Landscapes of Movement: Exploring a Contemporary Approach to Long-Distance Non-Motorized Backcountry Recreation Trail Planning

Christopher Monroe Binder
Utah State University

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LANDSCAPES OF MOVEMENT:
EXPLORING A CONTEMPORARY APPROACH TO LONG-DISTANCE
NON-MOTORIZED BACKCOUNTRY RECREATION TRAIL PLANNING

by

Christopher M. Binder

A project submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF LANDSCAPE ARCHITECTURE

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UTAH STATE UNIVERSITY
Logan, Utah

2015
ABSTRACT

Landscapes of Movement:
Exploring a Contemporary Approach to Long-Distance
Non-Motorized Backcountry Recreation Trail Planning

by

Christopher M. Binder, Master of Landscape Architecture
Utah State University, 2015

Major Professor: Dr. Sean Michael
Department: Landscape Architecture and Environmental Planning

The discipline of long-distance non-motorized backcountry recreation trail planning and
design has traditionally been defined by ad hoc, volunteer-based approaches. Despite the
notable physical, affective, and cognitive benefits to individuals and populations derived from
utilizing such trails, little progress has been made in framing a rigorous and contemporary
method for their planning and design. Without such a framework, attempts in the field may fail
to engage the advantages associated with the application of ordered process, cross-disciplinary
proficiency, and geospatial technology that are continually evolving in the professional and
academic landscape architecture, environmental planning, and natural resource management
fields. This study addresses the lack of contemporary, process-driven planning and design
techniques for the creation of long-distance non-motorized backcountry recreation trails through
both research- and application-based approaches. The first portion of the study examines three sections of National Scenic Trails through the lens of sustainable development. These study sections define patterns and reveal relationships; information that is then applied to frame a contemporary approach to the planning and design of long-distance non-motorized backcountry recreation trails. The practical application of the framework in support of the proposed development of such a trail corridor in the Wasatch Range of southern Idaho and northern Utah completes the study.

(255 pages)
PUBLIC ABSTRACT

Landscapes of Movement: Exploring a Contemporary Approach to Long-Distance Non-Motorized Backcountry Recreation Trail Planning
Christopher Binder

Long-distance non-motorized backcountry recreation trails such as the Appalachian, Continental Divide, and Pacific Crest Trails are valuable resources for those who travel on them. Research has consistently proven that travelling on such trails, particularly for extended periods of time, can confer physical, affective, and cognitive benefits. While previous approaches to planning and designing such trails have been largely completed with a singular application in mind, this study seeks to explore a planning framework that could be applied across the board. The study examines key design features of three sections of long-distance recreation trails. The key design features are identified by through the lens of sustainable development and assessing environmental, economic, social, and aesthetic characteristics of the trails in question. This contemporary approach also modernizes the traditional methods of developing long-distance trails by utilizing advanced computer mapping techniques and professional processes. By applying this approach to long-distance trail planning efforts, trails can be designed in ways that respect environmentally sensitive areas, meet the needs of trails users, and fit the character and nature of the surrounding landscapes. The study results demonstrate how the application of the proposed framework to the Wasatch Range of southern Idaho and northern Utah results in a preliminary corridor that can help guide future trail planning in the region.
ACKNOWLEDGMENTS

To Anna and Eva, with all my love.

Special thanks also to my committee members, Dr. Sean Michael, Dr. Keith Christensen, and Dr. Steven Burr. Additional thanks are due to Dr. Shujuan Li for her assistance with GIS conundrums and to Dr. Bo Yang for his unfailing support.

Christopher M. Binder
“For untold thousands of years we travelled on foot over rough paths not simply as peddlers or commuters or tourists, but as men and women for whom the path and road stood for some intense experience: freedom, new human relationships, a new awareness of the landscape. The road offered a journey into the unknown that could end up allowing us to discover who we were”
– John Brinckerhoff Jackson

“As wanderers, we were free of shadows from the past. The experience of a beautiful emptiness within myself with neither material nor spiritual possessions unlocked my soul. It was a journey without destination. Journey and destination became one. Thought and action became one. In wandering, I felt a sense of union with the whole sky, the infinite earth, and the sea. I felt myself a part of the cosmic existence” – Satish Kumar
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CHAPTER I
INTRODUCTION

Project Background and Context

The history of American recreation trails dates to the beginning of the 19th century when the blossoming wealth of urban America created a population with both the freedom and the financial capacity to venture into the hinterlands in their spare time. This leisure group developed an interest in vacationing outside of cities to explore the wild places of America, not for the monetary gain of the trapper or the glory of the explorer but rather for the salubrious effects on personal health: simple enjoyment of the experience derived from a combination of physical and spiritual rejuvenation. Each passing season witnessed the arrival of greater numbers of this new leisure society in places such as the Catskills and Adirondacks of New York State and the Green and White Mountains of Vermont and New Hampshire. As the nation expanded and grew in wealth and prosperity over the following century, so too did recreational trail use. However, it was not until the economic boom of the post-World War II era that the nation saw outdoor recreation explode in popularity. An expansion of the use of recreation trails was at the forefront of this movement. A growing generation of outdoor enthusiasts desired to explore the beautiful and culturally significant landscapes of the nation on footpaths for the same reasons as their ancestors: to experience the myriad benefits associated with recreational trail use in primitive settings.

Today, the physical, affective, and cognitive benefits of human exposure to nature and recreation in backcountry settings, once supported only through anecdote and hearsay, are widely
studied and confirmed through scientific research. As in the past, one of the primary avenues through which access to the backcountry and its benefits is achieved continues to be through non-motorized trails and trail systems. In particular, appropriately planned long-distance non-motorized backcountry trails provide access to physical, affective, and cognitive benefits for large numbers of people for extended periods of time. However, despite a rich history of trail development and use in America, there is currently no widely-accepted contemporary planning approach for the creation of long-distance non-motorized backcountry recreation trails.

The history of establishing long-distance non-motorized backcountry recreation trails in America is predominantly the story of individuals who dreamed of creating such trails, built a local, grassroots constituency to support those visions, and developed the trails largely ad hoc using volunteer donations of time, skill, and money. Individuals such as Benton MacKaye and Myron Avery (Appalachian Trail), Clinton Clarke (Pacific Crest Trail), Dale Shewalter (Arizona Trail), and Jim Kern (Florida Trail) promoted their respective visions and personally oversaw much (if not all) of their trail’s construction. Unfortunately, despite good intentions, best practice in planning, designing, and constructing the trails was often unknown, overlooked, or forced to the wayside for the sake of expedience or in the face of constraints such as land ownership issues or lack of funds. This poor planning and design foundation has, over time, led to a consistent need for trail rerouting, countless instances of severe erosion and trail degradation, and costly construction of on-trail mitigation structures for much of the length of our nation’s long-distance trail system (Birchard & Proudman, 2000). In some cases, the lack of proper planning and design constitutes a serious impediment to the completion of long-distance trails (Federal Interagency Council on Trails, 2014). In addition, modern technological
advances in geographic information systems (GIS) and remote sensing have created opportunities for trail planning that were unavailable to earlier generations and remain largely unexplored and under-utilized in the discipline today. Further, academic research and professional practice have combined to aid in the development of a more complete understanding of the impacts of recreation trails and trail users on the natural environment, allowing for a more nuanced and sensitive approach to trail interactions with the ecosystems through which they pass.

Despite such advances, specific research into the best approach for planning and design of long-distance non-motorized backcountry recreation trails has been virtually nonexistent. Although the most notable of such trails are federally designated National Scenic Trails, the National Trail System Act (NTSA) and subsequent legislation and related publications provide only a vague outline of how such trails should be conceived and brought into existence. The federal land management agencies that oversee National Scenic Trails (as well as a large portion of all recreation trails on public land), the United States Forest Service (USFS) and the National Park Service (NPS), both publish guidelines that direct employees in the design and maintenance of trails on a small scale. However, neither agency has produced a contemporary and comprehensive method for landscape-scale trail planning or design that would assist planners or land managers interested in developing long-distance non-motorized backcountry recreation trails.

It is essential to recognize that although long-distance trails may confer similar benefits to their users as shorter trails, the experience of traveling on a long trail is inherently different than the experience of traveling on a short trail. Obviously, those undertaking to journey a
large portion or even the entirety of a long-distance trail will be immersed in the experience for a period of significant duration, often weeks or months on end. Perhaps less obvious is that such an extensive time period intensifies the user’s experience of the trail and sense of place. Traveling the long-distance trail becomes an immersion into a landscape of movement not found while traversing shorter trails. There is born a connection to the landscape that only develops over weeks or months as the long-distance trail transitions through place and time, forging a unique bond between the trail user and the surrounding environments. In such an experience, place derives a deeper and more symbolic meaning that is wholly separate and beyond the experience of traveling a shorter route. This significant difference is crucial to the understanding of the scope of spiritual, affective, and cognitive health values that can be derived from traveling on a long-distance trail.

Numerous publications extol best practice in the planning and design of short trails (or short sections of long trails) (Basch, Duffy, Giordanengo, & Seabloom, 2007; Birkby, 2008; Hesselbarth, Vachowski, & Davies, 2007). However, these publications do not provide any special consideration for long-distance trails as being inherently different or unique; traits that would require a distinctive planning approach. In other words, traditional trail-building publications treat long-distance trails simply as longer versions of short trails. Even those guides specifically meant for long-distance trails, such as the design and construction guide for the Appalachian Trail (Birchard & Proudman, 2000), are primarily maintenance guides or are meant to provide direction for short relocations of sections for previously established trails. These publications address neither the entirety of a long-distance trail nor do they present a strategy or process for planning one from the ground up.
The purpose of this study, therefore, is to address the need in the recreation trail planning profession for exploring a contemporary approach to the planning and design of long-distance non-motorized backcountry recreation trails. This will be done based on the premise that such trails are inherently separate and distinct from shorter trails and are not (or should not be) simply amalgamations of short trails. To create a unique long-distance trail experience requires a unique approach to planning and design. Further, this study will apply such an approach to the planning of a long-distance trail corridor in the Wasatch Range of southern Idaho and northern Utah.

**Opportunities in the Wasatch Range**

There are numerous unexplored opportunities throughout the country for the development of long-distance trails. One such opportunity exists in southern Idaho and northern Utah within the rugged environment of the Wasatch Range (Figure 1). This impressive range stretches approximately 250 miles from end to end and contains peaks that reach heights of nearly 12,000 feet. There are at present no long-distance non-motorized backcountry recreation trails in the Wasatch Range (see Definitions and Terminology in Chapter II for this study’s definition of such a trail).

The Wasatch Mountains are a sub-range of the Rocky Mountains and lie on the far western border of that range. To the west of the Wasatch Range lie the Great Salt Lake and the eastern extremity of the Great Basin, an arid landscape of sagebrush and dust that stretches across western Utah, Nevada, and as far as the eastern edge of the Sierra Nevada Mountains in...
Figure 1. Overview of the Wasatch Range.
California. The Wasatch are characterized by rugged alpine peaks, steep, rocky canyons, gorgeous stands of aspen and pine, and significant snowfall in the winter months. The range consists of five major sub-ranges or sections which, from north to south, are the Bear River Range, the Wellsville Range, the North Wasatch, the Central Wasatch, and the South Wasatch (Figure 2). There are six designated Wilderness areas in the range and several additional locations under consideration for future designation (wilderness study areas).

In addition, the Wasatch Range is well-known for attracting outdoor recreationists and providing them with excellent opportunities for hiking, mountain biking, equestrian activity, snow sports, and other such pursuits. The infrastructure for a majority of these activities is already in place. The ski industry, for example, is well-established in the range with thirteen resorts. The quality and quantity of snow sport facilities is attested to by the fact that the area’s major metropolitan center, Salt Lake City, and the surrounding area hosted the 2002 Winter Olympics. Similarly, there are hundreds of maintained trails available for day hiking and short equestrian or mountain bike rides. The popularity of outdoor recreation in the region is enhanced by the range’s proximity to a majority of Utahns and its ease of access for travelers. Roughly 80% of the state’s population lives along the Wasatch Front and Salt Lake City’s international airport boasts of the fact that arriving passengers can be recreating in the mountains less than an hour after landing (Economic Development Corporation of Utah, 2008). However, despite such rich prospects for outdoor recreation in a natural environment, the range lacks a long-distance non-motorized backcountry trail. This shortcoming severely limits the opportunities available to trail users seeking a multi-day non-motorized backcountry recreation
Figure 2. Subranges of the Wasatch mountains.
experience. In short, the necessary trail infrastructure for extended backpacking, mountain biking, or equestrian activity is simply not available in the Wasatch Range.

Currently, there are two long-distance recreation trails traversing parts of the Wasatch Range: the Great Western Trail, and the Bonneville Shoreline Trail. Neither of these trails meets the definition of a non-motorized backcountry trail, and therefore neither confers the same type or degree of benefits to trail users that can be gained from long-distance non-motorized backcountry trails.

The Great Western Trail (GWT) traverses approximately 4,500 miles as it passes through Arizona, Utah, Idaho, Wyoming, and Montana. The trail through Utah is heavily braided and mostly follows previously existing forest roads in the Dixie, Fishlake, Manti-La Sal, and Uinta-Wasatch-Cache National Forests (Figure 3). Rather than being conceived and built as a single entity, the GWT is instead a system that largely connects existing forest roads and trails, often via paved highways. While some segments are non-motorized and some are shared use, most of the trail is developed for motorized use (Great Western Trail Association, n.d.). Significant segments of the trail pass through areas that are rural or suburban in character rather than through backcountry or designated wilderness. In fact, designated wilderness areas are often avoided to ensure motorized access to the trail. Though the GWT is a valuable resource for recreationists throughout the West, the route does not meet the criteria needed for consideration as a long-distance non-motorized backcountry recreation trail.
Figure 3. The Great Western Trail in Utah.
The Bonneville Shoreline Trail (BST) is a partially built route that follows the bench formed by a portion of the eastern extremity of ancient Lake Bonneville (Figure 4). Upon completion, this trail would stretch 280 trail miles from the Utah/Idaho border south to Santaquin, UT. This proposed trail is intended to provide for recreation needs and non-motorized connections between communities along the Wasatch Front (Bonneville Shoreline Trail Coalition, n.d.). However, this is strictly a suburban trail that does not pass through wilderness areas or backcountry. It runs almost exclusively on the edge of the urban/wildland interface and in some cases the trail corridor borders directly on residential backyards. The trail also runs through some highly developed areas, including passing across the front steps of the Natural History Museum in Salt Lake City. While a valuable community resource and a popular destination for runners, mountain bicyclists, and day-hikers, the BST does not offer the same opportunities or experiences as a long-distance non-motorized backcountry recreation trail.

Beyond simply lacking a long-distance non-motorized backcountry trail the Wasatch Range is suitable for consideration in this study for several additional reasons. First, a great majority of the range is owned and managed by the USFS. In Idaho, the northern tip of the range forms part of the Caribou National Forest (managed jointly with the Targhee National Forest). In Utah, the Uinta-Wasatch-Cache National Forest manages over 2,500 acres in the range (United States Department of Agriculture [USDA], n.d.h). The presence of so much public land under the direction of the USFS is significant because providing infrastructure for recreation is a stated priority for the agency (United States Forest Service [USFS], 2010). In contrast to private land, USFS land is much more readily available for trail development.
Figure 4. The Bonneville Shoreline Trail.
Second, the alpine nature of much of the range provides an ideal backdrop for recreation in a natural, backcountry setting. Rugged peaks, glacial cirques, high-altitude lakes, an abundance of wildflowers, charismatic mega fauna, and unspoiled beauty combine to make the Wasatch Range a world-class destination for outdoor pursuits. Six wilderness areas have been designated in the range, a testament to the untrammeled quality of much of the natural environment.

Third, the range is large enough to host a long-distance trail. While approximately 250 miles long from north to south as the crow flies, any trail that traversed the entire range would likely run up to 400 miles in length as it meandered in and out of valleys and up and down over passes. While other ranges in the Rockies such as the Tetons or the Ruby Mountains are considered to be spectacularly scenic, they lack the size required for hosting long-distance trails, which are generally considered to be over 100 miles (see Definitions and Terminology in Chapter II for further clarification).

Fourth, the range is well-known and easily accessible to the researcher. Personal connection with a site or region and a well-developed sense of place are essential for the successful planning and design of any landscape intervention. Although this study relies heavily on remote sensing technology, such contemporary methods work best in conjunction with, rather than in place of, more traditional techniques for assessing landscape constraints and opportunities such as site visits and in situ evaluations. The intimate relationship between the researcher and the subject has lent an indispensable facet of familiarity and passion to this project.
Goals and Objectives

The purpose of this study is threefold:

(1) To identify and adopt a contemporary planning process for long-distance non-motorized backcountry recreation trails and to identify the essential planning and design features of such trails;

(2) To map and analyze these features in case study trail sections and to apply the knowledge gained to the development of a set of performance outcomes that are applicable on a wide scale;

(3) To use the process and performance outcomes to guide the creation of a master plan for a long-distance non-motorized backcountry recreation trail in the Wasatch Range.

The first stated purpose will be accomplished through a consideration of contemporary and sustainable landscape design processes combined with a thorough study of three sections of National Scenic Trails already in existence. The second stated purpose will be achieved by analyzing the results of that study and combining that information with recognized best practices to develop performance outcome goals. The third stated purpose will be satisfied by applying the process and performance outcomes to the creation of a proposed trail corridor. The name of the proposed trail is the Wasatch Mountain Trail (WMT).

The issues involved in such an undertaking follow a path that is best traveled by a landscape architect. At all levels of such a process the landscape architect finds himself on firm, familiar ground. Through a clear comprehension of landform, landscape-scale interactions, environmental sensitivity, and user satisfaction, the profession equips its practitioners with the tools necessary for success in the planning and design of long trails and
large trail systems. Further, the American Society of Landscape Architects publishes policy statements “applicable to the stewardship of mountain trails and the sustainability ethic to minimize impact to public land, natural and cultural resources, and their associated intrinsic values” (Basch et al., 2007). While the landscape architect must rely on complimentary disciplines of engineering, ecology, leisure recreation, natural resource management and others, professional landscape architects are in the best position of professionals in any of these disciplines to assimilate information from related fields and develop a consensus that best satisfies all interests involved.

**Project Significance**

This study provides both a contribution to the field of knowledge in landscape architecture as well as to the discipline’s practice. The literature review and examination of study sections of National Scenic Trails undertaken in this research provide a solid, defensible basis for understanding the essential features of long-distance non-motorized backcountry recreation trails. This knowledge is critical for trail designers and administrators in determining how to develop and design such trails.

By incorporating this research with contemporary design approaches including GIS analysis and contemporary planning theory, this study also provides a defensible approach for a thorough and evidence-based method for the design and planning of long-distance non-motorized backcountry recreation trails. Once published and otherwise disseminated, these
methods can be adopted and replicated, either in part or in whole, by others who are seeking to develop such trails anywhere.

Finally, the application of the aforementioned methods to the planning of a long-distance non-motorized backcountry recreation trail in the Wasatch Range provides federal and state agencies, private organizations, and individual citizens along the Wasatch Front with a tool to develop a trail of potentially national significance. The prospective value of the proposed Wasatch Mountain Trail for conferring the benefits of long-distance non-motorized backcountry recreation on trail users is exceptionally promising, and this study provides the initial steps towards reaching those goals.
CHAPTER II
LITERATURE REVIEW

Definitions and Terminology

For clarity, the definitions of significant terms used in this study are outlined in this section.

A long-distance trail is a path characterized by the ability to support a variety of multi-day experiences. This ability derives from the greater distance, and therefore greater length of time, needed to traverse the trail when compared to a trail that can be enjoyed in a single day or less. For this study, and according to the definition of an “extended trail” provided by the 1983 amendment to the National Trails System Act of 1968, a 100-mile minimum will be required for a trail to be considered long-distance (Section 3(b)).

Non-motorized activity is defined as hiking, trail running, backpacking, mountain biking, and equestrian activity. In some regions other non-motorized activities such as skiing and snowshoeing take place during the winter months and are considered important but secondary uses.

A wilderness area is defined by the Wilderness Act of 1964 as “an area where the earth and its community of life are untrammeled by man … undeveloped … retaining its primeval character and influence, without permanent improvements or human habitation”. For the purposes of this study, wilderness will be used to denote areas that have been specifically designated under the Wilderness Act of 1964 or subsequent acts of Congress. Similarly, but separately, backcountry is a term that refers to places that are remote, undeveloped, isolated, and
may be difficult to access. As cited in Duffy, Basch and Sharlow (2012), 2006 National Park Service Policies echo this description by defining backcountry as “primitive, undeveloped portions [of landscapes]”. Many backcountry areas are de facto wilderness despite lacking the official designation (Absher & McAvoy, 1986; McCloskey & Spalding, 1989). In this research, the term backcountry will be used to refer to any area that demonstrates these characteristics, inclusive of designated wilderness.

