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Small-Hydroelectricity and Landscape Change in the Bitterroot Mountains: Public Perceptions and Attitudes

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SMALL-HYDROELECTRICITY AND LANDSCAPE CHANGE

IN THE BITTERROOT MOUNTAINS:

PUBLIC PERCEPTIONS AND ATTITUDES

By

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The development and use of renewable energy resources within America has made significant progress over the last two decades. Many state governments have adopted legislation requiring the development of their local renewable resources for generating electricity. In 2005, Montana's State Legislature passed Senate Bill 415, The Montana Renewable Power Production and Rural Economic Development Act. This piece of legislation mandates the development and use of renewable energy resources by energy producers and requires that fifteen percent of the electrical energy consumed within Montana be produced by renewable energy resources by January 01, 2015. Though this action has been praised by the numerous advocates of renewable energy, many physical and environmental impacts associated with the development of renewable forms of energy have been largely overlooked. This thesis evaluates the public's attitudes and perceptions surrounding this development; specifically, it attempts to measure how the inevitable aesthetic and physical impacts associated with the development of small-hydroelectric facilities are perceived by local residents. Western Montana's Ravalli County was chosen as the geographic location for this study as its world renowned trout fishing and breathtaking views will likely be compromised through developing the small streams originating in the Bitterroot Mountains. A survey of Ravalli County residents was conducted to assess public perceptions and attitudes of using these resources. Socio-demographic characteristics, use of local streams, and knowledge of renewable energy resources are evaluated as possible measures for explaining the attitudes and perceptions of local residents. These data, though presenting mixed results, provide some insight into the values of local residents and how these perceptions and attitudes can potentially influence the development of renewable energy resources and help shape the policy that is ultimately responsible for advocating the use of local resources for generating electricity.

With much love, I dedicate this thesis to my family:
My wife Nicole,
daughter Cecelia, and our unborn baby.

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CHAPTER ONE: INTRODUCTION

Issues surrounding American energy markets have resurfaced as rising demands for electricity, natural gas and fossil fuels have been met with sharp increases in price. The last decade has produced a number of factors influencing this volatile market. Increased international competition for natural resources is being experienced as global populations are becoming increasingly dependant on energy and new technologies. Terrorist attacks on America in 2001 resulted in U.S. military action and severe unrest and instability in the oil producing nations of the Middle East, while damage caused by the 2005 hurricane season furthered national concerns within energy markets. In response to these high profile national and international issues, demands for energy within the United States continue to increase as global non-renewable energy supplies continue to be depleted.

Environmental concerns regarding the ever-increasing concentration of greenhouse gases have swayed many post-industrial nations to consider alternatives to traditional large-scale modes of energy production. In response to these environmental concerns, and taking into account the economic realities of the growing demands for energy and energy resources by developing countries, the development of renewable energy resources such as wind, flowing water, geothermal, bio-fuels, and solar energy are quickly becoming an economically feasible solution. Though the U.S. abandoned the air quality and fuel efficiency standards targeted by the Kyoto Protocol in 2001, a host of American states have enacted legislation to mandate the development and use of renewable energy resources.

In 2005, Montana's legislature passed Bill 415 to pursue an energy portfolio relying on fifteen percent renewable resources by the year 2015 (MCA 69-8-1004 2005). Though this action has been well received by Montana residents and environmental organizations, a very small percentage of Montana's robust renewable energy base has yet been developed. Some headway has been made with the recently installed wind farms at Judith Gap and Great Falls (AWEA 2007), and through residential distributed generation installations such as small wind, micro-hydro, and solar electric generation; however, renewable energy resources within Montana remain largely undeveloped.

Contributing to the stagnation in developing Montana's renewable energy base are that renewable energy resources are geographically bound, they are widely dispersed, and all but geothermal and landfill methane are greatly restricted by seasonal variations (Hartsoch 2004). The wide-spread use of any of these resources will require the construction of multiple small-scale energy production facilities throughout the state. As well, the reliance on renewable energy resources for providing an uninterrupted flow of energy will require the use of multiple forms of renewable energy resources in combination with the traditional modes of generating electricity (i.e., coal, large-scale hydroelectric, and natural gas) in order to offset the effects of seasonal variations. Furthermore, this dispersed development will require significant investments in infrastructure for supporting new electrical generating facilities and will create increased competition for transmission space along Montana's congested network of electrical transmission lines known as the "grid."

One alternative presented at international and national levels, and recently adopted within Montana's energy policy, is to stimulate the development and use of renewable electrical generation resources in and around communities to support local residential and commercial energy consumption (NWCC 2000, WADE 2003, MCA 69-8-1004 2005). Though this option offers only to buffer from volatile energy markets for most communities, it stands to reduce the local reliance on fossil fuels, large-scale energy production facilities, and the economic constraints associated with grid supplied electricity.

Problem Statement

While shifting energy generation to the local level may be beneficial in providing some stability to local energy markets, the development of renewable energy resources is not without impact. The reliance on grid supplied electricity has long removed Montana's residents from the source of where their energy is derived, and developing renewable energy resources will require modifications to natural resources and natural landscapes. The physical and visual impacts associated with this development stand to alter local aesthetic landscape qualities, create changes in traditional land use practices, and potentially affect fish and wildlife habitat. It is within the public's perception and acceptance of these changes that the development of renewable energy resources in Montana may find its strongest opposition.

Purpose Statement

This thesis evaluates some of the components that seem to influence why Montana's rural communities, rich in alternative energy resources, have yet to develop renewable energy for residential and commercial use. As the economic viability of using renewable energy is realized, Montana's rural communities are not only presented with the option to modify where their energy is derived but also with the option of having some degree of influence over local residential energy prices.

A comprehensive evaluation of public perception regarding the wide range of impacts associated with all forms of available renewable energy resources and within all of Montana's regions and landscapes presents researchers with a daunting, and perhaps overwhelming task. Therefore, this thesis addresses public perception of the impacts associated with developing small-hydroelectric resources and is limited to one geographic region of Montana. Western Montana's Ravalli County has been identified as possessing significant small-hydroelectric potential (INEL 1993). These hydroelectric resources would be primarily derived from the Bitterroot Mountains, a mountain range known for its jagged peaks, breathtaking scenery, and diverse wildlife habitat including populations of deer, elk, moose, and recently re-introduced populations of grey wolf. The Bitterroot Mountains, comprising a segment of the Idaho/Montana border, are almost exclusively contained within the Selway-Bitterroot Wilderness area located in the Selway and Bitterroot National Forests of Idaho and Montana. This mountain range comprises the northern-most portion of the largest continuous tract of wilderness in the lower forty eight states (i.e., comprised of the Frank Church Wilderness of No Return, Gospel Hump Wilderness, and the Selway Bitterroot Wilderness Area), and offers not only a variety of recreational opportunities for hikers, mountaineers, equestrians and other outdoor enthusiasts, but provides significant and desirable aesthetic amenities for local and regional residents.

Research Questions

By focusing on the public's perception of developing small-hydroelectric resources within the Bitterroot Mountains, two specific questions are being addressed: 1) are the impacts associated with developing local hydroelectric resources and acceptable tradeoff for gaining some local control over the production of electricity; and 2) do Montana's energy policy statements reflect the perceptions and attitudes of local residents? The data used to evaluate these questions were collected through a survey of Ravalli County resident's in the autumn of 2006. Participants were shown a poster providing a brief introduction to renewable energy in Montana, small-hydroelectricity, and a graphic representation of the facilities required for harnessing the potential energy of small streams (Appendix B). These individuals were then asked to respond to survey questions pertaining to resource use and their perceptions and attitudes regarding using renewable energy resources (Appendix A). This will be further discussed in Chapter Four of this Thesis.

Thesis Organization

The goal of this thesis is to address three specific issues of concern. First, the research reported here has been developed to provide an indicator of public perception and attitudes regarding the aesthetic and physical impacts associated with small-hydroelectric resource development. Second, it is intended to provide a means in which to assess the attitudes of Ravalli County residents and how they pertain to the potential environmental and aesthetic tradeoffs associated with developing local energy resources while considering the possibility of the long-term stabilization of local energy prices. Third, through the evaluation of the relationships between aesthetics, physical impacts, public perception, and existing policy, this research identifies some of the political and value-based roadblocks associated with the development of small-hydroelectric resources in Western Montana.

This analysis will begin by reviewing the pertinent background information necessary to provide a theoretical base for this study. Included here are discussions and evaluations pertaining to: 1) human perception and how perception relates to the concept of landscapes, 2) electricity and energy markets, 3) the impacts and technologies associated with developing small-hydroelectricity, 4) energy in Montana, 5) Montana's renewable energy base and supporting policies. Subsequent chapters will include: a description of the study area, the methods used, the results of this study, and an evaluation of results and how they pertain to the formulation and implementation of policy. Finally, recommendations for future research and evaluation regarding the advocacy, development, and use of renewable energy resources are presented.

CHAPTER TWO: BACKGROUND

Introduction

This chapter provides both the conceptual information and a logical framework necessary for understanding the significance of this research. Key for this discussion, the underlying theoretical approach incorporates both temporal and spatial dimensions for addressing the use of small-hydroelectric resources and how they relate to the concepts of landscape and perception. This chapter is organized into six sections for the presentation of this information.

Offered first is an evaluation of perceptions and landscapes, what they are and how they pertain to the development and use of natural resources for human use. These are considered in order to provide a basis for evaluating perception studies within the field of geography, specifically, studies that have been conducted on the recent development of wind energy resources around the globe. This is followed with a discussion of how energy is produced, transmitted, distributed, and how energy markets both work to facilitate the availability of electricity and limit the diversification of how electricity is produced. Next, small-hydroelectricity is addressed by evaluating the technologies, civic structures, and impacts associated with its development. Current and historical considerations regarding Montana's electricity market are then discussed. This information is introduced to provide both a spatial and temporal context for the use of water for generating electricity within the state and provide a basis for establishing how energy and energy markets are currently perceived by local residents. Finally, Montana's renewable energy resources and the policies directing their development and use are presented.

Perception and Landscape

Perceptions

Attitudes and perceptions are not uniform across or within cultures, nor are they static through time. Not only do they provide a basis for forming a system of personal beliefs that are responsible for shaping our decisions and actions in how we relate to the world around us, they draw upon the aggregate of all past personal experiences for their formation. Though attitudes and perceptions are defined as separate entities, (i.e., that perceptions are formed from the combination of all past life experiences and are highly individualistic gestalts, and attitudes address the feelings and beliefs of an individual regarding an object or situation), the concepts of attitude and perception are loosely combined for this research as each rely upon one another for shaping how individuals respond to external stimuli (Schiff 1971, Tuan 1974). Some of the factors that have been associated with influencing the variation of attitudes and perceptions within and among cultures are upbringing, education, income, employment, heritage, recreational pursuits, where one lives, religious and political affiliations, and individual physiological variation (Tuan 1974, Mitchell 1994). The analyses of these perceptions and attitudes have been used extensively by researchers, marketers, and political organizations throughout the last fifty years. These studies have proven important in determining issues ranging from the setting of political agendas to deciding on marketing strategies for virtually all industries and businesses throughout the world.

Social and physical scientists have discovered the use of perceptions and attitudes as a point at which to merge theoretical backgrounds as perception studies provide a segue for transcending chemical and biological phenomena into the social/environmental realm of conservation and landscape ecology, and have set the stage for debate on issues such as global warming, cloning and embryonic stem cell research. Pertaining to the field of geography and the concept of landscape, perceptions and attitudes provide both culture and the individual with a sense of place (Tuan 1974). Human perceptions and attitudes regarding the shape, form, and natural and aesthetic quality of the landscape help determine its function for culture, hence, the use of its resources. Trepel (1997) makes this distinction through his work on landscape by stating:

> The 'nature as seen by science,' which is an abstract one, not visible or tangible, only accessible by reasoning and by natural laws and rules that have to be learned to be known, requiring an intellectual effort. Science teaches people what is universally true and valid, and requires landscape to be split up into its components, which have to be analyzed in order to be understood in general terms. The 'nature of landscape,' which is formed by the landscape view [and] in the eye of the beholder, is always a gestalt and a particular event, a historically and culturally determined whole, principally inaccessible to scientific analysis" (as quoted in Haber 2004, 103).

In this light, the value of human perception becomes significant in that it provides a basis not only for determining the biological significance of natural systems, but takes into account the visual attributes as significant, rendering the form, function, and perceived qualities as somewhat equivalent. This becomes important in understanding the concept of landscape and how it has evolved.

Landscapes

The concept of "landscape" has taken on multiple definitions and many forms across cultures and throughout the course of history. Transformations of the word and its meaning began with the 10^{th} century Germanic language designation of "Landschaft" (loosely translated in English as "landscape") as a term used for defining a regional land ownership based on the pastoral landforms "carved out" by a people (Olwig 1993, Haber

2004). Used in this context, the term "landschaft" was used to define the geographical boundaries of kingdoms.

The term landscape remained in the English vocabulary and was transformed to define artwork depicting natural and agrarian gestalts and cartographic perspectives created in the 15th and 16th centuries (Olwig 1993, 2001). The term was later used to describe ornamental gardens of the 18th century as affluent landowners attempted to bring earlier works of art to life (Tuan 1974, Olwig 1993). Further changes in the meaning of landscape are seen in modern-day use of the word. Though concepts and definitions of "landscape" had evolved independently of "nature" and "scenery," the 19th and 20th century definitions of landscape encompass these terms as almost interchangeable (Olwig 2001). Today, the geographical concept of landscape is used to describe both physical landforms and their cultural attributes. Relph (1985) touches on this concept by stating: "[Landscape] is both the context for places and the attribute of places." Antrop (2000) further illustrates this idea in his work on integrated landscape analysis: "As an abstract concept, landscape has no borders and refers to concepts such as scenery, system, and structure. In a concrete use, different landscapes are distinguished, each one referring to a more-or-less well-defined and bordered piece of land" (2000: 18). Given these multifunctional definitions and integrating them with the aforementioned thoughts of Trepal, it becomes clear that the concept of landscape transcends physical attributes by acknowledging the visual continuum and provides for what Tuan (1974: 18) has defined as "Topophila, or the affective bond between people and place or setting." It is within this definition of landscape that geographers have adopted perception studies as an integral method for evaluating human and environmental interactions.

Theoretical Framework

The evaluation of human perceptions in determining the appropriate use of natural resources is not bound to one deterministic theoretical approach or within one specific branch of scientific research. Disciplines governing the field of perception studies range from psychology to economics and incorporate forestry, geography, art, anthropology, and philosophy into the evaluation of perceptions, landscapes, and resource use, each as unique and individual components.

The nature of the theory being incorporated for this study involve, at least to some degree, those paradigms that are charged with being responsible for driving the analysis of culture, economics, and human behavior. However, relating these paradigms as individual influences is somewhat problematic as the breadth of these paradigms extends far beyond the scope of what is being analyzed within this study. Instead of addressing the specific contributions from the social and physical sciences, a brief chronology of some of the more prominent cultural and human geographers and their contributions are presented. The resulting synthesis of ideas and concepts developed by these researchers provide the theoretical basis for this study.

Positivism within geography, dictating early landscape evaluations as seen in Alexander Von Humboldt's *Cosmos* (1848-1862), provided highly detailed and scientific descriptions of landforms, while environmental determinism was regarded as the driving force for shaping culture. These theoretical considerations remained dominant within geography and science throughout the remainder of the 19th century and are evident in works by Charles Darwin and Alfred Russell Wallace as well as a myriad of others from the 19th and early 20th centuries. In 1927, geographer Carl Sauer formally rejected positivism and environmental determinism in presenting how cultural landscapes are made up of the forms superimposed on the physical landscape (Sauer 1927). Throughout the remainder of the 20^{th} century, the field of cultural geography expanded on Sauer's work. As a result, the morphological impacts of humans and cultures upon the physical landscape were linked. Significant contributions to the development of both human and cultural geography are seen in the works of J.B. Jackson and his dedication to *Landscape* and writings therein, and George Perkins Marsh's evaluations of culture and environment supporting the further conviction of environmental determinism. Yi-Fu Tuan further developed these concepts in establishing his theory of Topophila, or the "sense of place" an individual shares with his/her environment. Tuan's influence is the most recent and most comprehensive in synthesizing the fields of cultural and human geography. Tuan's ideas developed over the last three decades and have gained significant ground within the field of geography - that landscape qualities are more than the physical landform, cultural attributes, or personal gestalts. Instead, Tuan regards all of these as being responsible for shaping the individual's perception of landscape, that the concept of landscape is more than how individuals view and interact with their surroundings, and that landscape and landscape qualities help to shape the individual's "sense of place" within the environment, hence shaping the individual's place within the landscape. Tuan insists that these personal gestalts, combined with the cultural phenomena driving landscape perceptions, cannot be quantified through traditional scientific inquiry.

Perception Studies

Pertaining to attitudes and values, perception studies within the field of geography represent a diverse and interesting body of literature. The range of variation being explored by researchers include work conducted by Haber (2004) regarding human perceptions of landscape qualities as a 'bridge' for linking the psychology of humans and how they interact with their surroundings and the ecological function of landscapes. Kaltenborn and Bjerke (2000) studied Norwegian landscape preferences by comparing respondent perceptions of photos and paintings depicting different landscapes with respondent attitudes to survey questions evaluating ecocentric, anthropocentric, and apathetic statements regarding the environment. Nohl (2001) evaluates landscapes as aesthetic objects and the potential implications of human perception of sustainability and landscape quality. Research by Ryan (1998) provides insight into the perception and values of local residents on land use change and environmental preferences within a Mid-Western American river corridor. By comparing respondents land use practices and length of residency to perceptions and attitudes regarding landscape and the importance of natural systems, survey results presented significant differences between these groups.

Perception and landscape studies relating to the use of renewable energy resources focus geographical research within this field and provide a basis for comparing the results of this study. Though research concerning landscape and perception in the development of small-hydroelectric systems is virtually non-existent, research conducted throughout Europe, Australia, and within the United States regarding the development of wind energy resources provides some insight into the public's perception of using renewable energy resources and some of the unforeseen impacts associated with their development, such as quantifying the visual impacts of developing renewable energy resources against the associated economic and long term environmental benefits.

Surveys conducted over the last three decades in the United States and Europe indicate that the public not only advocates for an increased use of renewable energy resources, but that support for the reliance on environmentally friendly sources of energy has been steadily increasing (Fahar 1995, Devine-Wright 2001). Stimulated by this public support, legislators in many nations around the globe have implemented national energy policies advocating the development of renewable energy resources. Resulting from this political backing, significant increases in global wind installations have been made. Since 2000, the world-wide use of wind energy has quadrupled with a capacity of 74,223 megawatts (MW) being reported in 2006 (GWEC 2007). Though this makes up only one percent of the total electricity produced globally, countries such as Denmark, Spain, and Germany rely on wind for producing up to twenty percent of their electricity needs (EWEA 2007). Reports from the American Wind Energy Association, the European Wind Energy Association, and the Global Wind Energy Council predict that this trend will continue by estimating a world wide installed capacity for wind energy will total over 160,000 MW by the year 2010 (AWEA 2007, EWEA 2007, GWEC 2007). Despite the growing popularity surrounding the development of renewable energy resources, opposition to wind energy is being experienced as local residents and environmental groups are identifying what they consider unacceptable impacts associated with the use of wind energy resources.

The term "wind energy landscapes" has recently been used in describing the large-scale wind farms developed in many countries around the globe (Pasqualetti 2000: 381). Modern wind turbines, towering to 100m in height, are equipped with a propeller spanning some 50m in diameter, roughly the size of a commercial jet airliner (Mercer

2001). Both Pasqualleti (2000) and Nohl (2001) have compared the visual impacts of wind farms with those of other industrial developments.

Though industrial landscapes are found throughout the world, the development and use of wind for the generation of electricity provides a unique situation. As a result of the spatial constraints associated with wind energy (i.e., that areas of significant wind energy potential are geographically bound), these turbines have been sited within the rural countryside, across mountain passes, and along many coastlines throughout the world. The visual impacts of wind towers are intensified as the physical properties of harnessing wind energy require turbines be sited in large and open areas. In many instances, wind farms have been developed within geographic areas considered to hold significant natural beauty or possess aesthetic qualities for natural or rural settings (Hull 1995, McGowan & Conners 2000, Pasqualetti 2000, Khan 2003).

Additional points of controversy surrounding the development of wind turbines include: the fragmentation of offshore bird habitat (Sorenson et.al. 2001); bird mortality due to the physical impact of migrating birds and raptor populations with turbine rotors (Osborn et al. 1999, Barrios and Rodriguez 2004); the real and perceived noise associated with the turning rotors, the potential for electromagnetic interference with television and microwave transmissions (Hull 1995, McGowan and Connors 2000); and the flickering of sunlight through moving turbine blades (Khan 2003). Though these concerns appear relatively benign when compared to the environmental impacts associated with the use of coal, large-scale hydroelectric dams, and nuclear technologies for the generation of electricity, the effects of public perception regarding these impacts are beginning to limit or halt the development of wind energy facilities within many regions of the world (Mercer 2001, Khan 2003).

Considering the use of small-hydropower resources for the generation of electricity, it is anticipated that the public's perception of using local resources and changing local landscapes will render contention similar to what has been experienced with developing wind energy resources. Impacts unique to small-hydroelectric technologies are discussed in the following sections of this Chapter.

Electricity and Energy Markets

Energy and energy markets are a complex web filled with physical and economic constraints. There are four main parts to the electricity industry that need to be addressed in order to understand these complexities and how they relate to the history of electricity in Montana, the state's current energy situation, and its policies directing the development and use of renewable energy resources.

Generation

The generation of electricity is accomplished through harnessing the energy of flowing/ falling water, burning coal or natural gases, wind, heat produced by nuclear processes, geothermal heat, or the energy produced by the sun. Typically, for the large-scale production of electricity, industry has favored coal, water, natural gas, and nuclear energy to satisfy the electricity demands of the world. The energy captured from these resources is used to turn a turbine/generator which results in the production of electricity. Electrical energy is typically generated as relatively low voltage (i.e., less than thirty kilovolts [kV]) and is then put through a series of transformers to intensify or "step up" the electricity to the desired frequency for transmission (MDEQ 2004).

Transmission

The transmission of electricity occurs through a system of interconnected electrical transmission lines referred to as the "grid." These transmission lines do not provide for the complete interconnectedness of electrical generation facilities; instead, they allow for redundancy of these facilities, hence, reliability within the system (MDEQ 2004). The North American transmission network has developed into eight major regional areas contained within four synchronous interconnected systems. Montana is almost completely contained within the western grid with only a small portion of the eastern side of Montana being supplied by the eastern grid.

