Evaluating Repeat Photography in Documenting Natural and Cultural Landscape Changes: a Changing Crown of the Continent Ecosystem between 1899 and 2010

Dusty Leigh Waltner

The University of Montana

Follow this and additional works at: https://scholarworks.umt.edu/etd

Let us know how access to this document benefits you.

Recommended Citation
https://scholarworks.umt.edu/etd/393

This Thesis is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact scholarworks@mso.umt.edu.
EVALUATING REPEAT PHOTOGRAPHY IN DOCUMENTING NATURAL AND CULTURAL LANDSCAPE CHANGES: A CHANGING CROWN OF THE CONTINENT ECOSYSTEM BETWEEN 1899 AND 2010

BY

DUSTY LEIGH WALTNER

Bachelor of Arts, The University of Montana, Missoula, 2009

Thesis

presented in partial fulfillment of the requirements for the degree of

Masters of Science in Geography

The University of Montana, Missoula, Montana

Official Graduation Date May 2011

Approved by:

Alexander Ross, Associate Provost for Graduate Education
Graduate School

Dr. Ulrich Kamp (Chairperson)
Department of Geography, The University of Montana

Dr. Thomas Sullivan
Department of Geography, The University of Montana

Dr. William Wyckoff
Department of Earth Sciences, Montana State University

Rick Graetz
Department of Geography, The University of Montana
Abstract
Photography can be an invaluable tool in human geographical research, for example, to better understand the importance of place to people. Increasingly, geographers are looking at how photography can play an active role in the construction of geographical knowledge, that is, how photographs are seen rather than what they show. This study examines the use of repeat photography as a research method by conducting a case study on landscape change in the Crown of the Continent Ecosystem. Grounded in extensive archival research on the past, present, and future uses of photography as a research method, a repeat photography survey was conducted in order to interpret natural and cultural landscape changes over time. The study involves three sets of photographs ranging from 1870 to 2010. However, this study is not just about documenting change, it is about analyzing perceptions of wilderness through photography. The original photographs in the study were taken during the earliest days of photography, a period in which the US Congress sent photographers out to record the West. Followed by a time when forestry and conservation started taking on new meanings with the policies of the first United States Forest Service Chief, Gifford Pinchot. This study investigates the role of photography in shaping the landscape of the West by taking a contemporary look at the study area through the repeat photographic survey conducted.
Acknowledgements

I would like to thank all of my committee members for their assistance and guidance, Dr. Ulrich Kamp, Dr. Thomas Sullivan, Dr. William Wykoff, and Rick Graetz, in addition to Dr. Anna Klene who also offered advice and support.

Particularly, I would like to thank Dr. Ulrich Kamp, who was not only my committee chair, but also a great friend throughout my graduate career. Without his guidance and support this research could not have been possible. He has been a great mentor and incredibly understanding professor.

Furthermore, I would like to thank Dr. Thomas Sullivan who opened my world to the wonders of human geography and social theory. The endless conversations and guidance are something I will take with me forever. His door was always open and he was always willing to listen to my hair-brained theories no matter how busy he was. He has been amazingly encouraging throughout this process and I could not have reached my full potential without him.

Also, I would like to thank Rick Graetz for his guidance on the back roads of Montana, his expertise on photography, as well as the use of his camera in the field.

In addition, I would like to thank Bill Cunningham for allowing me into his home in Choteau to stage my fieldwork out of and being able to unwind at the end of the day with his wonderful four dogs: Zena, Marley, Sam, and Lucy.

A special thank goes to Nate Rogers for his assistance with pounding GIS into my head; in addition to the rest of the graduate students in the department. They offered great support, friendship, and sympathy during frustrating times.

Lastly, I thank my family for their support throughout this process and putting up with my long hours of writing and researching, as well as my husband, sister and mother for all reading my thesis and making sure it was coherent. I definitely could not have completed this research without their support and encouragement. I especially thank my son George and friend Briar for being great field assistants and navigators.
Table of Contents

Abstract ............................................................................................................................................................ ii
Acknowledgements .................................................................................................................................. iii

Chapter 1 – INTRODUCTION .......................................................................................................................... 1
1.2 Thesis Outline ............................................................................................................................................. 2

Chapter 2 – BACKGROUND .......................................................................................................................... 4
2.1 Project Origin ............................................................................................................................................... 4
2.2 Other Photographers ................................................................................................................................ 5
2.3 History of Photography .......................................................................................................................... 7
2.4 History of Repeat Photography ............................................................................................................. 10

Chapter 3 – CONCEPTUAL FRAMEWORK .................................................................................................. 12
3.1 Introduction ............................................................................................................................................... 12
3.2 Photography in Geography .................................................................................................................. 12
3.3 Photography in Research ...................................................................................................................... 13
3.3 Photographic Interpretation of Landscape Change ............................................................................. 20
3.4 The Photographic Role in Shaping the American West ....................................................................... 22

Chapter 4 – STUDY AREA .................................................................................................................................. 24
4.1 Introduction ............................................................................................................................................... 24
4.2 Conservation Areas ................................................................................................................................ 25

Bob Marshall Country .................................................................................................................................. 25
Glacier National Park .............................................................................................................................. 26

4.3 Photo Point Areas ......................................................................................................................... 28

Rocky Mountain Front ......................................................................................................................... 28

East Side of Flathead Lake .................................................................................................................. 29

4.4 Photograph Sites .......................................................................................................................... 29

Photo Set One – Circle 8 Ranch ........................................................................................................... 30

Photo Set Two – Sawtooth Ridge ......................................................................................................... 30

Photo Set Three – Castle Reef ....................................................................................................... 31

Photo Set Four – Bean Lake .................................................................................................................. 31

Photo Set Five – Daphnia Pond ........................................................................................................... 32

Chapter 5 – METHODS .................................................................................................................. 33

5.1 Field Work .................................................................................................................................... 33

5.2 Post-processing of Photographs ............................................................................................... 34

5.3 Landscape Change Detection ..................................................................................................... 35

Chapter 6 – RESULTS ..................................................................................................................... 37

Photo Set One – Circle 8 Ranch ........................................................................................................... 37

Photo Set Two – Sawtooth Ridge ......................................................................................................... 37

Photo Set Three – Castle Reef ....................................................................................................... 38

Photo Set Four – Bean Lake .................................................................................................................. 38

Photo Set Five – Daphnia Pond ........................................................................................................... 39

Chapter 7 – DISCUSSION ............................................................................................................... 41

7.1 Landscape Photography ............................................................................................................... 41

7.2 Subjectivity in Landscape Photography .................................................................................... 44
Chapter 1 – INTRODUCTION

This thesis examines the use of repeat photography as a research method by conducting a case study on landscape change in the Crown of the Continent Ecosystem (CCE) in Western Montana, U.S.A. The CCE is one of the wildest and most diverse ecosystems in the temperate climate zones and is a sub-region of the greater Yellowstone to Yukon Ecosystem (figure 1), the largest intact mountain ecosystem on Earth. The CCE includes key areas such as Glacier National Park (GNP), which has been greatly impacted by climate change. GNP is predicted to have no remaining glaciers by 2030 (Fagre 2007). In addition, photographs in tourism brochures can be attributed to bringing in a portion of the millions of tourists visiting the region annually, which can also have a great impact on the ecosystem.

In order to analyze the uses of repeat photography I used several methods including: archival studies, a photographic survey, and auto-ethnographic methods utilizing extensive field notes and journals. First, archival research was conducted on the past, present, and future uses of photography as a research method. Second, a repeat photography survey was conducted in the CCE. A photographic survey allowed the documentation of natural and cultural landscape changes over time by drawing on a series of photographs obtained from The University of Montana’s Mansfield Library Archives. This involved two sets of photographs by the United States Forest Service (USFS); the first was taken between the 1870s and 1940s; the second was an inventory of the same locations, re-photographed between the late 1970s and early 1980s. I produced
a third inventory: a 2010 photographic survey of the same camera points in order to analyze landscape changes in the selected areas. This third set involved my own interpretations by using field journals and notes of my experiences and observations.

Photography has long been used in geographical research; however, in recent decades geographers have begun to question the use of photography as a valid research method. Geographers such as Gillian Rose (2008) and Peter Goin (2001) have raised questions about the subjectivity of photography and the ways in which geographers elicit photography within their own research. By conducting a repeat photographic survey case study, I also hope to contribute to the methodological discussions about the use of repeat photography in geographical research.

1.2 Thesis Outline

This thesis analyzes the subjective nature of photography as well as the use of photography in current geographical research. After giving a brief introduction in Chapter 1, beginning with Chapter 2, I provide an overview of my project background as well as a brief history of photography, starting with the first photograph recorded and ending with current day digital photography. Chapter 3, the conceptual framework, places my research within the context of broader research concerning the uses of photography. The next chapter, Chapter 4, gives an overview of the study areas for my fieldwork. Chapter 5 details my photographic survey conducted and the methods used. Chapter 6 includes my photographic survey results, while Chapter 7 details the problems encountered in the field, as well as future research possibilities. Finally, Chapter 8 is my
conclusion, which brings the research together. All supporting figures and tables are in an accompanying appendix.
Chapter 2 – BACKGROUND

2.1 Project Origin

George E. Gruell, a retired wildlife biologist with the Fire Effects and Use Research Work Unit Northern Forest Fire Laboratory in Missoula, Montana, compiled a repeat photography survey of eighty-six sites in Montana and adjacent areas of Idaho between 1979 and 1982. Gruell’s assignment was to develop baseline information on the historical influence of fire on wildlife habitats and to identify prescribed burning opportunities for improving wildlife habitats. Gruell gathered photographs from various sources for his study, some dating back to 1870.