A recreation trail is identified as a physical path explicitly and exclusively constructed for leisure activity.

**Benefits to Human Exposure to Nature in a Backcountry Setting**

The physical, affective, and cognitive benefits of exposure to nature in general, and recreation in the backcountry in particular, have been confirmed in numerous studies (Frumkin, 2001; White & Hendee, 2000; Wilson, 1986; USFS, 2013). This section of the literature review will focus on providing evidence for why such exposure is a vital component of the well-being of individuals who experience nature in a backcountry setting, and therefore provides a solid basis for the need for long-distance non-motorized backcountry recreation trails as components of the nation’s outdoor recreation infrastructure.

The physical health benefits derived from exposure to nature, and particularly to recreation in the backcountry, are well documented and widely accepted among professionals and academics who work and study in the field of natural resource management and physiology (Maller, Townsend, Pryor, Brown, & St Leger, 2006; Norman, Annerstedt, Boman, & Mattsson,
A number of these benefits result from the physical exertion that is often required to access these areas. Research indicates that due to the remote character of wilderness and the backcountry, visitation and recreation typically require extended aerobic exertion (Roggenbuck & Driver, 2000), which in turn provides cardiovascular benefits, weight loss potential, and quicker recovery from illness, among other benefits (Warburton, Nicol, & Bredin, 2006; Haskell et al., 2007).

Aside from the physical benefits derived from human interactions with the backcountry, there is a distinct field of research that delineates affective benefits of those interactions. Philosophical musings by early figures in the environmental movement, such as Frederick Law Olmsted (1865) and John Muir (1898), supposed the existence of emotional and spiritual benefits that could be obtained through contact with such remote areas. Modern science has largely proven their assertions correct. For example, research into stress mitigation through exposure to natural environments, including the backcountry and wilderness, demonstrates that these experiences not only reduce stress but help to prevent its recurrence even after leaving that environment (Kaplan, 1995). Similarly, such recreation can provide social interaction which often has a positive psychological effect on participants (Denissen, Penke, Schmitt, & van Aken, 2008). Borrie and Bizzell (2001) confirm that recreation in wilderness improves overall satisfaction and contributes to self-affirmation of participants, while White and Hendee (2000) have concluded that development of self and spiritual growth can both result from wilderness experiences.

Further research suggests that exposure to natural settings, including recreation in the backcountry, can have cognitive benefits. Studies have linked such exposure to improvements
in attention capacity (Berto, 2005; Cimprich & Ronis, 2003), an increase in high-order cognitive control and performance (Berman, Jonides, & Kaplan, 2008), and increased self-discipline (Taylor, Kuo, & Sullivan, 2002). Further evidence indicates that extending such exposure over a sustained period of several days or longer significantly increases those gains (Atchley, Strayer, & Atchley, 2012).

Use of Non-Motorized Backcountry Trails and Trail Systems

The primary access to wilderness and the backcountry is through non-motorized trails and trail systems (Cordell, 2004; Krumpe & Lucas, 1986). Designated wilderness areas are defined by the Wilderness Act of 1964 as having, “... no permanent road ... no temporary road, no use of motor vehicles, motorized equipment ... no other form of mechanical transport...”. This means that virtually all access and recreation in such areas must be by foot, pack animal, or paddle craft. Results from recreation trend studies show that wilderness visitation has experienced impressive growth over recent decades and that such growth is expected to increase in the future (Cole, 1996; Hammitt & Schuster, 2000). Other natural recreation settings such as non-wilderness areas of the backcountry may be accessed by roads or motorized trails, but even here the overwhelming preference is to visit those areas on non-motorized trails.

Approximately 42% of visits to National Forests include participation in hiking/walking, with 19% reporting that as their primary activity (USFS, 2013). In contrast, participation in motorized activity (on trails or not) is only undertaken by 4% of visitors, with 1.6% reporting it
as a primary activity (USFS, 2013). In addition, multi-day excursions on non-motorized trails are a fast-growing trend, with participation increasing 54% from 1995 to 2000 (Boulware, 2004).

Long-Distance Non-Motorized Backcountry Trail Use and Access

Appropriately planned long-distance non-motorized trails can provide access to the benefits of recreation in the backcountry for large numbers of people for extended periods of time. For example, the Appalachian National Scenic Trail (AT) was conceived by Benton MacKaye in his seminal article “An Appalachian Trail: A Project in Regional Planning” in the Journal of the American Institute of Architects in 1921. The trail was completed in 1937 and stretches nearly 2,200 miles through the Appalachian Mountains of the eastern US, running in large part through National Forests (Appalachian Trail Conservancy [ATC], 2012). The trail currently receives approximately two million visitors each year (Zarnoch et al., 2011). In addition, long-distance hiking on the trail is continually increasing in popularity. Approximately 665% more people hiked the entire trail between 2000 and 2009 than did between 1970 and 1979: a pace that far exceeds population increases (ATC, 2012). An estimated 14,000 people have hiked the entire trail with each spending an average of 5-6 months doing so (ATC, 2012). Countless other hikers have completed long sections of the trail and many return to hike various sections year after year.

Similarly, the Pacific Crest Trail (PCT), which runs from the US/Mexico border to the US/Canada border through California, Oregon, and Washington, was first conceived in 1926. It was officially completed in 1993 and stretches nearly 2,600 miles through the Sierra Nevada and
Cascade Mountains, with much of its length passing through National Forests (Pacific Crest Trail Association [PCTA], n.d.). While it is not known exactly how many people use the trail, the Pacific Crest Trail Association estimates that hundreds of thousands of visits occur annually, with nearly 2,000 people annually traveling more than 500 miles in a single trip (PCTA, 2013). As these two examples demonstrate, long-distance trails encourage and enable large amounts of people to spend more time in wilderness and backcountry areas.

In comparison, the National Forest Service’s 2013 Visitor Use Monitor Report states that roughly two-thirds of all National Forest visits last six hours or less, with 45% of visits to wilderness areas lasting three hours or less. The report further concludes that backpacking on trails is one of the best activities for prolonging the duration of a visit to a National Forest (USFS, 2013). Therefore, the exposure to the benefits of recreation in wilderness and backcountry areas for the average visitor is much more limited than for those who travel via long-distance trails and cover greater distances over longer periods of time.

**The National Trail System Act**

This study will identify essential features of long-distance non-motorized backcountry recreation trails in the United States. In order to narrow the scope of this investigation, and to demonstrate the need for a contemporary, thorough, and defensible planning strategy for such trails, this research will focus on those trails that conform to the previously stated definition of a long-distance non-motorized backcountry recreation trail and are designated in the 1968 National Trails System Act and subsequent Congressional acts as National Scenic Trails (Figure 5).
Figure 5. National Scenic Trails nationwide.
Although completed long-distance trails were in existence in America for decades prior to the passage of the NTSA (such as the AT) and other contemporary long-distance trails are not protected under the act (such as the Long Trail in Vermont), the official designation of National Scenic Trail has conferred some degree of standardization and expectation that is useful in trail planning and development. Therefore, the following section provides an overview of that Act in order to better understand society’s goals for such trails as expressed in the democratically informed legislation that enables and protects many of them.

**Historical context.** The post-war economic boom of the 1950s created a growing middle class with increasing leisure time, mobility, and interest in recreational pursuits. As individuals and groups sought to meet their growing outdoor recreation needs it became clear that existing recreation infrastructure could not support them and that recreation facilities (including trails) were in demand that far exceeded supply (Gilbert, n.d.). Approximately 90% of all Americans participated in outdoor recreation in the summer of 1960 on 4.4 billion separate occasions. This trend was predicted to grow steadily. By 2000, it was expected that 12.4 billion outdoor recreation occasions (a threefold increase) would occur (Outdoor Recreation Resources Review Commission [ORRRC], 1962). Without a national plan in place for developing outdoor recreation resources such as trails, the nation could not hope to meet the population’s ever-increasing demand. This popular need led to action on the part of legislators to provide such a national plan.

In 1958, Congress created the Outdoor Recreation Resources Review Commission (ORRRC) to determine recreation needs, inventory recreation resources, and to recommend policies and programs on a national scale (Dilsaver, 1994). This commission produced a report
in 1962 that recognized the “expanding population” and its demands for outdoor recreation infrastructure as well as the “diminished [resources for such recreation] in the face of demands for everything else” such as housing, industrial sites, highways, schools, and airports (ORRRC, 1962). Essentially, the report put into stark contrast the potentially conflicting American desires for pristine resources for outdoor recreation and for increasing development and increasing standards of living based on exploitation of those same resources. Among the report’s many findings were the following facts:

- Walking for pleasure ranked second in popularity among all recreation activities in America
- Considerable land is available around the country that is not (but could be) developed for recreation
- Outdoor recreation is often compatible with other resource uses (ORRRC, 1962)

The commission also recommended the creation of a Bureau of Outdoor Recreation (BOR) to oversee the development of outdoor recreation throughout the country. This Bureau was founded later that year by Secretarial Order and formally established with the passage of the National Outdoor Recreation Act early in 1963 (Udall, 1964). The BOR was eventually absorbed into the Heritage Conservation and Recreation Service in 1977, which itself was disbanded in 1981 when its responsibilities were transferred to the NPS.

On February 8, 1965, President Lyndon B. Johnson addressed Congress with a speech that continued in the vein of the ORRRC report and challenged legislators to “preserve and extend” the heritage of America’s natural resources through conservation, restoration, and innovation (Johnson, 1965). Johnson announced intentions regarding a number of issues under
the aegis of conservation and recreation, including recommending that the Secretary of the Interior Stewart Udall “encourage a national system of trails”. Johnson directed him to “copy the great Appalachian Trail in all parts of America” (1965).

This clear commission to develop trails on a nationwide scale was immediately taken up by Udall. In April of 1965, he requested that the BOR “take the lead in a nationwide trails study” (Bureau of Outdoor Recreation [BOR], 1966). This study was called ‘Trails for America’ and proposed the development of three categories of trails for the nationwide system including National Scenic Trails (the other two categories never came to fruition). The report identified the already established Appalachian Trail as the first such trail and proposed three others (the Pacific Crest Trail (PCT), Continental Divide Trail (CDT), and Potomac Heritage Trail) that could also meet this designation. Five other routes were described that exhibited a high potential for future designation (BOR, 1966).

The results of the ‘Trails for America’ report took two years to develop into legislation (Gilbert, n.d.) that was passed by Congress as the National Trails System Act and signed into law on October 2, 1968 (The National Trail System Act [NTSA], 1968).

The passage of the NTSA in 1968 established both the Appalachian and the Pacific Crest as National Scenic Trails, called for the study of fourteen other routes for possible future designation, and described National Recreation and side or connecting trails that would also be managed under the law (NTSA, 1968). While it delegated sole responsibility for designating National Scenic Trails to Congress, it also outlined a decentralized management policy that allowed for each trail to be constructed and managed according to local conditions.
In addition, the act recognized the “ever-increasing outdoor recreation needs of an expanding population” and noted that its purpose was to “promote the preservation of, public access to, travel within, and enjoyment and appreciation of the open-air, outdoor areas and historic resources of the Nation” (NTSA, 1968). Specifically, the act required the establishment of National Scenic Trails “so located as to provide for maximum outdoor recreation potential and for the conservation and enjoyment of the nationally significant scenic, historic, natural, or cultural qualities of the areas through which such trails may pass” (1968). Thus, the National Trail System’s organic act clearly states that the purpose of the legislation is multiple-use, to meet social, recreation, conservation, and economic needs. Interestingly, though the appellation National Scenic Trail clearly includes the word scenic, such trails can be designated for reasons beyond scenic value. In practice, these trails are long (a 1983 amendment describes them as “extended” or traveling 100 miles or more (National Trail System Amendment Act, 1983) and therefore often encompass a variety of worthy qualities such as historic or cultural value that combine to make that trail worthy of designation. Such vague and loose language pervades the NTSA. There is little guidance given to those who would seek to develop a National Scenic Trail and no planning strategy or design approach is recommended. This remains the case today despite decades of amendments and updates to the act.

A 1978 amendment included the designation of a new category of trail, National Historic Trails, and identified the Continental Divide as the third National Scenic Trail (National Trail System Amendment Act, 1978). Subsequent amendments in 1980 and 1983 added an additional five National Scenic Trails. Most recently, with the passage of the 2009 Omnibus Public Land Management Act, President Barack Obama designated the three newest National
Scenic Trails, effectively adding over 2,000 miles of new trail to the National Scenic Trail system (Obama, 2009). Since this time National Scenic Trail policy has been focusing on mapping, outreach, and improving the existing system rather than expanding it (Federal Interagency Council on Trails, 2014). However, there is no doubt that additional trails will be considered for inclusion in the system in the future. The 50th anniversary of the system will occur in 2018, and agencies and partners in charge of managing trails are enacting an effort titled “A Decade for National Trails, 2008-2018” that is prioritizing trail promotion, youth involvement, resource protection, planning coordination, capacity building, and interagency collaboration (Federal Interagency Council on Trails, 2014). These efforts hope to make the National Trails System stronger than ever while continuing to provide access to recreation that involves interacting with our nation’s natural and cultural resources. This celebratory occasion provides a suitable outlet for the introduction of a planning process to the development of long-distance trails including National Scenic Trails. Such a fundamental process for planning long-distance non-motorized backcountry recreation trails is the focus of this study.

Currently, the eleven National Scenic trails are the Appalachian, Arizona, Continental Divide, Florida, Ice Age, Natchez Trace, New England, North Country, Pacific Crest, Pacific Northwest, and Potomac Heritage National Scenic Trails (Table 1). However, only nine of these trails conform to this study’s definition of a long-distance non-motorized backcountry trail. These trails are the Appalachian, Arizona, Continental Divide, Florida, Ice Age, New England, North Country, Pacific Crest, and Pacific Northwest National Scenic Trails. Neither the Natchez Trace nor the Potomac Heritage trails meet the definition of a backcountry trail as they largely follow paved roads that are also open to motorized traffic.
Table 1

<table>
<thead>
<tr>
<th>National Scenic Trail Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trail Name</strong></td>
</tr>
<tr>
<td>Appalachian Trail</td>
</tr>
<tr>
<td>Pacific Crest Trail</td>
</tr>
<tr>
<td>Continental Divide Trail</td>
</tr>
<tr>
<td>North Country Trail</td>
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<tr>
<td>Ice Age Trail</td>
</tr>
<tr>
<td>Florida Trail</td>
</tr>
<tr>
<td>Potomac Heritage Trail</td>
</tr>
<tr>
<td>Natchez Trace Trail</td>
</tr>
<tr>
<td>Arizona Trail</td>
</tr>
<tr>
<td>New England Trail</td>
</tr>
<tr>
<td>Pacific Northwest Trail</td>
</tr>
</tbody>
</table>

† Completed trail lengths are best estimates: official trail length varies by year due to maintenance, reroutes, closures, etc.

* Trails are considered a work in progress and therefore never 100% complete.

Information Sources

1. National Park Service, n.d.c
4. Continental Divide Trail Coalition, n.d.a
6. Ice Age Trail Alliance, n.d.

**Trail administration under the National Trail System Act.** The NTSA did not establish a uniform planning or management framework for National Scenic Trails as a group or individually (Table 2). This has led the development of each trail to take its own unique path in an attempt to provide quality recreation experiences while maintaining the integrity of surrounding lands and ecosystems. These goals have been achieved to varying degrees across
the National Trail System. While each trail is required to have a managing council that
develops a management plan, these plans are largely site-specific and are not required to be
standardized in any way from trail to trail. It should be noted that management plans form the
basis of decision-making for trails once they are already in existence and are not used in the
initial trail planning process. Some management plans are concerned with the completion of
trails that are already begun, and all include actions that, to a greater or lesser degree, address
issues and problems that have arisen on the trail due to a lack of a thorough and contemporary
trail planning process during the initial stages of trail development. The lack of a homogeneous
framework amongst National Scenic Trails allows managers to make policy decisions based on
local conditions. This process can be further described through examples drawn from the
wording of the 1968 NTSA in relation to the Appalachian and Pacific Crest Trails. That
wording reveals two items of note. Despite both trails being given the same designation, the
authority for the administration of each trail is placed with different agencies. Additionally, the
nature of use on only one trail is defined, and then only vaguely.

Table 2
*Selected National Scenic Trails Management and Uses*

<table>
<thead>
<tr>
<th>Trail Name</th>
<th>Agency</th>
<th>Primary Management Partner</th>
<th>Allowable Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appalachian Trail</td>
<td>NPS</td>
<td>Appalachian Trail Conservancy&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Foot traffic &amp; limited pack stock&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pacific Crest Trail</td>
<td>USFS</td>
<td>Pacific Crest Trail Association&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Foot traffic, pack stock, &amp; equestrian&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Continental Divide Trail</td>
<td>USFS</td>
<td>Continental Divide Trail Coalition&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Foot traffic, pack stock, equestrian, limited motorized&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>North Country Trail</td>
<td>NPS</td>
<td>North Country Trail Association&lt;sup&gt;6&lt;/sup&gt;</td>
<td>Foot traffic, some equestrian, some mountain bike&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ice Age Trail</td>
<td>NPS</td>
<td>Ice Age Trail Alliance&lt;sup&gt;7&lt;/sup&gt;</td>
<td>Foot traffic, some mountain bike, some motorized&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Trail</td>
<td>Admin. Agency</td>
<td>Association</td>
<td>Use</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>----------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Florida Trail</td>
<td>USFS</td>
<td>Florida Trail Association</td>
<td>Foot traffic, some bicycle, some equestrian</td>
</tr>
<tr>
<td>Potomac Heritage Trail</td>
<td>NPS</td>
<td>Potomac Heritage Trail Association</td>
<td>Foot traffic, some canoe, some kayak, some bicycle, some equestrian</td>
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<tr>
<td>Natchez Trace Trail</td>
<td>NPS</td>
<td>None</td>
<td>Foot traffic, some equestrian</td>
</tr>
<tr>
<td>Arizona Trail</td>
<td>USFS</td>
<td>Arizona Trail Association</td>
<td>Foot traffic, mountain bike, equestrian</td>
</tr>
<tr>
<td>New England Trail</td>
<td>NPS</td>
<td>Appalachian Mountain Club &amp; CT Forest &amp; Parks Assoc.</td>
<td>Foot traffic</td>
</tr>
<tr>
<td>Pacific Northwest Trail</td>
<td>USFS</td>
<td>Pacific Northwest Trail Association</td>
<td>Foot traffic &amp; equestrian</td>
</tr>
</tbody>
</table>

NPS = National Park Service  
USFS = United States Forest Service

**Information Sources**

1. National Park Service, n.d.c  
4. Continental Divide Trail Coalition, n.d.a  
7. Ice Age Trail Alliance, n.d.  
10. None  

The original legislation called for the AT to be “administered primarily as a footpath by the Secretary of the Interior, in consultation with the Secretary of Agriculture” (NTSA, 1968). However, the very next paragraph establishes that “The Pacific Crest Trail shall be administered by the Secretary of Agriculture, in consultation with the Secretary of the Interior” (1968). No clear direction is given as to why each trail is to be administered differently, nor is there an indication of how the administration of future trails should be adjudicated.

Language in the act specifies the use of the Appalachian Trail “primarily as a footpath”.

This follows the historical ban on that trail of any motorized or wheeled activity that had been a
key feature since its conception in 1921 (MacKaye, 1921). This wording conveniently sidesteps the issue of equestrians and pack animals, essentially promoting the status quo that has persisted to this day: some pack animals are allowed but horse riding is not. This policy is consistent with traditional recreational trail use in the East, as exemplified in similar restrictions on the use of pack animals and a complete ban on equestrian riders on Vermont’s Long Trail. In contrast, there is no equal restriction on use given for the Pacific Crest Trail. In accordance with trail use customs in the West, all non-motorized use (with the exception of the ban on wheeled vehicles, such as mountain bikes, from wilderness areas and national parks) was initially allowed on the Pacific Crest Trail. The effect of this was primarily to allow equestrian access to the trail, a recreation activity that was highly valued in the West, but that was considered less important in the East. However, environmental concerns and user conflict issues caused the banning of mountain bikes from the entirety of the Pacific Crest Trail in 1988 (Bergeron, 2013). For further detail on trail use on other National Scenic Trails see Table 2: National Scenic Trails Management & Uses. These examples illustrate that the NTSA has not been a useful tool for planners seeking to develop new National Scenic Trails as it does not provide adequate guidance on even the most basic of planning decisions.