Transmission lines within the grid are rated to handle a specific voltage of electricity which is expressed in kV, and a specific load of electricity, expressed in the amount of kilowatts (i.e., kilowatts per hour or kW-h). Of these features, the load is the limiting component for the physical transmission of electricity as it is the volume within the system (MDEQ 2004). Electricity is transmitted across long distances as either alternating current (AC) or direct current (DC) and is typically transmitted using 161 kV to 500 kV AC systems. However, exceptionally large loads of electricity are most efficiently transmitted over long distances using 230kV or 500kV DC systems as the technology required to convert AC electricity to DC and back again is cost-prohibitive for smaller loads (MDEQ 2004).

Electrical transmission lines are the limiting component for electricity markets. Physical limitations on the amount of electricity they can handle presents significant congestion issues and economic barriers as there are a limited number of rights that can be purchased for the transmission of electricity (MDEQ 2004). Energy loss experienced in the transmission and distribution of electricity is significant due to the physical distance traveled and congestion of electricity on transmission lines. Rates of energy loss are estimated to range from 7.2 percent over interstate transmission lines (DOE 2003), to forty six percent when taking into account energy losses experienced in the lower-voltage distribution networks (Nelson 2006).

Distribution

The distribution of electricity occurs at the local level. Individual communities or geographic regions tap into the high voltage grid at specific points, and through a series of transformers, "step" the electricity to lower voltages ranging between thirty three kV to 115 kV for transmission across local distribution networks for residential, commercial and light industrial use (MDEQ 2004).

Energy Markets

Historically, electricity markets have developed through time creating vertically integrated companies that provided all of the necessary services for generating, transmitting and distributing electricity to consumers. The physical structure of how electricity is produced and transmitted has created a market situation allowing for the formation of national and international oligopolies.

Until deregulation of wholesale electricity markets began at the national level in 1977 (discussed in greater detail in Section Five of this chapter), the investor-owned electric utility industry had provided relatively few economic constraints for the electric utility industry. Electricity was typically generated, transmitted and distributed within geographically bound areas while competition for energy resources, available transmission space, and distribution areas were nominal as there was little to no market competition for electricity providers. Pricing for electricity was set and regulated by multiple tiers of federal and state regulatory commissions such as Public Service Commissions, the Federal Energy Regulatory Commission, and the Regional Transmission Organization (Abel 1999, Zucchet 2002, MDEQ 2004). Today these agencies, combined with a variety of state regulatory controls, ensure that this privately owned public utility remains available, that it is extended fairly and justly, and that the prices charged for electricity are representative of the true value of this resource through the use of price caps and contracts (Zucchet 2002).

Small-hydroelectricity: Technology and Impacts

Defined by Parish (2001: 31) as "the exploitation of a river's hydro [electric] potential without significant damming," small-hydroelectricity remains the most cost-effective of renewable energy technologies and, in the eyes of European researchers, is one of the most "clean and environmentally friendly" energy options available (Dragu et al. 2001: 9). These electrical generation systems rely on the use of water pressure to turn turbines, thereby converting the energy of flowing water to drive an electrical generator or other machinery. The power available for use is proportional to the product of pressure head and volume flow rate. The general formula used in determining the energy potential of flowing water is given (Parish 2002).

$$P = h \rho g Q H$$

Where: P = mechanical power produced at the turbine shaft (Watts)
h = hydraulic efficiency of the turbine
ρ = density of the water (kg/m^3)
g = acceleration due to gravity (m/s^2)
Q = volume flow rate passing through the turbine (m^3/s)
H = the effective pressure head of water across the turbine (m)

Figure 2.1 illustrates a typical medium or high-head hydroelectric system. Small dams are commonly constructed on smaller water ways to maintain a constant water level at the weir intake point.

Water is diverted from a stream or river through a weir or pipe channeling water across the slope. Before the water is allowed to descend to the turbine, it passes through a forebay, or settling tank, allowing for the settling of foreign objects and suspended particles. Water then enters the penstock which descends directly into the power house. Upon entering the power house, water pressure is increased by reducing the diameter of the penstock and the water flows through the turbine. Depending on the rating of the system (i.e., low, medium, or high head), the water pressure may be further increased by adding a nozzle or series of nozzles to the system. Different types of turbines, designed for different needs, are used to maximize the available head and are listed in Table 2.1. Once water passes through the turbine, it is then released from the powerhouse into the tailrace and is returned to the natural streambed. High-head hydro systems provide the most cost-effective projects as less water is required to obtain larger amounts of electricity. Implications for geographical settings result in mountainous terrain being the best suited for significant small-hydroelectric generation potential (Parish 2002).

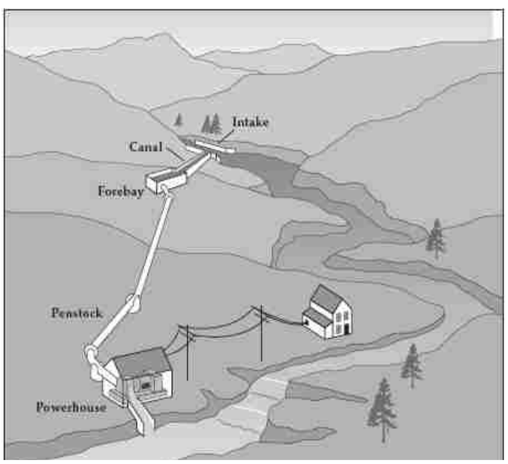


Figure 2.1. Typical Small-Hydroelectric Layout (Source U.S. DOE 2001)

Though research conducted in Europe has deemed the development of small-hydroelectric systems as one of "the most environmentally benign" renewable energy technologies available (Parish 2002: 531), research in the United States has determined that small-hydroelectric systems have significant environmental impacts.

Table 2.1. Turbine Type and Head Classification

Turbine Type		**Head Classification (Water Pressure)**		
		High (>50m)	Medium (10 – 50m)	Low (<10m)
Impulse	Requires water jets to be offset ~ 20° from turbine blades.	Pelton Turgo Multi-jet Pelton	Crossflow Turgo Multi-jet Pelton	Crossflow
Reaction	Propeller style, requires water "spin" prior to turbine contact.	N/A	Francis (spiral case)	Francis (open flume) Propeller Kaplan

(source: Parish 2002)

Studies conducted by the United States Department of Agriculture (USDA) Forest Service, in conjunction with the Bonneville Power Administration, indicate that developing these hydroelectric technologies impact aquatic habitats in three distinct ways (U.S. DOE 1983, Leathe & Graham 1984):

1) Increased stream sedimentation through reducing or removing high flows that are responsible for the annual flushing of streambeds. This results in the clogging of stream bed gravel substrate, removing critical spawning habitat for fish as well as the natural habitat required by many species of aquatic invertebrates.

2) Dewatering or reducing natural in-stream flows can be responsible for increased water temperatures, increased algae production, and can present significant barriers to fish spawning migrations; and

3) Changing natural concentrations and balances of nitrogen and oxygen by pressurizing water within the penstock alters natural habitat and provides a physical barrier for the migration and life-cycle of young fish and aquatic invertebrates.

However, it is important to note that the studies conducted by the USDA Forest Service and the BPA studies were focused on small streams and projected that eighty to one-hundred percent of stream flows would be used for the generation of electricity (U.S. DOE 1983, Leathe & Graham 1984). This is significant in that a reduced utilization of stream flow in a high head system can produce desirable amounts of electricity. Other impacts, such as changes to landscape characteristics and the perceived aesthetic qualities to natural land forms, were not considered by either the European studies or those conducted in the United States. The visual and aesthetic impacts associated with constructing diversion structures, weirs, penstocks, and powerhouses within natural landscapes (represented in Figure 2.1) present unique barriers to the development of small-hydroelectric generation facilities. These will be evaluated and further discussed in the following sections of this thesis.

Electricity in Montana: Current Situation and History

As observed with the development of energy resources and the transmission of electricity throughout the United States (and around the world), the organization of Montana's electrical energy systems have resulted from the local and regional influences over time. In Montana, local industry was the primary force driving the early development of energy resources within the state. However, through time, residential needs and increases in the regional demand for electrical energy would eventually take the lead in shaping Montana's current energy situation.

Current Energy in Montana

Montana provides a very small contribution to both the total energy produced and consumed in the western grid. In 2004, Montana's total electrical generating capacity was 5,100 MW. However, due to annual fluctuations in stream flows and down-time required for maintenance and repairs to electrical generation facilities, Montana's average electrical generation was 3,000 average MW. This makes up less than two percent of the total 90,772 average MW produced and consumed in the western United States (MDEQ 2004).

The current energy structure of Montana includes nineteen contributing utility companies and thirty-six electrical generation facilities producing greater than one MW (Table 2.2). Of the energy consumed in Montana in 2003, sixty-three percent is produced by coal, thirty-five percent by large scale hydro and the remaining two percent by natural gas, wind power and biomass (MDEQ 2004). In sharp contrast to historic trends, electrical consumption rates for the state today are split evenly between residential, commercial and industrial uses. Roughly one-quarter of the electrical energy consumed in Montana is provided by power marketers outside the state such as NorthWestern Energy, Pennsylvania Power and Light, and the Bonneville Power Administration. Industrial customers are the primary consumers for out of state service providers (MDEQ 2004). Prices for electricity sold in Montana in 2003 were 7.6 cents per kW-h for residential, 6.46 cents for commercial, and 4.5 cents for industrial consumption. Average price per kW-h for Montana was 6.28 cents proving significantly lower than the national average of 7.4 cents per kW-h for the same year (MDEQ 2004).

The distribution of electricity in Montana is provided by two investor-owned corporations, twenty-six rural energy co-ops, three federal agencies, and one municipal utility. Electrical sales generated in the state in 2002 were: forty-three percent from the investor owned utilities, twenty-six percent from co-ops, and twenty-seven percent from power marketers. The remaining four percent of sales were provided by federal agencies. Roughly three quarters of the entities providing energy for Montana reside within the state (MDEQ 2004).

Historical Considerations

Similar to the development of electrical energy around the world, energy systems in Montana originated as being reliant on run of the river hydroelectric technologies. The earliest electrical generation facility in Montana was the Black Eagle hydroelectric facility established at Great Falls on the Missouri River in 1881 (MPC 1941). Subsequent hydroelectric facilities were installed along the Missouri River at Helena, the Madison River at Bozeman, the Yellowstone River at Billings and the Clark Fork River at Missoula and Butte. The electricity produced at these locations would lead to the eventual establishment of these small towns as regional urban centers. The earliest installed hydroelectric facilities provided low voltage DC electricity for local communities (MPC 1941). This form of electricity could not be transmitted over long distances without experiencing a significant loss of energy. As a result, early applications for electricity were confined to local areas in close proximity to electrical generation facilities. New technology developed in the late 1880's introduced AC electricity and electrical transformers that were responsible for allowing for electricity to be "stepped up" to higher voltages (Tesla Patents 2007). These new technologies provided for the long-distance transmission of electricity without an excessive loss of energy and allowed for the electrification of America.

Table 2.2. 2007 Operational Commercial Electric Generation Facilities in Montana

Power Plant	Company	Source	Location (County)	Capacity (MW)	Year Completed / Year Modified
Black Eagle	PPL-M[1]	Water	Cascade	21.0	1891 / 1926
Madison	PPL-M	Water	Madison	8.8	1906
Rainbow	PPL-M	Water	Cascade	35.6	1910
Bigfork	PacifiCorp	Water	Flathead	4.1	1910
Hauser	PPL-M	Water	Lewis and Clark	17.0	1911
Ryan	PPL-M	Water	Cascade	48.0	1915
Thompson Falls	PPL-M	Water	Sanders	87.5	1916
Hell Roaring	MVPC[2]	Water	Lake	0.4	1916
Lake Creek	NLC[3]	Water	Lincoln	4.5	1917
Holter	PPL-M	Water	Lewis and Clark	38.4	1918
Mystic Lake	PPL-M	Water	Stillwater	12.4	1925
Gibson	USBR[4]	Water	Lewis and Clark	15.0	1929 / 1938
Morony	PPL-M	Water	Cascade	45.0	1930
Kerr	PPL-M	Water	Lake	211.5	1938
Fort Peck	USCAE[5]	Water	McCone	185.3	1943
Hungry Horse	USBR	Water	Flathead	428.0	1952 / 1995
Canyon Ferry	USBR	Water	Lewis and Clark	49.8	1954
Cochrane	PPL-M	Water	Cascade	48.0	1958
Lewis & Clark	MDU[6]	Coal/Natural Gas	Richland	48	1958
Noxon Rapids	Avista	Water	Sanders	466.2	1959
Yellowtail	USBR	Water	Big Horn	250.0	1966 / 1968
Miles City	MDU	Natural Gas/Fuel Oil	Custer	23.3	1972
Colstrip Unit 1	PPL-M/PSP&L[7]	Coal	Rosebud	358	1975
Libby	USCAE	Water	Lincoln	525.0	1975

Table 2.2. 2007 Operational Commercial Electric Generation Facilities in Montana (continued)

Power Plant	Company	Source	Location (County)	Capacity (MW)	Year Completed / Year Modified
Colstrip Unit 2	PPL-M/PSP&L	Coal	Rosebud	358	1976
Glendive #1	MDU	Natural Gas/Fuel Oil	Dawson	40.7	1979
Corette	PPL-M	Coal	Yellowstone	160.0	1983
Colstrip Unit 3	Co-ownership[8]	Coal	Rosebud	778.0	1984
South Dry Creek	Hydrodyanmics	Water	Carbon	2.0	1985
Colstrip Unit 4	Co-ownership	Coal	Rosebud	778.0	1986
Broadwater	MT DNRC[9]	Water	Broadwater	9.6	1989
Montana One	CEP[10]	Waste Coal	Rosebud	41.5	1990
BGI	YP[11]	Petroleum Coke	Yellowstone	65.0	1995
Glendive #2	MDU	Natural Gas/Fuel Oil	Dawson	43.0	2003
Tiber Dam	TM[12]	Water	Liberty	7.5	2004
Gilbert # 3	SME[13]	Coal	Cascade	250.0	2005
Martinsdale	TD Wind LCC	Wind	Meagher	0.7	2005
Judith Gap	Invenergy	Wind	Wheatland	135.0	2005
Horseshoe Bend	United Materials	Wind	Cascade	9.0	2006

(Source: MDEQ 2004, MT.Gov 2004, Bureau of Reclamation 2007, AWEA 2007, SME 2007)

1 PPL-M – Pennsylvania Power and Light Montana
2 MVPC – Mission Valley Power Company
3 NLC – Northern Lights Cooperative
4 USBR – U.S. Bureau of Reclamation
5 USACE – U.S. Army Corps of Engineers
6 MDU – Montana-Dakota Utilities
7 PPL-M/PSP&L – Co-ownership between PPL-M and Peugeot Sound Power and Light
8 Co-ownership – between PPL-M, PacifiCorp, Avista, Portland General Electric, and PSP&L
9 MT DNRC – Montana Dept. of Natural Resources and Conservation
10 CEP – Colstrip Energy Partnership
11YP – Yellowstone Partnership
12 TM – Tiber Montana, LCC
13 SME – Southern Montana Electric

Unprecedented demands for copper were experienced throughout the nation in response to the advent of electricity. Montana's mining industry quickly realized the prospective applications for new electrical technologies and began to capitalize on Montana's potential electrical resources. The relationship between electricity and the mining industry developed as the economic base for Montana and became the dominant factor in shaping the geography of Montana's energy systems.

The Montana Power Company (MPC) was established in 1912 as a subsidiary of America's largest copper producer, the Anaconda Mining Company. The MPC became responsible for the consolidation of Montana's energy market and as a result, the development of energy resources and transmission lines in Montana focused on supplying electricity for the mining and ore smelting facilities at Butte, Anaconda, Helena, and Great Falls, and for the harvesting, processing, and transporting natural resources required by the mining industry (MPC 1941).

Residential and commercial use of electricity had developed as a mere consequence of Montana's mining industry. By 1940, roughly eighty-two percent of the electricity produced by the MPC was consumed by Montana's mining industry, while residential, commercial, municipal, and rural consumption of electricity within the state comprised the remaining eighteen percent (MPC 1940). Though population increases and state-wide economic diversity would eventually close the gap between residential, commercial, and industrial consumption of electricity, Montana's industrial base would continue to be the largest consumer of electricity within the state until the combination of environmental concerns and falling metal prices in 1983 forced the termination of Montana's mining industry (Gammons et al. 2006).

The closure of industrial mining facilities began to significantly shift the balance of energy consumption within the state, however, residential and commercial consumption of electricity would not match industrial consumption rates until the restructuring of Montana's energy market in 1997 (MDEQ 2004). As a result, the actual amount of energy consumed within Montana has not increased significantly; instead, Montana energy companies have entered into out of state energy markets requiring the observed need for increased production. It is important to note that all of the electricity produced for consumption within Montana was generated by relatively small and/or local hydroelectric facilities until 1951 when the first coal fired electrical generation facility was installed at Billing (Table 2.2 provides a chronology of this development).

Renewable Energy and Policy in Montana

The state of Montana possesses a very robust base of renewable energy resources. Available resources include solar, biomass, biofuels, geothermal, water and wind. Of these, wind and water resources are found in the greatest abundance and are considered as the possessing the greatest potential for development within Montana (Hartsoch 2004). Though both of these resources are dispersed throughout the state, each has regional concentrations. Wind energy resources are found in the greatest abundance in the eastern side of Montana, while the mountainous terrain of western Montana holds the greatest potential for establishing small-hydroelectric facilities. This distribution results in two relatively distinct geographic regions being split along the east slope of the Rocky Mountains. Figure 2.2 and Figure 2.3, provide representations of this distribution. Recent development of renewable energy resources within Montana include wind farms at Judith Gap, Martinsdale and Great Falls, small-hydroelectric facilities at Tiber and in

Granite County, and bio-fuel facilities in Butte and Cut Bank. Proposed development of renewable energy resources include: wind farms at Browning, Livingston, Helena and Cut Bank; landfill methane production facilities at Missoula and Billings; and multiple bio-fuel production facilities throughout the state. It is important to note that Montana possesses multiple large-hydroelectric facilities throughout the state. However, and regardless of water's designation as a renewable energy resource, the significant detrimental impacts associated with large-scale hydroelectricity (i.e., barriers to migrating fish and the large geographic areas required for water storage) have precluded this resource from being considered an environmentally friendly renewable energy resource.

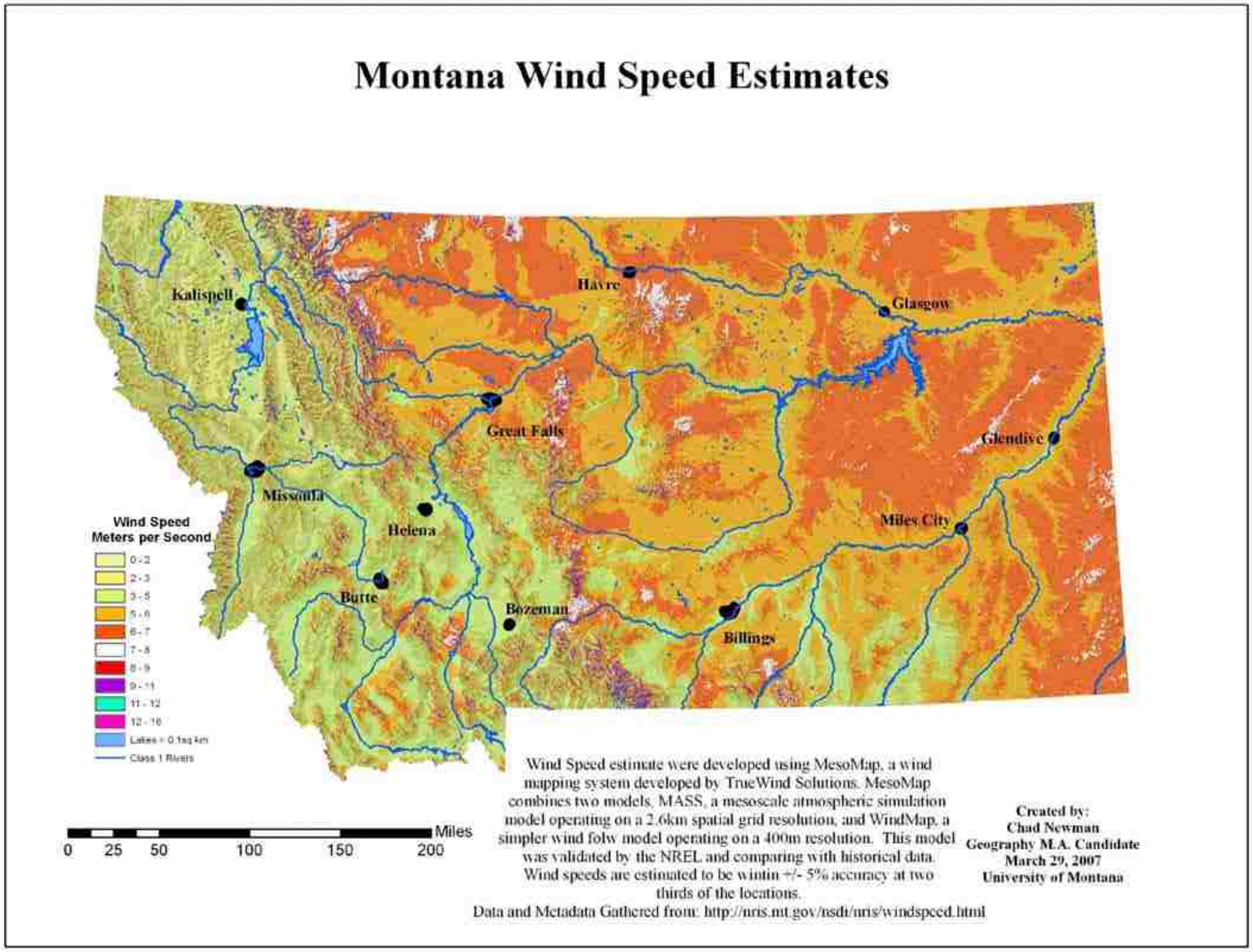


Figure 2.2. Montana Wind Speed (source: Author)