I moved to Missoula, Montana in the winter of 2005. Originally from Louisiana, a relatively flat landscape, I wanted to experience Montana, the Rocky Mountains, and endless wilderness. Unfortunately, after arriving I was too busy with work and school to devote time to travel and experience Montana. I chose this research to enable myself to explore the areas of Montana and the Rocky Mountains that I had read about in classes. I had seen pictures of towns and surrounding mountain ranges and had imprinted an imagined geography of these places in my mind. In seeing endless photographs of Montana landscapes during my coursework I began thinking about the role that the photographs play in wilderness perceptions for people who are not familiar with such topics, in addition to the role that photographs play in research. This led me to consider the subjectivity that arises with photography such as place, topic, performance, and photographer decisions, which can all have a great impact on what is actually seen in a photograph.
Photography is not as simple as point and shoot. There is a vast array of decisions that go into a photograph, which made me question why the photographs in my project were taken in the first place. Be it for tourism promotion, evidence of a specific phenomena, political gain, nostalgia, etc., there is always some reason behind conducting photography or it merely would not exist. The original photographs in my research, for example, were taken during a time when politicians were promoting westward expansion; the earliest in 1899, only a decade after the State of Montana entered the Union. The second set of photographs was taken to promote fire management and wildlife habitat sustainability during the rise of the modern environmental movement in the United States after the publication of the pivotal book *Silent Spring*, by Rachel Carson in 1962. The third set was taken for analysis of photography as a method. There is no doubt that in the future, someone may use my photographs from 2010 for some other analysis of landscape, fire, tourism, etc., just as I have used westward expansion and fire management photographs for unrelated analysis.

### 2.2 Other Photographers

In the previous section I described my background as well as the background of George Gruell, who compiled the photographs of the original study. The photographers responsible for the images in first two surveys are listed in a table (Appendix A.2). I will give brief biographies on the photographers, H.B. Ayres, C.D. Walcott, and M.J. Elrod, for which information has been gathered. I have found little info on W.J. Reich and R.F. Wall, and there are two photos in which the photographers are unknown.
Horace B. Ayres (1856-1932), photographer of the 1899 Circle 8 Ranch photograph, had a great many publications during his career. The majority of his research was based on timber and forestry issues in the Appalachians. He also conducted research in Montana and Washington, as well as Minnesota. His most famous publication in Montana, *The Lewis and Clark Forest Reserve, Montana*, was published in 1905 and the 1899 photograph was included in the publication with the captions “a colony of half-breed woodcutters on south fork of Teton Creek” (Ayres 1905).

Charles D. Walcott (1850-1927), photographer of the 1900 photograph of Wallace Bean Ranch, was the Director of the Department of Interior – US Geologic Survey from 1894 to 1907. Walcott was a professional Paleontologist and after meeting Andrew Carnegie in 1902 became one of the founders of the Carnegie Institution of Washington. Walcott became the Secretary of the Smithsonian Institution in 1907 and served in that position until 1927. He served as president of the American Association for the Advancement of Science in 1923 and during the same time was an advisor to president Theodore Roosevelt (Yochelson 1967).

Morton J. Elrod (1863-1953), photographer of the 1902 Daphnia Pond photograph, arrived at The University of Montana in 1897 as head of the science department. He taught course in biology, protozoology, entomology, and photography. He later became head of the biology department and was extremely active in both the academic and social sides of university life. Elrod helped to found the Montana Kaimin, the campus newspaper, and founded the Montana Biological Station on Flathead Lake in 1899, one of the first freshwater laboratories of its kind in the United States. Elrod was one of The University of Montana’s most prolific photographers, photographing every
aspect of campus life during the first two decades of the 20th century. He also took many scenic photos of western Montana including the Mission Mountains, Glacier Park, Flathead Lake, and the Bitterroot Mountains. Elrod loved teaching photography and participated in many photo and camera clubs, taking students on outings to practice their skills (Mansfield Library Archives).

William J. Reich, photographer of the 1979 Sawtooth Ridge and 1979 Castle Reef photographs, graduated from The University of Montana School of Forestry in 1978 and was a temporary employee of the Fire Effects and Use Laboratory in Missoula, Montana during 1979 and 1980.

2.3 History of Photography

The first permanent landscape image was taken in 1826 by French inventor Joseph Nicéphore Niépce (1765-1833) using a camera obscura to burn an image of the countryside at his estate in Le Gras, France onto a chemical coated pewter plate. He named the technique heliography. The exposure took eight hours to complete (figure 2). Just thirteen years later, his partner Louis Jacques Mande Daguerre (1787-1851) announced his discovery of a twenty-minute exposure using heated mercury, a process called daguerreotype (figure 3). Over the years, improvements in chemical processes and optics allowed for exposures between ten and thirty seconds, greatly improving the capabilities of photography.

The British Fox Talbot (1800-1877) read about Daguerre’s invention in 1839 and acquired an effective fixer, from British astronomer John Herschel (1792-1871), who had
previously shown that sodium thiosulfate would dissolve silver salts. Later that year, Herschel made the first glass negative. By 1840, Talbot had invented the calotype process, in which he coated paper sheets with silver chloride to create an intermediate negative image. Unlike a daguerreotype, a calotype negative could be used to reproduce positive prints.

US-American George Eastmann (1854-1932) later refined Talbot’s process, which is the basic technology used by chemical film cameras today. In 1884, he developed dry gel on film, replacing the photographic plate so that a photographer no longer needed to carry around boxes of plates and toxic chemicals. In July 1888, Eastman’s Kodak camera went on the market with the slogan ‘You press the button, we do the rest.’ This allowed for anyone to take photographs and leave the complexities of processing to the professionals.

The first color photo, an additive projected image of a tartan ribbon, was taken in 1861 by Scottish physicist James Clerk Maxwell (1831-1879), but there were problems with displaying red and green light (figure 4). Autochrome, an additive color process based on a screen-plate method, reached the market in 1907. The screen let filtered red, green, or blue light into a photographic emulsion. The plate was then developed to a negative and reversed to a positive, which restored colors approximating the original when viewed through the screen.

In 1889, National Geographic Magazine published its first photograph, a halftone photo engraving of a topographic map of North America. The publication of photographs was a turning point for the magazine. It was believed that it would turn the magazine into
a picture book, but the subscription base increased from 3,000 to 20,000 within the first few years. By 1915 subscriptions reached 424,000, setting the tone for the magazine and assuring that photography would play a major role in the future of National Geographic.

As early as 1905, German optics engineer Oskar Barnack (1879-1936) had the idea of reducing the negative format and enlarging the photographs at the development stage. He took an instrument for taking exposure samples for cinema film and turned it into the first 35 mm camera, the ‘Ur-Leica’, arguably the first truly successful small-format camera in the world. The photographs created in 1914 were of incredible quality for the time. However, delayed due to WWI, the first Leica did not enter production until 1924 and was introduced to the public in 1925.

On October 17th, 1969, George Smith and Willard Boyle, at Bell Labs, invented the charge-coupled device (CCD). The CCD is the key image sensor used by all digital cameras. It was not until 1981, however, that Sony Corporation produced the first prototype digital still camera, the Mavica. The Mavica recorded images as magnetic impulses on a small two-inch floppy disk. The camera created a 720,000-pixel image and each disk could hold up to twenty-five images. CCDs are fingernail sized silicon chips that contain millions of photosensitive diodes called photosites. With the quickness of a button each photosite records the intensity or brightness of light that it encounters by accumulating a charge; the more light the higher charge. The brightness recorded by each photosite is then stored as a set of numbers that can be used to set the color and brightness of pixels on a computer screen or reconstructed for printing with ink.
2.4 History of Repeat Photography

In its infancy, photography had a documentary purpose, such as recording news events, capturing the brutality of war, and preserving images of famous people. Scientific photography began in the western United States with surveying appropriate routes for transcontinental railways (Bell 1869), and illustrating geological features of the Earth (Powell 1895). The images of many of these first photographic surveys were preserved in archives, making them available to future generations for the study of landscape change (Webb 2010).

Sebastian Finsterwalder began conducting photogrammetric surveys in 1888. He returned to the same photo points a year later obtaining repeat images of the same view (Hattersly-Smith 1966). Following Finsterwalder, early glaciologists in the Canadian Rockies used repeat photography, establishing the groundwork for a technique that has grown in importance in Glaciology (Webb 2010). Shortly after its use in glacial studies, repeat photography was soon used to document plant population and landscape changes. In 1905, ecological texts recommended using matching photo pairs to aid research on plant population management (Clements 1905). Prior to the 1940s, only a few studies used repeat photography, and those that did were narrowly focused. However, by the 1940s, repeat photography became an emerging technique for documenting landscape change. In addition, repeat photography gained popularity in the discipline of geology as a means of documenting weathering and bedrock erosion, for example in southern Utah, Bryan and La Rue (1927) compared signs of weathering over a two-decade period using images of the Navajo Twins Bluff. Prior to photography, early survey work involved
artists recording the landscape through sketches, as well as field journals from expedition members.

Lockett (1939) pioneered analysis techniques that combined historical records with photographs to describe landscape changes. Shantz and Turner (1958) completed the first book-length publication of landscape change, depicting their excursions in Africa from Cape Town to Cairo. It was the first to rely solely on repeat photography. This publication inspired many more researchers to utilize repeat photography in scientific research.

At the beginning of the twentieth century, the Carnegie Institution of Washington endowed a number of biological research stations designed to study ecosystems of the United States, the most prominent being the Desert Laboratory, in the Sonoran Desert. The Desert Laboratory embarked on many scientific studies involved with understanding adaptations of plants and animals in the regions, as well as cataloging species that occupied the area. It was not until the 1980s, however, that repeat photography began to dominate research in the Lab. Today the Desert Laboratory houses one of the largest repeat photography collections in the country. In recent years repeat photography has become well established globally as a technique to address a vast array of issue and research questions, such as fire effects and recovery, habitat assessment, land use, documenting historic routes and trails, and assessing perceptions of change (Webb 2010).
3.1 Introduction

Because of the cross disciplinary nature of photography this thesis incorporated literature from various fields. In order to grasp the timeline of photography as well as the traditional uses of photography in research, I drew from several works in art history. An understanding of landscape change research, as well as environmental field methods were needed and, therefore, literature in forestry, environmental studies, and geosciences were examined. Due to the strong focus of this thesis on perceptions and the role of photography, literature from psychology and sociology was included. Finally, because of its broad discipline, literature from geography was used to juxtapose everything together.