The administration of the two original National Scenic Trails also lacks uniformity, allowing for differing management styles to affect decision-making. The NTSA wording states that the AT is to be primarily managed by the NPS under the Secretary of the Interior. However, the PCT is to be managed primarily by the USFS under the Secretary of Agriculture. This decision was not made on the basis of land ownership: the AT runs for approximately 170 miles through two national parks (70 miles in Great Smoky Mountains and 101 in Shenandoah)
while the PCT runs for more than 200 miles through six national parks (75 miles in Sequoia and Kings Canyon, 70 in Yosemite, 17 in Lassen Volcanic, 33 in Crater Lake, and 10.5 in Mount Rainier). Instead, the decision seems to be based on the most appropriate management style for each trail, with the goal that the AT, being closer to urban centers and in the already much-disturbed forests of the East, would benefit from the Park Service’s single-use directive focused on preservation. In contrast, the PCT, somewhat more isolated in the largely roadless regions of the Sierra Nevada and Cascades, would benefit from the multiple-use stance of the Forest Service. Neither the USFS nor the NPS has undertaken the task of developing a standard planning or management process for National Scenic Trails under their administration.

Additionally, the act provides for further localization of management by directing both the Park Service and the Forest Service to encourage state and local governments, private organizations, and landowners to become actively involved in the development and management of segments of the trails (Gilbert, n.d.). These organizations are further explored in following section: Direction of Management Decisions.

Along with other issues, this lack of clarity in the organic legislation has meant that those attempting to create or manage each National Scenic Trail have been forced to develop unique planning processes and management approaches with a greater focus on local solutions rather than a reliance on outside guidance. Essentially, each trail is created by grassroots organizations and, though administered by a national federal agency, each is also managed by state and local groups. This avoidance of a one-size-fits-all approach has helped to negate some of the negative results typically associated with far-removed bureaucratic management, but has
also contributed to a chronic lack of funding, staff, and effective planning for the National Trail System.

Another effect of the lack of clarity in the NTSA is that long-distance trail planners have not benefitted from a blueprint or guide that provides instruction in the planning and development of such trails. While the legislation makes clear the diversity of trail environments that should be responded to by local managers, it only gives vague indications of the nationwide environmental, economic, social, and aesthetic values that should be followed when planning and designing these trails. Little or no concrete guidance is provided for developing new trails. This aspect of the NTSA forms the basis of the need for this study to devise initial trail planning concepts that are widely applicable to long-distance non-motorized backcountry recreation trails.

**Direction of management decisions.** While the NTSA of 1968 dictates that National Scenic Trails are to be administered by the NPS or the USFS, there was little funding allocated in the act for the development and maintenance of the trails or for land acquisition to ensure routes are established and protected in perpetuity. In addition, since the trails pass through lands owned by myriad public and private entities and agencies, the management of any section of the trail must reflect the values and expectations of the respective landowners. National parks, national forests, state parks, municipalities, and private owners are just a few of the players. In order to more effectively manage National Scenic Trails, non-profit conservation groups have been developed, often through the impetus of the individual who initially conceived of the trail. These partnering groups are listed in Table 2. Such independent groups partner with the NPS, USFS and other landowners and managers to shoulder significant responsibility for trail
maintenance, public outreach, planning, and other management tasks. However, none of these groups has produced a contemporary process for the planning of new long-distance non-motorized backcountry recreation trails.

These non-profit groups are largely funded through individual and corporate donations, in-kind contributions, and government grants. The functioning of the organizations relies heavily on volunteers. The Pacific Crest Trail Association, for example, received over 120,000 hours of volunteer support in 2012, and spent nearly $4 million towards managing the PCT. Of these funds, nearly $3 million came from private sources (PCTA, 2013). The Appalachian Trail Conservancy received nearly 240,000 hours of volunteer time in 2012, and spent nearly $6.5 million towards managing the AT. Of these funds, all but $2 million came from private sources (ATC, 2013). In some cases, such as on the AT, additional local trail groups, such as the Maine Appalachian Trail Club or the Potomac Appalachian Trail Club, assist the larger organization and also perform management and maintenance duties on a local level.

By utilizing private non-profit groups to assist with much of the management of National Scenic Trails, the federal land management agencies have reduced their need to find appropriations, political will, and manpower for much of the responsibility for the National Trail System. This has both positive and negative repercussions.

On the positive side, this management strategy encourages local involvement, volunteerism, and constituency-building for the support of the trails. While centralized federal groups might face difficulty in monitoring the trails for illegal use, corridor violations, or needed maintenance, local groups that use the trails anyway are already aware of many of these issues. Rather than being forced to wade through red tape, a local group may be able to address concerns...
quickly and cheaply given their local knowledge and connections. In addition, the freedom allowed to local groups could have a positive effect on the planning of new long-distance trails. If provided the outline for a trail-planning process such as produced by this study, local groups could effectively apply regional knowledge that might not be available to bureaucratic planners, greatly enhancing the proposed trail’s ability to meet various performance goals efficiently and effectively.

However, the lack of centralized federal management has also meant that many National Scenic Trails languish out of sight of lawmakers. Many trails are far from complete (Table 1) and see very little trail building and land acquisition from year to year (Federal Interagency Council on Trails, 2014). In addition, relying on donations leaves smaller and less-known trail organizations with very little money with which to manage the trails. Though the Appalachian and Pacific Crest Trails are generally well-funded due to their popularity amongst recreationists, other trails are not as fortunate. This leads to a great disparity between the management possibilities for each trail. It has also led to deficiencies in efforts to adequately plan and design new trails.

The decentralized management of National Scenic Trails means that effective and considered planning of trails is extremely crucial and needs to be undertaken before any new trails begin construction. Trail organizations that are striving to realize the completion of a trail must rely on donations and grants, which are often dispersed based on an organization’s ability to show that they have a high-quality and well-considered plan to follow. These same criteria are necessary to convince federal, state, and local landowners of the value of the proposed trail and of the mitigation measures that will be pursued to decrease the possible negative
environmental impacts of the trail. In addition, these organizations suffer greatly after trails have been built from the financial and manpower burdens of trail relocation and excessive maintenance requirements that go hand-in-hand with poorly conceived trail planning. The small trail organizations that are the impetus and backbone for most long-distance trails can be more effective, efficient, and successful by following an established and professionally-developed trail planning process such as the one developed in this study.

**Future opportunities and applications.** As previously discussed, the purpose of the NTSA was “to provide for maximum outdoor recreation potential and for the conservation and enjoyment of the nationally significant scenic, historic, natural, or cultural qualities of the areas through which such trails may pass” (1968). Over the past 46 years, 11 National Scenic Trails have been designated towards this purpose. With the creation of National Historic and National Recreation Trails, the American people now have much greater access to recreation in areas of natural beauty and cultural significance than ever before. The success of the act in providing a public trail system is evident in both the trails that crisscross our nation and also in the emulation of other nations that have attempted to imitate or replicate what has been achieved.

In particular, the National Scenic Trails have created the basis for what is arguably the world’s greatest long-distance recreational trail system. Nowhere else on earth can boast of so many miles of recreation trails that traverse such consistently undeveloped land. National Scenic Trails have developed a worldwide reputation and draw thousands of international visitors annually to the challenge and rewards of traveling upon them. Much like our national parks, our National Scenic Trails have inspired other nations to follow in America’s footsteps and create their own long-distance footpaths. For example, New Zealand is developing Te
Araroa (The Long Pathway) to traverse the length of both the North and South Islands, Australia has embraced the 5,000 kilometer Bicentennial Trail (specifically “to rival America’s Appalachian Trail”) (The Bicentennial National Trail, n.d.), and Israel has designated the Israel National Trail. Canada’s Great Divide Trail (an extension of the CDT) is currently struggling to obtain official recognition by provincial and national governments (Derworiz, 2014). The fact that other nations are also buying into the idea of national trail systems is a strong vote of confidence for our own.

In addition, the proliferation of long-distance trail systems throughout the world creates a ripe opportunity for American trail planners to develop contemporary trail planning methods for domestic use and for export abroad. By creating such methods, this study seeks not only to influence the future of American trails, but of trails throughout the world seeking to emulate America’s robust trail system.

**The National Trail System Act as a basis for long-distance trail planning.** There has been ample time since the passage of the NTSA for federal agencies and their partners to monitor and evaluate the law and its effects. Subsequent amendments (notably in 1978, 1980, 1983, and 2009) have modified the original law, but have not changed its basic structure or purpose. Rather, these amendments have created the legal backing necessary to continue to expand the National Trail System through the addition of more national trails. Rather than deviate from the original law, these amendments have largely supported the initial core of the act. Given that the 1968 legislation called for the study of 14 trails for possible future inclusion in the system, thereby foreseeing and embracing future additions to the law and the system, these amendments are a testament to lawmakers’ judgment that the system can and should be
expanded. No alternate processes or laws have been proposed and enacted that negate the NTSA, and no major changes in management or implementation have been made. Although society is evolving and trends in outdoor recreation have changed since 1968, we are still a people that largely value scenic beauty, preserving sites of cultural significance, and the predominance of walking, biking, and equestrian activity as some of our primary forms of outdoor recreation. The incremental modification of the act has continued to support these values while strengthening the core of the National Trail System and supporting its apparent success. However, the evolution of the act has not provided the structure for a planning method that would support those seeking to develop new long-distance trails with the hope of eventual inclusion in the National Trail System.

The gradual but consistent expansion of the NTSA is further evidence of its appropriateness for the basis of America’s long-distance trail system and of the need for the creation of a trail planning and development method. While it has its faults, the NTSA in general, and the National Scenic Trails in particular, are the best available source of information upon which to build a long-distance non-motorized backcountry trail planning method. The following section will discuss both how this study develops such a method to replace the historic ad hoc approach to long-distance trail design and how that method is applied to planning the proposed WMT. The chapter begins with a consideration of contemporary design approaches, and then covers the mapping and analysis of essential trail features on sections of three National Scenic Trails. The chapter also discusses the desirable performance outcomes determined by analyzing the essential trail features, and outlines how those performance outcomes can be applied to planning the WMT in the Wasatch Range.
CHAPTER III

METHODS

This chapter addresses the development of a method for the exploration of a framework for planning long-distance non-motorized backcountry recreation trails and its application to the creation of the proposed WMT. The first section of the chapter is primarily focused on a contemporary approach to the landscape design process and the exploration of applying that process to three sections of existing National Scenic Trails. The following section, Trail Study Findings, reports the findings of the research into the three trail study sections, and explains how the performance outcomes that result from that research can be combined with the planning process and applied to the creation of additional long-distance non-motorized backcountry recreation trails. The final section, Wasatch Mountain Trail Methods, explains how the developed framework is applied to the Wasatch Range and the formulation of a master plan for the proposed WMT.

The formulation of the design framework consists of five major tasks, the first three of which are addressed in this chapter. First, a contemporary, sustainable approach to landscape design in general, and long-distance non-motorized backcountry recreation trail design specifically, is considered. Second, trail study sections are chosen and a process of identification, inventory, and analysis of key features of three sections of National Scenic Trails is undertaken. This step illustrates the essential features of a long-distance trail and how they can be quantified. Third, the application of the aforementioned design approach is combined with the identified features to develop specific goals for planning a proposed trail corridor. In
other words, a compilation of key design features and desirable performance outcomes are established. Fourth, design alternatives for a proposed trail are created based on the desired performance outcomes. Finally, the formation of these design alternatives is followed by their integration into a single proposed corridor.

A Contemporary Design Approach in Landscape Architecture

This section discusses the design approach utilized in this study. This research adopts an approach to design which champions environmental, economic, social, and aesthetic considerations as foremost concerns. By combining these four design aspects, the approach to contemporary long-distance, non-motorized backcountry recreation trail planning developed here is assured to reflect a professional and widely-accepted design method. In addition, the planning method used herein advocates for the development of alternative design interventions, each of which represents a distinct ideal. These alternatives are fused into a final design solution that integrates the most desirable features of each. This research is designed to follow a rational approach. The drawbacks and limitations to such an approach are discussed below. However, this research is not meant to be comprehensive, but rather is a first but vital step in exploring the development of a framework for planning long-distance non-motorized backcountry recreation trails. Suggestions for additional, essential steps in the process are provided in Chapter V: Discussion.

Informing design through sustainable development. Much like allied professions such as architecture and engineering, landscape architecture as a discipline has evolved alongside
and as a part of human society. As the importance of sustainability and resiliency have come to the forefront in decision-making in Western society, and indeed around the globe, so too have these modern considerations influenced landscape architecture in general, and specifically recreation trail planning. Sustainable design in landscape architecture has been growing in influence since the late 1980s and today has an undeniably powerful presence in practice and academia. The UN commissioned Brundtland Report first defined what are known widely as the three pillars of sustainability – the environment, the economy, and society (Figure 6) (Brundtland, 1987). These facets of sustainability have been applied to design and widely embraced in the modern practices of landscape architecture and environmental planning, especially as each facet has a rich history reaching back to the roots of both professions.

This history can perhaps be best illustrated by noting that prominent landscape architects and planners have embodied the three aspects of the contemporary concept of sustainability. Frederick Law Olmsted is remembered as a visionary for social change who advocated for and facilitated the creation of public parks for the enjoyment of all and the betterment of society. Ian McHarg and his seminal Design with Nature are largely credited for providing the profession with a defensible framework through which environmental sensitivity can be achieved and balanced with development. Urban restructuring to foster economic revitalization has been on the agenda of many individuals, from Daniel Burnham to Andres Duany.

Recently, the Landscape Architecture Foundation has also embraced this three-pillared approach to assessing landscape design. Its 2010 launch of the case study-based Landscape Performance Series seeks to publish research that assesses the benefits of cutting-edge landscape designs by quantifying their performance in environmental, economic, and social categories.
Figure 6. Traditional three pillars of sustainability (adapted from Brundtland, G. H. & World Commission on Environment and Development, 1987).
However, this tripartite approach fails to consider an aspect of landscape design and the built environment that has been indispensable to the profession since its inception and which plays an extremely vital role in trail planning and design. This concept is aesthetics. While some consideration of visual appeal is often lumped together with social sustainability, doing so fails to acknowledge aesthetics as one of the most important aspects of what landscape architects and environmental planners can achieve with their designs, an aspect that deserves to be on equal footing with environmental, economic, and social concerns. It also fails to do justice to the skills and talents that set landscape architects apart from those in related fields that traditionally favor a purely technical approach to resolving design issues. The need to consider aesthetics is no less true in the specialized field of trail planning and development where, along with the desire for robust physical activity, the visual experience of nature is a primary motivating factor for use. A trail design that does not consider the aesthetic implications of trail construction or corridor location will fail in one of the primary considerations tasked to a trail designer: to engage trail users in the beauty and experience of nature. This is even more important with a non-motorized backcountry trail that conveys trail users to areas that are largely untouched by human actions and lack the distractions of large-scale human intervention. Additionally, long-distance trails offer the possibility of extending these aesthetic experiences over greater periods of time.

While long recognized by practitioners of traditional landscape architecture, the formal inclusion of aesthetics as a design goal for environmental planners and trail designers has not been as widespread as some environmental, social, or economic concerns. Still, there are examples of aesthetics being formally integrated into a land planning method. One such
example is at the firm Design Workshop, whose Legacy Design philosophy is utilized as a grounding point for all projects, from traditional residential or commercial landscape designs to regional environmental plans including trail development. Legacy Design added aesthetics as the fourth pillar of a sustainable approach, and serves as a cutting-edge though widely-accepted industry standard (Figure 7). The four pillar approach also serves as a model for this study.

**A sustainable approach to National Scenic Trail design.** The four-legged approach of environmental, economic, social, and aesthetic considerations in trail design, while not overtly codified, is further bolstered by its presence in the organic legislation for the National Trails System, and specifically for National Scenic Trails. Section 3(2) of the NTSA of 1968 states that National Scenic Trails shall be “extended trails so located as to provide for maximum outdoor recreation potential and for the conservation and enjoyment of the nationally significant scenic, historic, natural, or cultural qualities of the areas through which such trails may pass”.

This wording states the values and qualities of long-distance non-motorized trails that are expected in National Scenic Trails. Viewing this legislation through the lens of modern landscape architectural and planning practice can provide guiding principles for trail planning that also conform to contemporary concepts of sustainability and success in the design profession. The phrasing “conservation … of nationally significant … natural … qualities” has the same intent as environmental sustainability. These trails are not meant to degrade or damage the surrounding lands and ecosystems, but instead to protect them by concentrating use along narrow corridors. The economic sustainability argument can be found in the wording “maximum … potential”. The trails will only be worthwhile insofar that they are able to be used, that is: accessible to people, safe, free of charge or inexpensive, and otherwise
Figure 7. Contemporary four pillars of sustainable design (adapted from Moses, 2007).
economically viable. The terminology “enjoyment of the nationally significant scenic, historic, natural, or cultural qualities” is analogous to social sustainability. Such trails are meant to be designed in a way that allows for recreation and appreciation of the resources along the trail for the betterment of individuals, groups, and society as a whole. Finally, the idea of an aesthetically pleasing experience is clear in the use of the term “scenic” and the decision to name National Scenic Trails with that same word in the official title, despite the fact that “historic, natural or cultural qualities” are also mentioned as worthy of being highlights along each route. Scenic value is therefore worthy of being the defining value of these trails. Each of these four major categories is assessed based on the design features and principles derived from the examination of existing National Scenic Trails.

**Forming and integrating alternatives.** Following the identification of the trail features that fall into the environmental, economic, social, and aesthetic categories is the development of design alternatives. This process individually uses each of the four facets as separate bases for four design alternatives, each attempting to maximize the performance outcomes of the features it is focused upon. For example, the socially preferable alternative would be a trail corridor specifically routed to take advantage of the socially sustainable features in the area of the trail corridor, such as permitted trail uses or proximity to points of interest. After all four alternatives have been delineated, areas where they align can be considered to be the most suitable for the trail. Areas where they diverge must be closely examined in order to assess which route (or combinations of routes) would be ideal. This leads to a final corridor with defensible performance outcomes.

Following this method conforms closely to part of a legally required process that such a
A project must adhere to: the standard decision-making procedure required by the National Environmental Policy Act (NEPA) of 1969 (Figure 8). As following the NEPA process is mandated for any projects that receive federal funding or are undertaken on federal property (both likely to be the case for a long-distance, non-motorized backcountry recreation trail such as the proposed WMT and thus far true for all existing National Scenic Trails), following this method may prove useful for future considerations of fund-raising, legal compliance, and agency approval. The use of this planning framework, therefore, has both a solid theoretical and practical underpinning.

**An evidence-based planning model.** The practice of identifying key problems, assembling scientific data, developing alternative solutions, and evaluating outcomes to arrive at a final design is a well-established practice in landscape architecture and environmental planning. Indeed, it follows an entrenched model developed by planning theorists and in use in multiple related disciplines. This model is known alternatively as policy analysis (Friedmann, 1987) and as the rational comprehensive planning model (Harper & Stein, 2006). This model champions rationality, technical expertise, and scientific objectivity (Harper & Stein, 2006). However, this theory also suffers from critical shortcomings. It can fail to account for factors that are not spatially explicit and may disregard the input of any save the expert who performed the analyses. While critics of the theory challenge its reliance on positivism and utilitarianism, the theory remains popular with professional planners, largely because it is evidence-based and produces defensible and quantifiable results (Harper & Stein, 2006).

This study utilizes a rational approach (Figure 9) and acknowledges that it has serious limitations. For example, the methods used in this study are largely limited by the accuracy and
Figure 8. Simplified NEPA decision-making framework (adapted from The Shipley Group, 2012).
Figure 9. Simplified planning approach (adapted from Harper & Stein, 2006).
precision of publically available GIS data, which may be out of date or over-generalized. Some of the drawbacks of working with this type of data are explored further in Chapter V. In addition, though extensive site visits have been undertaken, the difficulties inherent in understanding landscapes of such size are immense. Due to logistical constraints, this research has not been informed by any form of public process: no input was solicited or obtained from those who have travelled on the trail sections, may choose to use the proposed trail, or who own or manage the land it would pass through. These limitations are representative of the some of the difficulties involved in large-scale land planning.

It should be noted that this research does not attempt to be comprehensive and is meant to be only the first step in exploring a planning method for long-distance non-motorized backcountry recreation trails. This study should be complimented by additional efforts including (but not limited to) public input, agency coordination, and economic feasibility studies. Despite limitations, this preliminary research is crucial for informing the initial steps towards establishing a nationally significant trail in the Wasatch Mountains.

Determining Key Features of Existing National Scenic Trails

This section discusses the selection of study areas, general sources used for assembling data pertaining to each trail study section, and the process through which trail features were sorted into the four established categories: environmental, economic, social, and aesthetic.