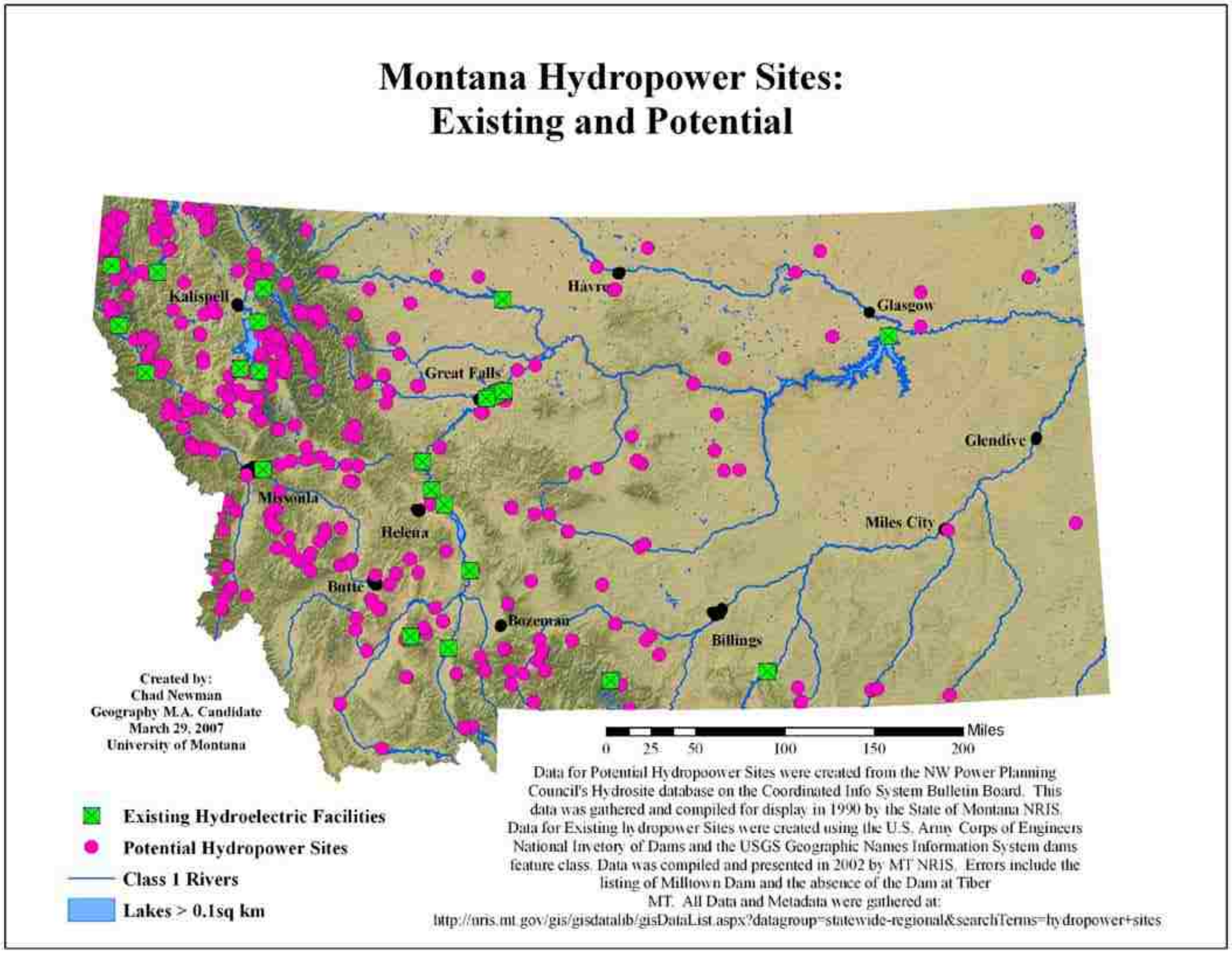


Figure 2.3. Montana Potential Hydropower Sites (source: Author)

Policy

Efforts to restructure American energy markets throughout the last few decades have produced some interesting results in both national and state energy policies. Early attempts to modify national energy policies by the Carter administration, largely in response to the energy crisis and oil embargo's of the 1970s, resulted in establishing the Public Utility Regulatory Policies Act (PURPA) in 1978. The PURPA provided the first direct governmental advocacy for the development and use of renewable energy within America. Federal tax credits were used to stimulate the development of alternative sources of energy and a series of national mandates were set in place requiring energy produced by qualifying facilities (i.e., small-scale energy producers, renewable energy production facilities, and energy produced through the heat and waste by-products of industry referred to as co-generation facilities) to be purchased by electric utilities (Zucchet 2002). The same legislative body that formed the PURPA replaced and renamed the Federal Power Commission (FPC) with the Federal Energy Regulatory Commission (FERC), which assumed the authority of the FPC in overseeing the generation, pricing, marketing, and transmission of electricity. However, two important responsibilities had been added to the FERC's role. The FERC had been given the responsibility to govern the rules of PURPA and to begin a partial deregulation of electricity across the nation (Abel 1999). The combination of these two actions provided a framework which would be essential for deregulating the sale and transmission of wholesale electricity through the establishment of the Energy Policy Act of 1992 (Abel 1999). Though the FERC and the Energy Policy Act would only restructure wholesale electricity and natural gas within the national energy market, they allowed individual states the choice and authority to completely restructure their energy markets (Abel 1999). As a result, many states have chosen to adopt legislation restructuring their energy markets. Though restructuring has been adopted primarily to create competition for energy monopolies and oligopolies by providing consumer choice for the lowest priced energy, this state-by-state restructuring has inadvertently proved beneficial for developing renewable energy markets.

Currently, legislation mandating renewable energy standards (RES) has been adopted by 24 individual states. Of these states, Wisconsin is the only one that has not restructured its energy market (NCSU 2007). Common elements found within the individual state RES include: the target percentage for the desired amount of renewable energy to be used, a time schedule for which these policies will be implemented, the identification of renewable energy resources considered acceptable for generating electricity, required minimum percentages for specific technologies such as wind or solar power, and if the trading renewable energy credits (i.e. purchasing renewable energy as a commodity from outside individual state boundaries) will be allowed. Appendix C provides an overview of these state RES by outlining the differences between standards, policies, accepted renewable energy resources, and how RES will be implemented.

In 2005, Montana adopted its own RES with the passage of Senate Bill 415, Montana Renewable Power Production and Rural Economic Development Act. This legislation has provided RES requiring public utilities to obtain a percentage of their retail electricity sales from eligible renewable resources according to the following schedule (percentages are listed as proportional to total electrical generation capacity):

- Five percent in 2008 through 2009
- Ten percent in 2010 through 2014

- Fifteen percent in 2015 and thereafter

Montana's legislators have determined that eligible renewable energy resources for development include: wind, solar, geothermal, small-hydroelectric, landfill or farm-based methane gas, wastewater-treatment gas, low-emission nontoxic biomass, and fuel cells produced with renewable fuels. Electrical generation facilities using these resources must either be located in Montana, or begin operation after January 01, 2005 in another state if the electricity is used to satisfy Montana RES requirements. Utilities can meet these standards by directly developing renewable energy resources, by entering into long-term purchase contracts for electricity bundled with renewable-energy credits (RECs), by purchasing the RECs separately, or a combination of all (MCA § 69-8-1004 2005). Included in this legislation, Montana has also adopted language supporting the development of renewable energy resources by local communities and local economies.

The renewable resource standard, as listed in the Montana Renewable Power Production and Rural Economic Development Act, mandates a percentage of the renewable energy procured by utilities to meet the RES come from both in-state facilities and community renewable energy projects. Table 2.5 provides the schedule of graduated increments developed by SB 415 (MCA § 69-8-1004 2005).

While the Montana Renewable Power Production and Rural Economic Development Act has opened the door for tapping the state's underutilized renewable energy resource base, this legislation is not without flaws. Significant to this study (and unique from all other states definitions of water resources), Montana's legislators have defined the generation of electricity through small-hydroelectric facilities as: "Water power, in the case of a hydroelectric project that does not require a new appropriation, diversion, or impoundment of water" (MCA § 69-8-1004 3(6d) 2005).

Table 2.3. Montana Community and Economic Development Standards

Compliance Time Line	From In-State Resources	From Community Renewable Energy Projects
Jan 01, 2008 – Dec 31, 2009	5 % of total retail sales	No requirements
Jan 01, 2010 – Dec 31, 2014	10 % of total retail sales	Electrical output totaling at least 50 MW in nameplate capacity
Jan, 2015 and on	15 % of total retail sales	Electrical output totaling at least 75 MW in nameplate capacity

(Source: MCA § 69-8-1004 section 5 subsection (2) through (4) 2005)

Further limitations to the development of small-hydroelectric facilities are identified in Montana state laws regulating water use (MCA § Title 85 2005). The Montana state legislature has mandated a temporary closure on the permitting of new water rights in Montana's hydrological sub-basin 76H, the Bitterroot River and its tributaries above the confluence with the Clark Fork River, as it has been deemed a "highly appropriated sub-basin" (MCA § 85-2-344 & MCA § 85-2-319 2005). Though the verbiage offered within these policies indicates the abolition of using water resources within Ravalli County for the generation of electricity, permitting for a non-consumptive use of water resources within Ravalli County is possible. The most recent installation of a small-hydroelectric facility within Montana occurred by a private landowner within Ravalli County located twenty miles south of Darby MT (MGP 2007). The implications and significance resulting from this language will be further discussed in subsequent chapters.

CHAPTER THREE: STUDY AREA

Introduction

Western Montana's Ravalli County was selected as the study area for a variety of reasons. First, the combination of available local water resources and the regional physical geography are well suited for the development of small-hydroelectric systems. Second, significant increases in population, largely a result of in-migration, are changing regional demographics and are increasing diversity in social structure and social attitudes regarding resource use. Third, development pressures within Ravalli County are changing landscape qualities at increasingly rapid rates providing for possible increased contention over developing local renewable energy resources. Finally, the natural beauty and scenic landscapes within Ravalli County stand to be altered through developing renewable energy resources, making this small western Montana County a prime location for conducting this research.

Physical Geography

Montana's Ravalli County (Figure 3.1) is located on the western-most side of the state along the Idaho border. The physical boundaries of the county are defined by the crest of the Sapphire Mountains to the east and that of the Bitterroot Mountains to the west. These two mountain ranges converge at the south end of the valley to forming Ravalli County's southern boundary. The northern extent of Ravalli County is a geometric boundary separating Ravalli and Missoula Counties and is located roughly 1.5 miles north of Florence, Montana. The mountains surrounding the Bitterroot valley provide a vertical relief ranging roughly 6,000 feet. Elevations range from the 3,280 ft valley floor at Florence to 10,157ft Trapper Peak in the Bitterroot Mountains and the

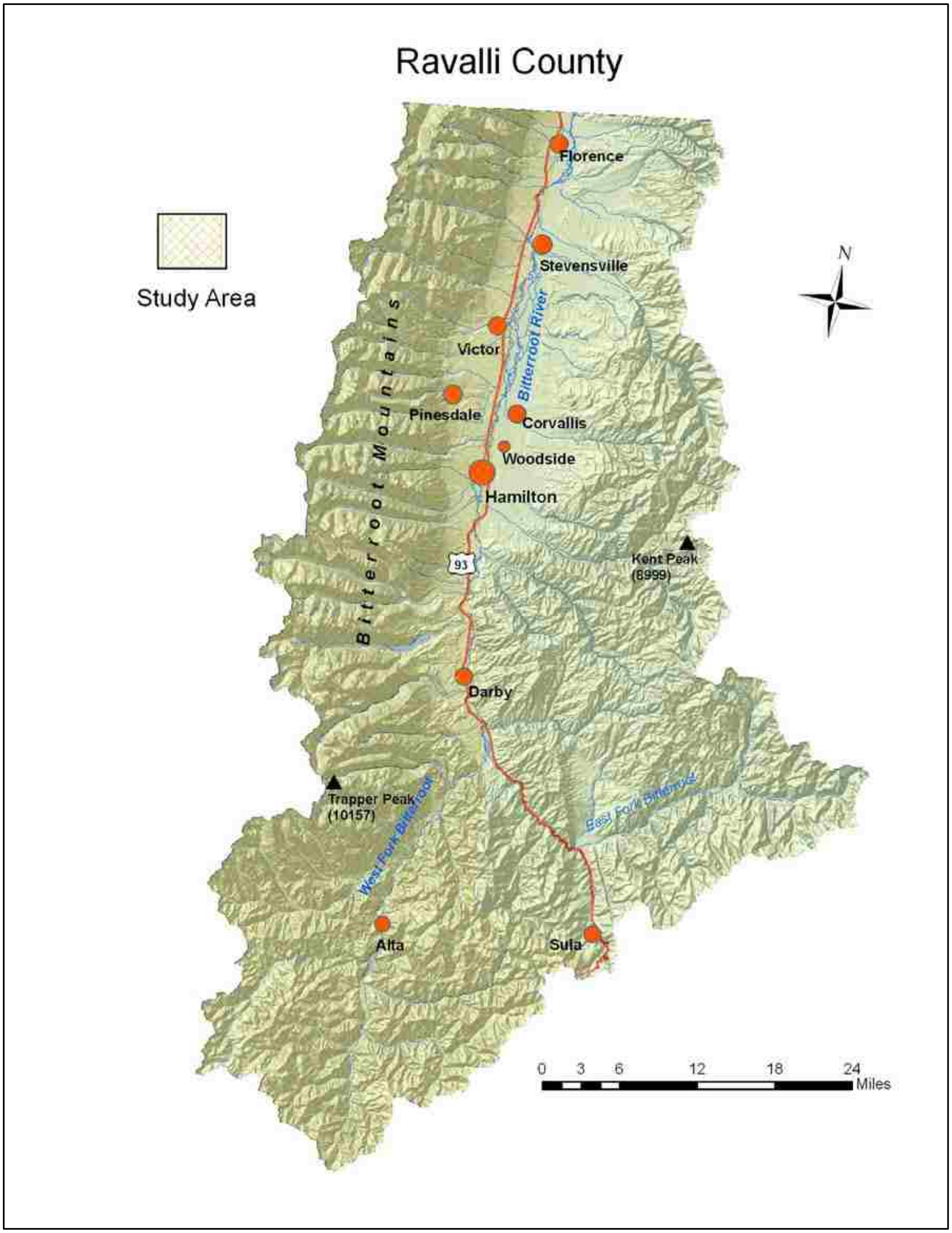


Figure 3.1. Study Area (source: Author)

8,999 ft Kent Peak in the Sapphire Range. Average annual rainfall for Ravalli County varies with the topography, with ten inches per year being recorded along the valley floor increasing up to seventy five inches per year at higher elevations. Peak rainfall within Ravalli County occurs from October through June.

Ravalli County's total area is 2,398 square miles (1,534,720 acres) comprising 1.65 percent of Montana's total area (MTNRIS 2007). Of the total land within Ravalli County, 1,127,565 acres (roughly seventy three percent), are administered by the federal government. Some 46,107 acres are administered by state and local government, with the remaining 361,039 acres being owned by private entities (MTNRIS 2007). The largest urban area located in Ravalli County is Hamilton, Montana with a population of 3,705 being reported by 2005 census estimates. Other towns within Ravalli County include Florence, Stevensville, Pinesdale, Victor, Alta, Conner, Grantsdale Woodside, Corvallis, Sula and Darby. Of these, Hamilton and Stevensville are the only two with populations over 1,000 (Census 2000).

The Bitterroot River finds its origin just south of Darby at the confluence of the East and West Forks of the Bitterroot River. As the Bitterroot River meanders through this picturesque valley, it is fed by sixty seven small mountain tributaries; thirty of these originate within the Bitterroot Mountains (MTNRIS 2000). Twenty-nine dams exist within Ravalli County with twenty two being situated within the Bitterroot Mountains. All of the dams in Ravalli County have been constructed to ensure the availability of water for late season irrigation. All of these structures were constructed prior to 1970 with the Mill Creek Dam, the oldest dam in the Bitterroot Mountains, being built in 1907. The largest of these are West Fork Dam at Painted Rocks Reservoir and Como Dam at

Como Lake. None of these dams are used for the generation of electricity (MTNRIS 2003).

<u>Population and Demographics</u>

Since 1970, the population of Ravalli County has more than doubled. Currently, Ravalli County is one of the fastest growing county in Montana. Census estimates (2006) reported a population of 40,582 residents, a forty-four percent increase from 1990 census results (Census 1990, Census 2006). Dr. Larry Swanson of the O'Connor Center for the Rocky Mountain West projects annual growth rates of 1.8 to 2.8 for Ravalli County continuing over the next two decades. Using these numbers, Swanson estimates Ravalli County's population will increase to 57,000 – 72,000 by the year 2025 (Swanson 2006). Figure 3.2 shows the population trends, estimates, and predictions for Ravalli County.

As populations increase, demographics within Ravalli County are changing. As observed in many areas throughout the western United States, in-migration within Ravalli County continues to be the most significant factor driving this rapidly expanding population. As a result, the average age of Ravalli County residents is increasing with the median age increasing from 32 in 1980 to 41 in 2000 (Swanson 2006).

A primary reason for this recent in-migration is described by many researchers as amenity migration. This migration is cited as a movement of people to areas possessing "scenic, recreational, and climatic amenities" (Smith & Krannich 2000: 396, Stewart 2000). This trend goes against traditional economic models relying on income level and potential used for predicting human migration paths as the majority of those moving to rural areas stand to experience reductions in income (Stewart 2000). Ravalli

County possesses many desirable natural amenities and as a result, has experienced significant shifts in local economies.

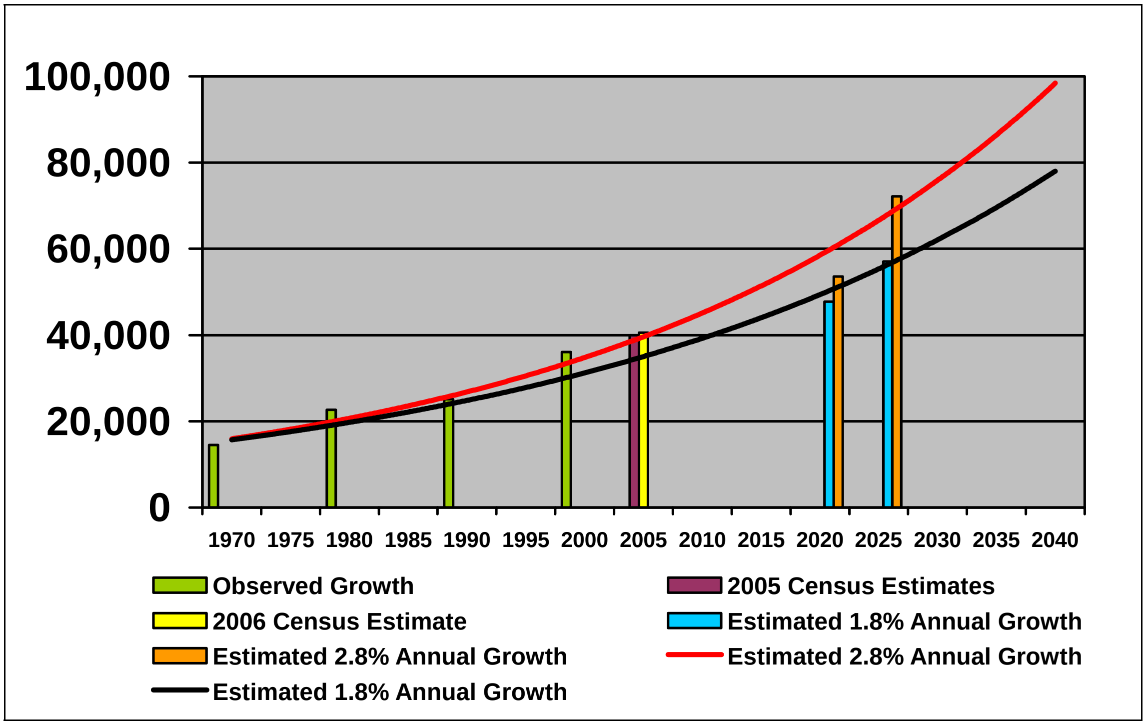


Figure 3.2. Ravalli County Population Trends (source: Census 2000, Swanson 2006)

Research by Shumway and Otterstrom (2001) identify this amenity migration as the "new west" as rural counties possessing high levels of desirable natural amenities are shifting to a service-based economy. Ravalli County has been identified as one of eight Montana counties shifting to "new west" economies (Shumway and Otterstrom 2001). Largely this has occurred as migrants tend to be somewhat older, of higher affluence, and have been reliant on services typically associated with large urban areas. As well, settlement patterns associated with amenity migration has resulted in increased sprawl. Traditional Euro-American settlement patterns have historically resulted in the two way economic interaction between small rural towns and those working the land. However, amenity based migration has resulted in the fragmentation of agricultural lands as developers providing larger lots and homes to attract these "new west" migrants and the natural amenities associated with a rural lifestyle are spreading these migrants across the landscape. Though research by Smith and Krannich (2000) indicate some degree of variation is found within these trends and between communities, amenity migration has resulted in changing demographics, significant population increases, and landscape changes for many rural western communities.

History and Economy

Ravalli County holds a rich historic background for Montana. The Salish Indians were the Native American inhabitants of the Bitterroot Valley when Lewis and Clark traversed it in 1805. Named after the Bitter Root flower, the Bitterroot valley is home to one of Montana's first settlements. In 1841, the region's first mission and school were constructed at Stevensville, Montana. In 1855, the Treaty of the Hellgate was signed designating the Bitterroot Valley at the traditional homeland of the Salish Indians and was to be preserved in perpetuity as the Salish Indian Reservation. Copper mogul Marcus Daly established logging and lumber industries in the Bitterroot valley in 1890 in support of his mining operations in Butte. In 1891, President Grant ratified the Hellgate Treaty of 1855, reclaiming the Salish Indian Reservation and relocated the Salish Indians to the Jocko Valley within the current day Flathead Indian Reservation (CSKT Comprehensive Resources Plan 2005). Interest by Marcus Daly in the Bitterroot Valley resulted in the creation and development of Hamilton, Montana, as the county seat in 1893. The economy of Ravalli County developed as being primarily dependant on agriculture, horticulture, livestock, and forest resources for the majority of the 20th century as Missoula, the regional center for trade, provided a market and trade routes for the products produced in Ravalli County.