3.2 Photography in Geography

Since its invention, photography has changed the way we view the world around us. Probably every field including journalism, medicine, art, and geography, has been revolutionized by photography. In the field of geography in particular, photography has been used in many ways, from the National Geographic Magazine dating back to 1889, to the increased utilization in fieldwork over hand-drawn sketches. The past few decades have seen a rise in the debate of meaning and representation in photography with topics of reading and writing the landscape. Amidst these debates has been the reconsideration of the role of photography in geographic studies. There have been various works on the role of photography in recent decades including (Hall 2009; Harper 2002; Knowles and
Sweetman 2004; Lutz and Collins 1993; Markwell 2000; Pink 2001; Rose 2000, 2001, 2008; Ryan 1997; Schwartz 1996; Sidaway 2002). Reviewing such work on photography and geography, Rose (2000 p. 555) noted that:

Recent work on photography and geography has certainly focused on the meanings of things photographed. Several writers have made a strong case for the importance of photographs as a source for historical geographers ...but not because photographs accurately record what places looked like in the past. Like many other historians of photography...these geographers argue that photographs are not simply mimetic of the world they show. Rather, it is being argued that the production, circulation and consumption of photographs produce and reproduce the imagined geographies of the social group or institution for which they were made.

3.3 Photography in Research

Photography can be an invaluable tool in human geographical research, in addition to many other academic fields such as journalism, medicine, art, and history. For example, photographs can help one to better understand the landscape and practices of a given region and can act as a mirror into the eyes of a culture. Photographs can be a great resource; however, they are also subject to interpretation. Interpreting photography is subjective in that it depends on the context, the photographer, the actual content of the image, and many more variables.
When interpreting photographs there is the realistic approach, the idea of photographs as a true record; but also post-structural views, photographs can never truly capture reality and are always partial to cultural context (Hall 2009). The realistic approach or photographic survey is seen as a way of collecting, recording, and presenting information about the landscape. This method of research situates the researcher’s own observations into the heart of the research process. Photographic surveys provide a way of comparing change through time across space. The limitations to this, Hall outlines, are that while this realistic approach can be quite effective with documenting landscape change, it can be challenging when people are the subjects of a photograph.

The alternative approach that Hall describes is the post-structural view, which rejects the notion that photography is simply a record of reality. A photograph is a document that is not an absolute truth, rather it is embedded in and part of a variety of social contexts. Post-structuralists argue that a photographic survey is always partial to the subjectivity of those choices made by the photographer and the constraints within which they must work. Photography is a representation of social constructs that only show aspects of a culture, not records of complete cultures and fixed meanings. Thus, the shift must be made not to focus on the subject or content of a photograph, but rather the contexts within which photographs are produced, circulated, and viewed. The choices made about the production and display of a photograph can make a huge impact in the meaning that an audience attaches to the image, for example, an image displayed in a newspaper might have a completely different meaning attached than one displayed in an art exhibit. The key to correctly analyzing photography is to always situate and read photographs within the appropriate contexts.
Likewise, another important contributing factor is the meaning attributed by the research subjects to the phenomenon under study (Markwell 2000). Visual imagery plays an important role in modern western cultures. As a consequence, such images have been used to promote tourism, shape our understanding of nature and culture, and contribute to our perceived ideas about cultures and social groups. Photography, according to Markwell, has a profound impact on place making, how we see the world, the people and places in it, and the associated meanings we conjure. Markwell’s research in particular examines the meaning that the subjects attach to a particular place by giving the tourists cameras. By examining the photographs taken by a tourist group, also known as self-directed photography, Markwell concludes that photographic analysis is a valid method of research when working within social contexts, especially when combined with other research methods such as interviews and observations. By analyzing the self-directed photographs taken by tourists, Markwell was able to examine the meanings and ideas that tourists in particular attach to places such as authenticity and untamed versus tamed wilderness.

Douglas Harper also focuses his work on the interpretations of research subjects by inserting a photograph into a research interview, often referred to as photo elicitation. Harper argues that photographs evoke certain emotions from individuals and that the thrill found in a photograph is with the onrush of memory. This is why he argues that photo elicitation is a great way to enhance ones research interviews (Harper 2002).

Through several examples in his article, Harper states that photographs can jolt interview subjects into a new awareness of their social existence. Harper believes that “photo elicitation mines deeper shafts into a different part of human consciousness than
words alone,” thus he thoroughly encourages the use of photographs in research interviews (Harper 2002).

Although much of the research on photography use focuses on anthropological and sociological research fields, many of the same ideas and methods can be applied to geographical research. By looking deeper into a photograph, into the emotions that a photo evokes, one can gain a greater insight into a culture, social behaviors, and historical events.

Peter Goin (2001) argues, “The photograph is a constructed illusion woven within a cultural frame of reference and point of view.” Photographs displace time and space and can act as a time machine. In addition, photography is a representation not without politics according to Goin in his article *Visual Literacy* (Goin 2001). How the image is presented is as important as the image itself. The question of “For whom was the photograph intended?” needs to be considered as well as the role of the photographer. The photographer may have been a participant or an observer. He or she may have directed a scene that would otherwise not have existed or may have operated under a distorted cultural frame of reference. Captions also play a key role in photography. If the caption is removed or altered it can change the meaning of a photograph drastically. The entire idea of meaning is a social construct and therefore highly subjective to the interpreter and the context in which the image is presented.

“Every time an image is taken a fiction is created. Inherent in the medium of photography is the potential for truth” (Goin 2001). To the uninformed, Goin argues, there is the overwhelming conviction of fact. The accuracy and fine details of photography are very persuasive and many geographers depend on the presumed
accuracy of reproduced fact when using photographs in their research, rather than the
metaphorical and lyrical elements within an image. Goin suggests that there be more
research into the understanding of photography use in social science journals and that the
subtexts of visual imagery must not be ignored when conducting scientific research (Goin
2001).

Since the invention of photography in the 1830s, photographs have always played
a role in geographical studies. The use of photographs, however, has typically been to
provide illustrations of what a location looks like, as a window into whatever the
geographer is studying. It was not until recent years that geographers have started to
question the ways that photographs are used in geography. Increasingly, geographers are
looking at how photography can play an active role in the construction of geographical
knowledge; that is, how photographs are seen, rather than what they show. Gillian Rose
is a great example of a researcher that has delved into the uses and meanings attached to
photography. In her article, Using Photographs as Illustrations in Human Geography,
Rose (2008) divides photography use into two categories, researchers that use
photographs made by others, and those that create photography for their own research.
Rose explains that photographs are typically used less as illustrations or visual aids and
more as absolute representations.

Rose elaborates on the use of photography as illustrations, in that geographers
should reflect on their use of photography, the reflection of how and why a photograph is
made. By doing this one can shift to using photographs not to illustrate empirical reality,
rather, to illustrate an analysis. Photographs are not self-evident objects and careful
thought should be considered into why and how one would use photography in their own geographical studies.

When a photograph contains human subjects, there are ethical issues attached to the use of the photography; however, to take it a step further, even photographs containing only landscapes, natural and human-made, can still be a strong creator of imagined geography about a particular place or culture. A photograph need not contain a human subject to convey perceptions about humans. For example, an immaculate trail in an affluent neighborhood and a rundown park in Chicago can each project a perception about the surrounding culture. In addition, Rose argues that most work by geographers has concentrated on looking at photographs produced by the powerful and that there is a lack of research done into the areas of photographs taken by less powerful social groups.

Photography has often gone hand in hand with historical geography when documenting change; however, four key criteria need to be considered when using documentary material: authenticity, credibility, representativeness, and meaning (Emmison and Smith 2000). In the case of authenticity, photography by nature is a reproducible image and therefore the argument of authenticity comes into play. It is especially important in today’s age of digital editing software such as Adobe Photoshop. Even the most innocent touch ups can alter an image to the degree that it alters the authenticity of what it is meant to represent.

Credibility is an even bigger issue when considering that the photographer plays a very active role in the production of photographs. This is not to say there is direct trickery involved, but only that photographs should be considered a selective version of reality when interpretation is involved. For example, a photograph of an English family
could appear to give us evidence of dress style, demeanor, affluence, etc; however, there is no proof they are not dressed in their Sunday’s best, and that the photographer constructed the pose, attitude, and props to impress meaning upon the viewer. According to critical theorists, those of which argue that photographs are social constructs, some major shortcomings of photography are that it is inauthentic and linguistically reflective (Sanders 2007). Photographs say more about the photographer than the image itself.

Sanders uses photography as an aid in teaching upper level geography courses in urban landscapes. Although the photograph only tells part of a story, it can give clues into what is occurring and at what time. One downside to this is that when looking at urban landscapes it is not easy to discern what is cause and what is effect. For example, visual changes of the landscape may precede social change, e.g. a flood, earthquake...or they may lag behind social change as with businesses closing down.

When considering representativeness and meaning one has to take into account that when taking a photograph, stereotypes have already been imprinted on the senses. Thoughts have already been constructed based on education, memory, imagination, and experience. When viewing a photograph, we are seeing the past through present eyes. These must be considered when photographs are used in research. This is especially potent when factoring in social issues and policy making.

Caroline Bressey (2003) focused research into the black identity in Britain. Historical geographies of black people in Britain, she states, is sorely lacking and she therefore found that photography was a way of finding historical records of blackness. A key point made by Bressey was that while photographs may be said to record and can show a glimpse of an individual’s life – they can show religion, ethnicity, economic
status, etc. – they do not truly tell us anything about the family. The photograph is a snapshot and tells us nothing about the individuals’ lives before and after the picture. Bressey also argues that a photograph cannot ever properly speak or describe in the way that language can, yet language can easily manipulate an image and often the image is framed by the linguistic messages that surround them. The same can be said for landscape photography. For example, an image of a fertile forest only shows that moment in time. It does not tell the viewer that there might have been a fire a decade before or that the area will have succumbed to a beetle devastation years after the photograph was taken.

In addition, with any historical photograph we are seeing a representation of a past time from present eyes. Bressey suggests that the power of a photograph is not necessarily in what knowledge the past might show in the image, but in what knowledge we bring to them that make them historically significant.