Selecting trail study sections. There are eleven trails currently designated as National Scenic Trails, nine of which correspond to this paper’s definition of a long-distance non-
motorized backcountry recreation trail. These nine trails total over 15,547 miles of existing or proposed trail or trail corridor. A thorough examination of this amount of trail and trail corridor is beyond the scope of this study. Therefore, in lieu of assessing all existing National Scenic Trail corridors, this study will focus on three trail sections. These sections are the Appalachian National Scenic Trail where it passes through the White Mountains, 152 miles from the Vermont/New Hampshire border to the New Hampshire/Maine border (Figure 10), the Continental Divide National Scenic Trail in the southern Colorado Rockies, 133 miles from the border of the Weminuche Wilderness to its intersection with US Highway 50 at Monarch Pass (Figure 11), and the Pacific Crest National Scenic Trail in the southern High Sierra, 150 miles from Kennedy Meadows to Piute Creek at the border between Kings Canyon National Park and the Sierra National Forest (Figure 12).

These segments were chosen for a combination of reasons. First, they are all high alpine trails that pass through environments that have a similar physical character to the Wasatch Range. Each travels through designated wilderness and, in general, is devoid of large-scale human intervention in the surrounding landscape. Second, the segments are largely located on public land managed either by the USFS or the NPS. This is similar to the Wasatch Range, which is largely owned and administered by the USFS throughout much of its length. Third, each segment is approximately 150 miles long. Therefore, they are of comparable length to each other and each is long enough to meet the definition of a long-distance trail in its own right. Fourth, each section is well-known as a premier and nationally-recognized destination for outdoor recreation and each is among the most popular sections of the National Scenic Trail system. Fifth, each section is part of the so-called Triple Crown of long-distance hiking: the
Figure 10. Study segment #1: The Appalachian Trail in the White Mountains.
Figure 11: Study segment #2: The Continental Divide Trail in the Colorado Rockies.
Appalachian, Pacific Crest, and Continental Divide National Scenic Trails. These trails are generally more complete, better funded, host more users, and are maintained with more and better resources than many other trails in the system. Finally, all three of these trail segments are advantageous for study due to the author’s personal familiarity with them. In the course of over 8,500 miles of long-distance backpacking over the past seven years, the author has walked the entire length of each of the three segments chosen. The author hiked the entire AT including the New Hampshire section in 2008, the PCT from the Mexico/US border to central Oregon including the High Sierra in 2012, and the Colorado Trail including the CDT through the southern Colorado Rockies in 2014. This experience has proven invaluable in the course of this research.

Assembling trail data. Data collection for general information about these three trail segments was undertaken in order to begin the process of identifying key design elements of long-distance non-motorized backcountry recreation trails. First, data files containing trail centerlines were obtained from the respective non-profit trail advocacy groups: the Appalachian Trail Conservancy (ATC), the Continental Divide Trail Coalition, and the Pacific Crest Trail Association. These data were brought into ESRI ArcMap software to begin the establishment of a GIS for each trail. The trails were clipped to reflect just the portion of the each trail being studied. Additional trail information was gathered from other sources that offer reliable information. There are many sources for trail information, but this study chose to consult those sources that were assessed by the author to be most useful and accurate when personally hiking the trail in question. By physically hiking each trail section the author was able to vet a number of sources and determine which contained the most useful and accurate data regarding physical
location of the trail, trail features (such as campsites), natural features (such as high points) and
other essential information. For the AT in the White Mountains, the official maps and
guidebook for New Hampshire and Vermont produced by the ATC were consulted. For the
PCT in the High Sierras, USGS topographical maps and the official PCT guidebook for southern
California were used. For the CDT in Colorado, the Colorado Trail guidebook was the best
source of information (the CDT and the Colorado Trail are co-located in the section analyzed for
this study) along with USGS topographical maps. Information regarding the areas surrounding
the trails was compiled from other reliable resources, largely from state- or university-run GIS
data clearinghouses. The resources utilized are specifically credited on each map as well as in
the text of each section alongside the design aspect inventoried for each trail section studied.
Further information (including photographs) was obtained by the author while backpacking on
the trail sections in question.

**Compiling features and determining feature categories.** As the maps of the three
trail sections were studied, features and qualities of importance were inventoried. Additional
information sources consulted in the formation of this inventory fell into four categories. The
first information source category is relevant academic research, primarily in the fields of
landscape architecture, recreational ecology, and recreation planning. Relevant academic
literature includes journal articles, conference proceedings, and other peer-reviewed publications.
The second information source category is grey literature (non-commercial publications),
primarily disseminated through federal agencies. These sources include USFS guides and NPS
pamphlets. The third information source is trail-building handbooks, such as those produced by
the Student Conservation Association, the Appalachian Trail Conservancy, and the International
Mountain Bike Association. These sources were particularly useful in evaluating technical aspects of trail building, especially as they pertain to environmental sustainability. The fourth information source is site visits conducted at each of the case study sites. By carefully observing various trail design features and elements while hiking each trail section, the author was able to identify features of significance. The compiled features are therefore researcher derived.

Upon completion of the trail design feature inventory, the spatial information pertaining to each was digitized (if necessary) and assembled in ArcMap software that was subsequently used to produce maps that locate those features. A thorough analysis of each feature was undertaken to outline and understand the relationship of the trail to each studied aspect. For example, each trail passes either through, next to, or near to points of interest. Inventory maps were created showing the relationship of these points to each trail section. Analyses of these interactions revealed that the points of interest trend into three types: viewpoints, cultural sites, and unique environmental features. Analyses were also performed to ascertain the distance between each point in order to understand how they shaped a trail user’s experience. By mapping all the features of all three trails in this way, relationships and interactions between those features and the trail became more apparent and more readily analyzed.

All the features were then sorted into the four established categories (environmental, social, economic, and aesthetic) for ease of reference and for later use in the creation of alternative trail corridor options for the proposed WMT. The features were sorted into the four categories based upon the researcher’s determination of which label was appropriate. Naturally, there are some cases in which assignation of a feature to two different categories
would be equally logical. In these cases of conflict, the features were allocated to the category that was deemed to be most applicable. For example, trail slope is crucial not only for determining the environmental impact of a trail route, but also for the social enjoyment of the trail. In either case, a trail that is too steep would likely be undesirable. However, while slope is one of only a few crucial factors in determining the effects of trail erosion, it is only one of practically countless factors involved in determining the social enjoyment of a trail. In addition, scientific research has provided great insight into the desirable slope threshold needed to avoid trail erosion issues. Therefore, trail slope is a feature designated within the environmental category rather than the social category.

Following below are the compiled features mapped for each trail section arranged by category, as well as the sources for the data used. These features are also outlined in Figure 13.
Figure 13. Trail design feature inventory.

- Highpoints
- Cultural Sites
- Unique Natural Features
- Camping Opportunities
- Designated Wilderness Areas
- Permitted Trail Use
- Water Sources
- Shelters

- Aspect
- Trail Slope
- Landform Slope
- Existing Roads
- Existing Trails
- Sensitive Habitats
- Threatened & Endangered Species

- Trailheads
- Land Ownership
- Existing Recreational Facilities
- Connections to Side Trails
- River Crossings
- Road Crossings
- Trail Signage & Branding

- Trail Viewshed
- Construction Techniques & Materials
Trail Study Methods

Environmental. Central to a consideration of environmental factors influencing trail routes in the study of existing National Scenic Trail sections is the desire to reduce negative impacts on the surrounding natural landscape. Towards that end, the following features were inventoried for each trail section:

- Threatened and endangered species’ habitats (both animal and plant)
- Sensitive habitats
- Landform slope and trail slope
- Aspect
- Overlap with roads and preexisting trails

These features are outlined in Figure 14.

Threatened and endangered species and sensitive habitats. Threatened and endangered species are defined as those species listed by the United States Fish and Wildlife Service (USFWS) under the Endangered Species Act. Sensitive habitats are those areas surrounding the study sections that research has determined to be most susceptible to negative impacts from recreation.

Appalachian Trail. The locations of threatened and endangered species on the study section of the AT were assessed based on information from the USFWS, which operates a Critical Habitat Portal website. The USFWS lists eight threatened and endangered species in the state of New Hampshire. However, only one of these is known or believed to occur in either of the counties through which the AT study section passes. This species is known or
Figure 14. Environmental features.
believed to occur in Grafton County and is a flowering plant: the small whorled pogonia (*Isotria medeoloides*). It was listed as endangered in 1982 and upgraded to threatened status in 1994 (United States Fish and Wildlife Service [USFWS], n.d.). A more nuanced habitat model was not available for this species. As it is typically found at slopes between 8-15% (USFWS, n.d.), this information was used to identify all likely locations within Grafton County.

While the Canada lynx (*Lynx canadensis*), a threatened species, is not known or believed to occur in New Hampshire, that state is still listed as being a location where the species might occur (USFWS, n.d.). As no known populations exist in the state, the Canada lynx in New Hampshire will not be considered in this study.

The most sensitive habitats occurring within New Hampshire are high alpine tundra and wetlands (Sperduto, 2011). Spatial GIS data concerning these habitat-types was obtained from the New Hampshire GIS data clearinghouse through the following datasets: wetland data for the state was derived from the USFWS National Wetlands Inventory (USFWS, 2014); alpine tundra locations were included in the New Hampshire Wildlife Action Plan (New Hampshire Fish and Game Department, 2010).

*Continental Divide Trail.* The location of threatened and endangered species on the study section of the CDT was assessed based on information from the USFWS obtained through their Critical Habitat Portal website. 13 species in the vicinity of the CDT study section are listed as threatened, endangered, or candidate species. Spatial data for the critical habitat of nine of these species was available and downloaded from the Critical Habitat Portal (USFWS, n.d.). Additional species distribution information for the Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*), skiff milkvetch (*Astragalus microcymbus*), and Uncompahgre
Fritillary butterfly (*Boloria acrocnema*), was found at the NatureServe Explorer website (NatureServe, 2014). The black-footed ferret (*Mustela nigripes*) has been classified as extirpated from the region and is not considered in this study (USFWS, n.d.). Of the thirteen threatened or endangered species located in the vicinity of the CDT the trail only passes through the habitat of one: the Gunnison sage-grouse (*Centrocercus minimus*).

Wetlands and alpine tundra are the most sensitive habitat areas in the Colorado Rockies (Colorado State Forest Service, 2013). Wetlands data for the state of Colorado were obtained from USFWS National Wetlands Inventory (USFWS, 2014). Alpine tundra zones were identified by consulting vegetation maps (United States Forest Service [USFS], 2014).

*Pacific Crest Trail.* The location of threatened and endangered species on the study section of the PCT was assessed based on information from the USFWS obtained through their Critical Habitat Portal website. Nineteen species in the vicinity of the CDT study section are listed as threatened, endangered, or candidate species. Spatial data for the critical habitat of all of these species was available and downloaded from the Critical Habitat Portal (USFWS, n.d.). The PCT passes through habitat for four of the species identified: Yosemite toad (*Anaxyrus canorus*), Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*), Sierra Nevada yellow-legged frog (*Rana sierrae*), and mountain yellow-legged frog (*Rana muscosa*).

Similar to other areas, the most sensitive terrains within the Sierra Nevada are high-altitude alpine tundra (above 9,500 feet) and wetlands (Hauptfield & Kershner, 2014). Wetlands data for the state of California was obtained from USFWS National Wetlands Inventory (USFWS, 2014) and the location of alpine zones was determined by consulting vegetation zones mapped by Region 5 of the USFS (United States Forest Service, 2014).
By using the Intersect tool in ArcMap, the species and habitat locations that were crossed by each study section were determined and isolated. The amount of each trail that passed through those locations was assessed by reviewing the statistics for each intersection between the trail and species or habitat location.

**Landform slope and trail slope.** Landform slope is the grade change of the area through which a trail passes. Trail slope is the grade change that a path undergoes along its length. All elevation-derived analyses, including landform and trail slope, were performed with publically available data in the form of digital elevation models (DEMs).

**Appalachian Trail.** All terrain slope data for the AT study section are derived from DEMs at 10 meter resolution acquired from the United States Geological Survey (USGS) elevation products database (United States Geological Survey [USGS], 2014) except for high resolution bare earth light detection and ranging (LiDAR) data that was available for the western portion of the White Mountain National Forest. This data was downloaded from the New Hampshire GIS data clearinghouse (Earth Systems Research Center, 2011).

**Continental Divide Trail and Pacific Crest Trail.** All terrain slope data for the CDT and PCT study sections are derived from DEMs at 10 meter resolution acquired from the USGS elevation products database (USGS, 2014).

The Slope function in ArcMap was used to produce terrain slope maps displaying percent grade of the areas the trails pass through. The Zonal Histogram function was used to determine the length of trail passing through various categories of terrain slope.

Trail slope was determined by analyzing centerline trail data and elevation data from the sources previously described. Each trail was converted to a raster and each resultant cell was
assigned data based on the elevations it passed through. The Focal Statistics tool was used to
determine the change in elevation from one raster on the path line to the next. The difference in
elevation (rise) was divided by the size of the raster cell (run) to determine trail slope.

**Aspect.** Aspect is the direction in which a slope faces, such as northeast, west, etc.
The aspect of the landform a trail traverses can help determine how much snowfall and runoff it
will receive.

All aspect maps were created using the Aspect function in ArcMap and the elevation data
sources described above. The Zonal Histogram function was used to determine the length of
trail occurring on various slope aspects.

**Existing roads and trails.** Overlap with roads and preexisting trails is defined as areas
where the tread of the trail in question is co-located directly on the roadbed or tread of roads or
preexisting trails for a minimum of 50 feet. This is distinct from road crossings which are
defined as occurring when the tread of the trail in question coincides with the road for less than
50 feet. This distinction is meant to separate those parts of trails which rely on the road bed or
preexisting trail surface for substantial sections and those which merely try to cross roads or
trails because they cannot be avoided.

**Appalachian Trail.** Data on forest roads near the AT study section were obtained from
the White Mountain National Forest GIS data webpage (United States Department of Agriculture
[USDA], 2013a). New Hampshire municipal road data were downloaded from the New
Hampshire GIS data clearinghouse (New Hampshire Department of Transportation, 2014). Old
roadbeds and railroad beds that currently host the AT were located through trail descriptions
from the AT guidebook for New Hampshire and Vermont (Taylor-Miller, 2008). Data on trails
in existence before the construction of the AT were found by consulting a historical map from the early part of the 20th century (Cutter, 1916). Unfortunately, only maps depicting approximately 44 miles of the current AT study section route were discovered during research. It is possible that the rest of the study section, though it is outside of the major recreation zone of the Presidential Range in the White Mountains, contained some trails that eventually became the Appalachian Trail, though at a far smaller percentage. It is a telling fact that in-depth research was unable to turn up any trail maps outside the Presidential Range prior to the construction of the AT, but easily found a number of maps within that range, even extending as far back as the mid- to late-1800s. If there were no or very few trails, there would likely be no or very few maps.

Continental Divide Trail. Data on state and local roads in Colorado was obtained from the Colorado Department of Transportation (n.d.). Forest Service road data was obtained from the Rio Grande National Forest website (USDA, n.d.d) and the San Juan National Forest website (USDA, n.d.f). Old roadbeds that currently host the CDT were found by consulting the Colorado Trail guidebook (Colorado Mountain Club [CMC], 2013). No historical trail data were found to determine which preexisting trails (if any) are now parts of the CDT study section.

Pacific Crest Trail. Data on state and local roads in California was obtained from the state’s geoportal (California Department of Technology, n.d.). Forest Service road data was obtained from the Pacific Southwest Region National Forests website (USDA, n.d.c). Old roadbeds that now act as the tread for the PCT were found by consulting the PCT guidebook for southern California (Schirfin, Jenkins, Winnett, & Schaffer, 2003). No historical trail data were found to determine which preexisting trails (if any) are now parts of the PCT study section.
The Intersect tool in ArcMap was used to determine the location and distance for which the trail centerlines were located on the features described above.

**Economic.** To better understand the economic implications of trail design that affect access and safety of trail users, several key factors of trail location and trail features were inventoried. These factors combine to influence the manner in which the trail design can reduce personal risk to users (including trail signage for way-finding), reduce liability to trail designers, builders, and maintenance organizations, increase trail visibility and branding in the public domain, and maximize the opportunities for access both to the trail (for its recreational use) and from the trail to nearby economic centers (for the purposes of resupplying food and other necessities while users are engaged in extended travel). Those features determined to be most influential in this regard were inventoried. They are as follows:

- Location of trailheads
- Design of road crossings
- Design of river crossings
- Location of existing recreational facilities (e.g. ski areas, tourist destinations, etc.)
- Connections to side trails
- Land ownership along the trail corridor
- Design of trail signage
- Trail branding

These features are outlined in Figure 15.

*Location of trailheads, road and river crossings, and recreational facilities.*

Trailheads are relatively easily accessible points along a trail where users can join the trail.
Figure 15. Economic features.
Generally, trailheads provide parking and information, and may provide other amenities such as bathroom and/or camping facilities. Road crossings are defined as locations where a trail crosses a road at a more or less 90 degree angle in order to pass over it rather than to follow along it. River crossings are defined as locations where a trail crosses a moving body of water sufficient in size and strength to be noted on most maps and in the trail guidebook. River crossings may be dangerous in times of high water. Existing recreational facilities are operated by organizations or businesses that cater to outdoor recreationists. The facilities mapped are within a reasonable distance from the trail and could potentially attract similar users as the trail.

**Appalachian Trail.** Data sources for the location of trailheads on the AT study section were the ATC (ATC, n.d.), and the AT guidebook and maps for New Hampshire and Vermont (Taylor-Miller, 2008). Road crossings were determined from public roads data (New Hampshire Department of Transportation, 2014) and river crossings were determined from stream data (New Hampshire Department of Environmental Services, 2006) and the AT guidebook and maps for New Hampshire and Vermont (Taylor-Miller, 2008). Existing recreational facilities were located based on information from the AT guidebook and maps for New Hampshire and Vermont (Taylor-Miller, 2008).

**Continental Divide Trail.** Trailhead locations were determined through information in the Colorado Trail guidebook (CMC, 2013) and from the CDT website (Continental Divide Trail Coalition, n.d.b). Road crossings were determined from public roads data (Colorado Department of Transportation, n.d.), and river crossings were determined with information from the Colorado Trail guidebook (CMC, 2013) and state hydrology data (Colorado Division of Water Resources, n.d.). Existing recreational facilities were located based on information from
the Colorado Trail guidebook (CMC, 2013).

*Pacific Crest Trail.* Trailhead locations on the PCT were located through information in the PCT guidebook (Schirfin et al., 2003). Road crossings were determined from data on state and local roads in California obtained from the state’s geoportal (California Department of Technology, n.d.) as well as roads in Sequoia and Kings Canyon National Parks (Lineback, 2007). River crossings were determined with information from the National Hydrography dataset for California (USGS, 2012) and the PCT guidebook (Schirfin et al., 2003). Existing recreational facilities were located based on information in the Schirfin guidebook (2003).

Data points were created at the locations of all the features noted in this category. Road crossings were amended with additional notes regarding the road type (highway, railroad, or local road) and the method of crossing (underpass or standard). River crossings were amended with additional notes regarding the type of crossing (ford or bridge) and, if applicable, the type of bridge (highway, road, suspension, or foot). Recreational facilities were amended with notes concerning the type of facility (ski area, campground, visitor center/headquarters, and other).

*Trail connections, land ownership, and signage.* Trail connections are junctions with other maintained non-motorized recreation trails that occur along the trail study section. To be considered, these connections must be official, marked trails that are maintained. Property ownership along the trails refers to the land through which the trails directly pass. Rights of way and easements are considered to be public lands. Signage refers to the official signs established by trail builders, maintainers, and organizing bodies. This research does not identify the actual location of individual sign along each trail section. Rather, this study compares the non-spatial design aspects of trail signage along each study section.
Appalachian Trail. Data on connections to side trails along the AT study section were found on the White Mountain National Forest GIS website (USDA, 2013a) and by consulting the AT guidebook and maps for New Hampshire (Taylor-Miller, 2008). Land ownership along the AT was determined through data from the White Mountain National Forest GIS website (USDA, 2013a). State-owned lands data were found at the New Hampshire GIS data clearinghouse (Society for the Protection of New Hampshire Forests, 2013). Representational signage was photographed by the author while hiking the AT study section in July 2008.

Continental Divide Trail. Data on trails connecting to the CDT study section were obtained from the Rio Grande National Forest GIS Data website (USDA, n.d.d), the San Juan National Forest GIS Data website (USDA, n.d.f), trail maps of the Gunnison National Forest (USDA, 1997) and from the Colorado Trail guidebook (Colorado Mountain Club, 2013). Land ownership was determined through statewide land ownership data provided by the Bureau of Land Management [BLM] (2014). Representational signage was photographed by the author while hiking the CDT study section in August 2014.