Currently, Ravalli County's economy is experiencing significant changes as population increases have outstripped the local economy's ability to support the number of people moving into the area. Traditional agricultural lands within Ravalli County are quickly being subdivided in order to both attract people to the area and support the demands of increasing populations. Total agricultural lands have declined roughly 50,000 acres from 1980 to 2005. Future projections of current trends indicate that an additional 40,000 acres of agricultural land may be lost by 2025, reducing the current acreage to around 170,000 acres (Swanson 2006). Fragmentation of land combined with a decline in traditional industries have left Ravalli County largely dependant on tourism and providing service base industries as twenty percent of its residents commute north to Missoula County for employment. Roughly sixty five percent of the employment found in Ravalli County is within the service, retail, and construction industries (Ravalli County Growth Policy 2003).

Hydroelectric Potential

The streams that have been identified as possessing the highest potential for developing small-hydroelectric systems within Ravalli County find their origins in the Bitterroot Mountains and are the western tributaries to the Bitterroot River (Figure 3.3). As a result of this, and considering the natural and visual amenities associated with the Bitterroot Range, the Bitterroot front and it's streams were used as hypothetical examples for this research. There are thirty streams originating in the Bitterroot mountains within the boundaries of Ravalli County that possess the potential for electrical energy production. Table 3.1 lists the streams that flow into the main Bitterroot Valley and are in direct view from multiple points within the valley floor. Figure 3.3 shows all of these

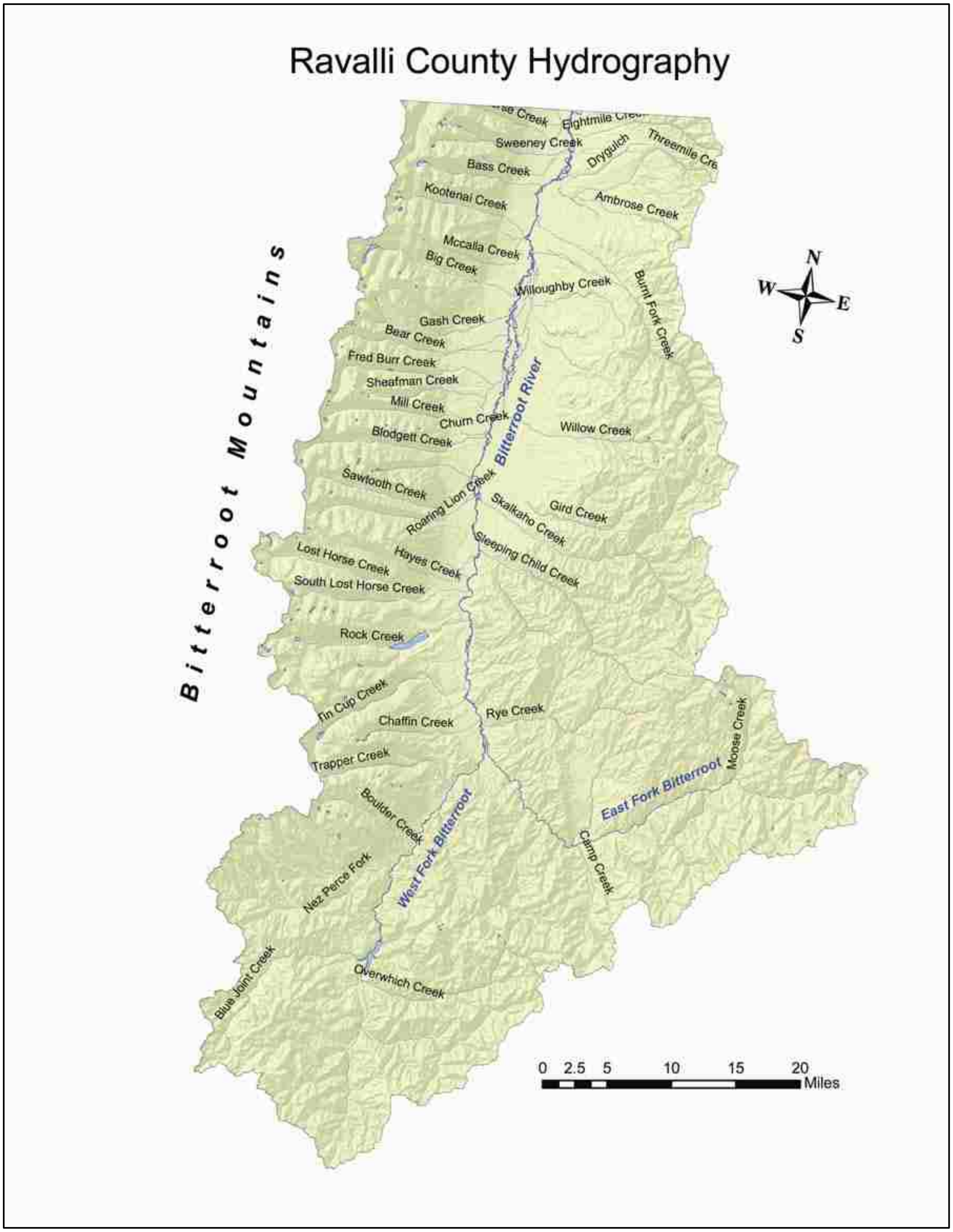


Figure 3.3. Ravalli County Hydrography (source: Author)

streams. Each of these streams differs in the actual amount of energy that can be produced as the size of each individual watershed differs; some streams can only be used for the generation of electricity on a semi-annual basis as spring snowmelt limits this potential, with significant flows occurring March through July. Though flow data collected by the USGS is available for eight streams, comprehensive data for all streams are unavailable; therefore, the use of a predictive flow model was necessary to determine an estimate for the amount of water being discharged from that portion of the Bitterroot Mountains located within Ravalli County. Data used for flow model input included flow data from the West Fork of the Bitterroot and Lolo Creek, (located four miles north of the study area in Missoula County) as both of these water courses represent large hydrologic sub-basins and allow for more accurate numbers to be generated by this model.

Table 3.1. Streams flowing from the Bitterroot Mountains

Stream Name	Flow Data Available	Stream Name	Flow Data Available	Stream Name	Flow Data Available	Stream Name	Flow Data Available
Tie Chute	No	One Horse	No	Roaring Lion	No	Lost Horse	No
Sweeney	No	McCalla	No	Trapper	No	Camas	No
Big	No	W. Fk Biroot	Yes	Mill	No	Hays	No
Larry	No	Sweathouse	No	Canyon	No	Rock	Yes
Bass	No	Bear	Yes	Sawtooth	No	Tin Cup	No
Kootenai	Yes	Fred Burr	Yes	Blodgett	Yes	Chaffin	No
Overwhich	No	Blue Joint	No	Nez Perce Fork	No	Boulder	No
Churn	No	Gash	No	Sheafman	No		

Flow predictions for this section of the Bitterroot Mountains, the 1,092 square mile geographical area shown in Figure 5, are based on the observed flow data for the eight streams and their watershed areas. This information is provided by current and historic USGS surface-water data (USGS 2006). Flow estimates are made by obtaining an average monthly discharge per square mile for each of these sub-basins. This is accomplished by dividing the average monthly discharge (cfs or Q) from each watershed sub-basin by the area of the sub-basin (square miles or *k*). The sum of monthly discharge from individual sub-basins with available data (i) is then averaged and multiplied by the total square miles within the study area (A). The formula developed for determining discharge estimates within this area is:

[illegible]

Using these data, it is estimated that an average of 2,287 cubic feet of water per second (cfs) per month flow from this section of the Bitterroot Mountains; however, actual monthly discharge varies considerably and is strongly affected by seasonal influences (USGS). Table 3.2 provides monthly flow estimates for this section of the Bitterroot Mountains and the observed flow data from the Bitterroot River at Florence.

Table 3.2. Average Monthly Discharge from Bitterroot Mountains

Average Discharge (in cfs)	Jan.	Feb.	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Study Area	491	502	589	2,489	7,796	8,068	3,151	1,266	836	851	750	655
Bitterroot River	809	920	978	2,300	6,120	7,970	1,950	709	948	1,130	1,030	929

(Source: USGS 2006)

These data indicate that though some of the larger streams, such as the West Fork of the Bitterroot River, may be used for generating significant amounts of electricity on a year-round basis, most all of the smaller tributaries could only be used during high flows for generating beneficial amounts of electricity while still allowing appropriate amounts of water to remain in natural stream beds. It is important to note that the observed discrepancies between average monthly discharge during runoff from snowmelt is significantly higher than what is being recorded in the Bitterroot River at Florence as much of this water is being stored behind irrigation dams for agricultural use during the late summer months. As well, these data do not reflect the effects of ground infiltration rates, water removed by irrigation canals located above historic flow stations or other natural/cultural factors involving water use along the Bitterroot front.

Chapter Summary

The combination of the physical geography, social demographics, small hydroelectric resource potential, and natural beauty found in western Montana's Ravalli County not only provide an excellent setting for evaluating the development of local streams for generating electricity, but the evaluation of these individual components provide some insight into the complexities associated with evaluating the values of local residents and how they pertain to local natural resources and aesthetics. Though these factors are largely unrelated, in considering the attitudes and perceptions of local residents as a common thread for measuring the impacts of developing small-hydroelectric resources, some interesting results are generated. The following Chapters provide a detailed description of the methods used for evaluating these values, results from this study, and the recommendations for future research pertaining to renewable energy, the values of local residents and how they pertain to the formation of public policy.

CHAPTER FOUR: METHODS

This chapter presents the methods utilized in this study, including those related to data collection and to data analysis. Both quantitative and qualitative data were generated with the aid of a survey instrument, and parametric statistical methods were employed to analyze these data.

Data Collection

To assess the attitudes and perceptions of Ravalli County residents regarding the development of local streams for generating hydroelectricity, a survey (Appendix A) was administered to 104 subjects in the Bitterroot Valley during the fall of 2006. This survey contained questions addressing visual and written information provided on a poster (Appendix B) to measure these attitudes and perceptions providing a mix of quantitative and qualitative data.

This poster provided a generalized outline of Montana State energy policy, a brief overview of the Montana legislature's implementation strategy and some of the tradeoffs associated with developing renewable energy resources, including the potential for stabilizing local energy prices and some of the environmental impacts associated with developing resources. It also displayed a series of images including maps showing the concentration of wind and hydroelectric resources throughout Montana, the physical layout of small-hydroelectric systems, and a series of photos from operational and historical small-hydroelectric facilities located in and around Logan, Utah and outside of Philipsburg, Montana. These visual aids were used to inform survey participants of the availability and abundance of local renewable energy resources and to provide some idea of what types of visual/aesthetic impacts may be incurred upon the landscape with developing local streams for generating electricity. Once participants had completed their evaluation of the poster, they were asked to fill out the survey. This survey consisted of a series of questions developed for gauging the respondent's knowledge of renewable energy, the policy driving its development, and attitudes and perceptions regarding the use of local renewable resources. As well, questions regarding the tradeoffs associated with local control over energy production and the inevitable aesthetic and environmental impacts associated with resource development were posed. Additional questions concerning basic demographics and residential use of local resources, including purpose and frequency of use, were asked to aid in the analysis of attitudes and perceptions of participants. Most of the questions pertaining to perceptions and attitudes, resource knowledge, use, and policy were developed using a five point Likert scale to facilitate the statistical analysis of these data. However, other qualitative data were gathered for assessing demographic information. One open-ended question was included at the end of this survey to allow participants an opportunity to provide further comments regarding the development and use of renewable energy resources and providing some qualitative data for this study. Qualitative data gathered by this survey are reported within a separate section at the end of Chapter Five.

The administration of the survey took place over the course of seven concurrent Saturday's in September and October of 2006. Data were collected on six occasions at the Ravalli County Farmers Market with the final data collection taking place at Ravalli County's McIntosh Apple Day celebration. All data were collected in Hamilton Montana. The choice of this location and these events was based on the social components associated with these functions. A large cross section of Ravalli County residents frequent the Farmers Market and participate in the McIntosh Apple Day celebration as these events provide not only a market for locally grown produce, arts, and crafts, but serve as a social gathering place for many.

All surveys were conducted out doors at a table set up among the local vendors. Two chairs, clipboards, and writing instruments were provided and $100.00 raffle was offered to survey participants in order to increase interest in this research. Participation in this research was completely voluntary. Willing participants were asked to evaluate the poster and were informed that they would not be provided with additional information other than the location of the small-hydroelectric facilities on display and clarification of survey questions. One common question that was answered and eventually became incorporated into the verbal instructions for the survey was that on question number 10 d. (Appendix A) regarding perceptions of the associated impacts to/for the local economy. Respondents were instructed that perceived impacts "to" the economy were negative impacts and should be answered as a "one" or a "two", while impacts "for" the economy were intended to imply positive economical impacts and should be represented by responding "three" through "five". All other questions were deferred to the end of the survey process. Participants required between five and fifteen minutes to complete the survey, and were provided with a raffle ticket at the end of the survey process.

Measures

Following the administration of the survey, all quantitative data were coded and entered into SPSS® computer software for statistical analyses. Analyses included cross-tab analysis, one way analysis of variance (ANOVA), and both independent samples and paired samples T tests to evaluate similarities between and within the variables being measured. General population characteristics such as age, length of residence and income were used to evaluate differences between variables regarding the development of local streams for generating electricity. Similarly, these variables were tested against the reported perceived impacts associated with developing resources and the extent to which they use these resources for recreation and their regard for the resources' amenity values. The results of these analyses were evaluated with respect to how survey participants responded to the questions pertaining to tradeoffs (i.e., willingness to pay more, the same, or less if water resources were developed). The results from these analyses were then evaluated in the context of Montana's current energy policy statements to evaluate whether or not there is concurrency between its renewable energy policy and the perception of Ravalli County residents regarding the use of local streams for generating electricity.

An assortment of variables was included within the survey for evaluating the attitudes and perceptions of Ravalli County residents. Within the survey, respondents were asked to rank, on a five point Likert scale (with 1 being a very negative perception or attitude and 5 being a very positive perception or attitude): 1) how favorable they are to using these resources for generating electricity, 2) if they believed small-hydroelectricity was suitable for development or has the potential for development within Ravalli County, 3) whether or not they were aware of the potential impacts associated with developing small-hydroelectric resources, and 4) if they were familiar with Montana's renewable energy policy. Using a paired samples T test, these variables are paired both against one another and with participant responses to questions developed for gauging perceptions of the possible impacts associated with the development of small-hydroelectric technologies, including the perceived impacts to aesthetics/view, water quality, fish and wildlife habitat, and to/for the local economy.

One way analysis of variance (ANOVA) and independent samples T tests were used to evaluate additional variables regarding age of the respondents, income level, how and how much survey participants use these local resources, and length of residency of survey participants. Each of these variables is measured as nominal/ordinal data within the survey and then recoded for statistical analysis. Ages of respondents, annual income, and length of residency within Ravalli County are separated into five groups for analysis. Resource use was gauged by asking respondents to indicate how many days per year they use the streams and canyons along the Bitterroot front for hiking/bird and wildlife viewing, fishing, hunting, or for other recreational activities such as kayaking, picnicking, or camping. The variables and categorical recodings that are used for statistical analysis are listed in Table 4.1. Both the one way ANOVA and an independent samples T tests were used to analyze each of the variables listed within Table 4.1 against the perceptions and attitudes of survey respondents and if they favor using these local resources for the generation of electricity.

Table 4.1. Independent Variables Used for Statistical Analysis

Age of Respondents	Income Brackets	Length of Residency	Resource Use
18-30	0-25k	0-6 years	Do not use
31-40	25-45k	7-16 years	1-5 days per year
41-50	45-65k	17-26 years	6-10 days per year
51-60	65-85k	27-36 years	11-15 days per year
61 +	85k +	37 years +	16-20 days per year
			21 or more days per year

Every attempt was made to ensure that consistent parameters were used in creating these groups, however, the demographics of survey respondents proved somewhat problematic for providing consistency in both grouping parameters and group size. Brackets used for length of residency were determined by using decennial breaks as is done by the U.S. Census Bureau. Further difficulties were encountered with gauging resource use as some use categories, such as those developed to measure the perceptions of hunters and fishermen, resulted in very low response rates. As a result, all use categories were recoded as nominal data (i.e., use/no use) to provide a second measure for gauging these perceptions. An independent samples T test was used to assess variances between these different resource uses.

Chapter Summary

Though alternative methods could have been employed for gathering data for this study and slightly different questions posed (discussed further in Chapter Six), the haphazard sampling of Ravalli County residents through the use of this public perception survey provided a good data set for analysis. These data included some basic socio-demographic characteristics and resource use categories for which to analyze the values of those participating in the survey process. In performing the statistical analysis of these data against the reported attitudes and perceptions of Ravalli County residents, some interesting results have been generated. The following Chapter (Chapter Five) provides a comprehensive account of these results.

CHAPTER FIVE: RESULTS

This chapter reports the results of this survey and the results from the statistical analyses used for evaluating these data. Descriptive statistics provide a breakdown of the age and use categories as found by the survey instrument. Statistical analyses of the perceptions and attitudes of survey respondents' are then performed using the paired samples T test. Analysis of variance and the independent samples T test are used to analyze the socio-demographic variables and those regarding the use of local resources with attitudes and perceptions of survey respondents. Additional statistical analyses are conducted on the knowledge of survey respondents regarding renewable energy resources, their environmental impacts, and of Montana state energy policy in order to determine if any of these factors have any bearing on the attitudes and perceptions of Ravalli County residents.

Socio-Demographic Profile

A total of 104 people completed this survey. Though the majority of survey participants responded to all of the questions within the survey, some respondents missed questions, provided inappropriate responses, or did not respond to questions. Missing or inappropriate responses were treated as missing data. Additionally, in the case of the resource use categories, if a respondent indicated they used the canyons and streams located within the Bitterroot Mountains for any of the four categories but did not provide responses to the other categories, these missed categories were treated as "do not use" in the analyses.

Table 5.1 presents the frequency distribution of survey respondents' age, income, and length of residency. Both means and median values are reported in order to

Table 5.1. Descriptive Statistics for Age, Income, and Length of Residency

Age of Respondents	Percentage	Income Brackets	Percentage	Length of Residency	Percentage
18-30	8.7	0-25k	18.0	0-6 years	35.6
31-40	10.6	25-45k	29.2	7-16 years	20.2
41-50	17.3	45-65k	29.2	17-26 years	12.5
51-60	27.9	65-85k	14.6	27-36 years	10.6
61 +	35.6	85k +	9.0	37 years +	21.2
Mean Age: 53.25 Median Age: 54		Mean Income: $45-55k Median Income: $45-55k		Mean Residency: 14.5 years Median Residency: 11 years	

compare the socio-demographic data generated by this survey with 2000 U.S. Census statistics. Though the medians and means being reported for age and income are somewhat higher than what are reported by the 2000 U.S. Census for Ravalli County (median age is forty-one and mean income is $41,225, respectively), the socio-demographic characteristics of Ravalli County's population as determined by the survey instrument are fairly consistent with 2000 Census results (Census 2000). One factor, the length of residency of survey participants, deviates significantly from that of the general population of Ravalli County. The length of residency reported by survey participants indicates that newcomers (those residing within Ravalli County 0-6 years) comprise 35.6 percent of all survey respondents. Census estimates for 2006 indicate that a 12.5 percent increase in population (4,512 persons) was experienced between 2000 and 2006 within Ravalli County (Census 2006). An explanation for this phenomenon can not be rendered based on the data collected within this survey; however, it is possible that newcomers are more likely to visit the events at which the survey was administered than longer-term residents.

Resource Use

As previously stated, resource use was separated into four categories for analyzing both how, and how frequently, respondents use the canyons and streams along the Bitterroot front. Table 5.2 displays these uses as found in this study. Though these data suggest moderate to heavy use of local resources by Ravalli County residents, the evaluation of the specific use categories shows the majority of recreational use is for "Hiking/Bird and Wildlife Viewing" and "Other Recreation" (kayaking, picnicking, camping) while the "Hunting" and "Fishing" categories present very different results.

Table 5.2. Resource Use: Cross-Tabulation

Total Use of Resources by Survey Respondents	**Little to No Use**		**Moderate Use**		**Heavy Use**		**Total N ***
N (Percent)	41 (41.4%)		29 (29.3%)		29 (29.3%)		99
Use Categories and Frequencies (dpy - days per year)	**Do not use**	**1 – 5 dpy**	**6 – 10 dpy**	**11 – 15 dpy**	**16 – 20 dpy**	**21+ dpy**	**Total N***
Hiking/Bird and Wildlife Viewing	11	10	15	16	5	42	99
Fishing	45	18	10	5	6	15	99
Hunting**	71	15	3	4	2	4	99
Other Recreation (kayaking, picnicking, camping)	17	19	17	10	15	21	99

* Data regarding resource use was missing for five survey respondents.
** Unexpectedly low numbers were generated within the hunting category. These frequencies prove problematic for statistical analysis; therefore Hunting is recoded as a use/no use category and is treated as a separate variable.

In evaluating this data set, it is evident that the number of people responding as using these resources for "hunting" proves problematic for conducting bivariate analyses of these data. Therefore, the "hunting" use category has been re-coded as a binary response variable (i.e., use/no use). A cross-tab analysis was performed using the resource use and socio-demographic categories to summarize how the portion of the population who participated within this study uses their local resources. These results are presented in Tables 5.3 and 5.4.