3.3 Photographic Interpretation of Landscape Change

Throughout American history photography has played an important role in migration and tourism. One key state that has had one of the greatest influences from photography is California. Gregory Graalfs (2007) describes the pivotal change of California, being seen as a rugged unforgiving desert to a lush and bountiful Eden, as attributed to photographic publications. In the days of early settlement photographs were viewed as a truthful image, unalterable by man, and therefore were used and manipulated by those with vested interest in California’s settlement (railroad companies, businesses,
civic organizations, and agricultural cooperatives). Photography was a critical player in promoting the image of the State to fit the needs of interested parties.

Just as photography was important for migration to California it has also played a role in landscape change in Puerto Peñasco, Mexico (Finn et al. 2009). Puerto Peñasco changed from a fishing town to a tourist mecca in just a few decades and Finn used historical postcard images to document these changes. The postcard images also hold some responsibility for bringing in the tourists that have fueled the changes. Finn argues that tourism is the key contributor to the changing landscape by conducting repeat photography. According to Finn, his research shows how repeat photography can be employed to understand the transformation of a humanized landscape. However, a critical mistake arises in Finn’s assumptions that the pictures show evidence of human caused change. Finn states, “repeat imagery takes a viewer beyond a single depiction of a historical landscape and creates a narrative of place through time.”

This is a critical error and often reoccurring problem when it comes to using photographs in research. Researchers use photographs as evidence rather than just to visualize the research. Researchers should not make the mistake of regarding photographs as pure evidence in landscape change. Photographs are snapshots of change, but they cannot define the change. The how and why need to be answered with other research methods that can support the change viewed in the photographs. When photographs are used as an object of absolute truth, to manipulate actions, and further agendas, it threatens the validity and credibility of the research and the researcher.
3.4 The Photographic Role in Shaping the American West

During the Nineteenth Century photography found its place in the American West. The ideas of the American West loomed in the imagination of Americans. Known only through paintings, drawings, and stories from travelers, it was fabled as an exotic place with exquisite topography and the keystone for the future of America. Due to the initiative of photographers in preceding settlers to the West, reinforcing the imagined perceptions of grandeur, photography became a substitute for firsthand experience. The relationship between photography and the American West is a co-dependency. Emerging ideas about the West enforced an understanding of the potential uses of photography, and in turn the pictorial representations of the West shaped popular thought about the very subjects they portrayed (Klett 2004).

As the West became better known during the late Nineteenth Century, attitudes towards the West shifted. Photography had a great role in this change. Captions included with the photographs directed viewers’ understanding of the images, imposed meaning, and favored one interpretation over others. These words constructed narrative stories out of static images, reinforcing the preconceived ideas about the West that many Americans had conjured. At the same times the public remained unaware that the words enhanced the views and intentions of their creators more so than the subjects they claimed to represent. Martha Sandweiss (2002) argues that no part of American historical imagination is so shaped by visual imagery than the imagined view of the Nineteenth Century West. Photography’s role in this area is central, because photographers were witnesses to the epic story of the American settlement of the western
half of the continent. Sandweiss (2002) in her publication, *Photography and the American West*, discusses the intricacies of the ability for countless Americans to summon visual memories of key historical events, places, and people such as Geronimo, Custer, gold miners, homesteaders, the rock peaks of Yosemite and the steep walls of the Grand Canyon, all through photography.
Chapter 4 – STUDY AREA

4.1 Introduction

The Crown of the Continent Ecosystem (CCE) is a ten million acre wilderness complex bordering the U.S.A and Canada, containing Glacier National Park and Waterton Lakes National Park. The study area for this research is the U.S. portion of the CCE in northwestern Montana (figure 5). The major wilderness conservation components in the study area include the Bob Marshall Wilderness, Scapegoat Wilderness, and Great Bear Wilderness. As the headwaters of three of the largest river basins in North America – the Columbia, Missouri, and Saskatchewan – the CCE is the home to numerous watersheds. Furthermore, the CCE is home to 1,200 species of native vascular plants, over 240 species of birds, and more than 65 species of native mammals, providing critical habitats to grizzly bears (*Ursus arctos horribilis*), mountain goats (*Oreamnos americanus*), gray wolves (*Canis lupus*), lynx (*Lynx canadensis*), and elk (*Cervus elaphus*). Approximately 100,000 people live within the borders of the CCE and an additional million tourists visit it annually. In 2009 Glacier National Park received a 12.4 percent increase in visitors from the previous year, reaching over two million visitors.
4.2 Conservation Areas

*Bob Marshall Country*

The Secretary of Agriculture officially designated the Bob Marshall Wilderness on August 16, 1940. ‘The Bob,’ as locals call it, finds its borders in the east at one hundred ten miles of craggy limestone mountains, including Ear Mountain, a prominent Front Range peak. The Bob’s western edge is at the Swan Range, while the northern border is at Glacier National Park and Marias Pass, and the southern terminus is the valley of the Blackfoot River. No single road crosses The Bob, but it can be circled by highway, a 380-mile journey. Bob Marshall Country comprises the Bob Marshall, Great Bear, and Scapegoat Wilderness areas encompassing 1.5 million acres in addition to one million acres of surrounding wildlands.

The Continental Divide is the backbone of the Bob, and two of Montana’s most prized rivers get their start in the Bob: the South Fork, starting at the Danaher River on the southern boundary of the wilderness, and the Middle Fork, starting as only a trickle from Strawberry Creek at Badger Pass along the Divide. Other prominent streams and rivers that emanate from the Bob are the Sun River, the South Fork of Two Medicine River, Birch Creek, Badger Creek, and the Dearborn River.

The peaks of the Bob are not high in comparison to other Montana mountains with the highest, Red Mountain, rising only 9,411 feet. However, because they start at a considerable low elevation, the peaks of the Bob appear much taller than the numbers recorded. The Chinese Wall, a thirteen-mile long limestone escarpment with an abrupt rise of 1,000 feet above its eastern side, is one of the many unusual features in the Bob.
The Chinese Wall can only be reached on foot, but it is well worth the hike as the views are spectacular. Heavy snow loads, especially on the Swan Range and the peaks directly south of Glacier National Park, feature several high cirque glaciers, and the small alpine ice fields that remain on the slopes of Swan Peak, Holland Peak, and Great Northern Mountain, are remnants of the large valley glaciers that sculpted the wilderness long ago. The Rocky Mountain Front with its towering limestone walls rocketing above the prairie is the easternmost and best-known range not only for its location and grandeur, but also for its controversy over oil and gas exploration.

The pristine country of the Bob is known for its mixture of big grassy meadows and dense forest. The dominant trees in the area are ponderosa pine, larch, Douglas fir, lodgepole pine, aspen, and cottonwood. The abundance of wildflowers is also a prominent feature of the Bob Marshall Wilderness.

Virtually all of the land in the wilderness areas and surrounding wildlands is under US Forest Service control and is accessible to the public. Many outfitters and guides offer trips into the wilderness for sightseeing, hunting, fishing, and backpacking, and the extensive trail system provides routes in just about any direction. The roads that lead to or near the wilderness boundaries provide only a small sampling of what lies just beyond.

Glacier National Park

The nation’s tenth National Park, Glacier National Park, was designated in 1910. Glacier is home to some of the most beautiful mountain peaks in Montana. Like the Bob
Marshall Wilderness ranges to the south, this northern extension of the Lewis Overthrust (a geologic fault structure, meaning that older rocks slid over younger rocks), was pushed eastward with great force leaving behind the trenches that became the Flathead and North Fork Valleys. It is estimated that the rocks were moved thirty to fifty miles from their original location to form the peaks in Glacier National Park. There are an estimated thirty-seven active alpine glaciers scattered throughout the 1,538 square mile park. The largest of the glaciers include the 430-acre Blackfoot, the 217-acre Grinell, and the 220-acre Sperry. At one time glaciers filled most of the area’s valleys, but it estimated that at the current rate of warming and melting, all of the remaining glaciers will be gone by the year 2030 (Fagre 2007).

In addition to the glaciers it is named for, nearly two-thirds of the park is covered with rich evergreen forests. On the west side of the park in the area of McDonald Lake, there is an abundance of moisture allowing for the tall Western Red Cedars to flourish, while the heavy forests on the slopes to the north provide excellent habitat for endangered Grizzly Bears.

The only road to cross the park is the narrow and winding Going-To-The-Sun Highway. Construction was completed in 1935, giving travellers the ability to see parts of backcountry from the comforts of their vehicle. However, the majority of the park is wilderness and there are over 700 miles of trails. The areas only accessible on foot are some of the most spectacular places in the country (Graetz 2003).
4.3 Photo Point Areas

*Rocky Mountain Front*

The majority of the photographs in this study are located along the Rocky Mountain Front, a 120-mile north-south stretch of geography where the plains abruptly hit the mountains. Because of its brilliant convergence of mountains and plains, with no transition zone of foothills, it is one of the most biologically diverse regions in the United States. It is the only place in the United States where grizzly bears still venture onto the prairies.

The Front has little human population. However, the biggest threat facing it today is the subdivision of land. If the land is subdivided, the risk to wildlife habitat and species diversity is very high and the exploitation of resources would ensue. There have been major collaborative efforts from conservationists and surrounding communities to preserve the wild lands of the Front.

There are few roads that head west into the mountains from US 287. A northern road, highway 89, extends west from Choteau, population of 1,781 (US Census Bureau 2000), into the Teton Canyon. One from the community of Augusta, population approximately 284 (US Census Bureau 2000), points towards Gibson Reservoir and the Sun River Canyon, and another is south of Augusta and heads toward Dearborn Canyon and Bean Lake. These roads are some of the only roads to extend into the Rocky Mountain Front, and they do not extend far. Access into the wilderness is limited to foot traffic or horseback beyond the terminus of the roads.
East Side of Flathead Lake

One photograph was located on the east side of Flathead Lake and to the west of the Bob Marshall. Flathead Lake is the largest body of freshwater west of the nation’s heartland. Flathead Lake boasts 185 miles of shoreline. Due to its unique microclimate, more moderate weather than typical of Montana and less radical temperature changes, one can see cherry groves lining the shore of the lake.