Pacific Crest Trail. Data on trails connecting to the PCT study section were obtained for Sequoia and Kings Canyon National Parks (Lineback, 2004) and the Inyo, Sierra, and Sequoia National Forests (USDA, n.d.c). Additional information was gathered from the PCT guidebook for southern California (Schifrin et al., 2003). Land ownership along the trail study section was determined by GIS data from the California Department of Forestry and Fire Protection (2014). Representational signage was photographed by the author while hiking the PCT study section in May 2012.

Each trail connection was marked as a point, and the result was analyzed to determine the
number of connections and the average distance between them. Land ownership was spatially located and divided into two major categories (public and private), with the public lands further divided into five subcategories (NPS, USFS, BLM, state, and municipal). In some cases, such as in eastern New Hampshire, the Appalachian Trail runs on land that is owned and/or managed by two or more groups, such as the Appalachian Mountain Club and the USFS. In these cases, priority was given to the public land management agency. As noted earlier, rights of way or easements across private land are considered to be public. The amount of trail that crosses each ownership type was assessed with the Intersect or Zonal Histogram tools in ArcMap.

Signage along each trail study section was photographed by the author. This included reassuring signage such as chevrons, blazes, and directional arrows that inform users they are following the correct trail, as well as informational signage that locate a user and/or provide mileage data to nearby landmarks.

**Trail branding.** Trail branding is not a spatially explicit aspect of trail planning and design. While trail branding cannot be shown on a map, it is a crucial aspect of the economic design of a long-distance trail. By defining the brand of each trail through a logo, the trail becomes more widely visible and easily recognizable. The chief form of branding for National Scenic Trails, including the AT, CDT, and PCT, is achieved through their respective logos in the form of trail chevrons.

The chevrons for each National Scenic Trail were obtained through each trail’s website. Analysis of all the chevrons, with particular attention to the AT, CDT, and PCT chevrons, was undertaken.

**Social.** The social facet of inquiry into the existing conditions of the National Scenic
Trail study sections revolves around understanding the implications of trail design for the enjoyment of trail users. Ultimately, long-distance non-motorized backcountry recreation trails are serving their purpose only if they are able to provide trail users with a positive recreation experience. Countless factors (many of which are out of the control of the trail designer) influence a trail user’s experience. Of those aspects of the experience that can be most directly affected through careful trail planning, this research has identified allowable uses on a trail or trail segment, Wilderness designations, camping or shelter opportunities, and the relationship between the trail and those natural resources that are desirable for a positive experience such as points of interest and water sources. This study has inventoried the following aspects of trail design for the three sections of trail examined:

- Location of points of interest
- Location of designated wilderness areas
- Permitted trail use (e.g. foot traffic, bikes, equestrian, etc.)
- Location of camping opportunities
- Location of shelters
- Location of water sources

These features are outlined in Figure 16.

*Points of interest, designated wilderness, and permitted trail use.* Points of interest are defined as locations of outstanding value on or near to the trail that are nationally or regionally significant. These locations are likely to draw the attention of trail users and add significant value to the trail experience. In addition, these points may draw a trail user off of the trail in order to investigate the site or area more closely. An example of this would be a side trail that
Figure 16. Social features.
leads to a nearby highpoint or cultural site. Designated wilderness are those areas protected under the Wilderness Act of 1964 or subsequent amendments. Trails are considered as being in a wilderness area where they run through or directly adjacent to wilderness. Permitted trail use refers to the official regulations regarding what activities are allowed on a given section of trail.

**Appalachian Trail.** Data sources for points of interest on the AT study section were the White Mountain National Forest GIS website (USDA, 2013a) and the AT guidebook (Taylor-Miller, 2008). Data on designated wilderness areas in New Hampshire and western Maine were downloaded from Wilderness.net, a website run by the Wilderness Institute at the University of Montana (n.d.). Permitted trail use along the AT was researched on the ATC website (ATC, n.d.b).

**Continental Divide Trail.** The data source for points of interest on the CDT study section was the Colorado Trail guidebook (Colorado Mountain Club, 2013). Data regarding designated Wilderness areas in southern Colorado were downloaded from Wilderness.net (Wilderness Institute, n.d.). Permitted trail use along the CDT was researched in the Colorado Trail guidebook (Colorado Mountain Club, 2013).

**Pacific Crest Trail.** The data source for points of interest on the PCT study section was the PCT guidebook (Schifrin et al., 2003). Data regarding designated Wilderness areas in southern California were downloaded from Wilderness.net (Wilderness Institute, n.d.). Permitted trail use along the PCT was researched in the PCT guidebook (Schifrin et al., 2003).

All highpoints, cultural sites, and unique natural features (points of interest) were marked with a point and analyzed to determine how often the trail passes each. The Intersect tool was used to determine the length of each trail in each wilderness area. The portions of the trail that
are governed by different trail use regulations were separated.

Camping, shelters, and water sources. Camping refers to areas that are officially established campsites along or very close to a trail, as well as the areas along a trail where dispersed camping is allowed. Shelters are built structures on or very close to a trail that were raised and are maintained specifically for the benefit of trail users. Water sources are locations, either natural or manmade, at which water is available for trail users without a significant detour off of the trail. While a vast majority of trail users will bring food with them on a long-distance hike, resupplying their store by traveling off the trail and into towns to purchase additional food at intervals, water is most often procured from sources along the trail. The distance between and quality of water sources significantly impacts the experience of using a trail as it determines how much water must be carried over a given distance. This has a substantial effect on the weight that a trail user must carry.

Appalachian Trail. Information on the location of shelters along the AT study section was obtained from the ATC GIS data website (ATC, n.d.a). Camping regulations and water source data were obtained from the AT guidebook (Taylor-Miller, 2008), while the ATC website provided additional regulatory information (Appalachian Trail Conservancy. (n.d.b). Water source information as obtained from the AT guidebook (Taylor-Miller, 2008).

Continental Divide Trail. Information on the location of shelters, official campsites, and water source data was obtained from the Colorado trail guidebook (Colorado Mountain Club, 2013). Camping regulations along the CDT were assessed based on information from the USFS (USDA, n.d.e).

Pacific Crest Trail. Information on the location of shelters, camping regulations, and
water sources along the PCT study section was obtained from the PCT guidebook (Schifrin et al., 2003). Additional camping regulations for Inyo National Forest (Recreation.gov, 2014) and for the Sequoia and Kings Canyon National Parks (National Park Service, 2014) were found online.

Locations of official campsites and shelters were mapped with data points. Distinctions were made between those campsites and shelters that collect mandatory fees and those that do not. The Buffer tool was used to delineate areas around the trail, water sources, roads, shelters, and other features where camping is not permitted. A 500 foot buffer was placed around the trail study segments to outline those areas adjacent to the trail that would be most attractive for dispersed camping. The size of this buffer was based on the assumption that trail users would be unlikely to travel further than 500 feet from the trail to find a suitable camp site. The intersection between the two buffer groups delineates the areas that are desirable, but not available, for dispersed camping. Water sources were also mapped with data points where the trail crossed the source or came within 100 feet of it. When a trail continued alongside a source for some distance (indicating multiple points of access to the same source) only a single point was created. A distinction was made between reliable, perennial sources and unreliable, seasonal sources.

**Aesthetic.** The aesthetic concerns of trail design are extremely influential in two separate aspects of trail planning and construction. On a large scale, the consideration of scenery and viewsheds is critical in determining the preferable route of a trail to provide users with opportunities to experience and enjoy those areas near the trail that are largely bereft of significant human intervention. This is fundamental to achieving a sense of detachment from human society and creating a feeling of immersion in a backcountry setting. Additionally, the
physical method of construction of the trail influences a trail user’s aesthetic experience. Those materials and techniques used to build the trail can have a direct effect on the sense of place derived from traveling on a trail. This study will examine the following aspects of aesthetic design in the three trail sections:

- Viewshed from along the trail
- Trail construction materials

These features are outlined in Figure 17.

**Trail viewshed.** A viewshed is defined as the physical area that can be seen by trail users while traveling on the trail. The most influential factor in determining a viewshed are geographical features such as ridges, mountains, and hills that can obscure a view. Because of the backcountry nature of the trails in question, this study is concerned with the amount of each viewshed that includes developed areas. In order to quantify the amount of area that demonstrates development within the viewshed, development is defined as areas of significant human disturbance including roads, buildings, and any other permanent non-trail related structure.

Elevation, landcover, and road data were used to determine unwanted viewsheds. All elevation data used for the three trail sections are the same as previously described. All landcover data were downloaded from the USGS national GAP analysis program database (2004). All roads data are the same as previously described.

The Viewshed tool was used in ArcMap to determine the viewshed from each trail. A base height of 1.8 meters (approximately 5’9”) was used to simulate the height of a trail user above ground level. Areas of development were determined from landcover and roads data.
Aesthetic Features

Trail Viewshed

Construction Materials

Figure 17. Aesthetic features.
Where the data provided a distinction, major roads were assumed to be 30 feet wide while local roads were assumed to be 20 feet wide. In all other cases, roads were assumed to be 25 feet wide. The Intersect tool was used to determine where the areas of development are visible from the trail. The difference in size between the areas of development and that of the viewshed from a trail was determined and considered as the unwanted view area. On the AT study section views were restricted to the state of New Hampshire.

**Trail construction materials.** Trail construction materials are defined as the physical objects specified by a trail designer to create structures (such as retaining walls, cribbing, steps, drainage structures, etc.) or signage. These materials are significant as they may influence a trail user’s experience by molding perceptions of naturalness, solitude, and remoteness from permanent habitation. Trail construction materials were observed by the author while hiking each of the trail sections, and representative photographs were taken.

**Trail Study Findings**

By examining the inventory map and analysis for each feature on each trail study section and combining this information with literature available from agency documents, scholarly research articles, and private and organizational publications such as trail design and construction manuals, it is possible to identify patterns and determine which facets of each section’s design may be desirable for replication and which provide examples of poor planning or design that should be avoided. These lessons provide the basis for the trail design performance outcomes that form a quantifiable process for an exploration of a contemporary
method of planning and designing long-distance non-motorized backcountry recreation trails. This section communicates those findings.

Environmental. Careful consideration of environmental factors affecting trail design is crucial for the protection of sensitive species, ecosystems, and other natural resources that exist in a proposed trail corridor. Although a trail is by definition a scar across the landscape, a well-designed trail will have few and minimal negative impacts to the surrounding environs. In order to ensure that a trail minimizes these negative impacts environmentally preferable trail features can be established. The full results of the environmental features examined for each trail study section can be found in Appendix A: Trail Study Environmental Features Data.

Threatened and endangered species and sensitive habitats. The most environmentally preferable route would have little to no impact on threatened or endangered species. A trail will likely increase negative human impact on threatened or endangered species when it traverses that species’ habitat. Therefore, the goal of avoiding such a negative impact can best be achieved by assessing likely habitat for those species and avoiding such areas wherever possible (Birkby, 2008).

The AT study section (Figure 18) passes through 15.1 miles of likely small-whorled pogonia (*Isotria medeoloides*) habitat. This length of trail represents about 10% of the total length of the study section. The CDT study section (Figure 19) passes through 5.8 miles of Gunnison sage-grouse (*Centrocercus minimus*) habitat. This length of trail represents about 4.4% of the total length of the study section. The PCT study section (Figure 20) passes through 7.5 miles of Yosemite toad (*Anaxyrus canorus*) habitat, 18.8 miles of Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) habitat, 34.7 miles of Sierra Nevada yellow-legged frog (*Rana
Figure 18. Environmental features: Threatened and endangered species and sensitive habitats on the AT.
Figure 19. Environmental features: Threatened and endangered species and sensitive habitats on the CDT.
Figure 20. Environmental features: Threatened and endangered species and sensitive habitats on the PCT.
sierrae) habitat, and 50.3 miles of mountain yellow-legged frog (Rana muscosa) habitat. Since several of the areas of habitat overlap, the combined mileage is 92.3 miles which represents about 61.7% of the total length of the study section.

The PCT section clearly has the greatest potential for disturbing threatened and endangered species’ habitats. This likely is the result of routing the trail through pristine areas that have seen little human impact and therefore are still home to a multitude of species, some of which are threatened or endangered. Nevertheless, the example of the CDT section serves as a goal for future trail development by limiting its route to less than 5% within these fragile habitats.

The environmentally preferable route would also limit a trail’s negative impact to all sensitive land types regardless of whether or not threatened or endangered species are present. Therefore, trail routing should be responsive to those areas that are most at risk from damage by recreational use (Price, 1985; Monz, Marion, Goonan, Manning, Wimpe, & Carr, 2010). In the trail study sections and the Wasatch Range the most sensitive areas are wetlands and alpine tundra (Sperduto, 2011). Other geographic locations may present other sensitive areas, such as cryptobiotic soils in desert landscapes. An understanding of the local conditions is required to fully assess which areas are to be avoided.

Large portions of the AT study section are above tree-line and within alpine tundra zones, particularly while traversing the Presidential Range, home to the highest peaks in the Northeast. 28.8 miles (19%) of the trail cross alpine tundra. Conversely, the AT study section runs for only 1.0 miles (0.7%) through wetlands, and of those areas 0.2 miles are bridged or crossed on puncheon, greatly reducing the impact of the trail on those sensitive areas and reducing the total area of tread in wetlands to only 0.7 miles or 0.5% of the total distance. Despite each step of
the CDT study section being at a much higher elevation than any point on the AT study section, only 7.6 miles (5.7%) runs through alpine tundra. However, 2.7 miles (2.0%) of the CDT study section passes through inventoried wetlands and none of it is on puncheon or other protective structures. The PCT study section crosses the least alpine tundra of the three sections: only 1.0 mile or 0.6% of the total distance. However, the PCT also crosses the most wetlands with a total of 6.8 miles (4.5%) with negligible amounts on bridges or other protective structures.

While the PCT section runs through the largest amount of threatened and endangered species habitat, it simultaneously avoids other sensitive habitats more than the AT or CDT sections. Only about 5% of the PCT crosses such areas. While the AT runs for many miles on ridgelines that consist largely of alpine tundra, both the PCT and CDT tend to follow courses that run partway up a valley wall, below the fragile alpine tundra and above the sensitive wetlands. This routing technique should be reproduced to avoid conflicts with fragile habitats.

**Landform slope and trail slope.** When considering slope, the negative impacts of a recreation trail on the areas both inside and outside of the actual tread are largely produced through the effects of water and soil disturbance. Large amounts of earth must be removed to construct a trail on a landform slope that is extremely steep. In addition, soil saturation can undermine such a trail resulting in landslides. A percent grade of 70% or greater is generally considered too steep for most trail-building (Basch et al., 2007; Birchard & Proudman, 2000). Conversely, when a trail is built on a landform slope that is not steep enough, the result can be areas of the trail that retain moisture, either from precipitation or groundwater, and resist drying out quickly after a storm. Such areas may easily become muddy, inciting users to widen the original tread to avoid the mud and water, thus expanding the area of the trail’s impact (Marion,
A percent grade of 10% or less is generally considered too gentle for adequate drainage and is not recommended for trail-building (LaPorta et al., 2012; Duffy et al., 2012). Assessing landform slope provides crucial information for designing trails that avoid areas where the slope is too steep or too gentle.

Based on this information, the landforms through which the study sections pass were categorized into three groups by grade: 0-10%, 10-70%, and 70%+. All of the study sections had a vast majority of their tread constructed on the ideal 10-70% slopes. Within this range the AT study section (Figure 21) runs 123.7 miles (81.7%), the CDT study section (Figure 22) runs 93.3 miles (70.2%) and the PCT study section (Figure 23) runs 118.3 miles (79.1%). Similarly, the majority of the remaining trail for each study section runs on gentle 0-10% grades. In this range, the AT study section had 24.7 miles (16.3%), the CDT study section had 39.5 miles (29.7%), and the PCT study section had 30.5 miles (20.4%). Very little trail was built on slopes exceeding 70%: only 3.1 miles (2.0%) of the AT study section, 0.1 miles (0.1%) of the CDT, and 0.7 miles (0.5%) of the PCT.

All of the trail study sections are generally successful at avoiding landform slopes that are extremely steep. However, the AT is the most successful at staying on slopes between 10-70%, with the PCT close on its heels. These results must be evaluated in combination with considerations of trail slope, presented below.

Trail slope is a critical factor in reducing the amount of erosion that occurs on the trail and in the areas directly adjacent. Low grades are preferable and when the grade of a trail is too steep, water is likely to collect in the tread and rush downhill, increasing in speed and volume the longer the grade continues. The scouring impact of water on steep trails can be devastating,
Figure 21. Environmental features: Landform slope and trail slope on the AT.
Figure 22. Environmental features: Landform slope and trail slope on the CDT.
Figure 23. Environmental features: Landform slope and trail slope on the PCT.
creating ditches full of rocks and debris where trails were meant to be. Avoiding trail grades in excess of 12% reduces the risk of such erosion (Duffy et al., 2012, Basch et al., 2007). Average percent grade over the entire trail should remain in the 5-10% range (Hesselbarth et al., 2007). A maximum grade of 15% over normal soil types is the recommended upper limit (Duffy et al., 2012). Out-sloping trails is also of crucial concern for diverting water off trails, but requires more detailed data gathering than is possible for this study.

Significant differences were observed between the trail slopes of the three study sections. Each section was analyzed based on the following trail grade categories: 0-5%, 5-10%, 10-15% (considered the maximum preferable upper limit), and 15%+. The CDT study section scored well above the other two with a majority of the tread (55.5 miles or 41.8%) at a 0-5% grade. This may be due in part to the higher amount of the trail that runs on existing roads. Only 35.6 miles (26.8%) is above a 15% grade. 23.9 miles (18.0%) is built from 5-10% grades and 17.9 miles (13.5%) is built at 10-15% grades. The average slope for the CDT study section is the lowest at 11.1%. The PCT study section ran for nearly one-third of its length under a 5% grade (47.1 miles or 31.5%) but ran for slightly more than that (50.9 miles or 34.1%) at a grade exceeding 15%. 29 miles (19.4%) ran at a 5-10% grade and 22.6 miles (15.1%) ran at a 10-15% grade. The average slope for the entire study section is 12.5%. Not surprisingly given its reputation as a steep trail, the AT study section was by far the steepest. A full 40.1% (61.4 miles) of the trail were at grades above 15% while only 28.5% (43.2 miles) were under 5%. 33.5 miles (22.2%) ran at 5-10% grade while 13.3 miles (8.8%) ran at a 10-15% grade. The AT also had the highest average slope at 15.3%.

Both the CDT and the PCT sections proved to be most viable for replication in terms of
trail slope. While the AT is successful at staying on landforms of an ideal slope, much of the actual trail is much too steep to resist damaging erosion through use and water. Sustainable trail slopes are generally found on both the CDT and the PCT and these sections should be emulated in any new trail development.

*Trail aspect.* Trail aspect is another factor crucial to environmentally responsible trail design. In alpine conditions with a late snowmelt date and greater soil moisture, significant trail damage and erosion can result from lingering snowmelt and greater amounts of runoff (LaPorta et al., 2012). For year-round, multiple-use trails (such as National Scenic Trails and the proposed WMT) a south, southeast, or southwest exposure is preferred (Basch et al., 2007).

Of the three study sections, only the PCT had significant portion (82.7 miles or 55.3%) of its tread on south, southeast, or southwest aspects. Both the AT (Figure 24) and the CDT (Figure 25) had less trail running on those exposures than would likely be found by chance. The south, southeast, and southwest quadrants of the compass make up 37.5% of a 360 degree circle, but the AT study section is built with only 55.82 miles (36.7%) facing towards those directions, while the CDT study section is built with only 48.6 miles (36.6%) doing so. The PCT (Figure 26) is the only trail section that showed concern for routing along favorable aspects.

*Existing roads and trails.* Finally, the environmentally preferable route would limit the creation of new environmental impacts wherever possible. These impacts can be largely negated by routing a corridor along existing roads and trails where such impacts already exist. However, it must be noted that existing roads and trails that are not themselves constructed in an environmentally sustainable manner will not result in environmentally sustainable trails if converted to that use (Basch et al., 2007). Nevertheless, the smaller the impact made by
36.7%
South, Southeast, or Southwest Aspect

Figure 24. Environmental features: Aspect on the AT.
Figure 25. Environmental features: Aspect on the CDT.
55.3%
South, Southeast, or Southwest Aspect

Figure 26. Environmental features: Aspect on the PCT.
building new trail, the less environmental damage is likely to result. Data on the existence of trails pre-dating the construction of the CDT and PCT study sections was not available. However, thanks to the well-documented history of the Appalachian Mountain Club, trail maps for some parts of the AT study section (Figure 27) (primarily in the Presidential Range) were found. Of 44 miles currently hosting the AT that are covered by the historical trail map, 30.4 miles are on trails that were built prior to the conception of the AT. When additional sections that run on old road or railroad grade, current roads, and current forest service roads are added to that tally, a total of 41.5 (27.3%) of the AT study section is on preexisting structures. The CDT (Figure 28), which as a whole is considered only partially complete and often connects trail sections via roads, relies on 37.3 miles (28.1%) of preexisting or current road grades, only slightly more than the AT section. The PCT (Figure 29), however, was built through largely untouched land and spends only 0.4 miles (0.3%) of the study section length on old road grade.