Table 5.3. Cross Tabulation of Survey Respondents Using Canyons and Streams along the Bitterroot Front for Hunting and Socio-Demographics

Use Canyons for Hunting	Age					
	18-30	31-40	41-50	51-60	61 yrs +	Total N
Use	3	1	8	10	6	28
Not Use	6	10	9	19	27	71
Total N	9	11	17	29	33	99
Use Canyons for Hunting	Household Annual Income					
	$0-25k	$25-45k	$45-65k	$65-85k	$85k +	Total N
Use	3	8	6	4	2	23
Not Use	13	18	20	8	6	65
Total N	16	26	26	12	8	88
Use Canyons for Hunting	Length of Residency					
	0-6 yrs	7-16 yrs	17-26 yrs	27-36 yrs	37 yrs +	Total N
Use	10	4	4	7	3	28
Not Use	27	16	9	4	15	71
Total N	37	20	13	11	18	99

Table 5.4. Cross Tabulation of Survey Respondents Using Canyons and Streams Along the Bitterroot Front for Other Recreation (Picnicking, Camping, Kayaking) and Socio-Demographics

Use Canyons for Other Rec. (dpy)*	Age					
	18-30	31-40	41-50	51-60	61 +	Total N
No Use	1	0	1	4	11	17
1-5 dpy	0	3	7	5	4	19
6-10 dpy	1	0	0	9	7	17
11-15 dpy	3	0	2	2	3	10
16-20 dpy	3	2	2	4	4	15
21+ dpy	1	6	5	5	4	21
Total N	9	11	17	29	33	99

Table 5.4. Cross Tabulation of Survey Respondents Using Canyons and Streams along the Bitterroot Front for Hunting and Socio-Demographics (continued)

Use Canyons for Other Rec. (dpy)*	Household Annual Income					
	$0-25k	$25-45k	$45-65k	$65-85k	$85k and higher	Total N
No Use	2	6	6	0	1	15
1-5 dpy	5	5	6	1	1	18
6-10 dpy	3	5	4	2	2	16
Use Canyons for Other Rec. (dpy)*	**$0-25k**	**$25-45k**	**$45-65k**	**$65-85k**	**$85k and higher**	**Total N**
11-15 dpy	2	3	0	3	1	9
16-20 dpy	0	1	6	2	1	10
21+ dpy	4	6	4	4	2	20
Total N	16	26	26	12	8	88
Use Canyons for Other Rec. (dpy)*	**Length of Residency**					
	0-6 years	**7-16 years**	**17-26 years**	**27-36 years**	**37 years and longer**	**Total N**
No Use	4	5	3	2	3	17
1-5 dpy	8	6	1	2	2	19
6-10 dpy	5	4	1	4	3	17
11-15 dpy	5	1	2	0	2	10
16-20 dpy	5	2	3	1	4	15
21+ dpy	10	2	3	2	4	21
Total N	37	20	13	11	18	99

*dpy = days per year

These data show that the majority of those using the canyons along the Bitterroot front for hunting and other recreational pursuits are older than forty-one years of age. Additionally, income and length of residency categories, though not quite as pronounced as the age category, show that most of those participating in this survey have annual household incomes between $25,000 and $65,000 and have lived in Ravalli County between zero and sixteen years.

Attitudes and Perceptions

As discussed within Chapter Two, attitudes and perceptions have significantly different meanings. An attitude is how one feels about an event or object, while a perception is the interpretation of the event or object by an individual based on his/her past experiences (Merriam-Webster 2007).

Attitudes regarding the use of local streams for generating electricity were measured by posing two questions: 1) "Do you think local streams are suitable for development, or have the potential for development within Ravalli County", and; 2) "Do you favor using the streams originating within the Bitterroot Mountains for generating electricity through the use of small-hydroelectric technologies". The second of these questions was further measured by three additional questions asking if respondents favored using resources if it resulted in increasing, stabilizing, or lowering their current utility costs. Tables 5.5 and 5.6 present the descriptive statistics regarding the attitudes of Ravalli County residents regarding these measures.

Table 5.5. Attitudes Regarding the Suitability of Streams Originating Within the Bitterroot Mountains for Developing Small-hydroelectricity

Suitability/ Attitudes	1=Not Suitable	2=Somewhat Suitable	3=Suitable	4=More Suitable	5=Very Suitable	$\bar{x}$	N
Resource Potential	6 (6.6%)	3 (3.3%)	22 (24.2%)	30 (33%)	30 (33%)	3.92	91

Table 5.6. Attitudes Regarding Using Local Streams for Generating Electricity with Small-hydroelectric Technologies

Use/Attitudes	1=Very Unfavorable	2=Somewhat Unfavorable	3=Neutral	4=Somewhat Favorable	5=Very Favorable	$\bar{x}$	N
Using Resources	11 (11.6%)	6 (6.3%)	19 (20%)	22 (23.2%)	37 (38.9%)	3.72	97
Using Resource if Increase Costs	43 (45.3%)	14 (14.7%)	16 (16.8%)	8 (8.4%)	14 (14.7%)	2.33	95
Using Resource if Stabilize Costs	9 (9.4%)	5 (5.2%)	17 (17.7%)	14 (14.6%)	51 (53.1%)	3.97	96
Using Resource if Lower Costs	7 (7.2%)	2 (2.1%)	4 (4.1%)	12 (12.4%)	72 (74.2%)	4.44	97

Using a five point Likert scale for measuring respondent attitudes and knowledge regarding the suitability of developing these streams, survey results show that 90.1 percent of the survey respondents ranked the streams originating within the Bitterroot Mountains as “suitable” to “very suitable” for producing electricity through the use of small-hydroelectric technologies. Only 9.9 percent of those surveyed considered these resources unsuitable for generating electricity, while 66.0 percent considered these streams “more suitable” or “very suitable” for producing electricity. Though not quite as pronounced, similar results are observed for the degree to which survey respondents’ favor using these resources for producing electricity. Responses showed that survey participants tended to favor using these resources as a mean of 3.72 was determined for this category. These data show that 62.1 percent of those surveyed stated that they were either “somewhat favorable” or “very favorable” to using the streams originating within the Bitterroot Mountains for generating electricity, 20.0 percent responded as being neutral, while 17.9 percent responded within the bottom two categories.

Further exploration into the attitudes of respondents for using local streams if this results in lowering, stabilizing, or increasing energy prices resulted in predictable outcomes. Survey respondents strongly favor using these resources if this would lower or stabilize energy costs (means of 4.44 and 3.97, respectively), while respondent attitudes resulted in a mean of 2.33 if using these resources resulted in increased energy costs. It is interesting to note that 23.2 percent of survey respondents were either somewhat or very favorable to using streams originating within the Bitterroot Mountains for generating electricity even if it were to result in increased energy costs.

A measure for understanding the perceptions of survey respondents was developed using a four part question within the survey. After evaluating the visual component of the survey (i.e., the poster), participants were asked to rank (on a five point Likert scale with 1 being very unacceptable and 5 being very acceptable) their perceptions of the impacts associated with developing small-hydroelectric resources as they relate to view, water quality, fish and wildlife habitat, and to/for the local economy. Responses to these questions, presented in Table 5.7, indicate that the impacts to view (mean of 2.79), impacts to water quality (mean of 2.46), and impacts to fish and wildlife habitat (mean of 2.38) are primarily perceived as "unacceptable" or "very unacceptable" by survey respondents, while impacts to/for the local economy are perceived as beneficial (mean of 3.73).

Table 5.7. Perceived Impacts of Developing Small-hydroelectric Resources

Perception of Impacts to:	1=Very Unacceptable	2=Somewhat Unacceptable	3=Neutral	4=Somewhat Acceptable	5=Very Acceptable	$\bar{x}$	N
View	23 (23.2%)	23 (23.2%)	21 (21.2%)	16 (16.2%)	16 (16.2%)	2.79	99
Water Quality	44 (45.4%)	11 (11.3%)	16 (16.5%)	6 (6.2%)	20 (20.6%)	2.45	97
Fish and Wildlife Habitat	39 (39.8%)	19 (19.4%)	18 (18.4%)	8 (8.2%)	14 (14.3%)	2.38	98
To/For Local Economy	12 (12.4%)	4 (4.1%)	22 (22.7%)	19 (19.6%)	40 (41.2%)	3.73	97

Analyses

The method used to analyze these data is broken into multiple parts. First, Attitudes (Table 5.8) and Perceptions (Table 5.9) are measured using paired samples T tests in order to assess whether the questions being posed by this survey both: (a) sufficiently isolate the attitudes and perceptions of Ravalli County residents; and (b) provide a starting point from which to conduct further analyses. Second, these attitudes and perceptions are analyzed against the socio-demographic characteristics (Table 5.10) and resource use categories (Table 5.11) using ANOVA. Looking for trends through this data set, these variables are further analyzed by conducting independent samples T tests between all socio-demographic/use categories and all perception and attitude categories (significant results are listed in Tables 5.12 and 5.13). Finally, the knowledge of survey participants is analyzed against all of the categories listed above (Tables 5.14 and 5.15).

Attitudes and Perceptions: Significance and Correlations

Comparing the attitudes of survey participants against one another shows that not only is the observed variance between mean responses statistically significant, a Pearson *r* test for correlation between paired responses indicates that some of these differences are moderately correlated (meaning that a moderate amount of the variation being observed in one attitude or perception can be explained by knowing the value of the other). Similarly, significant variations in the perception of survey respondents are observed. Pearson *r* correlation coefficients show that respondent perceptions are more strongly correlated than the attitudes of survey participants. For all of the independent variables analyzed concerning both the perceptions and attitudes of survey respondents, standard deviations were relatively similar (sd = 1.159-1.592) indicating a similar range of responses for all measured variables. Tables 5.8 and 5.9 present the range of variation, T and correlation statistics, and levels of significance within both the attitudes and perceptions categories.

An evaluation of the attitudes of survey participants regarding whether or not they favor using local resources for small-hydroelectric development indicates that though the development of small-hydroelectric resources is not favorable if it were to result in

Table 5.8. Attitudes: Paired Samples T Test and Pearson *r* Correlation

Paired Attitude Variables and Means	N	Paired SD	95% Confidence Interval		*t*	*t* Sig. (2-tailed)**	Pearson-*r* Correlation *r* & (r^2)	*r* Sig.
			Lower	Upper				
A* 3.71 B* 2.36	89	1.828	.963	1.733	6.957	.000	.195 (.038)	.067
A* 3.69 C* 4.00	90	1.242	-.571	-.051	2.376	.020	.566 (.32)	.000
A* 3.73 D* 4.45	91	1.165	-.968	-.483	5.939	.000	.575 (.33)	.000
A* 3.84 E* 3.83	83	1.194	-.273	.249	-.092	.927	.485 (.235)	.000
B* 2.43 C* 3.98	94	1.421	-1.929	-1.347	11.181	.000	.494 (.244)	.000
B* 2.33 D* 4.45	95	1.566	-2.445	-1.807	13.235	.000	.316 (.099)	.002
B* 2.30 E* 3.79	82	1.627	1.130	1.845	8.279	.000	.202 (.04)	.069
C* 3.98 D* 4.45	94	.888	-.650	-.286	5.108	.000	.753 (.567)	.000
C* 4.10 E* 3.81	84	1.331	-.575	.003	1.976	.053	.357 (.127)	.001
D* 4.56 E* 3.82	84	1.318	-1.024	-.452	5.132	.000	.238 (.056)	.029

*A = Favor using streams originating in the Bitterroot Mountains for generating electricity
*B = Favor using these streams for generating electricity if resulted in increased energy costs
*C = Favor using these streams for generating electricity if resulted in stabilized energy costs
*D = Favor using these streams for generating electricity if resulted in lowering energy costs
*E = Think streams originating in the Bitterroot Mountains are suitable for developing small-hydro technologies
** $p < .05$

increased energy costs, the majority of respondents favor the development of streams originating within the Bitterroot Mountains. The observed differences between means are found to be statistically significant in all cases regarding favoring use. However, in two paired instances, "favoring the use of resources + favoring use of resources if it resulted in increased energy costs" and "favoring use of resources if it were to increase energy costs + favoring use of resources if it resulted in lowering energy costs," the correlation between variables weak or insignificant. The remaining variable pairs tested show r values ranging from 0.494 to 0.753. The outcome rendered from comparing

Table 5.9. Perceptions: Paired Samples T Test and Pearson *r* Correlation

Paired Perception Variables and Means	N	Paired SD	95% Confidence Interval		*t*	*t* Sig. (2-tailed) **	Pearson-*r* Correlation *r* & (r^2)	*r* Sig.
			Lower	Upper				
A* 2.75 B* 2.45	97	1.260	.045	.553	2.338	.021**	.651 (.424)	.000
A* 2.79 C* 2.38	98	1.209	.116	.650	3.343	.001**	.638 (.407)	.000
A* 2.79 D* 3.73	97	1.306	-1.201	-.675	7.077	.000**	.557 (.31)	.000
B* 2.45 C* 2.38	96	1.107	-.151	.297	.645	.520**	.741 (.549)	.000
B* 2.46 D* 3.73	95	1.438	-1.556	-.970	8.561	.000**	.524 (.274)	.000
C* 2.38 D* 3.73	97	1.362	-1.265	-1.076	9.766	.000**	.532 (.283)	.000

*1: Perception of impacts to view associated with developing small-hydroelectric technologies
*2: Perception of impacts to water quality associated with developing small-hydroelectric technologies
*3: Perception of impacts to fish and wildlife habitat associated with developing small-hydroelectric technologies
*4: Perception of impacts to/for local economy associated with developing small-hydroelectric technologies
** $p < .05$

the attitudes of Ravalli County residents is that the null hypothesis is rejected; that significant differences in attitudes exist.

In evaluating whether the respondents have similar attitudes regarding the favoring of using these local resources for generating electricity against whether or not they felt the resources were suitable for development, results of the paired samples T test show that there is little to no correlation between these attitudes and that a significant difference in means exist for two grouped pairs; “think resources are suitable for development + favor if resulted in increased energy costs “and think resources are suitable for development + favor if resulted in lowering energy costs.”

Similar results are found in comparing the perceptions of the impacts associated with developing small-hydroelectricity. The *r* values associated with the perception variables show a stronger correlation between variables than was found with the attitudes of Ravalli County residents. Observed differences between groups are statistically significant for five of the six pairs being analyzed. Logically, the grouped pair showing the strongest correlation (r = 0.741) "the perceived impacts to water quality + the perceived impacts to fish and wildlife habitat," retains the null hypothesis; there no significant difference in how these impacts are perceived. As for the remaining five pairs, differences between means are significant and the null hypothesis is rejected. All of these pairs are moderately correlated with r values range from 0.542 to 0.651 (Table 5.9).

Socio-Demographics and Resource Use: Attitudes and Perceptions

In order to further explore the significant variation in observed means, both ANOVA and independent samples T tests are performed on the attitudes and perceptions of survey respondents. Socio-demographic elements and resource use categories are used as factors being evaluated for potentially influencing the observed variation in means. Tables 5.10 and 5.11 are matrices showing the results of these ANOVA.

The results shown in Table 5.10 demonstrate that there are no significant differences between groups defined on the basis of age, income, and length of residency in regard to their attitudes and perceptions. As evident with the F values and their significance listed in Table 5.10, data regarding the socio-demographic characteristics from this sample of the population results no statistically significant influence on the perceptions and attitudes of survey respondents. However, ANOVA results measuring the influence of resource use on attitudes and perceptions (Table 5.11), shows that some of the variables being measured are statistically significant (i.e., respondents who use these resources for hunting and their perception of 1) the impacts to water quality, and 2) fish and wildlife habitat, and the attitudes of those using resources for "other" recreation such as camping, picnicking, and kayaking in how they favor using these resources for generating electricity).

Table 5.10. ANOVA results for Socio-Demographic influence on Attitudes and Perceptions

Categories	Age		Income		Length of Residency	
	F	Sig.	F	Sig.	F	Sig.
Streams Suitable for Development	1.949	.110	.504	.773	.774	.545
Favor Use	.957	.435	2.079	.091	1.201	.316
Favor Use if Increased Costs	1.639	.171	1.079	.156	1.572	.198
Favor Use if Stabilized Costs	.457	.767	.372	.828	.606	.659
Favor Use if Lowered Costs	.096	.983	1.148	.340	.726	.576
Perception of Impacts to View	1.200	.316	1.843	.128	1.183	.324
Perception of Impacts to Water Quality	1.263	.290	1.458	.223	.521	.721
Perception of Impacts to Fish and Wildlife	1.206	.313	1.768	.143	.832	.508
Perception of Impacts to/for Economy	.371	.829	1.254	.295	.297	.879

Table 5.11. ANOVA results for the influence of Resource Use on Attitudes and Perceptions

Categories	Use Canyons for Hiking and Bird/Wildlife Viewing		Use Canyons for Fishing		Use Canyons for Hunting**		Use Canyons for Other Rec. (Picnicking, Camping, Kayaking)	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Streams Suitable for Development	1.077	.380	.318	.901	.479	.791	1.155	.339
Favor Use	1.027	.407	1.010	.417	1.019	.412	2.327	.049
Favor Use if Increased Costs	1.478	.202	1.318	.264	.681	.639	.604	.697

Table 5.11. ANOVA results for the influence of Resource Use on Attitudes and Perceptions (continued)

Categories	Use Canyons for Hiking and Bird/Wildlife Viewing		Use Canyons for Fishing		Use Canyons for Hunting**		Use Canyons for Other Rec. (Picnicking, Camping, Kayaking)	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Favor Use if Stabilized Costs	.411	.840	.688	.634	.404	.845	1.592	.171
Favor Use if Lowered Costs	.402	.846	1.054	.391	1.407	.229	1.665	.151
Perception of Impacts to View	1.530	.188	1.420	.225	1.765	.128	1.038	.400
Perception of Impacts to Water Quality	1.407	.229	1.772	.127	2.714	.025	.295	.914
Perception of Impacts to Fish and Wildlife	2.113	.071	.877	.500	3.677	.004	.736	.599
Perception of Impacts to/for Economy	1.090	.372	.989	.429	.569	.724	1.098	.367

**Sample size is problematic for some use groups. The hunting category was re-coded to represent use/no use categories and is run as independent samples T tests to analyze differences within this use category.

Socio-Demographics and Resource Use: a Closer Look

An independent samples T test was conducted on each individual variable measuring attitudes and perceptions for different age groups, income brackets, length of residency categories, and resource use categories. This was performed in order to further examine any differences in attitudes and perceptions for different resource use and socio-demographic groups not revealed by the ANOVA. It is important to note that the same thirty-nine variables are tested against each attitude and perception. Table 5.12 provides the statistically significant variables. Similarly, an independent samples T test was performed on the hunting use category to validate the significant results coming from the ANOVA. Statistically significant results for the "hunting" use category are listed in Table 5.13.

The results of these independent samples T tests presented in Tables 5.12 and 5.13 show statistical significance for twenty-eight combinations of variables ($p \leq 0.05$). Of these, seven variables were limited by sample sizes of ten or fewer, rendering these results unusable. Of the remaining twenty-one variables showing significance, multiple unrelated subgroups within one use category (i.e., those measuring the attitudes and perceptions of residents using the canyons and streams along the Bitterroot Front for "other recreation") are found as having statistically significant differences in means. The differences observed here support the ANOVA results listed in Tables 5.10 and 5.11 in that there is no observable pattern or trend in these data (i.e., significant results occur randomly throughout the data set).

Table 5.12. Independent Samples T Test Results: Statistically Significant Variables for Perceptions and Attitudes

Perceptions:
Perceived Impact to View • Age Group: "31-40" $\bar{x} = 2.09$[2] • Use Category: Fishing "16-20 days per year" $\bar{x} = 1.83$*[2]
Perceived Impact to Water Quality • Income Group "0-25k" $\bar{x} = 3.25$[1] • Use Category Fishing "16-20 days per year" $\bar{x} = 1.50$*[2]
Perceived Impact to Fish and Wildlife • Age Group "31-40" $\bar{x} = 1.73$[2]
Perceived Impact to/for Economy • Income Group "45-65k" $\bar{x} = 3.28$[2] • Use Category Other Recreation "16-20 days per year" $\bar{x} = 4.67$[1]
Attitudes:
Streams Suitable for Development • Age Group "31-40" $\bar{x} = 3.00$[2]

*N < 10
[1] Higher than the group mean for this variable
[2] Lower than the group mean for this variable

Table 5.12. Independent Samples T Test Results: Statistically Significant Variables for Perceptions and Attitudes (continued)

Favor Use

- Income Group: "25-45k" $\bar{x} = 4.32$[1]
- Income Group: "45-65k" $\bar{x} = 3.40$[2]
- Use Category: Other Recreation "1-5 days per year" $\bar{x} = 4.28$[1]
- Use Category: Other Recreation "11-15 days per year" $\bar{x} = 4.44$*[1]
- Use Category: Other Recreation "16-20 days per year $\bar{x} = 3.84$[1]

Favor Use if Increased Costs

- Age Group: "61+" - $\bar{x} = 2.83$[1]
- Use Category: Hiking/Bird and Wildlife Viewing "6-10 days per year" $\bar{x} = 1.67$[2]

Favor Use if Lowered Costs

- Income Group: "25-45k" $\bar{x} = 4.81$[1]
- Use Category: Fishing "21+ days per year" $\bar{x} = 4.93$[1]
- Use Category: Other Recreation "11-15 days per year" $\bar{x} = 4.88$*[1]

Favor Use if Stabilized Costs

- Use Category: Other Recreation "21+ days per year" $\bar{x} = 4.52$[1]

*N < 10
[1] Higher than the group mean for this variable
[2] Lower than the group mean for this variable

Table 5.13. Independent Samples T Test: Attitudes and Perceptions of Those Using the Canyons along the Bitterroot Front for Hunting.

Categories	Use Canyons for Hunting				
	Use	N	$\bar{x}$	t	Sig. (2 tailed)
Perception of Impacts to View	yes	28	3.25	-2.136	.033
	no	69	2.59		
Perception of Impacts to Fish and Wildlife	yes	28	3.00	-2.197	.004
	no	68	2.10		

Knowledge of Resources, Policies, and Environmental Impacts

The final analysis of the attitudes and perceptions of survey respondents evaluates the familiarity of respondents with renewable energy resources in Montana, their knowledge of the environmental impacts associated with developing small-hydroelectric resources, and their familiarity with Montana's energy policy. Independent samples T tests are conducted on all attitudes and perceptions using these three variables. In the first set of tests (presented in Table 5.14) that evaluate the survey respondents' knowledge of Montana's renewable energy resources, statistical significance is observed for how respondents viewed the hydroelectric potential of streams originating within the Bitterroot Mountains, whether or not they favored using these streams for generating electricity, and whether or not developing these resources would have impacts to the view-shed. In the second set of tests (listed in Table 5.15) that evaluate the perceptions and attitudes of survey respondents' with respect to their knowledge of the environmental impacts associated with small-hydroelectric systems, no statistical significance is observed. The results coming from the third set of tests (i.e. measuring survey respondents' knowledge of Montana's renewable energy policy as potentially influencing their attitudes and perceptions) show no significant relationships between any of the variables being evaluated, and as a result, are not shown here. However, the lack of observed significance has implications for this research both in how it pertains to the attitudes and perceptions of Montana residents and Montana's energy policy.

The outcome from these independent samples T tests provide some intriguing results. In measuring both respondents' knowledge of Montana's renewable energy resource base and their knowledge of the environmental impacts of developing small-hydroelectric systems, it is evident that there are relatively even response rates for both groups (i.e., those with knowledge and those indicating no knowledge). Table 5.15 illustrates that there is no statistical significance in the mean scores for attitudes and perceptions when tested against the respondents' knowledge of the environmental impacts of developing small-hydroelectric systems. However, while no significant variation is observed, the lack of variation presents some interesting implications that will be discussed in Chapter Six.