The town of Bigfork sits at the northeast corner of the lake with a population of 1,421 (US Census Bureau 2000). Bigfork was named for the Swan River, a fork of Flathead River that enters the lake at that point. The town was settled by Everit Sitler, who planted 500 apple, cherry, plum and pear trees on the east shore.

4.4 Photograph Sites

The photographs used are part of a collection originally chosen by George Gruell, retired USFS Wildlife Biologist, for a re-photographic survey conducted between the late 1970s and early 1980s. Gruell chose photographs located in mid-latitude areas due to the higher presence of vegetation. Gruell’s research focused primarily on fire areas for habitat management, therefore all eighty-six photograph pairs are related to fire and vegetation change (Gruell 1983).

By accessing Gruell’s photo collection, through the University of Montana’s Archives, I have chosen a smaller photo sample. Although I would have loved to re-
photograph the entire collection that Gruell used, the prospect was not possible due to time constraints for fieldwork and limited funding for the project. As a result, a sub-region of the CCE was chosen, primarily for accessibility and proximity to the University of Montana, as well as the importance of the region to local ecosystems. From the original eighty-six photo pairs, fourteen photo points were chosen, but only five were repeated due to accessibility in the field.

**Photo Set One – Circle 8 Ranch**

The camera point is located on a ridge above the road to the Circle 8 Guest Ranch, overlooking the south fork of the Teton River. The view is looking south-southeast, about thirty-five miles west of Choteau, Montana. The photos were taken in 1899, 1981, and 2010 (figures 6a, 6b, 6c). The ranch was opened in 1930 by Kenneth and Alice Gleason, who offered a rustic retreat in the Rocky Mountain Front. The ranch was later donated to The Nature Conservancy and has been operated since 1978 under the name Pine Butte Ranch.

**Photo Set Two – Sawtooth Ridge**

The view is located just outside the northwest point of the Sun River Game Range, looking south towards Sawtooth Ridge. The photos were taken in 1909, 1979, and 2010 (figures 7a, 7b, 7c). In 1948 Montana Fish and Game Department set aside nearly twenty thousand acres along the Rocky Mountain Front as a winter range for the
Sun River elk that drifted onto the ranches in the area during the winter. Today’s goal of the Montana Fish, Wildlife, and Parks for the Sun River Wildlife Management area is to maintain and enhance habitat diversity for elk and other wildlife that frequent the preserve.

*Photo Set Three – Castle Reef*

The camera views the opposite direction from the previous camera point (photo set two), north towards Castle Reef, across the road at the northwest point of Sun River Game Range. The photos were taken in 1909, 1979, and 2010 (figures 8a, 8b, 8c).

*Photo Set Four – Bean Lake*

The photo point is located near Dearborn River, in Northwestern Montana, approximately sixteen miles south of Augusta, Montana. The view towards the southwest is located across from Wallace Bean Ranch, near Bean Lake fishing access. The photos were taken in 1900, 1981, and 2010 (figures 9a, 9b, 9c). Bean Lake is an isolated small lake, sitting at an elevation of 4500 feet, at the edge of the Rocky Mountain Front. The lake site encompasses seventeen acres and has a variety of species including: rainbow trout, Flathead Chub, Lake Chub, and Longnose Sucker. Free camping is found along the public shores of the lake.
**Photo Set Five – Daphnia Pond**

The camera view faces north towards Daphnia Pond and the Swan Range in the distance, on the east side of Flathead Lake, three miles north of Woods Bay and across the highway from the Lutheran Camp. The photos were taken in 1902, 1981, and 2010 (figures 10a, 10b, 10c). Daphnia Pond lies along the road about a mile and a half from the Flathead Lake Biological Station. It is a small land-locked pond of glacial origin and was given its name for the great numbers of entomostracan *Daphnia pulex*, a crustacean arthropod also referred to as water fleas, found in the pond (Elrod 1902).
Chapter 5 – METHODS

5.1 Field Work

Gruell’s publication of the eighty-six photo pairs provided little information on the photo locations other than a brief description of each photo (Gruell 1983). The coordinates given in Gruell’s publication used the Public Land Survey System (PLSS), which gave approximation of photo points within one square mile; therefore, for this study the locations were narrowed down further with Google Earth and driving routes were decided. Topographic maps were then gathered for the study areas from the Mansfield Library, as well as Bill Cunningham, a resident of Choteau and backcountry guide that allowed me to stay in his home, and offered expertise on the study areas, in addition to the use of his extensive map collection. The topographic quadrangles gathered include Cave Mountain for photo set one, Sawtooth Ridge for photo sets two and three, Bean Lake for photo set four, and Bigfork for photo set five; however, photo set five did not require cross-referencing the topographic map since it was located along the highway. Copies of the photos were also taken into the field to aid in finding and capturing the correct landscapes.

In order to replicate the camera points as accurately as possible, several factors were taken into consideration. First, different camera lenses produce different displacements of objects in space; therefore, a lens with similar characteristics to the original should be used for the greatest accuracy in reproduction. Unfortunately, information pertaining to the original photographs, lenses used, or even camera types was not available; as a result the lens used for the 2010 photographs was decided with regard
to availability rather than replication. The camera used for the 2010 photos was a Nikon D70s with a 28-85mm lens and polarizing filter. Second, depending on the location, the camera points needed to be adjusted to account for trees or other obstacles. Finally, attention was given to lighting and shadows. These can differ dramatically with seasonal changes, time of day, and variations in weather and therefore, were a factor when replicating the photographs. It just so happened that the summer of 2010 turned out to be a very wet summer for Montana. This led to many complications of clouds obstructing views and roads in poor conditions due to heavy rains.

In order to facilitate future research and aid in analysis, it was crucial to keep extensive field notes that included the time and place of the photographs. Several types of location descriptors were used including: place names, mile markers along highways, geographic coordinates using a handheld Garmin GPS 72 as well as a field journal. The advantage of the field journal was to draw on not only the scientific findings, but also on the subjective human side of research.

5.2 Post-processing of Photographs

When dealing with photography and remote sensing, one is typically involved with aerial photography and to a lesser degree oblique aerial photography (Lillesand and Keifer 2000). Repeat ground based landscape photography has been increasing in popularity, but the majority of interpretation methods of those photos has been limited to qualitative research (Clark 2005). Ground based time series photographs have mainly been left to visual interpretation. In order to increase the accuracy of visual
interpretation, this research used methods developed by Fagre et al. (2007) in their research on landscape change analysis in Glacier National Park.

Modern computer software significantly aids in the processing and analysis of photographs. I used Adobe Photoshop® to manipulate the photos in order to get them all the same size and resolution. Photo sets one, two, and five were resized to 2400 by 1800 pixels due to the constraints of the original photos, while photo sets three and four were resized to 4800 x 3200 pixels. This made the analysis portion much smoother, although because of the differences in camera angles, it was not possible to overlay and crop them perfectly.

5.3 Landscape Change Detection

The photos were then taken into ArcMap and a fishnet grid was created on all of the photos. The grid was 25 by 25 allowing for 625 individual cells. Trying several sizes and visually judging the greatest number of cells before reaching diminished returns made the decision of 625 cells. Each cell of the grid is an individual polygon, allowing for detailed information about land cover to be stored in each cell. The cells were assigned according to majority category within the given cell by visual interpretation. The grid attribute table had a field added for type and the cells were then manually classified using six basic categories including: 1 – ‘bare ground and rock’, 2 – ‘grass and non-tree vegetation’, 3 – ‘trees’, 4 – ‘manmade’, 5 – ‘sky’, and 6 – ‘water’. The class ‘sky’ was useful for determining the accuracy of the repeat photo point angles; for example, if there is significantly varying amounts of sky present between photos of the
same camera point the conclusion that the re-photos were not captured accurately could be made. The counts for each category were exported into an excel file in order to calculate percentages for each category. In addition, the colors in all of the photos were adjusted using the stretch option in ArcView in order to optimize the greatest visual accuracy when assigning classifications (figures 11 – 14). Once all of the grids were given a classification, the symbology was adjusted to make it easy to see the differences when comparing photographs (figures 15 – 18).
Chapter 6 – RESULTS

Photo Set One – Circle 8 Ranch

George Gruell (1983) noted that in the 1899 photo the foothills had been “repeatedly overrun by fire.” In addition, Gruell noted that snags were distributed across the landscape and that it was apparent that livestock had heavily grazed the valley.

Gruell described the 1981 photograph as showing evidence of mature aspen stands and that the slopes supported dense conifer cover, while the canopy cover resulted in loss of shrubs on the canopy floor. A gradual decrease in bare ground and grass occurred between all three photographs with a slight increase (3%) in trees from 1899 to 1981, and then an almost doubling (91%) of the number of trees from 1981 to 2010 (table 1). The 2010 photograph shows an 19% reduction of bare ground from the 1981 photograph, and a 78% reduction from the 1899 photograph. There was also a 200% increase in the manmade class from 1899 to 1981, the result of cabins and structures built in the area, however there was a complete loss of those cabins in the 2010 photographs.

Photo Set Two – Sawtooth Ridge

All three photo points were of such varying angles that the grid overlay was not used. Instead, visual interpretation was the only method used to estimate changes, in addition to the previous interpretation from George Gruell. Gruell (1983) described that the original 1909 photo depicts evidence of past fires; in particular, fires had swept the northwest ridge. The 1979 photo had a significant increase (10-15%) of coverage by
Douglas fir. In areas of conifer competition, aspen declined dramatically. By 2010 it seems that half of the tree cover was diminished. The 1909 photo showed fenced areas of livestock grazing, which were no longer present in 1979. There was a different fence erected in the 1979 photo, the previous border of the Sun River Game Range, but the fence border had shifted by 2010 allowing for more foothills and grasslands.

Photo Set Three – Castle Reef

A significantly steady increase (74%) in grass and non-tree vegetation occurred from 1909 to 1979, and then again (12%) from 1979 to 2010, with a steady decrease (42% and 12%, respectively) in tree cover (table 2). The predominant conifers in the 1909 photo are limber pines in the mid-ground and far slopes and a large aspen stand occupying the middle portion. The 1979 photo showed a lack of trees in the mid-ground and distance, a result of a fire in 1919. Limber pine on the near slope as well as in the upper left of the photo were also thinned by the same fire, in addition to the previously mentioned large aspen stand. Manmade was increased in the 2010 photo, due to the presence of a fence post in the lower left portion of the photo. There was a significant gradual decrease (49%) in trees from the 1909 to the 2010 photo.