To avoid additional environmental damage, following the model of the CDT on roads and the AT on trails would be advisable. However, the practice of following existing structures limits the trail route only to those areas that have been previously accessible. In contrast, while the PCT was built almost entirely through untouched land, it also offers users a trail through areas that would otherwise be nearly impossible to access. Such conflicts between environmental and social values will have to be adjudicated for any proposed trail corridor.

**Environmental summary.** A complete environmental evaluation of the trail study sections reveals that, while no one trail stood out as markedly more sensitive than the others, the CDT study section tended to follow a more environmentally benign route. Although the CDT is not built on south-facing aspects and is often on too gentle landform slopes, it succeeds in
Figure 27. Environmental features: Existing roads and trails on the AT.
PERCENTAGE OF TRAIL OCCURRING ON EXISTING ROADS

ON EXISTING ROADS

28.1%

18.3%
ON CURRENT FOREST SERVICE ROADS

6.2%
ON OLD ROAD GRADE

3.6%
ON CURRENT ROADS

LEGEND

- Continental Divide Trail Study Section
- CDT on Old Road Grade
- CDT on Current Roads
- CDT on Forest Service Roads
- Colorado Roads
- Forest Service Roads

Figure 28. Environmental features: Existing roads on the CDT.
Figure 29. Environmental features: Existing roads on the PCT.
avoiding much of the most sensitive habitats, is generally within recommended trail slope ranges, and makes use of existing grades most frequently.

**Economic.** The economic features of trail design determine the best routing for ensuring access to the trail and safety for trail users. By understanding the economic facets of routing, a trail planner can anticipate trail users interactions with existing infrastructure and natural features (such as roads and rivers) that may be potentially dangerous, determine the relationships between the trail and other recreational facilities and trails, and identify preferable routes based on land ownership. In addition, the economic features consider where trailheads should be located and how signage should be designed. The full results of the economic features examined for each trail study section can be found in Appendix B: Trail Study Economic Features Data.

*Location of trailheads, road and river crossings, and recreational facilities.* The most economically preferable route will cross roads in a manner that minimizes the potential for trail user/vehicle conflict. The ideal road crossing is an overpass or an underpass (LaPorta et al., 2012). This can be accomplished without adopting the financial burden of such a construction by routing trails to cross roads where such structures are already in place, such as points where roads cross rivers. When budgets or routing concerns do not allow for the use of underpasses or overpasses, at grade crossings must be designed with the safety of trail users and motorists as primary concerns. Both groups are least likely to be exposed to conflict and danger when a road crossing is short in length (at a ninety degree angle to the road), when there is readily visible signage for both the trail user and the vehicles, when the roads being crossed have low speed limits, and when there are clear lines of vision extending to both sides of the crossing
This study was able to determine the locations of road crossings, the type of road being crossed, and the existence of underpasses or overpasses on all three trail study sections. The AT study section (Figure 30) has the most road crossings by far: 18, or an average of one every 8.4 miles. A majority of these (13) were small, local roads with slow to moderate speed limits. Three highways with significantly higher speed limits were crossed, though one of these was managed by routing the trail under the highway where it crossed a river on an elevated bridge. The AT study section also crossed two railroads. The CDT study section (Figure 31), as noted above, follows paved roads for 4.8 miles and open USFS roads for 24.2 miles, exposing trail users to motorized conflicts far more than the AT or PCT study sections. In addition, the CDT study section crosses three roads (one highway and two local roads) at grade, or an average of one every 44.3 miles. The PCT study section (Figure 32) is only close to roads at its southern end where it crosses four dirt roads. The PCT study section is clearly an example of preferable routing to avoid trail user/motorist conflicts, though the AT section’s use of an existing underpass should be emulated where possible. However, most trails will not be routed through areas as distant from roads as the PCT. In areas where more roads must be crossed, the CDT provides an outstanding example by limiting its crossings to only those which are absolutely necessary.

The economically preferable route would also be concerned with the number and location of trailheads. Trailheads should be located near to where trails cross major roads and can be designed to control the number of people using a trail (Birchard & Proudman, 2000). Considerations of parking, sanitation, water, and stock facilities should be accounted for.
Figure 30. Economic features: Trailheads, road and river crossings, and recreational facilities on the AT.
Figure 31. Economic features: Trailheads, road and river crossings, and recreational facilities on the CDT.
Figure 32. Economic features: Trailheads, road and river crossings, and recreational facilities on the PCT.
Additionally, for long-distance trails, trailheads also become valuable places where resupply access can occur.

The AT study section has far and away more trailheads than the CDT or PCT sections with a total of 24, or an average of one every 6.3 miles. There are more trailheads than road crossings as some crossings have one trailhead for either direction of travel. The abundance of trailheads is likely due to the popularity of hiking on the AT in New Hampshire (both short and long trips) and high demand for parking at those locations used to reach popular destinations. The CDT section has 10 trailheads (an average of 1 every 13.3 miles), while the PCT section has only 1.

The limited access to the PCT section (due to only having one trailhead) results in far fewer trail users than are encountered while on the AT. This may be preferable for the design of a long-distance trail backcountry trail that seeks to provide solitude, but it also reduces the potential constituency for supporting trail building and maintenance efforts and reduces the number of people who can experience and benefit from the trail. In addition, too many trailheads may result in overcrowding on trails and a lack of opportunity for solitude. Therefore, trailheads should be moderate in number yet sufficient to meet the demands of users, a delicate balance that the CDT section appears to strike.

River crossings are a crucial consideration in planning for safety along a trail. Reducing the number of crossings to a minimum is preferable (Basch et al., 2007). When rivers must be crossed, providing the simplest, most primitive form of safe crossing is ideal (Birchard & Proudman, 2000; Hesselbarth et al., 2007). Utilizing existing structures such as road or highway bridges may be an option. Though such structures may expose users to the risks of
walking alongside a roadway, they effectively negate the financial cost of having to construct a new bridge. Constructing trail-specific structures such as suspension or footbridges can also be undertaken, but is a considerable expense and requires indefinite maintenance (Birkby, 2008). Constructing fords across minor rivers when they can be constructed at safe points is often the best solution (Hesselbarth et al., 2007).

The PCT study section has by far the most river crossings: 44, or an average of 1 every 3.4 miles. The vast majority of these, 38, are forded, while 5 are crossed on footbridges and 1 is crossed on a suspension bridge. The AT crosses 25 rivers (an average of one every 6.1 miles) but fords only 10 of these. 9 more are crossed on footbridges, 5 on highway or road bridges, and 1 on a suspension bridge. The CDT only crosses 10 rivers, an average of one every 13.3 miles. Of these the majority, five, are crossed on road bridges while four are forded and only one is crossed on a footbridge.

Despite the remote aspect of the PCT section, there are a significant number of trail-specific bridges in place. Still, the large number of fords, some of which cross considerable rivers such as Evolution Creek (which is often waist- or chest-deep) means that trail users must be highly self-reliant. The AT section fords a substantially lower percentage of its rivers and relies more than the other sections on footbridges. The CDT section relies mostly on road bridges to cross significant rivers and a nearly equal number of fords for smaller crossings. A defensible trail design strategy, therefore, would be to cross major rivers on suspension bridges, footbridges, or at road crossings, and to consider footbridges in areas that see high levels of use. Fords can be relied upon for crossing smaller rivers and in areas like designated wilderness where self-reliance comes with the territory.
A long-distance trail may be designed to pass within close vicinity of existing recreational facilities, such as ski areas, visitors’ centers, campgrounds, etc. This can be done in order to facilitate access to the trail, provide users with access to information or permits, to offer camping facilities, or for other reasons. The PCT study section passes close by only one such facility, a campground. The CDT section passes near to two ski areas and three campgrounds, an average of one every 26.6 miles. The AT section passes near to 13 recreational facilities, including 4 ski areas, 4 visitor centers, and 3 campgrounds, an average of one every 11.6 miles.

None of the study sections seem to make a systematic attempt to integrate recreational facilities into their route. There are a large number of recreational facilities in the White Mountains of New Hampshire, yet the AT study section lacks direct access or side trails to many of these. Though virtually no other facilities exist in the vicinity of the PCT section, the CDT likewise does not seem concerned with integrating such opportunities into the trail design. This is especially conspicuous with the ski areas, which are potentially excellent points of access for short- and long-distance trail users via existing lift systems. In addition, the summer use of ski areas for mountain biking is increasing in popularity and access to a trail system that allows mountain biking could be a strong draw. It could be productive to explore the possibility of tying a long-distance trail into such facilities rather than ignoring them.

**Trail connections, land ownership, and signage.** The interaction of a long-distance trail with other non-motorized trails is essential to the economy of the trail. Often, a long-distance trail will serve as a type of spine from which other trails radiate as ribs; connectivity and continuity of an entire region can be improved by a trail that is planned along a route that links
other existing trails (Moore & Barthlow, 1998).

Trail intersections were most frequent along the AT study section (Figure 33). There were 101 intersections (an average of one every 1.5 miles), and it is clear from examining a trail map of the area that nearly all the major trails in the White Mountains connect with the AT (or with a trail that itself connects with the AT). Both the CDT (Figure 34) and the PCT (Figure 35) sections had 38 intersections (on average one every 3.5 miles and 3.9 miles, respectively).

In order to provide opportunities for both short- and long-distance trail users the example set by the AT section seems ideal for replication. Such a plethora of trail intersections allows users to determine their own course of action, including side trips and alternate routes that may be of more value for an individual than a single trail. Both the CDT and the PCT appear to serve similar functions as connectors between other trails, but neither have such an abundance of nearby trails to connect as the AT.

Land ownership is of paramount importance for a long-distance trail and helps to ensure access, protection, and continued maintenance. Routing a trail on public land is ideal, though utilizing tools such as conservation easements or other agreements with private landowners can also be successful for short segments (Snyder, Whitmore, Schneider, & Becker, 2008).

The three trail sections are almost entirely on public land. The AT has only 0.1% (0.1 mile) of its route on private land, with the majority, 89% (134.8 miles) on USFS land. The remainder falls into state and municipal land holdings that are publically accessible. The CDT section has the largest percentage of its length on private land, 1.5% (2.0 miles), but a full 96.8% (128.6 miles) runs on USFS land with the remaining 1.7% (2.3 miles) on BLM land. Like the AT, the PCT section is on a miniscule 0.1% (0.2 miles) of private land while the rest is split
Figure 33. Economic features: Trail connections, land ownership, and signage on the AT.
between NPS land (64.5% or 96.4 miles) and USFS (35.4% or 52.9%).

All of the trail study sections rely on public lands for nearly their entire lengths. This is consistent with the goals and management strategies of public land agencies. In particular, a vast majority of the trail sections run through federally owned land managed by the USFS. Mimicking this strategy would likely yield benefits of access, protection, and inclusion in maintenance and upkeep plans for any long-distance trail.

Trail signage creates a trail brand, notifies trail users of important navigational and regulatory information, and warns of potential hazards (Birkby, 2008). Regulations, navigational needs, and hazard potential vary widely across the length of a long-distance trail. However, the basic necessity of providing users with information about their current location and providing the distance and direction to trail intersections, road crossings, shelters, campsites, or other points of interest are universal (Birchard & Proudman, 2000). An analysis of signage design along the three study sections (Figure 36) reveals that all three followed similar, two-pronged approaches to trail signage design. First, each trail had a consistent way of marking the trail so that users would be reassured that they were in fact following the official trail tread. On the AT study section, this signage consists of white blazes cut into and painted on trees along the trail route as well as stone cairns. On the CDT study section, this signage consists of posting the official trail chevron on trees and posts, stone cairns, and lower-case ‘i’-shaped blazes cut into trees. Similarly, on the PCT study section, signage consists of posting the official trail chevron on trees and posts, stone cairns, and ‘i’-shaped blazes. The second approach is to supplement these reassuring trail markers with less frequent but more substantial signs that generally note the sign’s location and provide distances to significant nearby
Figure 36. Signage design along the three study sections.
landmarks. This approach not only reassures the trail user that she is following the official
tread, but also provides valuable navigation information.

There are significant drawbacks to some aspects of the first signage approach used by all
three trail sections. First, blazing trees can create visually unappealing scars, cause confusion
to users, and jeopardize the health of the tree. Tree blazes, particularly the lower-case ‘i’ genre
favored by the USFS in western states can grow and contort so that they are large, obscure scars.
This can lead to a blight on the beauty of the trees, but can also lead trail users to confuse actual
tree scarring (caused by animals, fires, loss of limbs, and collisions from falling trees) with
blazing. The entire basis for the blazes is to reassure users, but there are many cases where they
only add to confusion. Further, any cut deep enough to leave a lasting blaze opens the tree to
substantial risk of disease and infestation by removing a portion of the natural protective
covering (bark) that fights such incursions. While such a result may be unintended, reducing
the health of a forest should be avoided by all aspects of trail design whenever possible.

Second, the materials and techniques used to attach chevrons to trees and to establish
posts that feature chevrons can be visually unappealing (this issue is addressed more thoroughly
in a later section, Aesthetics) structurally unsound, confusing to trail users, or damaging to tree
health. Often, and particularly with carsonite posts, the material used is insufficient to maintain
the post in a vertical position or to avoid breakages that can render the signage completely
useless. The common practice of nailing chevrons or other markers directly to trees generally
ensures structural stability, but if nailed too deeply or left unmaintained, such practices can lead
to deterioration of tree health or a partial or complete obfuscation of the marker itself as the bark
grows around and over it.
Third, the use of stone cairns as signage can also present drawbacks. Unlike official signs that carry a trail logo, there is virtually no restriction on who can build cairns or where they can locate them. For this reason, so-called social cairns, those built by trail users rather than trail builders, can pop up virtually anywhere. While they may lead other trail users to follow the trail they often mark other routes that may cause confusion or resource damage.

Analysis of the various practices for reassuring trail users that they are following the official tread of a long-distance trail leads to the following recommendations. First, chevrons or other clearly branded and recognizable markers should be favored over generic markers or any form of tree blazing (Birkby, 2008). This will ensure users that not only are they on a trail, but that they are on the correct trail. Second, markers should be attached to trees whenever possible, but should be done with the following caveats: nails should be left protruding from the tree as much as possible while still ensuring stability to avoid unnecessary damage to the tree, and markers should be regularly inspected and maintained in order to avoid being swallowed by tree growth following its installation (Birchard & Proudman, 2000). Third, where trees are unavailable, stone cairns should be built to mark the trail. These should be large enough (approximately four feet high and four feet in diameter) to make it clear that the cairns are official and not created (perhaps in an erroneous location) by other trail users (Birchard & Proudman, 2000). Where the stones for cairn building are unavailable, posts carrying the trail brand may be used, but they must be well set into a deep hole surrounded by compacted aggregate to ensure that they do not fall over. Carsonite posts are too prone to breakage are not recommended.

The second approach to signage design, providing more substantial information such as
distance to notable landmarks, should complement the signage used for reassurance. In the three study sections such larger signs were placed at nearly all trailheads and trail intersections, and at many road crossings, shelters, campsites, and land ownership boundaries. Similar recommendations emerge from the survey of these signs as for the smaller, reassurance signs: signage should not be generic but should specifically locate the trail user and identify the trail, should not be attached to trees in any way that unnecessarily jeopardizes their health, should be structurally secure to withstand both human and environmental stresses, and should be aesthetically pleasing (this issue is addressed more thoroughly in a later section, Aesthetics). In addition, this type of signage should also include accurate and specific distances to the next major landmark in either direction.

Additionally, it should be noted that all signage should be designed for four season use. This means that placement should consider height of snowpack and the relatively adjusted height of the average user when traveling on that snowpack. Signs that are completely buried in snow may lead to confusion in just that season during which confusion could be most detrimental to health and safety.

**Trail branding.** This study also focuses on the design of branding used in signage and for other official trail-related uses. National Scenic Trails are primarily branded through the use of chevrons (see Figure 37). Each chevron creates an identity for the trail and establishes a color scheme that is often repeated on signage throughout the trail.

The branding chevrons for the AT, CDT, and PCT were analysed (See Figure 38). The similarities between the three chevrons were evident in their minimal use of natural, blue-green tones along with black and white, a strong sense of vertical movement within each chevron, and
Figure 37. Branding chevrons for the National Scenic Trails.
Appalachian Trail
- Colors are a simple scheme & natural palette
- Focus is on the letters
- Sense of movement forward and up
- Letter T doubles as a directional arrow

Continental Divide Trail
- Colors are a simple scheme & subdued palette
- Focus is on the letters
- Sense of movement forward and up
- Letter T doubles as a directional arrow

Pacific Crest Trail
- Colors are a simple scheme & natural palette
- Focus is on the natural environment - pine tree and mountain
- Sense of movement forward and up
- Pine tree doubles as a directional arrow

Figure 38. Analysis of the AT, CDT, and PCT branding chevrons
use of the focal point as a directional arrow. This vertical movement and directional arrow integration helps the chevron double as a navigational tool that can be used to direct trail users in the direction of the trail. While the AT and CDT chevrons focus on text, the PCT chevron focuses on the images of the pine tree and mountain.

A trail brand following in the footsteps of these three chevrons would limit color choices to a simple, natural palette and likely focus on either text, natural features of the environment, or both. A strong sense of vertical movement and the ability of the chevron to double as a directional arrow would be ideal.

**Economic summary.** A complete economic evaluation of the trail study sections reveals several significant similarities. For instance, all of the trail sections utilize some bridges to cross significant rivers but leave a majority of crossings as fords. Existing recreational facilities appear to have been underutilized in all three sections, though connecting with other non-motorized trails was a priority in each. Road crossings were largely dictated by the level of development found near to the trail, but each section demonstrated an aversion towards crossing major roads unnecessarily. Trail signage and branding were very similar amongst the three trails, with signage design suffering several serious shortcomings. In addition, trailhead location and frequency was closely tied to expected numbers of trail users and locations of major road crossings.

**Social.** The social features of trail design help to determine the implications of routing for the enjoyment of trail users. Such enjoyment is dependent on countless factors, many of which are beyond the reach of a trail planner. This study focuses on those areas that can have broad impact and can be manipulated by planning and design: permitted trail uses, routing the
trail through or nearby to points of interest and designated wilderness areas, the areas permitted
for camping, and the location and frequency of shelters, campsites, and water sources. The full
results of the social features examined for each trail study section can be found in Appendix C:
Trail Study Social Features Data.

**Points of interest, designated wilderness, and permitted trail use.** Points of interest
have been divided into three categories: Highpoints, unique natural attractions, and cultural sites.
Highpoints are defined as peaks visible from the trail that reach a minimum elevation (4,000 feet
for the AT, 10,000 feet for the CDT, and 11,500 feet for the PCT). Unique natural attractions are
features such as waterfalls or scenic passes that are distinctive enough to be noted in trail guides.
Cultural sites are locations of significant cultural value such as former settlements or historic
structures. All of the points of interest may add to user satisfaction with the trail by being
destinations for side trips or simply by enriching the trail experience.

The AT section (Figure 39) passes 47 points of interest, an average of one every 3.2
miles. 33 (an average of one every 4.6 miles) of these are highpoints (mostly peaks in the
Presidential Range), 7 (an average of one every 21.6 miles) are unique natural attractions, and 7
are cultural sites. The CDT section (Figure 40) passes far fewer points of interest: 17 (an
average of one every 7.8 miles), including 10 highpoints (an average of one every 13.9 miles), 6
unique natural attractions (an average of one every 22.2 miles) and a single cultural site.
Although the PCT section (Figure 41) does not pass any cultural sites, it does pass 72 points of
interest (an average of one every 2.1 miles), which is the most of the three sections studied.
The majority of these, 56 (an average of one every 2.7 miles), are highpoints and the remaining
16 (an average of one every 9.4 miles) are unique natural attractions.
Figure 39. Social features: Points of interest, wilderness areas, and permitted trail use on the AT.
Figure 40. Social features: Points of interest, wilderness areas, and permitted trail use on the CDT.
Figure 41. Social features: Points of interest, wilderness areas, and permitted trail use on the PCT.
By far the most common point of interest on all the trails is highpoints, likely due to the fact that all three trails follow near to the crest of major mountain ranges. The PCT boasts exposure to the most peaks, as well as to the most unique natural features but is bereft of any cultural attractions. In comparison, the AT had the most cultural attractions, likely due to the proximity of the trail to areas of historic human settlement. While cultural sites are definitely important factors to consider, the dominance of natural features in the landscapes is characteristic of all three study sections.