Table 5.14. Independent Samples T Test: Attitudes, Perceptions, and Knowledge of Renewable Energy in Montana

Categories	Knowledge of Renewable Energy in Montana				
Attitudes and Perceptions	**Knowledge of REM****	**N**	**$\bar{X}$**	**t**	**Sig. (2 tailed)**
Is small-hydro suitable for developing	Yes	48	4.13	2.731	.008
	No	43	3.49		
Favor use	Yes	48	4.04	2.434	.017
	No	47	3.38		
Favor use if increase costs	Yes	49	2.62	1.1913	.059
	No	47	2.04		
Favor use if stabilize costs	Yes	49	4.18	1.626	.107
	No	48	3.74		
Favor use if lower costs	Yes	49	4.63	1.640	.105
	No	48	4.25		
Perception of impacts to view	Yes	51	3.06	2.024	.046
	No	48	2.50		
Perception of impacts to water quality	Yes	49	2.65	1.248	.215
	No	48	2.25		
Perception of impacts to fish and wildlife	Yes	50	2.62	1.719	.089
	No	48	2.13		
Perception to/for economy	Yes	49	3.86	.911	.364
	No	48	3.60		

**Renewable energy in Montana

Table 5.15. Independent Samples T Test: Attitudes, Perceptions, and Knowledge of Environmental Impacts Associated With Small-hydroelectric Systems

Categories	Knowledge of Environmental Impacts of Small-hydroelectric Systems				
Attitudes and Perceptions	**Knowledge of EI****	**N**	**$\bar{X}$**	**t**	**Sig. (2 tailed)**
Is small-hydro suitable for developing	Yes	46	3.59	-1.953	.054
	No	44	4.05		

Table 5.15. Independent Samples T Test: Attitudes, Perceptions, and Knowledge of Environmental Impacts Associated With Small-hydroelectric Systems (continued)

Categories	Knowledge of Environmental Impacts of Small-hydroelectric Systems				
Favor use	Yes	54	3.65	-.448	.655
	No	40	3.78		
Favor use if increase costs	Yes	55	2.38	.675	.501
	No	39	2.18		
Favor use if stabilize costs	Yes	54	4.06	.795	.429
	No	41	3.83		
Favor use if lower costs	Yes	55	4.60	1.545	.127
	No	41	4.22		
Perception of impacts to view	Yes	55	2.93	1.316	.191
	No	43	2.56		
Perception of impacts to water quality	Yes	55	2.47	.134	.893
	No	42	2.43		
Perception of impacts to fish and wildlife	Yes	54	2.39	.057	.955
	No	43	2.37		
Perception to/for economy	Yes	54	3.72	-.140	.888
	No	42	3.76		

**Environmental Impacts Associated with Small-hydroelectric Systems

In evaluating the attitudes and perceptions of those indicating prior knowledge of renewable energy resources within Montana, as presented in Table 5.14, some statistically significant differences are present. The attitudes of survey respondents who indicate knowledge of Montana's renewable energy resources show significant differences both in how they regard the hydroelectric potential, or suitability of streams originating within the Bitterroot Mountains for generating electricity, and in favoring the use of these resources. In both of these attitude categories, those with knowledge of Montana's renewable energy resources responded as being more favorable to using local renewable energy resources than those indicating little to no knowledge. Within the perception categories, those respondents indicating knowledge of renewable energy resources within Montana differed significantly in one category. In gauging the impacts to landscape quality, survey participants who indicate knowledge of renewable energy resources stated that they find the visual impacts associated with developing small-hydroelectric systems less intrusive than those with little to no knowledge of Montana's renewable energy base. These results will be discussed further in Chapter Six.

The final variable being evaluated for gauging the attitudes and perceptions of survey respondents is how informed survey respondents were regarding Montana legislation and policies concerning the development of renewable energy resources. For those reporting their knowledge of Montanan's renewable energy policy, only 9.9 percent state they were "very knowledgeable;" 26.7 percent indicate some familiarity with these policies, while the majority, 63.4 percent, reporting no familiarity with policies directing the use of renewable energy resources. Performing ANOVA and Independent Samples T tests comparing survey respondents' knowledge of renewable energy policy with their attitudes and perceptions presents no significant differences within or between groups. However, it is interesting to note that those responding as being "very knowledgeable" of renewable energy policy also responded as being the most knowledgeable of the environmental impacts associated with developing small-hydroelectric resources.

Qualitative Data

The final question posed by this survey requested participants to:

> *"Please provide any additional comments, opinion, or thoughts regarding the development of renewable energy resources."* (Appendix A)

Thirty one percent (N=33) of those participating in this study offered additional comments for evaluation. Seven distinct categories of responses were identified through the evaluation of these comments.

1. Advocacy – The largest response category (N=10) included statements providing general advocacy for the development and use of renewable energy resources. Statements deemed appropriate for inclusion into the "advocacy" category were determined by two specific elements; an obvious support for using renewable energy resources and a lack of specificity to any particular resource. Of those offering statements advocating the development and use of renewable energy resources, age and level of income are further discredited as factors responsible for shaping these attitudes and perceptions as the full range of these socio-demographic characteristics are represented. The responses offered within this category all identified the need for a change in how energy is produced in America and provided thoughts such as from this 36 year old individual:

> *"…it would be really exciting in my lifetime to see communities embracing alternative energy resources."*

2. Environmentally Conscious: Individual responses deemed as being "environmentally conscious" (N=7) were those found both advocating the development of renewable energy resources and voicing concern with potential long term environmental impacts. Responses placed in this category included comments such as:

> *"I'm for developing renewable energy resources as long as the long term ecological impacts are low to non-existent"* (age 52).

And:

"…so, to prevent negative [environmental] consequences, the need for alternative energy should be balanced in earths systems… I do not think small-hydro fits this description" (age 21).

Again, individuals providing additional comments comprise a broad range of socio-demographic characteristics.

3. Cynically Supportive: Responses defined as fitting within this category (N=7) provided comments as being advocates for the use of renewable energy resources, but present pessimistic statements regarding the oil and coal industries or skepticism of current political systems.

"…The U.S. needs to do all that is possible to wean us off of the oil based economy that we now have. Hydro is just one of the ways to do it… the political process will take years" (age 46).

4. Use Oriented: Three (N=3) survey respondent offering additional comment focused on using resources without identifying or acknowledging renewable energy resources or environmental impacts. These responses are exemplified in the following passage:

"…[we] need more generators on mountain streams" (age 71).

5. Inquisitive Advocates: Three (N=3) of the comments offered by survey participants indicated interest in renewable energy resources, and specifically small-hydroelectric technologies. In their remarks, these respondents voiced support for using alternative energy resources; however, specify their lack of knowledge of small-hydroelectric technologies. Each of these respondents stated that they desired to become better educated on this technology:

"More favored is solar or wind – I don't have a lot of knowledge of [small] hydro – I would need to learn more to make a knowledgeable choice" (age 51)

6. Wilderness Defenders: Responses placed within this category were limited to two (N=2) individuals. Criteria used for isolating these responses were based on the definitive nature of the comments offered. Both instances expressed grave concerns with adopting small-hydroelectric development in fear of sacrificing wilderness for using local renewable energy resources:

"I like the general idea of small-hydroelectric plants, but I am afraid certain elements of the Bitterroot Valley would use it as an excuse to build more roads into the wilderness [and] I think we have enough dams already" (age 54).

7. Aesthetics: One (N=1) respondent offered additional comments to the impacts to local landscape qualities offering suggestions for beautifying renewable energy technologies:

"I like the idea of wind and hydroelectric. As far as views, you can always use proper aesthetics such as granite bricks instead of bland cinder blocks. On a wind mill, build it to look like an old farm mill…" (age 42).

Due to the wide variety of topics emphasized by those providing additional comments, and combined with the low number of responses, the information received did not submit to analysis using the demographic, resource use, and attitude and perception data gathered through the rest of the survey. Regardless of this, the additional information provided by survey respondents greatly enhance the results reported in this thesis and deserve mention. Additionally, and observed in aggregate, the thoughts of these survey respondents show that Ravalli County's residents are interested in the prospects of using local renewable energy resources for generating electricity.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

This study set out to evaluate the perceptions and attitudes of Ravalli County residents concerning the aesthetic, environmental, and physical impacts associated with developing local small-hydroelectric resources to assess how these attitudes and perceptions are formed, how they may react to changing the characteristics of landscape quality, and if they present barriers to developing and using local streams for generating electricity. Through the evaluation of these attitudes and perceptions, this thesis has attempted to identify political and value-based road blocks associated with such development. Though individual state and international policies indicate increasing support for using renewable energy resources, the results of this study indicate that the successful development and use of local resources within Ravalli County is problematic. Seasonal and spatial limitations combined with the public's overall negative perception of the impacts associated with this development, as well as the reported lack of acceptance for changing local landscapes, present significant barriers for establishing a reliance on small-hydroelectric resources for the generation of electricity in Ravalli County.

Through the use of parametric statistical analyses, this study made every effort to associate these attitudes and perceptions with socio-demographic factors, how local residents use local resources, and knowledge of renewable energy. As evident from the frequency distributions regarding the attitudes and perceptions of survey respondents, the majority of residents residing within the Bitterroot Valley, though not favoring the physical and visual impacts associated with developing small-hydro-electric technologies, advocate using their local natural resources for the generation of electricity.

Using ANOVA and independent and paired samples T tests for measuring variation in the means within and between the attitudes and perceptions and the socio-demographics, resource use categories, knowledge of the actual physical impacts, and Montana's renewable energy policies, and using Pearson's *r* to test for correlation between categories, it emerges that the attitudes and perceptions measured within this survey cannot be quantified by these data. These results indicate that individual socio-demographics, how individuals use their local resources, how often local resources are used, knowledge of the actual physical impacts of developing small-hydroelectric resources, and knowledge of Montana's legislative policies directing the use and development of renewable energy resources do not have a significant influence on the attitudes and perceptions of local residents as measured by this study. Though the statistical analyses of the variables listed above provided insignificant results, one measure, a question developed for evaluating survey participants' knowledge of renewable energy in Montana:

> "*Were you familiar with Montana's renewable energy resources before I presented them to you? Please rank 1 through 5 (1 being completely unfamiliar and 5 being very knowledgeable)*," (Appendix A)

presented significant results. In analyzing this variable, statistical significance is observed in not only how survey respondents view the hydroelectric potential of small streams originating within the Bitterroot Mountains, but also in the attitudes of survey respondents favoring the use of these resources for generating electricity and in how this portion of the population perceives the visual impacts to landscape qualities resulting from this development. In each of these instances, survey respondents indicating a strong working knowledge of Montana's renewable energy resource base had a more favorable (or positive) perception of the impacts associated with using their local streams for generating electricity and indicated a stronger willingness to accept these impacts. The implications of these relationships are further discussed below.

Revisiting the research questions posed for this study [(1) if the physical and aesthetic impacts associated with developing streams originating in the Bitterroot Mountains were acceptable tradeoffs for gaining some control over how and where local electrical energy is generated, and (2) if Montana's energy policy statements reflect the perceptions and attitudes of local residents], it is evident that both significant and insignificant results generated by this survey, though not fully answering either of the research questions, are supported by the current existing research conducted on landscape perceptions and renewable energy, the findings reported by this thesis, and by the underlying theory responsible for driving perception studies within Geography. These relationships are further discussed below.

Relation to Theory

Strong similarities are observed between the results of this survey and the work of Yi-Fu Tuan. Throughout his work, Tuan states that the human perception of landscape and how individuals view landscape quality is defined as a gestalt, that the perception of landscape is the compilation of an individual's life experience and that it is within this perception that the individual finds his/her sense of place within the environment. Tuan argues that the perception of landscape cannot be quantified; instead, that this sense of place is a feeling experienced by a person and that this feeling is, in essence, how the person perceives the geographic continuum (Tuan 1974). Generally speaking, though this shared love of the landscape may exist as an end, the path leading to this shared affinity is unique unto each individual person. In this light, the results of this study are supported by Tuan's theory; the perceptions of survey respondents in relation to the potential for changes to landscape qualities cannot be quantified by how resources are used, the intensity of their use, or by socio-demographic factors. As well, perceptions and attitudes are only partially explained through relating them to a shared knowledge of Montana's renewable energy base. Similarly, these findings support Tuan's position that attitudes and perceptions regarding landscape quality are both imbedded in and driven by an individual sense of place. That the only legitimate generalization that can be made (as pertaining to landscape quality) is that human perceptions and attitudes are unique to each individual and that no single social or environmental factor can be charged as being fully responsible for shaping a collective sense of place. As a result (and elaborated upon in more detail below), the ability of legislators to mandate the use of local resources, or for researchers to make definitive statements regarding how populations view or accept changes to landscape and environmental qualities, are greatly limited.

Relation to Current Research

Comparing the findings of this study to existing research that has been conducted on how local residents perceive changes in landscape qualities, mixed results are revealed. Studies focusing on amenity migration and perceptions conducted by Ryan (1998) and Shumway and Otterstrom (2001) rely largely on land use practices and length of residency as responsible for influencing human perceptions and attitudes. The results from both of these studies indicate that the perceptions and attitudes of newcomers deviate significantly from long-term residents in that newcomers prefer the natural and unaltered landscapes over those modified by human activity. In essence, these researchers embrace the premise that newcomers are migrating to areas of natural beauty offering rural lifestyles and increased outdoor recreational opportunities. In contrast, research conducted by Smith and Krannich (2000) is more consistent with the results generated by this thesis. Smith and Krannich take into account three rapidly growing western communities and how changes to local economies, social dynamics and land use practices are perceived by local residents. Though trends observed by Smith and Krannich suggest that length of residency, land use, and resource use influence how these changes are perceived, the parametric statistical analyses used by these researchers in comparing demographics and resource use to perceptions and attitudes show no statistical significance between these variables.

Noting again that the results of this study indicate strong support in using local renewable resources for generating electricity, discrepancies regarding this support are observed in evaluating how local residents perceive the impacts to aesthetic and physical environmental qualities found along the Bitterroot Front. Responses provided by survey participants indicate that impacts to and for the local economy (resulting from developing local renewable energy resources) are perceived as being the only positive outcome. In all other cases (i.e., the perceived impacts to water quality, fish and wildlife habitat, and the aesthetic qualities of the Bitterroot Mountains) the majority of residents stated that these resources would be compromised if such development were to occur.

In comparing these results to other research conducted on public perception and renewable energy, the dichotomy between overwhelming public support for using renewable energy resources and concerns with the physical and aesthetic impacts associated with its use is most evident regarding the development of wind energy resources. In the use of wind energy resources in Europe (Hull 1995, Khan 2003), Australia (Mercer 2001), and America (Pasqualetti 2001), the development of local wind energy resources had received strong initial support in its use. Local populations, supportive of developing renewable energy resources, allowed the development of wind turbines within their communities only to find that wind turbines sited in close proximity to local communities and in areas of natural beauty produced negative and unwanted effects to local and aesthetically pleasing views (Pasqualetti 2000, Kahn 2003). Additionally, other impacts, specifically those associated with increased bird mortality rates (resulting from impacts with turbine blades), disturbances to communication systems and television reception (Barrios & Rodiguez 2004, Osborne 1999, Hull 1995), and the perceived noise associated with the moving turbine blades (Hull 1995, Khan 2003) have begun to affect the public's acceptance of developing available wind resources. Pasqualetti (2001), in reporting his observations from California's desert community of Palm Springs and the wind energy development at San Gorgonio Pass, has reported that though negative perceptions and attitudes fade through time, it is the initial negative response that is reported, and more importantly, remembered. This initial response to the development of wind energy has greatly impacted the reputation of using wind energy resources for generating electricity on a world-wide level.

Looking at the research conducted by the Bonneville Power Administration and U.S. Forest Service (1983) (responding to the 1970's oil embargos), the development of small-hydro electrical systems was determined as being environmentally unsound, as these agencies reported results from models relying on the use of eighty to one hundred percent of available water resources for generating electricity (Leathe & Graham 1984; U.S. DOE 1983). These findings have resulted in public agencies, such as the Forest Service and Bureau of Land Management, largely rejecting the idea of developing small-hydroelectric resources throughout the western United States and other areas possessing significant small-hydroelectric potential. These findings and results have remained popular throughout the United States regardless of the research by European scientists who regard small-hydroelectric technologies as “the most environmentally benign” energy option available for development, not to mention the successful implementation and use of small-hydroelectric resources by almost all European countries (Parish 2002: 537).

The methods used for gathering the data used in this thesis (i.e., placing local residents in a hypothetical situation and allowing each individual to visualize what the impacts being depicted on the poster would look like if situated along the Bitterroot Front) can by no means account for the real perceptions and attitudes that would be experienced if this development were to occur. Considering the negative local perceptions and attitudes reported from around the globe regarding the physical, aesthetic and environmental impacts associated with wind energy facilities, and taking into account the negative environmental and physical impacts predicted for using small-hydroelectric resources, it only stands to reason that the perceptions and attitudes of Ravalli County residents would be amplified with the actual development and use of these local small-hydroelectric resources. This is an important point to consider in examining these results and how they pertain to Montana’s current renewable energy policy.

Policies Revisited

As earlier discussed in Chapter 2, the policies being developed for directing the use of renewable energy resources has been primarily the responsibility of individual states. Policies, in the form of individual states setting Renewable Energy Standards (RES), have been created largely as a result of the deregulation of energy markets at the state level. In all cases, RES have been developed in a similar fashion; states have set schedules mandating the development of renewable energy resources as a series of performance-based goals relying on the incremental development of resources over time, requiring individual energy companies to either acquire renewable energy from states with strong resource potential, or to develop local resources. Within Montana, these mandates include language directing the RES as well as a portion of this development to occur at the local level. The results of this study show that local residential knowledge of these goals and mandates is largely not understood by Montana's residents, that regardless of the local support for developing renewable energy resources within the state, Montana residents remain uninformed of the RES as well as the requirements directing the local development of renewable energy resources.

Considering the use of Montana's mountain streams as renewable energy resources (and to reiterate the state's position regarding the use of these streams), Montana's legislature provided language within its current policy precluding the development of small-hydroelectric resources. This policy, which states "Water power, in the case of a hydroelectric project that does not require a new appropriation, diversion, or impoundment of water," omits the use of this resource from the list of renewables deemed appropriate for generating electricity (MCA § 69-8-1004 3(6d) 2005). Though this policy is largely grounded in the need to ensure the protection of individual water rights, the exclusion of water from the list of available renewable resources stands to negatively impact the immediate development and use of western Montana's most prominent and available renewable energy resource. However, much of the debate surrounding the appropriation of water rights within Ravalli County (and many other portions of the state) are centered on determining whether or not appropriated water rights are being fully used and their impacts on senior water rights holders. The assessment of water rights within the study area has been under way since 1979 and it is anticipated that this review process may be complete within the decade. Upon adjudicating these rights, new non-consumptive appropriations of water (such as generating electricity through small-hydroelectric technologies) should be available for use. Regardless of this, and provided with the information gathered by this study (i.e., that though the majority of survey respondents favored using local resources for the generation of electricity, these respondents voiced strong concern with the potential for impacting water quality, fish and wildlife habitat, and landscape aesthetics), it is possible that the current exclusion of Montana's small streams as potential renewable energy resources may actually reflect the values of western Montana residents.

Implications for Policy

Though providing only a glimpse into the political climate directing Montana's renewable energy policy, the evaluation of residential attitudes and perceptions within Ravalli County presents some interesting implications for using small-hydroelectric resources. In addressing the potential for developing western Montana's most abundant renewable energy resource, this thesis has identified individual knowledge and interest in renewable energy resources as potential driving forces for shaping the attitudes and perceptions of local residents regarding the use of small streams for generating electricity. Considering "knowledge" as a statistically significant variable for gaining support for developing small-hydroelectricity, Montana state legislators have perhaps directed their influence in the wrong direction. Mandating the development of renewable energy resources by large energy providers and within rural and local communities, though definitely beneficial to a certain degree, could perhaps be enhanced through mandating and funding a state initiated program for educating Montana residents on renewable energy and Montana's renewable energy resource base. The presentation of this material would generate a greater degree of interest in renewable energy and would better educate Montana residents on how and where their energy is created. Recent examples of programs used for increasing public awareness range from documentaries regarding global climate change to billboards and television commercials pertaining to methamphetamines. Though these campaigns have been primarily used in addressing problem issues, the same style of approach may be very successful in providing local Montana residents with an education for using local renewable energy resources. A vision for developing and using Montana's renewable energy resources (i.e., wind, water, landfill methane, bio-fuels, geothermal resources, and solar energy) could be effectively developed if local residents were provided with a non-biased presentation of this state's renewable energy base. Similarly, presenting a cost-benefit analysis for the development and use of local resources (as well as the impacts associated with their use) would provide local communities and residents the opportunity to decide the appropriate resources for development and the intensity for use.

Recommendations

Throughout the course of this study, multiple elements have come to light that could have been incorporated by this research or as questions for the public perception survey. Though hind-sight is 20/20, it is important that these elements be revealed as their use may have provided a "richer" data set for evaluation:

1) Survey process: in conducting this survey, it became evident that the data being gathered was focusing on only those individuals that frequented the Ravalli County Farmers Market in Hamilton. Though this venue provided an ease of access for the researcher, specific variables that should have been controlled for were impossible to gauge. For instance, in re-developing this research project, a more comprehensive design could have evaluated the values of Ravalli County residents based on residential location. This design could have focused on comparing the attitudes and perceptions of individuals living in close proximity to the streams that stand to be affected by developing small-hydroelectric technologies with the values of those living elsewhere in the County. This research would have required much more pointed research questions regarding values of individuals and their proximity to local resources be asked. Additionally, this would have required the survey process take place via mail, or as a series of interviews.

2) Survey Questions: In administering the public perception survey, it became evident that additional questions regarding land use and choice of residential location would have provided some very interesting variables on which to compare the values of Ravalli County residents. Additional questions, such as: "Do you live in town or in the country?" or "Does any of your family income come from agricultural or land based work?" could have been asked.

(3) Research Design: In evaluating the results of this survey it became evident that the limited qualitative data generated by this study provided a very "rich" data set. It is in the opinion of the researcher that this study would have been better facilitated by conducting a purely qualitative study. Through a series of interviews, it would have been possible to not only gauge the perceptions and attitudes measured within this survey, but the interview process could have better facilitated an evaluation of individual experiences with the land as well as landscape aesthetics.