Photo Set Four – Bean Lake

The results show an increase (8%) in tree cover from the 1909 photo to the 1981 photo, and then another increase (57%) to the 2010, with a decrease (82% and 50%,
respectively) in bare ground (table 3). George Gruell (1983) noted that the 1900 photograph showed evidence that snags and early succession aspen, willow, and other deciduous vegetation attest to wildfire in the late 1800s. By the 1981 photograph the cabin in the 1900 photo was no longer standing and the drainage bottom in mid-ground supported mature cottonwoods, aspen, and willow. The slopes in the distance that were formerly open were covered by Douglas fir. The 2010 photograph depicts an abundance of Douglas fir, willow, aspen, and cottonwood. The once open slopes are barely visible and the foreground also has significant tree cover. Although the cabin in the 1901 photo was no longer present in the 1981 photo, a different manmade structure was present keeping the percentage for the class the same. No cabin was visible in the 2010 photo, but a fence along the bottom left corner of the photograph was present increasing the manmade class by 800%. Grass also showed a significant increase (400%) from 1901 to 1981, and a small decrease (40%) from 1981 to 2010.

**Photo Set Five – Daphnia Pond**

The Daphnia Pond study area experienced significant change between the three photos. There was an increase (130%) in tree cover overall and decrease (100%) in water. The area that was once dominated by water was replaced by grass and non-tree vegetation (table 4). In the 1902 photo there was evidence of the fire in the 1800s that killed the majority of the coniferous forest around the pond. The 1981 photo showed dense regeneration of conifers including ponderosa pine, Douglas fir, larch, and spruce, in addition to the cottonwood and dogwood along the pond’s edge (Gruell 1983). The
2010 photo showed no presence of water with trees dominating the view. Tree cover increased by 103% from 1902 to 1981 and by 13% from 1981 to 2010. The 1981 photo had a small structure in the distance accounting for less than 1%, but by 2010 that structure was missing. The bare ground that was present in the 1902 photo was also missing by 1981 and remained absent in 2010.
Chapter 7 – DISCUSSION

7.1 Landscape Photography

There are many factors that make it difficult to analyze landscape photography including view blockage, scale variability, image quality, and photographer subtleties, which all have an impact on classification accuracy. Landscape photography is typically acquired from ground-based locations at severely oblique angles. These angles result in blockage from screening vegetation and terrain. If there is a large tree or object close to the camera point, the result is a blockage of a larger portion of landscape in the distance, making landscape analysis of blocked areas impossible without an aerial or bird’s eye view. This can have a radical effect on the land cover classification accuracy.

In addition, the oblique angles result in considerable distortion of scale variability with objects near the camera point appearing larger and objects at a distance appearing smaller (Richards and Jia 1999). Scale variability is of great concern when conducting land cover analysis. With aerial photography analysis there are formulas for easily calculating scale variability, as objects directly in the center of the photograph have the least amount of distortion and objects furthest from the center or nadir have the greatest distortion. Images acquired at nadir, meaning that the camera or viewpoint is directly or near directly overhead and the view angle is perpendicular to the surface, can be georectified (converted to a scaled two-dimensional representation of the landscape). Once an image is georectified it can then be used to determine vertical cover or other features. With oblique photography, however, one would have to conduct measurements
and calculations in the field in order to minimize scale variability. This is not always practical if photographing great distances and wide angles.

Image quality is also directly related to classification accuracy. The greater the image quality the better visual accuracy when trying to classify land cover; as such, poor image quality will result in lower accuracy. This is often a huge problem as many historical photos are of poor image quality making them difficult if not impossible to use for accurate classifications.

Another factor involves the photographers themselves. Every photographer has a different agenda with respect to accuracy. When using images that are created by others, we have to accept the variables of the photographer that created the image. Some photographers are extremely precise with photographic techniques, obtaining virtually identical reproductions, while others are much less accurate making it nearly impossible to quantify comparisons. When using historical photographs that have maybe two, three, or even more photographers, we are not only looking at the landscape changes in the photos, but in the intersection of the different minds involved (Wyckoff 2006).

This combination of factors makes it impossible to use the same analysis techniques used for aerial photographs. Due to a lack of analytical technology, landscape images have typically been interpreted using visual comparison methods, which can be quite subjective.

The methods used in this analysis do help to quantify changes between time series photographs; however, it is still subject to interpretation by the researcher. The researcher must manually assign classifications for every cell in the grid. The grid created for this research contained 625 cells, a large number but still possible.
originally hypothesized that accuracy would undoubtedly increase with a greater number of cells resulting in a smaller individual cell size; however, Dan Fagre (2007) noted while comparing cell size with two separate photo pairs, that the land cover percentages did not change significantly with changes in cell size. Fagre tested one cell size and then analyzed a grid four times larger than the first. Upon analysis, using three categories: bare ground, some land cover, and complete cover, Fagre discovered that while the bare ground and complete cover percentages both decreased with larger cell sizes and the partly covered percentage increased, the general land cover change trends remained the same aside from slight categorical shifts. As a result, cell size should be chosen based on factors other than accuracy, such as the goals of the analysis as well as time available. For example, the classification techniques become quite tedious if the number of cells is increased significantly, meaning that the individual cells are smaller. This can become even more problematic if a researcher has 200 photographs to analyze. Fortunately, I did not have a great number therefore the analysis was manageable.

More research needs to be done in the way of automating analysis of larger sets of photographs using possible methods of spectral signature classification techniques. For the purpose of this research the analysis achieved by the implemented method is quite acceptable. This research is not interested in species-specific distribution, but with land cover change in a very general manner (are there more trees or less than previous years?). In addition, the goal of this research was not focused on actually analyzing and documenting landscape change in the region, as five photographs would not be a large enough sample size to be representative of the study area, but rather with analyzing the use of photography.
7.2 Subjectivity in Landscape Photography

The subjective nature of photography makes it extremely difficult to accurately quantify landscape change using photographs. Photographs can only show a snapshot of what has happened to the landscape around us. For example, by just comparing the photographs of the study areas, they all show increases in tree cover and vegetation from the earliest photographs to the second set. However, a vast amount of landscape changes occurred in between when the photographs were taken. Historical records, prior and post knowledge, archival studies, and much more all have a role in determining the causes of change seen in a photograph. When using photographs in research one must always be aware of the variables surrounding those images.

For Example, in 1964, during the second week of June, the worst natural disaster in Montana’s history occurred. Heavy rains descended on the state and quickly turned the once picturesque creeks into raging, mile-wide rivers. Dams, roads, and railroads washed out, homes and ranches were swept away, and thirty people died in the devastation. The area affected by the flood amounted to nearly thirty thousand square miles, or roughly twenty percent of the state. On Thursday, June 11th, President Lyndon Johnson declared nine counties in northwest and north-central Montana a federal disaster (Parrett 2004).

This had a major impact on the landscape changes in the majority of my study area, but, the photographs do not accurately show this change. They do not tell whether there was more or less vegetation immediately before the flood.
Other factors that contribute to the cause of changes seen in the photographs include political decisions in the region and fire management. On August 16, 1940, the Secretary of Agriculture designated the Bob Marshall Wilderness. Virtually all of the land designated as well as the surrounding lands are under United States Forest Service control and accessible to the public. The land was set aside, with no roads or human infrastructure and the idea of preserving an area that is wild and free. This idea of conservation has undoubtedly had an impact on the amount of vegetation growth in the region. In addition, fire policy from the US Forest Service has also played a pivotal role in the landscape changes in the study area.

The US Forest Service, since its creation in 1905, has traditionally had a very strict fire suppression policy. This was exacerbated by the need for the agency to prove their qualifications. The Forest Service needed an uncomplicated anti-fire message for the public and came up with Smokey Bear’s anti-fire message “only you can prevent forest fires,” which became one of the most successful advertising campaigns in history (Kerr 2006). It was not until 1970 that the Forest Service acknowledged the ecological importance of fires. In 1978, the agency abandoned its previous fire policy requiring all fires to be extinguished as quickly as possible, and began taking advantage of topography and terrain differences to allow more fires to burn under controllable circumstances. However, in the late 1980s a series of extreme fires occurred leading to congress pushing for more fire suppression and pouring extra funding into the agency (O’Toole 2006, 219).

The difficulty in fire suppression policies is that not all landscapes are the same and therefore not all policies fit. In the Rocky Mountains for example, lodgepole pines are prominent. These conifers are serotinous, meaning that they only release seeds when
exposed to extreme heats. Other species of the Northwest such as larch, ponderosa pine, and Douglas-fir grow thick bark which allows older trees to withstand periodic light burning. It would appear that fire suppression policies withheld by the agency that also manages the study area in this research have a profound impact on the vegetation growth and decay cycles in the region. Due to their subjective nature photographs should not be used to define the change that has occurred in a given region, but rather only support primary research in the given region.

There is debate in the field of photography on whether every photograph tells a story. The photographer, Diane Arbus, was famous for photographing scenes and then choosing the most unreal odd photos out of hundreds. One of her most famous is the *Child with Toy Grenade in Central Park* photograph. The photograph features a boy, with the left strap of his overalls off of his shoulder; tensely hold his thin, long arms by his side. In one hand he is clenching a toy grenade, while the other is in a strange claw like gesture; his facial expression is maniacal. Arbus captured the photograph by having the boy stand while circling around him for the correct angle. The boy growing impatient with Arbus told her “Take the picture already!” The photograph shows his frustration with the whole process of being photographed as the contact sheet reveals. The photographs on the contact sheet show a very happy child. However, without this additional information, one may get a very different idea of who this boy is and what he is thinking.