Stark differences are present in the amount of each study section that passes through or on the border with designated wilderness. The PCT section has far and away the most miles in wilderness with 146.5 miles (97.9%) in 5 different wilderness areas. The AT section had the second most, 57.3 miles (37.8%) in 4 different wilderness areas. The CDT section passed through only 2 wilderness areas for a total of 20.4 miles (15.3%).

Wilderness areas provide a sense of solitude, self-reliance, and escape from urban life that may be some of the most motivating factors for individuals traveling on a long-distance non-motorized backcountry recreation trail. Maximizing the route through wilderness areas, such as is demonstrated by the PCT, can enhance a trail experience. However, the wilderness designation also restricts use, which can limit its attractiveness to certain types of users, as discussed in the following paragraph on permitted trail uses.

Permitted trail use on the study sections considers the regulations regarding foot travel, equestrian use, mountain bike use, and motorized use. While all of the sections are considered to be part of non-motorized trails, some small sections (most notably on the CDT) are routed on existing trails or roads that do permit motorized use. In addition, all wilderness areas are by
law closed to both mountain bike and motorized use.

The PCT section is the only trail studied that was open for its entirety to both foot travel and equestrian use and closed for its entirety to mountain bikes and motorized vehicles. It should be noted that while equestrian travel is permitted the entire length of the PCT study section, it may be impractical in some areas, particularly through high-altitude passes. The AT study section is open to foot travel but closed to equestrian use for its entirety. Mountain biking and motorized use are only allowed for 2.9 miles (1.9%) of its length, which are sections of the trail that coincide with current roads (although presumably foot travelers would utilize the sidewalk on some of these sections, such as where the trail passes through the town of Hanover, NH, clearly cars would still be traveling the same route on the adjacent road surface). The CDT section is likewise open for its entirety to foot travel, but also allows equestrian use. Mountain bikes are allowed for 112.8 miles (84.9%), including the 0.3 miles of the trail that is adjacent to the Weminuche wilderness. Motorized use is restricted to 29.0 miles of the section, or 21.8%.

The CDT section is open to foot travel, mountain biking, and equestrian use for essentially its entire length outside of wilderness areas. While there is a risk of conflict between motorized and non-motorized users on nearly a quarter of the trail, there is great value in having such a large proportion of the section open to multiple non-motorized uses. Providing routes around the wilderness areas for mountain bikers would help with the continuity of the trail for users who choose to travel via that method. The AT has the most restricted uses with essentially the entire trail closed to all but foot travel. While this reduces potential conflict between user groups to a minimum, it also restricts access to mountain bikers and equestrians that may not be advisable in other trail designs. The PCT section is the only one studied that
completely eliminated motorized use from the entire length of the trail. In final analysis it seems best to eliminate motorized use but promote foot travel, equestrian use, and mountain bike use throughout a trail, while providing mountain bikes alternative routes around wilderness areas.

**Camping, shelters, and water sources.** Shelters are locations where trail-specific structures have been installed for the overnight use of those traveling the trail. The three sections studied represent three markedly different approaches to providing shelters.

The AT section (Figure 42) passes a total of 30 shelters or an average of one every 5.0 miles. Although a vast majority of the shelters along the entire AT from Georgia to Maine are free, 18 of the 30 in New Hampshire charge a fee. In comparison, The CDT section (Figure 43) passes two shelters (an average of one every 66.4 miles), one which is free and one which requires a fee. The PCT section (Figure 44) passes only a single shelter which, in truth, is meant only for emergency use and is accordingly free of charge (as well as amenities).

The shelters (or huts as they are called in the White Mountains) that the AT section passes noticeably affect the nature of the trail and the experience of trail users. The role of shelters in concentrating use, providing amenities otherwise unavailable on the trail, and promoting socialization can be valuable assets, but may be outweighed by their negative effect on the solitude, self-reliance, and remoteness of the long-distance trail experience. In addition, the construction and maintenance of shelters can be a significant expense. By providing none or only a very few, well-placed shelters that are primarily intended for emergency use (such as on the PCT), trail designers can promote a more rugged and robust trail experience.

Similar to shelters, official campsites are areas specifically set aside for the overnight use
Figure 42. Social features: Camping, shelters, and water sources on the AT.
Figure 43. Social features: Camping, shelters, and water sources on the CDT.
Figure 44. Social features: Camping, shelters, and water sources on the PCT.
of travelers. These sites typically offer tent pads or perhaps platforms and may provide sanitary amenities such as an outhouse. Few if any other services are offered. Of the three study sections, only the AT section passes any official campsites. This section passes 13 such sites, or an average of one every 11.6 miles. While concentrating use in official campsites can be practical in locations that see heavy use, official campsites are not a preferred alternative for any of the three sections studied.

Despite the proliferation of shelters on the AT section, dispersed camping remains a vital concern for that trail as well as for the CDT and PCT sections. Dispersed camping refers to the use of a location for overnight camping even though it is not officially designated as a campsite. For this study, regulations prohibiting dispersed camping in certain locales were discovered through researching each managing body. As an example, in Kings Canyon National Park camping is generally allowed except within 50 feet of any water body, including streams, rivers, and lakes. All the areas off-limits to dispersed camping were assembled for each trail. Additionally, a 500 foot buffer was assumed as the farthest distance that trail users would comfortably move away from the trail to find a suitable campsite. The areas within this buffer that permit or prohibit camping determine those areas for each trail that are suitable for dispersed camping. It should be noted that in actuality few trail users respect all the regulations prohibiting camping, especially when it is prohibited directly alongside trails. Informal campsites that receive regular use often abound just off the trail tread in the most convenient and suitable locations.

On the AT section, dispersed camping is allowed on only 4.1 square miles or 12.5% of the 500 foot buffer. In comparison, the CDT section allows dispersed camping on more than
four times that percentage of land: 14.4 square miles or 59.4% of the buffer. Still more accommodating, the PCT section allows dispersed camping on 19.2 square miles or 70.3% of the buffer. These results indicate that a trail passing through areas where dispersed camping is largely permitted need not invest in official campsites to accommodate overnight trail use.

Water sources are points along a trail that provide users with access to drinking water. Such points are of fundamental importance to a long-distance trail traveler because she must rely extensively (if not exclusively) on natural sources of water, often for days or weeks on end. Additionally, the distance between water sources can significantly impact how much weight a trail user must carry. Extra weight can result in discomfort, a slower pace, and even injuries. By providing regular access to water sources, a trail design can help to improve the enjoyment of the trail experience (Birchard & Proudman, 2000). Water sources were divided into two categories: perennial sources (such as lakes, rivers, and streams that contain water year-round) and seasonal sources (such as draws, creeks, and springs that may go dry at certain times of the year or for multiple years on end).

Of the three trail study sections, the PCT section provides users with the most access to water sources. The PCT section crosses 125 water sources (an average of 1 every 1.2 miles). In addition, the PCT sources are the most reliable: 107 (85.6%) are perennial. The longest distance between perennial sources on the PCT study section is 10.1 miles. In comparison, the AT section passed 99 sources (an average of 1 every 1.5 miles). Of these, 78 (78.8%) are perennial. Only 3.6 miles separates the 2 perennial sources that are furthest apart. The CDT study section passes only 39 sources (an average of 1 every 3.4 miles) of which 28 (71.8%) are
perennial. A remarkable 21.5 miles separates the two furthest apart perennial sources on the CDT section.

As water plays such a critical role in the health and well-being of a long-distance trail user, routing a trail to pass numerous water sources (especially reliable, perennial sources) becomes a crucial planning consideration. Averaging 1 water source every 1-4 miles appears to be a valid target.

Social summary. A complete social evaluation of the trail study sections reveals several patterns that should drive trail planning decisions. First, there is a relationship between the number of natural points of interest that a trail passes and the amount of that trail that passes through designated wilderness. The PCT section is almost entirely on designated wilderness lands and has the most natural points of interest. Conversely, the CDT section is routed on only 15.3% designated wilderness and has the fewest natural points of interest. However, it should be noted that cultural points of interest are most prevalent on the AT section and almost completely absent on the other two study sections. It would appear that cultural sites are more likely to be encountered when a trail crosses more roads and is generally routed through areas with more significant human impacts to the landscape.

Additionally, the three study sections show remarkable diversity in the permitted uses along their lengths. The CDT is by far the most catholic in its approach to permitted use, generally allowing foot travel, mountain biking, and equestrian use on the entire length, with the exception of prohibiting bike travel in wilderness areas. Notably, all three trail sections either prohibit or allow very little motorized use.
There is also an intriguing pattern to be found in the relationship between the amount of area permitted for dispersed camping and the amount of shelters and designated campsites. While the AT section has a very small amount of land open to dispersed camping, it is by far the most successful in providing shelters and official campsites. In contrast, both the CDT and PCT sections have no official campsites and only three shelters between the two trails, yet both prohibit dispersed camping in far fewer locations.

Finally, examining the findings of the study in regard to water sources indicates that despite variations in climate between the trail sections, there is a relatively small range in the average distance between sources (1.2 miles to 3.4 miles). However, there is a great range when the longest distance between perennial sources is concerned: between 3.6 miles and 21.5 miles. Such a range indicates that trail planning goals should not only be concerned with lowering the average number of miles between sources to between one and four miles, but that the maximum distance between reliable sources should also be minimized, with perhaps ten to twelve miles as a reasonable cap.

Aesthetic. The aesthetic features of a trail design help to determine the visual experience of trail users, both in terms of large-scale scenery and in the construction of the trail tread and associated structures that are viewed up close. The full results of the aesthetic features examined for each trail study section can be found in Appendix D: Trail Study Aesthetic Features Data.

Trail viewshed. The results from the viewshed analyses performed on all three trail study sections indicate that trail users on all three paths overwhelmingly experience views that are largely devoid of areas of significant human impact.
The AT study section (Figure 45) has a viewshed that encompasses the largest areas of development relative to the total amount of area visible from the trail: 3% of the total viewshed of nearly 1552 square miles is developed land or roads. The CDT study section (Figure 46) has the largest overall viewshed (more than 1630 square miles) and has the second highest percentage of visible development at 0.4% of the total. Despite having the largest viewshed of the three sections analyzed, the CDT study section succeeds in avoiding views of developed land for almost the entirety of its length. The PCT study section (Figure 47) has both the smallest viewshed (just over 700 square miles) and the smallest percentage of visible development (0.3%). This is likely due to the fact that this section of the PCT travels in deep valleys surrounded by high peaks and is extremely remote from permanent areas of human habitation.

Based on the results of the viewshed analyses of each trail study section there is a clear trend towards minimizing trail user exposure to developed land. While the AT study section passes through areas that are in close proximity to towns, highways, and other significant human impacts, it still manages to maintain 97% of its viewshed in undeveloped areas. This figure stands as a recommended upper limit to the viewshed of developed land for a long-distance non-motorized backcountry recreation trail.

Construction materials. Trail construction materials are chosen to fulfill myriad functions. These materials must be durable (to withstand environmental stresses), economical (to avoid excessive expenditure), and aesthetically appropriate (to fit with the character of the place where they are installed). Generally, trail construction materials fall into two categories: introduced materials and natural materials. Introduced materials include metal, plastic, carsonite, treated wood products or other substances that do not naturally occur in the
Figure 45. Aesthetic features: Viewshed on the AT.
Figure 46. Aesthetic features: Viewshed on the CDT.
Figure 47. Aesthetic features: Viewshed on the PCT.
environment through which the trail passes. In contrast, natural materials include native stone, untreated wood, and other substances that are commonly encountered along the trail.

Some introduced materials are relatively durable and are able to withstand environmental stresses for decades without becoming damaged, while others show signs of wear after only a single season in the field. Materials such as metal (most commonly steel, but also aluminum) are virtually indestructible in most trail environments. Certain types of plastics that resist ultraviolet radiation can also last for generations without degrading. In contrast, thin carsonite posts and less hardy plastics will often show signs of failure only a few months after installation. Similarly, some natural materials, such as certain types of stone, have a lifespan that can only be measured in centuries. Rot-resistant wood-types such as cedar and bald cypress can function in harsh trail environments for decades.

Using naturally occurring materials on trails is generally less financially expensive than using introduced materials. This is largely due to the fact that naturally occurring materials are already in place near the trail and only need to be adapted for trail use, rather than manufactured, purchased, and transported to the trail. However, there are non-financial expenses involved in using natural materials. For example, if a particular species of tree is desirable for constructing bridges or cribbing, over time that species may suffer from being selectively cut near to the areas where trail structure construction occurs. Also, removing rocks from a slope to shore up a trail tread may reduce the ability of the slope to remain intact in the face of persistent rain or snow, leading to landslides or slippage. For these reasons, it may be more environmentally friendly and sustainable to use introduced materials in some applications.
In general, natural materials fit the character of a trail more appropriately than introduced materials. Trail users may find that introduced materials negatively influence their trail experience because they are reminders of urban, industrialized society. In contrast, natural materials may help to create a trail experience that feels more authentic because they express themselves in a native, vernacular language.

A wide array of construction materials can be witnessed in the three trail study sections (Figure 48). For example, signage on the CDT section includes entirely natural wooden signs, hard-wearing plastic composite and treated-lumber signs, flimsy carsonite poles, hardy metal chevrons, and decaying plastic emblems. The AT study section relies almost exclusively on treated lumber signs while the PCT study section also relies heavily on introduced materials, mostly in the form of metal signs. Materials used to channel or divert water on the study sections is often native stone (largely used in waterbars and trail armoring), but there are also metal pipes and culverts. Materials used in cribbing and retaining wall construction are almost exclusively natural, primarily native stone.

The survey of trail construction materials leads to the following recommendations. First, natural materials should be the first consideration for any material choice. Of natural materials, hard, native stone, such as granite, should be considered before wood because it will last longer. Using stone as the primary construction material will add to the authenticity of the trail experience while ensuring a virtually indestructible product (Birkby, 2008). However, there are applications where stone is unavailable and wood could quickly rot and fail (such as for cribbing where it is in contact with the ground). In these cases, introduced materials should be considered. Introduced materials should always be of metal or similar strength and durability.
Figure 48. Aesthetic features: Trail construction materials.
There are applications where natural materials are inappropriate. One such case is with most trail signage. Trail signs are essential for way-finding, are often difficult to install due to their remote locations, can easily become victims of vandalism, and are often subject to the most extreme environmental conditions. In order to combat these difficulties, long-lasting, impervious materials such as metal should be used. Although these materials may not seem appropriate to the character of the location in which they are installed, the benefits of the introduced material outweigh such drawbacks. Another case where natural materials may not suffice is in instances such as bridges or shelters wherein the structure is extremely expensive to install and maintain and where structure failure could be catastrophic. In such construction, the use of metal should be considered for structural components. However, features such as railings, decking, and facades can still be made of natural materials in order to minimize the visual presence of the introduced materials.

**Aesthetic summary.** The analyses of aesthetic features of the trail study sections reveal valuable patterns while providing excellent examples of both design features that should be replicated and others that should be avoided. First, the viewshed analyses were useful tools for confirming that recreation trails can enhance their backcountry character by following a route that minimizes views of developed land, thus ensuring that trail users have the opportunity to experience natural landscapes that can assist in promoting a sense of solitude, self-reliance, and detachment from urban society that is crucial to deriving benefits from traveling on a long-distance backcountry recreation trail.

Second, the aesthetic choices involved in determining trail construction materials are not straightforward but must be considered alongside concerns of durability and affordability.
While the first choice should always be durable, natural materials that occur in close proximity to the trail, there are myriad instances where such materials are inappropriate or simply unavailable. Introduced materials should also be durable and should only be used in applications where comparable natural materials are unavailable. Examples of structures that combine natural and introduced materials show how structural integrity and preserving the character of the trail do not need to be mutually exclusive features.

**Preferred performance outcomes derived from existing National Scenic Trails.** An analysis of the compiled design features led to the formation of desired performance outcomes, which are presented below. These outcomes are essentially the lessons learned from the examination of the three National Scenic Trail sections, and are directly related to the features analyzed on the AT, CDT, and PCT study sections.

- Trail length through habitat areas of threatened and endangered species should be minimal: 5% or less of the total trail length is preferred.
- Trail length through sensitive wetlands and alpine tundra should be minimal: 5% or less of the total trail length is preferred.
- Trail length through landform slope areas of 10-70% grade should be maximized: 80% or more of the total trail length in this range is preferred.
- Trail length at grades below 15% should be maximized. An average trail grade below 10% is preferred.
- Trail length on south, southeast, and southwest aspects should be maximized: 50% or more of the total trail length is preferred.
• Trail length on existing trails and roads closed to motorized use should be maximized in areas where those trails are relatively close approximations of what the trail planner would otherwise recommend. In other words, these trails should follow the general direction desired for the trail. This must be determined on a case by case basis.

• Highway crossings should be as minimal as possible: an average of 1 every 45 miles or more is preferred. Crossings should be made via under- or overpasses where possible, and always at the safest location available. Crossings of minor roads should be minimized as well.

• Trailheads should be constructed where the trail crosses major roads based on the amount of desired users and proximity to popular destinations. A trailhead every 5-15 miles on average is preferred.

• River crossings should be made at points where user safety is least at risk and should primarily rely on fords. Bridges should be utilized or constructed where no safe crossings are available and over all significant rivers.

• Existing recreational facilities should be incorporated into the trail plan, especially ski areas and existing campsites. An average of 10-25 miles between recreational facilities is preferred. Connecting trails may be used for this purpose.

• Connections to other trails should be maximized: an average of 1.5-4 miles or less between connections is preferred.
• Trail length on public lands should be maximized: 100% of the total trail length on public lands is preferred.

• Trail signage should consist of reassuring signs such as chevron marPokers attached to trees, cairns, or posts, and navigational signage that provides the sign’s location and distances to nearby landmarks.

• A trail brand should be developed through the creation of a trail chevron.

• Proximity to points of interest (particularly natural points of interest) should be maximized: an average of 1 every 2-8 miles is preferred.

• Trail length through designated wilderness should be maximized whenever possible. Alternative routes for mountain bikes should be established to provide trail continuity around wilderness areas.

• Trail length allowing foot travel, equestrian, and mountain biking uses should be maximized: 100% of the trail open to these uses is preferable (except in wilderness areas which should have alternative routes for mountain bikes). Motorized use should be prohibited for the entire trail length.

• Dispersed camping availability should be maximized: 60% or more of the area surrounding the trail is preferred. If this number is reached additional shelters and official campsites are unnecessary.

• Exposure to perennial water sources should be maximized: an average of 1 every 5 miles or less is preferred. The longest distance between two perennial sources should be 10 miles or less if possible. The average distance between perennial sources should be less than 4 miles.
• Trail routing should minimize viewsheds of developed lands and roads wherever possible with a goal of restricting unwanted views to 3% or less of the total viewshed.

• Durable, natural materials that occur near the trail should be the first consideration for any construction material. When unavailable or inappropriate for the application, introduced materials may be used but are best utilized in combination with natural materials to better preserve the character of the site. Signage should be of metal or other introduced materials of comparable durability.

**Wasatch Mountain Trail Methods**

This section outlines the application of the process for planning long-distance non-motorized backcountry recreation trails to developing such a trail in the Wasatch Range. In order to apply the lessons learned from the study of the three National Scenic Trail sections to the creation of a corridor for the proposed WMT, the same features inventoried and analyzed in that study were also evaluated within the Wasatch Range. Just as multiple and varied data sources were utilized in studying the AT, CDT, and PCT trail sections, a myriad of sources were consulted in order to map the location of possible trail features in the Wasatch Range. These sources and the techniques used to map each are described in this section. The following chapter, Results, outlines the manner in which the features of each facet of trail design under consideration (environmental, economic, social, and aesthetic) are synthesized into alternative trail corridors and the final chosen corridor is presented.
**Environmental.** The environmental factors considered are nearly identical to those considered on the three trail study sections: threatened and endangered species’ habitat, sensitive habitats, landform slope, aspect, and the locations of existing trails and forest roads. In addition, existing trails were further analyzed to determine candidate trails that are more likely than others to be appropriate for inclusion in the WMT.

Trail slope cannot be determined as there is not yet a proposed trail corridor route.

**Threatened and endangered species and sensitive habitats.** Threatened and endangered species with habitat in the Wasatch Range were identified through the USFWS Critical Habitat Portal (USFWS, n.d.). The USFWS lists twelve threatened or endangered species present in the Utah and Idaho counties which together comprise the Wasatch Range. Of these, only four have habitat within the boundaries of the range. These are the Canada lynx (*Lynx Canadensis*), Maguire’s primrose (*Primula maguirei*), the whooping crane (*Grus americana*), and Ute ladies’ tresses (*Spiranthes diluvialis*). One listed species, the grizzly bear (*Ursus arctos horribilis*) has been extirpated in Utah and is thought to have been extirpated in the Wasatch Range in Idaho. Therefore it is not considered in this study. One additional species, the greater sage-grouse (*Centrocercus urophasianus*) is a candidate species that is at high risk of becoming listed and is also considered in this study.