Recommendations for Future Research

Future research concerning perceptions and attitudes surrounding the development and use of renewable energy resources, specifically how this development pertains to landscape change, might encompass a broad and diverse range of topics. In the case of the inevitable impacts associated with small-hydroelectricity, research within the field needs to focus more on specific elements of human behavior and intellect.

Pertinent to the results reported by this thesis, more intensive research needs to be conducted on specific and subtle lifestyle activities such as how mindful individuals are in conserving energy, composting refuse, the pursuit of educational attainment, level of political activism, and preferences for personal modes of travel. Similarly, simple questions concerning individual knowledge of current energy, where and how it is produced, as well as individual preferences regarding the energy production paradigm (i.e., large centralized energy production facilities transmitting electricity long distances vs. small-scale local energy production for use at the local level). Evaluating these pointed issues will allow researchers to identify the pieces necessary to complete the social puzzle inhibiting the development and use of renewable energy resources.

Reiterating the ideas of Yi-Fu Tuan, individual values and perceptions are grounded in "place." The entirety of one's experience base, the gestalt, shapes and directs these values. Only through external forces, such as education (as the process becomes part of the individual gestalt), can these values and perceptions change. It is essential that future research address these components in assessing the attitudes and perception of landscape quality, landscape change, and the development and use of renewable energy resources. Failure to do so, and "mandating" the development of local community resources, will inevitably lead to public outcry similar to what has been experienced on a global level with the development of wind energy.

Additionally, research pertaining to the collaboration between individuals and groups deserves mention. Throughout the course of this research, and in reporting these findings, it is the language within Montana's legislation "mandating" the development and use of renewable energy resources that remains out of place. Though public support regarding the use of renewable energy is strong and growing, a concerted effort needs to be made to find the most appropriate means to identify the acceptable resources for use, and the appropriate level of use, for these resources. Given that Montana's renewable energy resources are geographically bounded and restricted by seasonal variation, research pertaining to the use of these common resources will be a key element for understanding and implementing appropriate levels of use. Individual communities and geographic regions will receive varying levels of benefits and impacts from this development, and the public process and a collaborative effort will become essential for gaining the support necessary to harness the energy of renewable resources. By combining a non-biased education of renewable energy potential with the low-impact and respectful use of these resources, advocacy for and dependence on renewable energy resources will be established for future generations at the local, regional, and national level. Through using the aforementioned concepts for developing local renewable energy resources, success will be found.

WORKS CITED

Abel, Amy. 1999. *Electricity Restructuring Background: The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992.* CRS Report for Congress 98-419 ENR. http://www.ncseonline.org/nle/crsreports/energy/eng-50.cfm (accessed 22 February 2007).

Antrop, Mark. 2000. Background Concepts for Integrated Landscape Analysis. *Agriculture, Ecosystems and Environment* 77: 17-28.

Arizona. 2006. Decision No. 69127. Arizona Administrative Code ("A.A.C.") § R14-2-1801 rough -181 5 ("Proposed RES Rules"). http://www.azcc.gov/divisions/util/electric/res.pdf (accessed 28 March, 2007).

AWEA-American Wind Energy Association. 2007. *Montana Wind Energy Development.* http://www.awea.org/projects/montana.html (accessed 04 April 2007).

Barrios, Luis, and Alejandro Rodrigues. 2004. Behavioral and Environmental Correlates of Soaring-Bird Mortality at On-Shore Wind Turbines. *Journal of Applied Ecology* 41(1): 72-81 http://www.blackwell-synergy.com/links/doi/10.1111%2Fj.1365-2664.2004.00876.x (accessed 16 February, 2006).

California. 2002. Senate Bill 1078. Ch. 516, CA Public Utilities Code § 399.11 et seq.. http://www.dsireusa.org/documents/Incentives/CA25R.pdf (accessed 28 March, 2007).

Colorado. 2004. CRS § 40-2-124. http://www.dsireusa.org/documents/Incentives/CO24R.htm (accessed 28 March, 2007).

CSKT – Confederated Salish and Kootenai Tribes of the Flathead Nation. 2005. Comprehensive Resources Plan, Volume I. Chapter 3: History and Culture. http://www.cskt.org/documents/tld/compplanvolume1.pdf (accessed 22 July, 2007)

Connecticut. 2006. Conn. Gen. Stat. § 16-245a. http://www.dsireusa.org/documents/Incentives/CT04Rb.htm (accessed 28 March, 2007).

Delaware. 2005. 26 Del. C. § 351 et seq. http://www.dsireusa.org/documents/Incentives/DE06R.pdf (accessed 28 March, 2007).

Devine-Wright, Patrick. 2001. *A Cross-National, Comparative Analysis of Public Understanding of, and Attitudes Toward Nuclear, Renewable, and Fossil-Fuel Energy Sources*. Institute of Energy and Sustainable Development; INTUSER (Information Network on the Technology of Utilization and Sustainability of Energy Resources) EU 5th Framework Project Grant. http://intuser.net/survey/survey_evaluation.pdf (accessed 10 April, 2006).

District of Columbia. 2006. D.C. Code § 34-1431 et seq. http://www.dsireusa.org/documents/Incentives/DC04R3.htm (accessed 28 March, 2007).

Dragu, Catalin, T. Sels, R.J.M. Belman. 2001. Small-hydro Power – State of the Art and Applications. *Power generation and sustainable development* 8 – 9. http://www.kuleuven.be/ei/Public/publications/EIWP01-02.pdf (accessed 22 February, 2007)

EWEA-European Wind Energy Association. 2003. *Wind Energy: The Facts; An Analysis of Wind Energy in the EU 25*. Volume 5, Market Development. http://www.ewea.org/fileadmin/ewea_documents/documents/publications/WETF/Facts_Summary.pdf (accessed 03 April, 2007).

________. 2006. *Wind Power Installed in Europe by end of 2006*. http://www.ewea.org/fileadmin/ewea_documents/documents/publications/statistics/070129_Wind_map_2006.pdf (accessed 03 April, 2007).

Fahar, Barbara. 1995. Trends in US Public Perceptions and Preferences on Energy and Environmental Policy (NREL) *Annual Review of Energy and Environment* 19: 211-239. http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.eg.19.110194.001235?cookieSet=1 (accessed 20 March, 2006).

INEL – Idaho National Engineering Laboratory. 1993. *U.S. Hydropower Resource Assessment for Montana*. By James E. Francfort. DOE/ID-10430 (MT).

Gammons, Christopher H, John J. Metesh, and Terence E. Duaime. 2006. An Overview of the Mining History and Geology of Butte, Montana. *Mine Water and the Environment* 25: 70–75. http://www.springerlink.com/content/ml854q9059116586/fulltext.pdf (accessed 16 February, 2007).

GWEC-Global Wind Energy Council. 2007. *Global Wind Energy Markets Continue to Boom-2006 Another Record Year*. Press Release. http://www.gwec.net/uploads/media/07-02_PR_Global_Statistics_2006.pdf (accessed 03 April, 2007).

Hartsoch, E.M. 2004. Renewable Energy in Montana: Resource Potential and Complementarity. Masters Thesis. University of Montana.

Hawaii. 2003. HRS § 269-91 et seq. http://www.dsireusa.org/documents/Incentives/HI06R.htm (accessed 28 March, 2007).

Horton, Dale. 2001. *Renewable Energy and Montana Rural Energy Needs.* Testimony Before the Senate Finance Committee. Billings, MT. http://www.senate.gov/~finance/hearings/testimony/082401dhtest.pdf (accessed 21 March, 2006)

Hull, Angela. 1995. New Models for Implementation Theory: Striking a Consensus on Wind Farms. *Journal of Environmental Planning and Management* 38(3): 285-306.

Illinois. 2001. ICC Resolution (Case 05-0437). http://www.dsireusa.org/documents/Incentives/IL04R.pdf (accessed 28 March, 2007).

Khan, Jamil. 2003. Wind Power in Three Swedish Municipalities. *Journal of Environmental Planning and Management* 46(4): 563-581.

Kaltenborn, Bjorn P. and Tore Bjerke. 2002. Associations Between Environmental Value Orientations and Landscape Preferences. *Landscape and Urban Planning* 59: 1-11

Leathe, Stephen A. and Patrick J. Graham. 1984. Cumulative Effects of Micro-Hydro Development on the Fisheries of the Swan River Drainage, Montana. First Annual Progress Report (Covering Field Season July-November 1982). Fisheries Research and Special Projects Bureau, Montana Department of Fish, Wildlife and Parks. Agreement No.DE-Al79-1982BP36717 (BPA Report DOE/BP-225)

Maine. 2000. 35-A M.R.S. § 3210. http://www.dsireusa.org/documents/Incentives/ME01R.htm (accessed 28 March, 2007).

Malay, Stephan. 2000. *Electrical Restructuring in a Nutshell*. http://leg.mt.gov/content/publications/research/past_interim/nutshellsummary.pdf (accessed 03 March 2007).

Maryland. 2004. Code of Maryland § 7-701 et seq. http://www.dsireusa.org/documents/Incentives/MD05R.htm (accessed 28 March, 2007).

Massachusetts. 2002. M.G.L. ch. 25A, § 11F. http://www.dsireusa.org/documents/Incentives/MA05R.htm (accessed 28 March, 2007).

________. 85-2-319. 2005. http://data.opi.state.mt.us/bills/mca/85/2/85-2-319.htm (accessed 03 March, 2007).

Mercer, David. 2003. The Great Australian Wind-Rush and the Devaluation of Landscape Amenity. *Australian Geographer* 34(1): 91-121.

McGowen, Jon G. and Stephen R. Connors. 2000. Windpower: A Turn of the Century Review. *Annual Review of Energy and the Environment* 25: 147-197.

MDEQ-Montana Department of Environmental Quality. 2004. *Understanding Energy in Montana; A Guide to Electricity, Natural Gas, Coal and Petroleum Produced and Consumed in Montana. Montana Electric Transmission Grid: Operation, Congestion and Issues*, II-9.

________. 2004. *Understanding Energy in Montana; A Guide to Electricity, Natural Gas, Coal and Petroleum Produced and Consumed in Montana. Electricity: Supply and Demand in Montana,* I-1 thru I-4

________. 2004. *Understanding Energy in Montana; A Guide to Electricity, Natural Gas, Coal and Petroleum Produced and Consumed in Montana. Montana Electric Transmission Grid: Operation, Congestion and Issues,* II-1 thru II-3.

________. 2004. *Understanding Energy in Montana; A Guide to Electricity, Natural Gas, Coal and Petroleum Produced and Consumed in Montana.Table E-7. Average Annual Prices for Electricity Sold, 1960-2003.* I-15.

Minnesota. 2007. MN S.B. 4, Minn. Stat. § 216B.1691. http://www.dsireusa.org/documents/Incentives/MN14R.htm (accessed 28 March, 2007).

Mitchell, Bruce. 1994. *Geography and Resource Analysis*, Second Edition. Longman Scientific and Technical, New York.

MCA – Montana Code Annotated. 2005. MCA § 69-8-1004. Montana Renewable Power Production and Rural Economic Development Act. (Senate Bill No. 415. *[SB0415.ENR]*). http://data.opi.state.mt.us/bills/mca/69/8/69-8-1004.htm (accessed 28 March, 2007).

________. 2005. MCA § 69-8-1004 3(6d). 2007. Montana Renewable Power Production and Rural Economic Development Act. (Senate Bill No. 415. *[SB0415.ENR]*). http://data.opi.state.mt.us/bills/mca/69/8/69-8-1004.htm (accessed 28 March, 2007).

________. 2005. MCA § Title 85. http://data.opi.state.mt.us/bills/mca_toc/85.htm (accessed 03 March, 2007).

________. 2005. MCA § 85-2-319. http://data.opi.state.mt.us/bills/mca/85/2/85-2-319.htm (accessed 03 March, 2007).

________. 2005. MCA § 85-2-344. http://data.opi.state.mt.us/bills/mca/85/2/85-2-344.htm (accessed 03 March, 2007).

MGP - Montana Green Power. 2007. *Micro-hydro System Meets Power Needs at Darby Home.* Other Renewables. http://www.montanagreenpower.com/renewables/hydropower/darby.html (accessed 15 April, 2007)

MTNRIS – Montana Natural Resources Information System. 2007. NRIS GIS Data List. Counties, Montana Cadastral Geodatabase. http://nris.mt.gov/gis/gisdatalib/gisDataList.aspx?datagroup=statewide-regional&searchTerms=counties (accessed 09 September, 2006)

________. 2003. NRIS GIS Data List. Metadata for Montana Dams. Montana State Library. http://nris.mt.gov/gis/gisdatalib/gisDataList.aspx?datagroup=statewide-regional&searchTerms=dams (accessed 06 October, 2006)

________. 2000. NRIS GIS Data List. U.S. Census 2000 Population and TIGER data -- 1:100,000 scale roads, streams, etc. Montana State Library. http://nris.mt.gov/gis/gisdatalib/gisDataList.aspx?datagroup=statewide-regional&searchTerms=dams (accessed 06 October, 2006)

MPC-The Montana Power Company. 1941. *The Story of the Montana Power Company.* McKee, Butte.

________. 1940. *Annual Report to stockholders*: McKee, Butte.

MT.Gov. 2005. *Judith Gap Wind Farm.* http://dnrc.mt.gov/trust/wind/judith_gap.asp (accessed 11 April, 2007).

NCSU-North Carolina State University. 2007. *Database for State Incentives for Renewable Energy, DSIRE.* http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MT08R&state=MT&CurrentPageID=1 (accessed 22 February 2007).

Nelson, Arthur C. 2006. Leadership in a New Era. *Journal of the American Planning Association* 72, no 4: 393-407.

Nevada. 2005. NRS 704.7801 et seq. http://leg.state.nv.us/NRS/NRS-704.html#NRS704Sec7801 (accessed 28 March, 2007).

New Mexico. 2007. SB 418 of N.M. Stat. § 62-16-1 et seq. http://legis.state.nm.us/Sessions/07%20Regular/final/SB0418.pdf (accessed 28 March, 2007).

New Jersey. 1999. N.J. Stat. § 48:3-49 et seq. http://www.dsireusa.org/documents/Incentives/NJ05R.htm (accessed 28 March, 2007).

New York. 2005. NY PSC Order, Case 03-E-0188. http://www.dsireusa.org/documents/Incentives/NY03R.pdf (accessed 28 March, 2007).

Nohl, Werner. 2001. Sustainable Landscape Use and Aesthetic Perception – Preliminary Reflections on Future Landscape Aesthetics. *Landscape and Urban Planning* 54: 223-237.

NWCC-National Wind Coordinating Committee. 2000. *Transmission Case Studies. Case Study #2.* http://www.nationalwind.org/publications/transmission/casestudies-2.pdf (accessed 10 January 2007).

Olwig, Kenneth. 2001. Landscape as a Contested Topos of Place, Community and Self. *Textures of Place; Exploring Humanist Geographies.* University of Minnesota Press, Minneapolis. 93-117.

________. 1993. Sexual Cosmology: Nation and Landscape at the Conceptual Intersitces of Nature and Culture; or What does Landscape Really Mean: 307-343. *Landscape: Politics and Perspectives*. Berg, Oxford.

Osborn, Robert G., Kenneth F. Higgins, Robert E. Usgaard, Charles D. Dieter, and Regg D. Neiger. 2000. Bird Mortality Associated with Wind Turbines at the Buffalo Ridge Wind Resource Area, Minnesota. *The American Midland Naturalist* 143(1): 41-52.

Paish, Oliver. 2001. Micro-hydropower: status and prospects. Proceedings of the Institution of Mechanical Engineers. 216(Part A): 31-40.

________. 2002. Small-hydro power: technology and current status; *Renewable and Sustainable Energy Reviews*, 6: 537–556.

Pasqualetti, Martin. 2001. Wind Energy Landscapes: Society and Technology in the Californian Desert. *Society and Natural Resources* 14: 689-699

________. 2000. Morality, Space, and the Power of Wind-Energy Landscapes. *The Geographical Review* 90(3): 381-394.

Pennsylvania. 2005. 73 P.S. § 1648.1 et seq. http://www.dsireusa.org/documents/Incentives/PA06Rb.htm (accessed 28 March, 2007).

Ravalli County Growth Policy. 2003. Section 2: Ravalli County Conditions and Trends. http://www.ravallicounty.mt.gov/planning/growthpolicy.pdf (accessed 16 November, 2006)

Relph, E. 1984-85. The Instant Landscape Machine, Vol. 15: 100-114 Geographical Inter-University Resource Management Seminar, Department of Geography, Wilfred Laurier University, Waterloo, Ontario. Quoted by Edward S. Casey. 2001. Landscape as a Contested Topos of Place, Community and Self. *Textures of Place; Exploring Humanist Geographies.* 403-425. University of Minnesota Press, Minneapolis.

Rhode Island. 2004. R.I. Gen. Laws § 39-26-1 et seq. http://www.rilin.state.ri.us/Statutes/TITLE39/39-26/39-26-4.HTM (accessed 28 March, 2007).

Ryan, Robert L. 1998. Local Perceptions and Values for a Midwestern River Corridor *Landscape and Urban Planning*, 42(2-4): 225-237.

Sauer, Carl O. 1927. The Morphology of Landscape. *University of California Publications in Geography* 2: 19-53

Schiff, M. R. 1971. The Definition of Perceptions and Attitudes', 7-12, Sewell, W. R. D. and Burton, I. (eds.), *Perceptions and Attitudes in Resources Management,* Information Canada, Ottawa. Quoted in Bruce Mitchell 1994. *Geography and Resource Analysis*, 102, Second Edition. Longman Scientific and Technical, New York.

Shumway, Matthew J, and Samuel M. Otterstrom. 2001. Spatial Patterns of Migration and Income Change in the Mountain West: The Dominance of Service-Based, Amenity-Rich Counties. *Professional Georgrapher*, 53(4): 492-502.

Smith, Michael D. and Richard S. Kranich. 2000. "Culture Clash" Revisited: Newcomer and Longer-Term Residents' Attitudes Toward Land Use, Development, and Environmental Issues in Rural Communities in the Rocky Mountain West. *Rural Sociology,* 65 (3): 396-421.

Soerensen, Hans C., Lars Kjeld Hansen, Karin Hammarlund, and Jens H. Larsen. 2001. “Experience with and Strategies for Public Involvement in Offshore Wind Projects.” Brussels: Offshore Wind Energy EWEA Special Topic Conference, Session B2 Social Acceptance, environmental impacts and legal issues. Photocopied.

SME-Southern Montana Electric. 2007. *Project Information*. http://www.smegt.net/project/ (accessed 13 April, 2007).

Stewart, Susan I. 2000. *Amenity Migration*. On-line Publication http://www.prr.msu.edu/trends2000/stewart.pdf (accessed 06 May, 2007).

Swanson, Larry. 2006. Growth and Change in the Bitterroot Valley and Implications for Area Agriculture and Ag Lands. O’Connor Center for the Rocky Mountain West, University of Montana.

Texas. 2005. Section 39.904 of Texas Utilities Code; PUCT Substantive Rule 25.173 http://www.dsireusa.org/documents/Incentives/TX03R.pdf (accessed 28 March, 2007).

Tuan, Yi-Fu. 1974. *Topophilia; A Study of Environmental Perception, Attitudes, and Values*. Prentice-Hall Inc, New York.

Tesla Patents. 2007. Electrical Transformer; Transformer for High Frequency Lighting. Twenty First Century Books. http://www.tfcbooks.com/patents/transform.htm (accessed 15 April, 2007).

Trepl, L. 1997. Ökologie als konservative Naturwissenschaft. Von der schönen Landschaft zum funktionierenden Ökosystem. In: Geographisches Denken (eds U.Eisel&H.-D.Schultz). Urbs et Regio 65 (Sonderband) pp. 467–492. GHS, Kassel. Quoted in Wolfgang Haber. 2004. Landscape Ecology as a Bridge from Ecosystems to Human Ecology. *Ecological Research.* 19: 99-106.

UCS – Union of Concerned Scientists. 2005. *Clean Energy, Year End Energy Net Policy Update 12/22/05; Montana*. http://www.ucsusa.org/clean_energy/energynet/year-end-energynet-policy.html#Montana (accessed 16 April, 2005).

U.S. Bureau of Reclamation. 2007. Dams, Projects, and Powerplants. http://www.usbr.gov/dataweb/html/mtdams.html (accessed 13 April, 2007).

U.S. Census Bureau. 1990. American Fact Finder, Ravalli County Montana. http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=Ravalli+County&_state=04000US30&_county=Ravalli+County&_cityTown=Ravalli+County&_zip=&_sse=on&_lang=en&pctxt=fph (accessed 12 April, 2007)

________. 2000 American Fact Finder, Ravalli County Montana. http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=Ravalli+County&_state=04000US30&_county=Ravalli+County&_cityTown=Ravalli+County&_zip=&_sse=on&_lang=en&pctxt=fph (accessed 12 April, 2007)

________. 2006 American Fact Finder, Ravalli County Montana. http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=Ravalli+County&_state=04000US30&_county=Ravalli+County&_cityTown=Ravalli+County&_zip=&_sse=on&_lang=en&pctxt=fph (accessed 12 April, 2007)

U.S. DOE – U.S. Department of Energy. 1983. Lower Flathead Fisheries Study. Bonneville Power Administration, by Paul D. Cross, James E. Darling and Joseph M. DosSantos. Agreement No.DE-AI79-1983BP39830, 113 electronic pages (BPA Report DOE/BP-202) http://www.efw.bpa.gov/publications/R202.pdf#search='Kerr%20hydroelectric%20facility' (accessed 23 November, 2005).

________. 2001. Energy Efficiency and Renewable Energy Clearinghouse: Small Hydropower Systems. DOE/GO 102001-1173 FS 217. http://www.ncgreenpower.org/documents/29065%20-%20Small%20Hydropower%20systems.pdf (accessed 26 December 2007).

________. 2003. U.S. Climate Change Technology Program *Technology Options for the Near and Long Term*. DOE/PI-0002 http://www.climatetechnology.gov/library/2003/tech-options/tech-options.pdf (accessed 25 February 2007).

USGS – U. S. Geological Survey. 2007. *Surface-Water Daily Data*. National Water Information System. http//waterdata.usgs.gov/mt/nwis/sw (accessed 16 December, 2006).

Vermont. 2006. 30 V.S.A. § 8001 et seq. http://www.dsireusa.org/documents/Incentives/VT04R.htm (accessed 28 March, 2007).

