore, it shows that even with a lack of mountain landscape features, with minimal pavement, there still is a potential to be a visually pleasing landscape.

Looking again into a negatively viewed variable, the third area investigated is the variable of vehicles present which is similar to the technique used to analyze the pavement variable. The data collected for vehicles in the photographs was compared to the area of mountain features and the visual quality score. Basing this investigation off the results of pavement percentage analyzation, I had planned to find the vehicular variable to behave in a similar manner. What I found, however was not as clear of a pattern. I found the photograph that

scored the best visually, had a higher percent of vehicular presence. For example, figure 11 below scored 25.86 in terms of visual quality, however it presented a 5.08% in terms of the variable representing vehicles. On the other hand, figure 12 scored a 43.61 visually and displayed 0% vehicles. The two photos are different in terms of urban make up, directional viewshed and vehicular presence. The interesting aspect is the opposite results concerning the comparison of vehicular presence, mountain area and visual quality. I was hoping to find that the presence of vehicles would significantly decrease the visual quality of the sampled areas. This is important because there seems to be a negative feeling associated with the presence of vehicles in urban areas.



Figure 11: Mixed Use West



Figure 12: Commercial Core East

Generally, the idea is to design with respect to pedestrian usage rather than vehicular in these types of urban settings. From these results, I gather that the negativity associated with vehicles has less to do with visual thinking than ecological or physical thinking. Overall, however the term visual quality takes into account the entire realm of the visual world including the impacts of variables regarding ecological and physical standpoints. Also, to take into consideration is a larger sample examining the presence of vehicles may lead to a more reliable pattern that agrees with the findings of the pavement variable. Future studies regarding mountain viewsheds could explore the specifics of the visual quality predictive model.

CHAPTER 6: Conclusion

The study of visual quality is such a newly explored topic there is a vast amount of future research still to be completed. The opportunities for future research are endless, the amount of variables, different theoretical backgrounds, and methods combine to create a large area for research, we have only touched the surface. The past research has proven useful through both successful and unsuccessful studies. Similar to previous investigations, this research posed some limitations as well as opportunities for future researchers.

One of the main limiting factors for this research was the sample size. The equation used for analysis has been proven before, so there wasn't necessarily a need for a large sample size in regards to the visual quality of mountain landscape features. However, upon further analysis of data, it was found that a larger sample size may have led to more precise results, especially when individual variables were taken into consideration. There wasn't enough data to outline a significant pattern for said variables. It did, however open the door for further research. The small sample size did hint at the possibility for patterns. If the individual variables were studied with more depth and intensity, I believe there is a possibility to gage the levels of impact each of the variables place on the visual quality of the landscape.

In addition to the possible potential studies, the data did bring concrete positive information into the realm of visual quality. This research put a quantitative value on the visual quality of a rocky mountain landscape. There is now significant meaning to these beautiful landforms that we are able to experience. This research has the ability to scientifically support the preservation of the viewsheds and physical mountains that stand to be threatened with further expansion.

Utilizing the findings in this study, policy makers and legislation have the ability to develop laws for the protection and optimization of rocky mountain viewsheds. Other professionals involved in development could use this information to support design decisions in their environmentally sensitive urban settings. Guidelines from this specific research could potentially recognize levels of enclosure throughout a city, material, amount of pavement and vehicular presence in the urban core. Just the beginning, there is so much room for growth regarding this topic. The potential research related to this topic could ensure a safer future regarding the natural environment. Further development can use this information to create the most pleasing area visually and ecologically for both humans and our natural environment.

APPENDIX



Figure 13: Commercial Core East



Figure 14: Commercial Core South



Figure 15: Commercial Core North



Figure 16: Commercial Core West



Figure 17: Lodge East



Figure 18: Lodge South



Figure 19: Lodge West



Figure 20: Lodge North



Figure 21: Mixed Use East



Figure 22: Mixed Use South



Figure 23: Mixed Used West



Figure 24: Mixed Use North



Figure 25: Residential East



Figure 26: Residential North



Figure 27: Residential West



Figure 28: Residential North

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