Many photographers like Arbus argue that the camera creates something that would not have otherwise existed, because the camera is able to capture instances, expressions, and gestures that are missed with the naked eye. This idea of photography
brings in a whole new way to analyze photography used in research and different ways of
digging deeper into photographic interpretation. If the lens actually does create the
images we see, then we are not photographing the landscape but creating the landscape.
The photographs we have taken have influenced our perceptions of wilderness, sense of
place, and actions of conservation; thus photography has created the world we see around
us.

Unfortunately, one of the most significant shortcomings of this research was the
lack of information available on the historical photographs. The purpose of this study
was to draw on the deeper meanings behind the photographs, but due to the absence of
information about the photographers’ experiences, there is the absence of depth that was
desired with this research.
Chapter 8 – CONCLUSION

My hope with this research was to impress upon the many researchers utilizing repeat photography to not just think about the when and where involved with the photographs in their study, but the how and why. Every photographer, in some way, shape, or form, embeds their soul into the photographs they produce. By looking deeper into the images created, one can gain a better understanding of the human thoughts and behaviors associated with those images. Trudi Smith (2011) said it best in her research on *Repeat Photography as a Method for Visual Anthropology*: “The intellectual effort of seeking to understand the perception of an early photographer is often as scientifically rewarding as identifying how the landscape has changed.” In addition, Smith articulates that the great strength of repeat photography as a method is in the act of doing it, rather than in the product itself. The process of conducting a photographic survey involves archival studies, finding and reoccupying historical locations, and in ground truthing, which provides new ways of viewing and using images to understand not only the process involved with repeat photography but also how we understand space and place.

Research is not solely involved with simple quantification, but in the human processes behind it. We are all human and those factors need to be brought to the forefront of scientific theory. Humans are emotional beings and photography has long been considered an artistic expression of those emotions. These factors must be considered if one is to truly understand the landscapes in which we roam.
When I started this research I did not want to just go out and take pictures. I wanted to provide future researchers an insight into why I embarked on this journey. In traveling along the back roads of Montana and visiting small communities I was able to experience some of the unique ideas of what it means to be a Montanan. The people that grow up in these parts are a unique breed. They have a close connection with and deep respect for the land in which they live. Perhaps the greatest things I will carry on beyond this research are the interactions with the folks in Choteau, Montana. They fit the quintessential definition of the small town neighborly relationships that so many of us dream about. I was welcomed wholeheartedly into the community as if they had known me for a lifetime.

This experience of conducting a repeat photographic survey has given me a connection with a region that I never thought was possible. I approached the project with a preconceived idea of Montana and the Rocky Mountains. I was expecting untamed wilderness, abundant wildlife, and little to no human influences. In contrast, I discovered that the region, while it contains what many view as stereotypical wilderness, also shows evidence of taming and being touched and altered by man. All of the areas in my study were near roads, surrounded by large ranches with livestock grazing, and had been that way for over one hundred years. Even so, the people that live and work in the region, giving it the human touch, make the area what it is and those are also the same people that have influenced and reinforced our spirit of conservation.

The path has now been set for those wanting to continue this work and this research will hopefully impress upon the next generation of researchers a deeper understanding of the photographs in this study. There has always existed a need to add to
the historical record of the world. With this record that I have created, others can mine
deeper into the perceptions of wilderness, landscape, and nature that influences and is
influenced by photography.
References


Elrod, Morton. 1902, Daphnia Pond: A Study in Environment, Lectures at the University of Montana Biological Station, Bulletin of the University of Montana. P: 230 – 233


Graetz, Rick. (2003) This is Montana: a geography-geographic history of Montana / vii, 440 p.: ill.; Helena, Mont.: Northern Rockies Pub..


Guide to the Morton J. Elrod Papers, 1885-1959; Archives & Special Collections, Maureen and Mike Mansfield Library, The University of Montana-Missoula


Hattersly-Smith, G. 1966 The symposium on glacier mapping, Canadian Journal of Earth Sciences 3:737-743


Appendices
A.1 Photographs

Figure 1: The Yellowstone to Yukon region, Y2Y Conservation Initiative, 2011.
Figure 2: Le Gras, France, Niépce 1826

Figure 3: The first photograph featuring people, Daguerre 1839
Figure 4: The first color image, James Clerk Maxwell, 1861

Figure 5: Study area locations in the CCE, Dusty Waltner 2011
Figure 6a: USGS Photograph of Circle 8 Guest Ranch by H.B. Ayres, 1899

Figure 6b: USGS Photograph of Circle 8 Guest Ranch by R.F. Wall, 1981

Figure 6c: Photograph of Circle 8 Guest Ranch by D.L. Waltner, 2010
Figure 7a: USGS Photograph of Sawtooth Ridge by unknown photographer, 1909

Figure 7b: USGS Photograph of Sawtooth Ridge by W.J. Reich, 1979

Figure 7c: Photograph of Sawtooth Ridge by D.L. Waltner, 2010
Figure 8a: USGS Photograph of Castle Reef by unknown photographer, 1909

Figure 8b: USGS Photograph of Castle Reef by W.J. Reich, 1979

Figure 8c: Photograph of Castle Reef by D.L. Waltner, 2010
Figure 9a: USGS photograph of Bean Lake by C.D. Walcott, 1900

Figure 9b: USGS photograph of Bean Lake by R.E. Wall, 1981

Figure 9c: Photograph by D.L. Waltner, 2010
Figure 10a: USGS Photograph of Daphnia Pond by M.J. Elrod, 1902

Figure 10b: USGS Photograph of Daphnia Pond by G.E. Gruell, 1981

Figure 10c: Photograph of Daphnia Pond by D.L. Waltner, 2010
Figure 11a: Color enhanced Circle 8 Ranch, 1899

Figure 11b: Color enhanced Circle 8 Ranch, 1981

Figure 11c: Color enhanced Circle 8 Ranch, 2010
Figure 12a: Color enhanced Castle Reef, 1909

Figure 12b: Color enhanced Castle Reef, 1979

Figure 12c: Color enhanced Castle Reef, 2010
Figure 13a: Color enhanced Bean Lake, 1900

Figure 13b: Color enhanced Bean Lake, 1981

Figure 13c: Color enhanced Bean Lake, 2010
Figure 14a: Color enhanced Daphnia Pond, 1902

Figure 14b: Color enhanced Daphnia Pond, 1981

Figure 14c: Color enhanced Daphnia Pond, 2010
Figure 15a: Classification photo Circle 8 Ranch, 1899

Figure 15b: Classification photo Circle 8 Ranch, 1981

Figure 15c: Classification photo Circle 8 Ranch, 2010
Figure 16a: Classification photo Castle Reef, 1909

Figure 16b: Classification photo Castle Reef, 1979

Figure 16c: Classification photo Castle Reef, 2010
Figure 17a: Classification photo Bean Lake, 1900

Figure 17b: Classification photo Bean Lake, 1981

Figure 17c: Classification photo Bean Lake, 2010
Figure 18a: Classification photo Daphnia Pond, 1902

Figure 18b: Classification photo Daphnia Pond, 1981

Figure 18c: Classification photo Daphnia Pond, 2010
<table>
<thead>
<tr>
<th>Photo</th>
<th>Date</th>
<th>Photographer</th>
<th>Aspect</th>
<th>Location</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>July 19, 1899</td>
<td>H.B. Ayres</td>
<td>SSE</td>
<td>Circle 8 Ranch</td>
<td>1555 meter</td>
</tr>
<tr>
<td>1b</td>
<td>Sept 8, 1981</td>
<td>R.F. Wall</td>
<td>SSE</td>
<td>Circle 8 Ranch</td>
<td>unknown</td>
</tr>
<tr>
<td>1c</td>
<td>2010</td>
<td>D.L. Waltner</td>
<td>SSE</td>
<td>Circle 8 Ranch</td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>1909</td>
<td>unknown</td>
<td>S</td>
<td>Sun River Game Range</td>
<td>1402 meters</td>
</tr>
<tr>
<td>2b</td>
<td>Oct. 9, 1979</td>
<td>W.J. Reich</td>
<td>S</td>
<td>Sun River Game Range</td>
<td></td>
</tr>
<tr>
<td>2c</td>
<td>2010</td>
<td>D.L. Waltner</td>
<td>S</td>
<td>Sun River Game Range</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>1909</td>
<td>unknown</td>
<td>N</td>
<td>Sun River Canyon</td>
<td>1402 meters</td>
</tr>
<tr>
<td>3b</td>
<td>Oct. 10, 1979</td>
<td>W.J. Reich</td>
<td>N</td>
<td>Sun River Canyon</td>
<td></td>
</tr>
<tr>
<td>3c</td>
<td>2010</td>
<td>D.L. Waltner</td>
<td>N</td>
<td>Sun River Canyon</td>
<td></td>
</tr>
<tr>
<td>4a</td>
<td>March 14, 1900</td>
<td>C.D. Walcott</td>
<td>SE</td>
<td>Wallace Bean Ranch</td>
<td>1372 meters</td>
</tr>
<tr>
<td>4b</td>
<td>June 3, 1981</td>
<td>R.E. Wall</td>
<td>SE</td>
<td>Wallace Bean Ranch</td>
<td>unknown</td>
</tr>
<tr>
<td>4c</td>
<td></td>
<td>D.L. Waltner</td>
<td>SE</td>
<td>Wallace Bean Ranch</td>
<td>1390 meters</td>
</tr>
<tr>
<td>5a</td>
<td>March 16, 1902</td>
<td>M.J. Elrod</td>
<td>N</td>
<td>Daphnia Pond</td>
<td>945 meters</td>
</tr>
<tr>
<td>5b</td>
<td>Sept. 28, 1981</td>
<td>G.E. Gruell</td>
<td>N</td>
<td>Daphnia Pond</td>
<td>unknown</td>
</tr>
<tr>
<td>5c</td>
<td>2010</td>
<td>D.L. Waltner</td>
<td>N</td>
<td>Daphnia Pond</td>
<td></td>
</tr>
</tbody>
</table>
A.3 Relevant Information on Photo Sets

Photo Set One – Circle 8 Ranch

The first point was found after travelling north from Choteau on Highway 89 and then west on Teton Canyon Road. There was a split for South Fork Road going south. This led me to the Pine Butte Ranch. I hiked a few hundred feet up the ridge above the road, just a few hundred yards from the ranch. Located at geographic coordinates 47.873228 latitude and -112.66744 longitude, the photo was taken on August 12\textsuperscript{th}, 2010 at 11:32 a.m., at an elevation of 5086 feet. It was very windy with clear skies. While trying to capture an accurate photo point a gentleman walking his dogs approached me to inquire as to what I was doing. He stated that he had worked for the guest ranch for many years and began telling me about the features in the photographs. It was quite interesting to meet someone that was familiar with the area and the history of the ranch.