Waddell, R. & P. Bryce. 1999. Micro-Hydro Systems for Small Communities. *Renewable Energy* 16: 1257-1261.

WADE-The World Alliance for Decentralized Energy. 2003. A Guide to Decentralized Energy Technologies. http://www.localpower.org/documents_pub/report_de_technologies.pdf (accessed 15 June 2006).

Washington. 2006. Initiative 937. http://www.dsireusa.org/documents/Incentives/WA15R.pdf (accessed 28 March, 2007).

Wikipedia. *Electrical Power Industry*. 2007. http://en.wikipedia.org/wiki/Electrical_power_industry (accessed 03 March 2007)

Wisconsin. 2005. Wis. Stat. § 196.378. http://www.dsireusa.org/documents/Incentives/WI05R.htm (accessed 28 March, 2007).

Zucchet, Michael J. 2002. Renewable Resource Electricity in the Changing Regulatory Environment; Federal Law and Regulations. http://www.i2p.org/federal.htm (accessed 16 April, 2006)

APPENDIX A

Public Perception Survey

Public Perception Survey

1. When you think of alternative energy, what types do you think of?
   ____

2. When you consider these different energy resources, which are you familiar with?
   a. Wind
   b. Small Scale Hydroelectric
   c. Biofuels
   d. Solar
   e. Geothermal

3. Were you familiar with Montana's **renewable energy resources** before I presented them to you? Please rank 1 through 5 (1 being completely unfamiliar and 5 being very knowledgeable) 1 2 3 4 5

4. Which of these Energy resources are suitable for development or has the potential for development in Ravalli County? Please rank 1 through 5 (1 being not suitable and 5 being very suitable)
   a. Wind 1 2 3 4 5
   b. Small Scale Hydroelectric 1 2 3 4 5
   c. Bio-fuels 1 2 3 4 5
   d. Solar 1 2 3 4 5
   e. Geothermal 1 2 3 4 5

5. Were you familiar with Montana's **renewable energy policy** before I presented it to you? Please rank 1 through 5 (1 being completely unfamiliar and 5 being very knowledgeable) 1 2 3 4 5

6. Are you aware of environmental impacts associated with developing small scale hydroelectric technologies? Please rank 1 through 5 (1 being unfamiliar and 5 being very familiar) 1 2 3 4 5

7. I/my household use the canyons and streams located along the Bitterroot Mountain front for:

   a. Hiking/Bird and Wildlife Viewing
      1. Do not use
      2. 1-5 days per year
      3. 6-10 days per year
      4. 11-15 days per year
      5. 16-20 days per year
      6. 21 or more days per year
   b. Fishing
      1. Do not use
      2. 1-5 days per year
      3. 6-10 days per year
      4. 11-15 days per year
      5. 16-20 days per year
      6. 21 or more days per year
   c. Hunting
      1. Do not use
      2. 1-5 days per year
      3. 6-10 days per year
      4. 11-15 days per year
      5. 16-20 days per year
      6. 21 or more days per year
   d. Other recreational activities (e.g. kayaking/picnicking/camping)
      1. Do not use
      2. 1-5 days per year
      3. 6-10 days per year
      4. 11-15 days per year
      5. 16-20 days per year
      6. 21 or more days per year

8. There are a number of streams originating in the Bitterroot Mountains that have potential for generating electrical energy using small hydroelectric technologies. Please rank on a scale from 1 to 5 how favorable you are to using these resources for generating electricity. (1 being very unfavorable and 5 being very favorable)

   1 2 3 4 5

9. If developing the streams in the Bitterroot Mountains resulted in effecting your electrical energy costs for your household would you be more or less favorable in developing this resource? Please rank on a scale from 1 to 5 (1 being unfavorable and 5 being very favorable)

   a. Resulted in increased electrical energy costs 1 2 3 4 5

   b. Resulted in stabilizing electrical energy costs 1 2 3 4 5

   c. Resulted in lowering electrical energy costs 1 2 3 4 5

10. Given what you have seen, do you consider the following impacts to the landscape acceptable in exchange for developing small hydroelectric energy? Please rank on a scale from 1 to 5 **your perception** of the associated impacts (1 being unacceptable and 5 being very acceptable).

   a. Impacts to the view? 1 2 3 4 5

   b. Impacts to water quality? 1 2 3 4 5

   c. Impacts to fish and wildlife habitat? 1 2 3 4 5

   d. Impacts to/for the local economy? 1 2 3 4 5

11. Are you a Montana resident? Yes No

12. If yes, how long have you lived in Montana? _______

13. If a resident of Ravalli County, how long have you lived here? _______

14. How do you heat your home?
   a. Gas
   b. Electric
   c. Wood
   d. Geothermal
   e. Solar
   f. Other _________

15. Do you own or rent your own home? Own Rent

16. Please indicate your household annual income:

a) Less than $15,000
b) $15,000 - $25,000
c) $25,000 - $35,000
d) $35,000 - $45,000
e) $45,000 - $55,000
f) $55,000 - $65,000
g) $65,000 - $75,000
h) $75,000 - $85,000
i) $85,000 - $95,000
j) Greater than 95,000

17. How many people reside in your household? ________

18. What is your Age? ______

19. Please provide any additional comments, opinions or thoughts regarding the development of renewable energy resources in the space provided below.

APPENDIX B

Renewable Energy Resources Poster

Renewable Energy Resources
Small Hydroelectric in the Bitterroot

The University of Montana

Chad Newman; Department of Geography

MONTANA ADVOCATES RENEWABLE ENERGY RESOURCES

In 2005, Montana State Legislature passed Senate Bill 415. This piece of legislature is mandating the use of renewable energy resources by public utilities within the state of Montana. Renewable energy resources, as defined by SB 415 include Wind, Water, Geothermal, Bio-fuels and Solar energy resources within the state of Montana.

By January 1, 2015, and for every year there after, Montana's public utilities are to procure a minimum of 15% of their retail sales of electrical energy in Montana from eligible renewable energy resources.

HOW WILL THIS WORK?

Renewable energy resources are geographically dispersed energy resources and will require the development of wind, water, geothermal, bio-fuel, and solar resources where they are in abundance. This form of electrical energy production is known as distributed energy production and will require multiple electrical energy generation facilities throughout the state of Montana. The development and use of renewable electrical energy resources are to be added to the current portfolio of electrical generating facilities and will either be into local electrical distribution lines or connect directly to the grid.

WHAT DOES THIS MEAN FOR YOU?

The development of distributed renewable energy resources are not projected to cost significantly more than developing traditional forms of electrical generating facilities while the development of distributed renewable electrical energy resources at the local level has the potential to provide long term stabilization for local energy costs.

The development of renewable energy resources will have local environmental impacts as developing these resources will require the construction of new roads and the installation of the appropriate technology to harness the energy of these renewable resources.

RENEWABLE ENERGY IN MONTANA

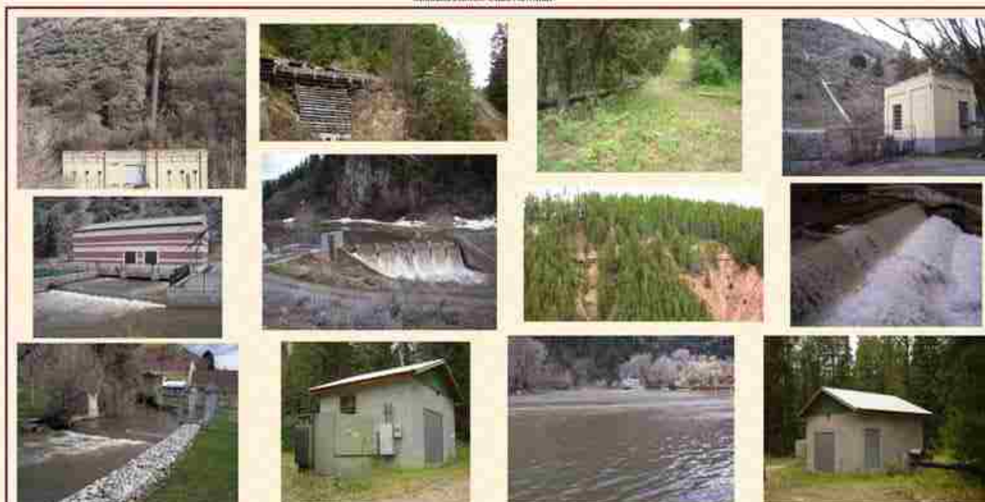
Though all forms of renewable energy resources, wind, water, geothermal, bio-fuels, and solar, are found in the state of Montana, wind and water have the strongest potential for development. These resources, as presented on the maps of Montana, show that the potential for developing wind and water resources are largely separated at the Rocky Mountain front with primary wind resources on the eastern half of the state and water resources in the west.

Renewable Energy Maps Courtesy of Montana Natural Resource Information System (NRIS) http://nris.mt.gov/gis/gisdatalib/mtmaps.aspx

Renewable Energy Maps of Montana

Common impacts associated with the development of small hydroelectricity include the construction of penstocks, weirs, powerhouses, new roads, small-scale dams, electrical transmission lines, and the manipulation of free flowing streams.

Utah Photos: Courtesy of Todd Newman
Montana Photos: Chad Newman



APPENDIX C:

Renewable Energy Standards (by State)

Renewable Energy Standards (by State)

State/ District	Effective Date	Standard/Schedule	REC* Trading	Eligible Technologies***	Technology Minimum
Arizona (A.A.C. § R14-2-1801)	11/2006	**Goal: 15.0% by 2025** Acceptable development of renewables for meeting standards includes systems installed by: utilities, residential, commercial, and industrial systems	Yes: Credits may be applied to non-DRES** requirements	AD, ATUA, B, C, CHP, D, FC, GE, GHP, HE, LG, PV, PVAC, SPH, SSC, SSH, STE, STPH, SWH, W	PV = 60% of total by 2012; 30% of total derived from DRES
California (Senate Bill No. 1078)	01/2003	**Goal: 20% by 2011 and 33% by 2021** Increase: 2% per year starting in 2003	No	AD, B, FC, GE, LG, MSW, OT, PV, SH, STE, TE, W, WE,	None
Colorado (CRS § 40-2-124)	12/2004	**Goal: 10% by 2015** 3% from 2007 – 2010 6% from 2011 – 2014 10% by 2015 and thereafter	Yes: Utilities that do not meet standard may purchase credits from others.	AD, B, FC, GE, LG, PV, SH,W	4% of total from PV, with ½ of this 4% installed by customers
Connecticut (Conn. Gen. Stat. § 16-245a)	10/2004	**Goal: 10% by 2010** 1/1/04: 1.0% Class 1 + 3% Class 1 or 2 1/1/05: 1.5% Class 1 + 3% Class 1 or 2 1/1/06: 2.0% Class 1 + 3% Class 1 or 2 1/1/07: 3.5% Class 1 + 3% Class 1 or 2 1/1/08: 5.0% Class 1 + 3% Class 1 or 2 1/1/09: 6.0% Class 1 + 3% Class 1 or 2 1/1/10: 7.0% Class 1 + 3% Class 1 or 2	Yes: May be purchased from NEPOOL-GIS****	Class 1: FC1, LG, OT, PV, RRH, SB, TE, W, WE Class 2: B, OH, TTE	Minimum % each year from Class 1 renewables
Delaware (26 Del. C. § 351 et seq.)	07/2005	**Goal: 10% by 2019** 1% by 6/1/07 1.5% by 6/1/08 2% by 6/1/09 2.75% by 6/1/10 3.5% by 6/1/11 4.25% by 6/1/12 5% by 6/1/13 5.75% by 6/1/14 6.5% by 6/1/15 7.25% by 6/1/16 8% by 6/1/17 9% by 6/1/18 10% by 6/1/19	Yes: Available only from renewable energy developed after 6/1/07	AD, B, FC, GE, HE, LG, OT, PV, STE, TE, W, WE,	None
Dist. of Columbia (D.C. Code § 34-1431 et seq.)	04/2005	**Goal: 11% by 2022** In 2007, 1.5% from T-1 resources; 2.5% from T-2 resources and 0.005% from PV In 2012, 4.0% from T-1; 2.5% from T-2, and a minimum of .066% from PV. In 2017, 6.5% from T-1, 1.5 from T-2 and a minimum of 0.192% from PV. In 2022 and beyond, 1.1from T-1, 0% from T-2 and a minimum of 0.366 from PV.	Yes: Utilities that do not meet standard may purchase credits from others.	T1 (tier one): AD, B, FC, GE, LG, OT, PV, TE, W, WE T2 (tier two) HE, MSW	0.386% PV by 2022
Illinois (ICC Resolution [Case 05-0437])	07/2001	**Goal: 8% by 2013** 2% in 2007 3% in 2008 4% in 2009 5% in 2010 6% in 2011 7% in 2012 8% in 1013	No	ATUA, B, C, CHP, HE, LG, PV, STE SWH, W	75% derived from wind. Requires a scheduled reduction in load growth for generation facilities

State/ District	Effective Date	Standard/Schedule		REC* Trading	Eligible Technologies***	Technology Minimum
Hawaii (HRS § 269-91 et seq.)	12/2003	**Goal:20% by 2020**		No	AD, B, BD, C, CHP, E, FC, GE, GHP, H, HE, IS, LG, M, MSW, OT, PV, PVAC, RTF, SAC, SSH, STE, STPH, SWH, W, WE	None
		7% of net sales by 12/31/2003 8% of net sales by 12/31/2005 10% of net sales by 12/31/2010 15% of net sales by 12/31/2015 20% of net sales by 12/31/2020				
Maine (35-A M.R.S. § 3210)	2000	**Goal: 30% 10% new renewables by 2017**		Yes: May be purchased from NEPOOL-GIS****	B, FC1, HE, LG, MSW, PV, STE, TE , W	None
		Requires energy providers to submit annual progress report				
Massachusetts (M.G.L. ch. 25A, § 11F)	04/2002	**Goal: 4% in 2009 (plus 1% each year after 2009)**		Yes:	B, LG, PV, OT, STE, TE, W, WE	Energy resources must have been installed after 1997 to qualify for RES
		1.0% by 2003 1.5% by 2004 2.0% by 2005 2.5% by 2006	3.0% by 2007 3.5% by 2008 4.0% by 2009			
		An additional 1.0% each year afterward until DOER ends additional requirements				
Maryland (Code of Maryland § 7-701 et seq.)	01/2004	**Goal: 7.5% in 2019**		Yes: Suppliers receive 200% credit for PV, 110-120% credit for Wand M	T1 (tier one): AD, B, FC, GE, LG, OT, PV, STE, TE,W, WE, T2 (tier two) HE, MSW, PL	None
		1% in 2006 from T-1resources, and 2.5 from T-2 resources. T-1 standard increases 1% every 2 years while T-2 remains at 2.5% through 2018. In 2019 and later, T-1 standard increases to 7.5% and T-2 standard sunsets.				
Minnesota (Minn. Stat. § 216B.1691)	2003	**Goal: 10% by 2015**		No	B, H, HE, LG, MSW, PV, STE, W	0.5% from B in 2005 and 1.0% in 2010
		1% in 2005, increasing 1% per year until 2015				
Montana (MCA § 69-8-1004)	04/2005	**Goal: 15% by 2015**		Yes Requires energy producers to purchase energy credits from community based systems	AD, B, FC, GE, SH, LG, PV, STE, W	None
		5% by 2009 10% by 2014 15% by 2015				
Nevada (NRS 704.7801 et seq.)	02/2006	**Goal: 20% by 2015**		Yes: Utilities that do not meet standard may purchase credits from others.	AD, B, BD, GE, HE, LG, PV, MSW, SPH, SSH STE, STPH, SWH, W, WT	5% from PV
		6% by 2006 9% by 2008 12% by 2010	15% by 2012 18% by 2014 20% by 2015 and thereafter			

State/ District	Effective Date	Standard/Schedule	REC* Trading	Eligible Technologies***	Technology Minimum
New Mexico (N.M. Stat. § 62-16-1 et seq.)	01/2005	**Goal: 10% by 2011** 5% by 2006 6% by 2007 7% by 2008 8% by 2009 9% by 2010 10% by 2011	Yes: 1kW HE = 1kW RPS; [a] 1kW B, GE, LG, FC1 = 2kW RPS; 1kW STE, or PV = 3kW RPS	AD, B, FC, GE, HE, LG, PV, STE, W,	None
New York (NY PSC Order, Case 03-E-0188)	04/2005	**Goal: 24% by 2013** New York has not set a mandated schedule; instead it has developed a market incentive approach using positive reinforcement for establishing renewable resources. This program has been funded with $45 million. Progress is monitored by NY State Energy Research and Development Authority.	None	AD, B, BD, BG, C, CHP, E, FC1, HE, LBF, LG, M, OT, PV, TE, W, WE,	2% of total RPS (7.71% of new development and 0.1542 of all renewables used) is set aside for customer sited development
New Jersey (N.J. Stat. § 48:3-49 et seq.)	1999	**Goal: 22.5% by 2025** New Jersey has set a schedule beginning in 2004 requiring 2.5% from C2 resources each year and an increasing % from C1. 3.250% by 5/31/05 22.5% by 5/31/2025	Yes: All RES compliance will be tracked using credits	C-1 (Class one): AD, B, FC, LG, GE, PV, W, WE, TE C-2 (Class two): C, CHP, SH	2.12% (1,500 MW) from PV, 17.88% from Class 1 and 2.5% from Class 2 renewable resources by 2021.
Pennsylvania (73 P.S. § 1648.1 et seq.) It is important to note that The PUC includes coal, coal processes and management practices as renewable energy resources.	02/2005	**Goal: 18% by 2021** The Pennsylvania Public Utilities Commission (PUC) has set fort a 15-year compliance schedule increasing annually. Tier 1 resources are to compile 8.0% of the total RES while Tier 2 resources are to make up 10%.	Yes: Utilities are allowed to bank REC for up to two years, provide for tracking RES progress	Tier 1: AD, B, CBM, FC1, GE, LIH, PV, STE, W, Tier 2: DGS, DSM, ICCG, LHE, MSW, WB, WC,	0.5% set aside for PV. PV is counted as 200% applying to RES.
Rhode Island (R.I. Gen. Laws § 39-26-1 et seq.)	06/2004	**Goal: 16% by 2020** 3% by the end of 2007. Increases 0.5% per year 2007 - 2010, Increases 1% per year 2010 - 2014 Increases 1.5% per year 2014 - 2019 In 2020 and every year thereafter, the RES 16% will be maintained	Yes: Credits may be purchased from the NEGIS[aa]	B, BD, FC, GE, LG, OT, PV, SH, TE, WE, W,	None

State/ District	Effective Date	Standard/Schedule	REC* Trading	Eligible Technologies***	Technology Minimum
Texas (Section 39.904 of Texas Utilities Code; PUCT Substantive Rule 25.173)	01/2000	**Goal: 5,880 MW by 01/2015** 2,280 MW by 01/2007 3,272 MW by 01/2009 4,264 MW by 01/2011 5,256 MW by 01/2015	Yes: One credit is equal to one MW. Excess credits may be banked for three years. REC provide for tracking progress	B, GE, GHP, HE, OT, LG, PV, STE, SWH, TE, W, WE,	Minimum of 500 MW from renewables other than wind
Vermont (30 V.S.A. § 8001 et seq.)	06/2005	**Goal: 10% by 2012** Provides for voluntary compliance by utilities and sets a requirement cap of 10% for each public electric utility. If the desired 10% is not reached by 2012, a mandatory RES will be adopted.	Yes: Utilities may purchase credits, develop new resources or retrofit exiting sites,	AD, B, FC, HE, LG, PV, STE, SWH, W,	None
Washington (Initiative 937)	11/2006	**Goal: 15% by 2020** **Cost-effective conservation** 3% of load 2012 – 2015 9% of load 2016 – 2019 15% of load by 2020	Yes: Companies receive REC bonuses for developing new facilities	AD, B, BD, GE, HE, LG, OT, PV, STE, TE, WE,	None
Wisconsin (Wis. Stat. § 196.378) The only state with RES that has not restructured its energy market	04/2006	**Goal 10% by 2015** Increase 2% by 2010 Increase 8% by 2015	Yes: Credits may be bought sold and banked	B, FC, GE, HE, LG, PV, STE, TE, W, WE,	None

*REC – Renewable Energy Credits: Defined by the state of Montana as "a tradable certificate of proof of one megawatt hour of electricity generated by an eligible renewable resource that is tracked and verified by the commission and includes all of the environmental attributes associated with that one megawatt-hour unit of electricity production" (MCA § 69-8-1004 2007).
**DRES – Distributed Renewable Energy Systems

***** Key to Table**

***AD – Anaerobic Digestion ***ATUA – Additional Technologies upon Approval ***B – Biomass ***BD – Biodiesel ***BG – Biogas ***C – Cogeneration ***CBM – Coal Bed Methane* ***CHP – Cogeneration Heat Pumps ***D – Daylight ***DGS – Distributed Generation Systems* ***DSM – Demand Side Management*[aaa] ***E – Ethanol ***FC – Fuel Cells (using renewable fuels) ***FC1 – Fuel Cells (using renewable or non-renewable fuels) ***GE – Geothermal Electric ***GHP – Geothermal Heat Pumps ***H – Hydrogen ***HE – Hydroelectric ***ICCG – Integrated Combined Coal Gasification* ***IS – Ice Storage ***LG – Landfill Gas ***LBF – Liquid Biofuels ***LHE – Large Hydroelectric	***LIH – Low Impact Hydroelectric ***M – Methanol ***MSW – Municipal Solid Waste ***OH – Other Hydroelectric ***OT – Ocean Thermal ***PL – Poultry Litter ***PV – Photovoltaic's ***PVAC – Solar HVAC ***RRH – Run of the River Hydroelectric ***SAC – Seawater AC ***SB – Sustainable Biomass ***SH – Small-hydroelectric ***SPH – Solar Pool Heating ***SSH – Solar Space Heat ***SSC – Solar Space Cooling ***STE – Solar Thermal Electric ***STPH – Solar Thermal Process Heat ***SWH – Solar Water Heat ***TE – Tidal Energy ***TTE – Trash to Energy ***W – Wind ***WE – Wave Energy ***WC – Waste Coal* ***WB – Wood Byproducts ***WT – Waste Tires *** By definition is not a renewable energy resource**

****NEPOOL-GIS (Generation Information Systems) – Database containing available renewable energy credits for purchase
[a]RPS – Renewables Portfolio Standard
[aa]New England Generation Information System
[aaa] Demand side management is a strategy using energy efficiency and energy conservation by consumers