Photo Set Two – Sawtooth Ridge

The second camera point, located at latitude 47.613387 and longitude -112.671921, was found after travelling south to Augusta from Choteau on Highway 287, then turning west on Sun Canyon Road for approximately 3.4 miles. The road split with the left leading to the Wildlife Management Area entrance and the right leading to Gibson Reservoir. I took the Gibson reservoir road and drove another 13.7 miles. Then it was just a matter of driving until an accurate angle was spotted. The original photos were at a higher vantage point, but the property was a private ranch with no access. Therefore, the photo was taken from the road. This photo was taken on August 12\textsuperscript{th},
2010 at 4:58 p.m., at an elevation of 4454 feet. It was partly cloudy with waves of clouds rolling in, which made it difficult to get a shot without cloud cover.

Photo Set Three – Castle Reef

The third point, at latitude 47.613152 and longitude -112.67523, was located directly opposite of the previous camera point. It was only a matter of turning around and walking approximately fifty feet to match up with the older photos. The photo was taken at 5:05 p.m. on August 12th, 2010, at an elevation of 4458 feet.

Photo Set Four – Bean Lake

The fourth photo point was captured September 11th, 2010 at 1:19 p.m. The weather conditions were mostly sunny with a temperature of 68 degrees Fahrenheit. The Bean Lake photo point was one of the easier points to find. The photograph was taken approximately 15 feet from the road at latitude 47.296452 and longitude -112.437497, and an elevation of 4560 feet. There was a fence around the property making it difficult to get the exact angle. The first photo appeared to be taken at a higher vantage point and larger zoom than the second as the 1981 photo has more fields in the view, but less height of the mountain peaks that are in the background.

Photo Set Five – Daphnia Pond

The final photo point was found located at latitude 48.041456 and longitude -114.073267, after traveling north along the east side of Flathead Lake on Highway 35. Employees from the Wayfarers State Park just half a mile south of Bigfork were able to tell me about the area in the photo. It was directly across the street from the Lutheran
Camp just a half-mile south of the park. The photo was taken on September 5<sup>th</sup>, 2010 at 2:26 p.m., at an elevation of 3068 feet. It was partly cloudy and the Swan Range in the distance was obstructed by haze.

<table>
<thead>
<tr>
<th>Photo Number</th>
<th>PLSS</th>
<th>Description</th>
<th>Quadrangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo one</td>
<td>T25N R8W S32</td>
<td>Teton River - Looking SSE across the south fork of Teton River opposite the Circle 8 Guest Ranch, 35 miles west of Choteau.</td>
<td>Cave Mountain</td>
</tr>
<tr>
<td>Photo two</td>
<td>T21N R8W S6</td>
<td>Sun River Game Range - Looking south from just outside of NW corner of range.</td>
<td>Sawtooth Ridge</td>
</tr>
<tr>
<td>Photo three</td>
<td>T21N R8W S6</td>
<td>Castle Reef Sun River - Facing north toward Sun River Canyon from 30-40 yards north of previous camera point.</td>
<td>Sawtooth Ridge</td>
</tr>
<tr>
<td>Photo four</td>
<td>T18N R7W S24</td>
<td>Dearborn River Bean Ranch - Looking SE from low bluff on Wallace Bean Ranch on Dearborn River south of Augusta.</td>
<td>Bean Lake</td>
</tr>
<tr>
<td>Photo five</td>
<td>T26N R19W S18</td>
<td>Daphnia Pond - Facing north towards Daphnia Pond and Swan Range on east side of Flathead Lake, 3 miles north of Woods Bay</td>
<td>Bigfork</td>
</tr>
</tbody>
</table>

75
A.4 Attribute Table Results

<table>
<thead>
<tr>
<th>Circle 8</th>
<th>1899 #</th>
<th>1981 #</th>
<th>2010 #</th>
<th>1899 %</th>
<th>1981 %</th>
<th>2010 %</th>
<th>% 1899 to 1981</th>
<th>% 1981 to 2010</th>
<th>% 1899 to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Ground</td>
<td>74</td>
<td>16</td>
<td>19</td>
<td>12.0</td>
<td>2.6</td>
<td>3.0</td>
<td>-78.0</td>
<td>18.8</td>
<td>-74.0</td>
</tr>
<tr>
<td>Grass</td>
<td>182</td>
<td>100</td>
<td>56</td>
<td>29.0</td>
<td>16.0</td>
<td>9.0</td>
<td>-45.0</td>
<td>-44.0</td>
<td>-69.0</td>
</tr>
<tr>
<td>Trees</td>
<td>187</td>
<td>193</td>
<td>369</td>
<td>30.0</td>
<td>31.0</td>
<td>59.0</td>
<td>3.2</td>
<td>91.0</td>
<td>97.0</td>
</tr>
<tr>
<td>Manmade</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0.4</td>
<td>1.4</td>
<td>0</td>
<td>200.0</td>
<td>-100.0</td>
<td>-100.0</td>
</tr>
<tr>
<td>Sky</td>
<td>179</td>
<td>307</td>
<td>183</td>
<td>28.6</td>
<td>49.0</td>
<td>29.0</td>
<td>71.5</td>
<td>-40.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1: Attribute table for Circle 8 Ranch photos

<table>
<thead>
<tr>
<th>Castle Reef</th>
<th>1909 #</th>
<th>1979 #</th>
<th>2010 #</th>
<th>1909 %</th>
<th>1979 %</th>
<th>2010 %</th>
<th>% 1909 to 1979</th>
<th>% 1979 to 2010</th>
<th>% 1909 to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Ground</td>
<td>38</td>
<td>15</td>
<td>12</td>
<td>6.1</td>
<td>2.4</td>
<td>2.0</td>
<td>-60.5</td>
<td>-20.0</td>
<td>-68.0</td>
</tr>
<tr>
<td>Grass</td>
<td>176</td>
<td>307</td>
<td>344</td>
<td>28.2</td>
<td>49.1</td>
<td>55.0</td>
<td>74.0</td>
<td>12.0</td>
<td>95.0</td>
</tr>
<tr>
<td>Trees</td>
<td>252</td>
<td>146</td>
<td>129</td>
<td>40.3</td>
<td>23.4</td>
<td>21.0</td>
<td>-42.0</td>
<td>-12.0</td>
<td>-49.0</td>
</tr>
<tr>
<td>Manmade</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Sky</td>
<td>159</td>
<td>157</td>
<td>133</td>
<td>25.4</td>
<td>25.1</td>
<td>21.0</td>
<td>-1.3</td>
<td>-15.0</td>
<td>-16.0</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Attribute table for Castle Reef photos

<table>
<thead>
<tr>
<th>Bean Lake</th>
<th>1901 #</th>
<th>1981 #</th>
<th>2010 #</th>
<th>1901 %</th>
<th>1981 %</th>
<th>2010 %</th>
<th>% 1901 to 1981</th>
<th>% 1981 to 2010</th>
<th>% 1901 to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Ground</td>
<td>214</td>
<td>36</td>
<td>16</td>
<td>34.0</td>
<td>6.0</td>
<td>3.0</td>
<td>-82.0</td>
<td>-50.0</td>
<td>-91.0</td>
</tr>
<tr>
<td>Grass</td>
<td>39</td>
<td>176</td>
<td>110</td>
<td>6.0</td>
<td>30.0</td>
<td>18.0</td>
<td>400.0</td>
<td>-40.0</td>
<td>200.0</td>
</tr>
<tr>
<td>Trees</td>
<td>165</td>
<td>190</td>
<td>278</td>
<td>26.0</td>
<td>28.0</td>
<td>44.0</td>
<td>7.7</td>
<td>57.0</td>
<td>69.0</td>
</tr>
<tr>
<td>Manmade</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>0.2</td>
<td>0.2</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>800.0</td>
</tr>
<tr>
<td>Sky</td>
<td>206</td>
<td>222</td>
<td>212</td>
<td>33.0</td>
<td>36.0</td>
<td>34.0</td>
<td>9.0</td>
<td>-5.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Attribute table for Bean Lake photos

<table>
<thead>
<tr>
<th>Daphnia Pond</th>
<th>1902 #</th>
<th>1981 #</th>
<th>2010 #</th>
<th>1902 %</th>
<th>1981 %</th>
<th>2010 %</th>
<th>% 1902 to 1981</th>
<th>% 1981 to 2010</th>
<th>% 1902 to 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Ground</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>4.1</td>
<td>0</td>
<td>0</td>
<td>-100</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>Grass</td>
<td>248</td>
<td>295</td>
<td>219</td>
<td>39.6</td>
<td>47.2</td>
<td>35</td>
<td>19</td>
<td>-26</td>
<td>-12</td>
</tr>
<tr>
<td>Trees</td>
<td>67</td>
<td>136</td>
<td>154</td>
<td>10.7</td>
<td>21.7</td>
<td>25</td>
<td>103</td>
<td>13</td>
<td>130</td>
</tr>
<tr>
<td>Manmade</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
<td>-100</td>
<td>0</td>
</tr>
<tr>
<td>Sky</td>
<td>210</td>
<td>190</td>
<td>252</td>
<td>33.6</td>
<td>30.4</td>
<td>40</td>
<td>-9.5</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Water</td>
<td>74</td>
<td>3</td>
<td>0</td>
<td>12</td>
<td>0.5</td>
<td>0</td>
<td>-96</td>
<td>-100</td>
<td>-100</td>
</tr>
</tbody>
</table>

Table 4: Attribute table for Daphnia Pond photos
A.5 Bar Graphs Results

Figure 8: Circle 8 Ranch

Figure 9: Castle Reef
Figure 10: Bean Lake

Figure 11: Daphnia Pond