Spatial data for these species were retrieved or digitized from the following sources. Data on the threatened Canada lynx were derived from information from the Utah Division of Wildlife Resources (n.d.) which indicates that the species’ critical habitat is montane, coniferous forest. Data on threatened Maguire’s primrose indicate that the species is found exclusively in Cache County on north-facing cliffs (interpreted as 100% grade or greater) between 4400 and

Wetlands data for the Wasatch Range was obtained from the National Wetlands Inventory maintained by the USFWS (2014). Alpine tundra locations for the range were determined by consulting land cover data (USGS, 2004).

**Landform slope.** Elevation data for the Wasatch Range was obtained in the form of 30 meter resolution DEMs from the USGS (2014). 30 meter resolution was chosen to reduce the processing times and memory requirements of elevation-related analyses. The Wasatch Range, which covers an area of over 4000 square miles, is considerably larger than the limited areas examined in the trail study sections which used 10 meter resolution data.

The Slope function in ArcMap was used to produce the terrain slope map displaying percent grade throughout the range.

**Aspect.** The same elevation data used in determining landform slope was also used to determine aspect within the range. The Aspect function in ArcMap was used to produce the aspect map. The data was manipulated to show only the favorable south, southwest, and southeast aspects in the range.

**Existing and candidate trails.** Data on existing trails in the Caribou-Targhee National Forest was found on the Region 4 geospatial data website (USDA, 2013b). Data on existing
trails in the Uinta-Wasatch-Cache National Forest was retrieved from that forest’s geospatial data website (USDA, n.d.h).

Candidate trails are defined as those trails that have qualities that make them possible candidates for incorporation into the proposed environmentally preferred route of the WMT, in whole or in part. These qualities are that the trails run generally north and south through the range and/or connect such trails. In other words, candidate trails follow routes that are generally parallel to or overlapping where the Wasatch Mountain Trail would likely run even if no existing trails were to be found in the range.

**Economic.** The economic factors considered in the Wasatch Range are locations of roads, highways, and major rivers, preferable road, highway, and river crossing points, preferable trails for optimizing connectivity, and locations of preferred recreational facilities. Additionally, land ownership is mapped throughout the range. Trailhead locations will be gauged after a trail corridor has been proposed as they rely on numerous factors including the number of road crossings and the proximity of the trail to points of interest. Other economic factors that are not spatially explicit, including signage design and trail branding, are also considered.
Preferred major road and river crossings and recreational facilities. Major rivers were extracted from the Utah AGRC water dataset (2011) and the water dataset from the Idaho Department of Environmental Quality (2011). Major roads were extracted from the Utah AGRC roads and highways dataset (2014b) and the Idaho Geospatial Data Clearinghouse road transportation dataset (2014). Ideal crossing locations for roads were determined by locating underpasses and overpasses. Where these features were not present, locations where roads are straight and offer long sightlines for motorists to see approaching trail crossings were chosen. Ideal crossing locations for rivers were identified where existing bridges are in place.

Recreational sites were extracted from datasets available from the Uinta-Wasatch-Cache and Caribou-Targhee National Forest geospatial data websites (USDA, n.d.h; USDA, 2013b). Campgrounds, camping areas, and ski areas were considered as pertinent recreational facilities. Boundaries for ski areas were obtained from Utah AGRC (2014c).

Land ownership and possible trail connections. Land ownership data for Utah was downloaded from the Utah AGRC (2014a). Land ownership data for Idaho was downloaded from the Idaho State Office (2014).

Trail data were retrieved from the National Forest geospatial databases (USDA, 2013b; USDA, n.d.h). Maximizing trail connectivity is a design goal for the WMT. A hierarchy of which trails would be most valuable to connect to is helpful for sorting through the large number of existing trails in the range. Therefore, priority for trail connectivity was determined by assessing the number of other trails that each existing trail connects to. Those trails that have more connections are deemed a higher priority because connecting with those trails would more efficiently increase the overall network connectivity.
**Trail branding.** Data from the trail study section trail branding analyses were compiled and served to focus the trail branding effort for the proposed Wasatch Mountain Trail. The proposed trail chevron for the WMT was created following the guidelines discerned from other National Scenic Trails and particularly the chevrons for the AT, CDT, and PCT.

**Signage design.** Proposed signage design for the WMT is based on the findings from the trail study sections reported earlier in this study. Considerations of aesthetic sensibility, durability, and economic feasibility were included in the design of the signage. While this study does not propose to design each individual sign that would be required along the route of the WMT, this study does provide conceptual renderings that can serve as a guide for general trail signage design. All signs will necessitate adaptation to the particular needs of each trailhead, trail intersection, and any other point along the trail that requires signage.

**Social.** The social aspects of the Wasatch Range that are considered in this study include points of interest (highpoints, cultural sites, and unique natural features), areas of designated wilderness, water sources, and locations where dispersed camping is currently permitted. There are no known public shelters in the Wasatch Range (aside from yurts which are open only for the winter season). Additionally, distinguishing between perennial and seasonal water sources has been omitted. Information for the status of water sources other than permanent rivers, lakes, and ponds is unavailable and beyond the scope of this investigation. Such a study would require multiple visits to each source over a period of several years to establish whether or not they were reliable, perennial sources or merely seasonal.

**Points of interest and wilderness areas.** Points of interest in the Wasatch Range were mapped based on information from several sources. Locations of highpoints and some cultural...
sites were determined by consulting maps and trail guides of the area (National Geographic Society, 1994; USGS, 2014). Highpoints were limited to named peaks above 8500 feet that appeared on the maps. Three National Historic Trails (Mormon Pioneer, California, and Pony Express) travel through the range. All three follow the same route, and therefore the corridor is considered to be culturally significant for the purposes of this study. The route for the trails was found at the National Park Service National Historic Trails and Routes webpage (n.d.b).

Unique natural features were compiled from information from previously cited water data (i.e. waterfalls), USGS maps (2014) and the Utah Geological Survey GeoSights website (n.d.).

Wilderness area locations were downloaded from the Wilderness Institute (n.d.).

Water sources and areas of permitted dispersed camping. Water sources in Utah were derived from the lakes, rivers, streams, and springs dataset available from Utah AGRC (2011). Water sources in Idaho were derived from two datasets from the Idaho Department of Environmental Quality: Lakes of Idaho (2002) and Streams of Idaho (2004).

Areas where dispersed camping is allowed were determined by consulting regulations for such activity on the Uinta-Wasatch-Cache National Forest website (USDA, n.d.g) and the Caribou-Targhee National Forest Website (USDA, n.d.a)

Aesthetic. The areas of concern for aesthetic features of the Wasatch Mountain Trail are the viewsheds containing areas of development from within the Wasatch Range and the construction materials proposed for use throughout the trail.

Viewsheds. As fits the character of a backcountry trail, the ideal routing of the WMT would minimize trail users’ exposure to views of developed or disturbed areas. In order to
determine which parts of the range would be subject to such views a thorough viewshed analysis was performed.

Elevation data were compiled for the areas surrounding the range. Elevation data sources were the same as those described above with the addition of elevation models for southwestern Wyoming which were obtained from the Wyoming Geospatial Hub (2009). Landcover data were assembled from the same sources described above with the addition of data for Wyoming (USGS, 2004). Road data for the range were also obtained from the same sources cited above. Areas of development were isolated from the landcover data and used in conjunction with the elevation data to perform a viewshed analysis using the Viewshed process in ArcMap. The resulting dataset indicates which areas in the range are visible from those areas of development. It also indicates which areas in the range have a viewshed that includes development. Adding the road layers to this information indicates all of the areas in the range that may detract from the aesthetic experience of a trail user.

**Proposed trail construction materials.** This study does not attempt to locate each individual trail structure that would be required for the completion of the proposed WMT. Instead, examples of construction materials in use are provided through conceptual renderings. These illustrations show one way in which the recommended materials can be put to use in common situations that are likely to be found along the proposed WMT route.
Corridor Development

Within each of the four categories described above (environmental, economic, social, and aesthetic) the results of the analyses can be overlaid to reveal patterns that help to describe preferable routes for the proposed Wasatch Mountain Trail. For example, overlaying the four maps depicting environmental features (threatened and endangered species and sensitive habitats, slope, aspect, and existing and candidate trails) indicates which areas would be most suitable for an environmentally preferable route. Although a path could be computed using GIS software to determine a route that, by the given criteria, best meets the goals of each category, this type of analysis would ignore intuitive and artistic considerations that may be advantageous to the final design solution. Intangible factors such as trail flow and continuity cannot be automated. Such characteristics of a design separate the trained and experienced landscape architect from technicians and scientists.

Four corridors were developed based on overlaying maps of the factors considered in each category. A 1000 foot wide buffer was applied to the route centerlines to indicate fluidity and to reinforce the concept that each preferable alternative is a generalization rather than an exact path (the actual tread must be determined in situ). Each corridor was created independently of the other three and only with considerations of those factors investigated in each category, plus the intuitive and experience-driven insights of the researcher.

After all four preferable alternatives were created they were overlaid to determine where the corridors were in alignment and where they were divergent. The areas of general alignment were considered to be indicative of the best locations through which to route the trail. The
divergent areas were considered to be indicative of areas in which tradeoffs between various features must occur. Following an identification and examination of the divergent areas in which the positive and negative attributes of each are considered, a final proposed corridor is created. This final corridor is mapped in greater detail to show a more precise response to topography, road and river crossings, existing trails, and other features of the landscape.
CHAPTER IV
RESULTS

This chapter outlines the three elements of the Wasatch Mountain Trail results portion of this study. Those three elements are inventory maps, four preferred alternative trail corridors, and a final proposed trail corridor. The inventory maps spatially locate the opportunities and constraints for a long-distance non-motorized backcountry recreation trail present in the Wasatch Range. These maps are based on information derived from the trail study section portion of this study. The various maps form the basis for creating the four preferred alternative trail corridors. One preferred trail corridor is delineated for each of the four previously described trail feature categories: environmental, economic, social, and aesthetic. Each preferred alternative trail corridor provides a route that best navigates the opportunities and constraints within its category. Finally, those four corridors are compared and their areas of divergence and alignment are revealed. Areas of divergence are adjudicated and a final proposed corridor is presented.

Environmental

The environmental features inventoried in the Wasatch Range are presented in four maps. Figure 49 displays the areas of the range that provide habitat for threatened and endangered species, as well as sensitive wetlands and alpine tundra. The most prominent and contiguous habitat areas are those of the greater sage-grouse. All other sensitive areas are relatively localized and do not present continuous areas of obstruction to a trail. Figure 50 shows the
Figure 49. Environmental features: Threatened and endangered species and sensitive habitats in the Wasatch Range.
Figure 50. Environmental features: Landform slope in the Wasatch Range.
landform slopes present in the range. A vast majority of the range falls in the preferred 10-70% slope category, though there are significant areas of flatter land, particularly in the North Wasatch. Most of the canyons in the range also feature small areas of extremely steep slope exceeding 70%. Figure 51 conveys information regarding preferred aspects in the range. While any trail would necessarily need to traverse undesirable aspects, the proposed corridor should be able to take advantage of the areas with a south, southeast, or southwest exposure. Figure 52 locates existing trails in the range. In addition, it highlights candidate trails that may be useful for routing the proposed trail corridor on ground that has already been disturbed by previous trail construction. There is a large, notable absence of trails in the North Wasatch indicating that new trail will likely need to be constructed through much of that section.

**Environmentally preferable alternative.** The four maps displaying environmental features were overlaid to provide the framework for designing an environmentally preferable corridor alternative. The environmental corridor was routed to utilize existing trails, avoid sensitive habitats and ecosystems, and to stay on appropriate slopes and aspects wherever possible. Figure 53 shows the preferred environmental corridor.

**Economic**

The economic features inventoried in the Wasatch Range are presented in two maps. Two additional figures present the results of the trail branding and signage analyses. The first map, Figure 54, displays preferred road and river crossings as well as recreational facilities within the range. This map will direct the routing of the preferred economic corridor to the
Figure 52. Environmental features: Existing and candidate trails in the Wasatch Range.
Figure 54. Economic features: Preferred major road and river crossings and recreational facilities in the Wasatch Range.
safest and least expensive crossings of major roads and rivers while also ensuring that existing recreational facilities (particularly ski areas) are considered as valuable trail assets. Figure 55 illustrates land ownership alongside those trails that have high connectivity and are therefore more desirable for connection to the proposed WMT. This map shows the discontinuity of publicly held lands, particularly in the North Wasatch, which may prove to be a difficult area to acquire permission for a trail corridor. Figure 56 shows the proposed branding chevron for the WMT alongside the branding chevrons for all the National Scenic Trails. Bullet points highlight the strengths of the chevron design as well as the similarities to the existing chevrons upon which it was based.

A conceptual rendering of proposed signage design is shown in Figure 57. The first rendering shows the proposed metal WMT branding chevron attached to a tree along the trail, reassuring trail users that they are following the official WMT tread. The second rendering shows a metal informational sign that both assures trail users they are following the WMT and provides valuable information on distances to upcoming trail junctions.

**Economically preferable alternative.** Where possible, the economic corridor is routed to cross rivers and roads in preferred locations, to stay on public land (especially federally managed land), and to connect with existing trails (particularly trails with high number of trail connections). Figure 58 shows the preferred economic corridor.
Wasatch Mountain Trail

- Colors are a simple scheme & subdued palette
- Focus is on the letters & the mountains
- Sense of movement forward & up
- Letters & mountain double as a directional arrow

Figure 56. WMT proposed branding chevron
Figure 57. Conceptual rendering of WMT signage design.
Figure 58. Preferred economic WMT corridor.
Social

The social features inventoried in the Wasatch Range are presented in two maps. Figure 59 displays the points of interest (highpoints, cultural sites, and unique natural attractions) as well as federally designated wilderness areas. Figure 60 identifies water sources and outlines the areas where dispersed camping is prohibited. The North Wasatch area appears to have large gaps between areas of permitted dispersed camping which may prove to be difficult for trail routing.

**Socially preferable alternative.** The preferred social corridor is routed to pass near to points of interest, through wilderness areas, directly past water sources, and to remain in areas where dispersed camping is allowed as much as possible. Figure 61 shows the preferred social corridor. Alternative routes around wilderness areas (wilderness alternatives) have been outlined to indicate routes that bypass wilderness areas for trail users traveling by mountain bike.

Aesthetic

The aesthetic features inventoried in the Wasatch Range are presented in one map. Figure 62 illustrates the location of developed areas and the viewsheds from within the range that are exposed to those areas. A large portion of the range can view developed areas, with especially contiguous unwanted viewsheds from the western side of the range along the Wasatch Front. There are some extended pockets of preferable viewshed through the middle of the range.
Figure 59. Social features: Points of interest and wilderness areas in the Wasatch Range.
Figure 60: Social features: Water sources and areas of permitted dispersed camping in the Wasatch Range.
Figure 61. Preferred social WMT corridor.
Figure 63 illustrates some applications of proposed construction materials that would be preferable along the WMT. The rendering on the left shows native stone being used in a retaining wall to hold back a steep slope while the rendering on the right shows native stone used to construct a turnpike to raise the tread out of a wet area. A metal culvert allows water to flow from one side of the turnpike to the other but is hidden from view by the stone.

**Aesthetically preferable alternative.** The aesthetically preferable corridor is outlined in Figure 64. This corridor delineates a route through the Wasatch Range that seeks to optimize viewsheds of natural and undisturbed areas while minimizing viewsheds of developed areas.

**Alternatives Comparison**

After the four alternative corridors were completed they were overlaid in order to identify areas of alignment and divergence. Figure 65 shows the overlay of the corridors and highlights those areas where the alternative paths are not in agreement. There are five such areas, each of which is referred to as an area of divergence.

Patterns that emerge from analyzing the alternative corridor overlays indicate that the environmentally and aesthetically preferable routes tend to align. Similarly, the economically and socially preferable routes are often congruent. In addition, the wilderness alternatives tend to align with at least one other route a majority of the time. In these cases, the appearance of divergence may indicate a strong argument for the use of alternative corridors to both accommodate mountain bike use and to allow other users to decide on the type of experience they would prefer: trending either more towards a socially and economically preferable route, or
Figure 63. Conceptual rendering of WMT construction materials.
Figure 64. Preferred aesthetic WMT corridor.
Figure 65. Alternatives comparison.
The following sections compare the tradeoffs between the different routes in areas of divergence (Figures 66-70) and explain the rationale behind the author’s choice of the final proposed route (Figure 71).

**First divergence area.** The first area of divergence occurs in the central Bear River Mountains section of the Wasatch Range. It is shown in Figure 66. The environmentally preferable route and the aesthetically preferable route are in close alignment, but are strongly divergent from the other three corridors. While the economically preferable and socially preferable routes align in the northern section of this area, they diverge for the remainder. The wilderness alternative route has virtually no alignment with other routes. This area of the range is almost entirely USFS property, which includes the Mount Naomi Wilderness Area. A major road, US Highway 89, runs through Logan Canyon parallel to the Logan River, effectively bisecting the range and requiring any trail to cross both obstacles.

The proposed solution for the first area of divergence is to establish sections of the socially preferable and economically preferable routes as the main branch of the WMT along with a wilderness bypass. The route of the main branch of the trail prioritizes the wilderness experience by traversing the Mount Naomi Wilderness Area. Providing access to areas of designated wilderness is an essential function of backcountry recreation trails and should be regarded as an essential feature of any such trail. In addition, this route will to provide access from the WMT to highly connective trails in the area, travel adjacent to highpoints, and cross the Logan River at a preferable river crossing location.
Figure 66. First divergence area.
By creating a wilderness bypass route, the trail plan provides an option for all users (except for mountain bikers who would be mandated to take the bypass) to choose between two options. A somewhat customizable trail experience is a particularly valuable amenity in the Wasatch Range due to the contradictory nature of much of the designated wilderness found there: while untrammeled, a large portion of the wilderness does have extensive viewsheds west into developed areas. The original wilderness alternative in this area was primarily routed so as to avoid the Mount Naomi Wilderness. The final proposed bypass route succeeds in that goal, and in addition passes directly by one of the unique natural attractions in the region, the Jardine Juniper, America’s largest known Rocky Mountain Juniper (American Forests, 2014). Furthermore, it connects back to the main trail before crossing the Logan River or Highway 89, obviating the need for an additional trail crossing that could prove dangerous or expensive.

**Second divergence area.** The second area of divergence occurs in the southern Bear River Mountains section of the Wasatch Range. It is shown in Figure 67. This area shows a clear alignment of the environmentally and aesthetically preferable routes. Similarly, the socially and economically preferable routes also align. There is no designated wilderness in this area so there is no wilderness alternative to consider. Unlike the previous section, this area does contain a significant amount of privately held land. However, most of the state-owned land in the area is part of the Hardware Ranch Wildlife Management Area, which is primarily used for recreational hunting. It could be dangerous to route the trail through this area due to the potential hazard of hunters mistaking trail users for game. In addition, a major road, Highway 39, bisects the entire range and therefore will need to be crossed at a safe location. The Blacksmith Fork River has its headwaters in this area, but can be circumvented by routing a
Figure 67. Second divergence area.
trail to the eastern side of the range.

The proposed solution for the second area of divergence is to route the WMT along the economically and socially preferable corridor. This decision is founded on three arguments. The first argument is based on land ownership. The environmentally and aesthetically preferable route in this area runs through a hunting area (Hardware Ranch WMA), a large block of privately held land, and through several parcels of School and Institutional Trust Lands Administration (SITLA) property. In contrast, the economically and socially preferable corridor is largely located on USFS land, with only small segments on private or SITLA land. This route also avoids the nearby WMA, effectively negating any concern for potentially deadly recreational conflicts. Second, this proposed route avoids crossing the Blacksmith Fork River. This is particularly valuable as there are no preferable river crossings aligned with any of the routes in this area. Finally, the viewshed from the proposed route is largely devoid of developed areas. The only visual detraction from this route is that it passes over and occasionally alongside several minor roads. However, these are small dirt roads and should not have a large impact on the overall visual quality of the corridor.

**Third divergence area.** The third area of divergence occurs along the border of the southern Bear River Mountains section and the North Wasatch section of the range, and it is shown in Figure 68. Similar to the previous two areas of divergence, this portion of the alternative routes shows general alignment between the environmentally and aesthetically preferable corridors. Additionally, there is some alignment between portions of the economically and socially preferable corridors. There are no areas of designated wilderness in this area and therefore no wilderness alternative to consider.
Figure 68. Third divergence area.
This area is defined by multiple challenges. First, there is a paucity of public land in this area, meaning that the proposed trail will likely need to receive permission from private landowners to cross this section, which could prove difficult. Second, this section of the trail must navigate around Ogden Valley, a large geographic barrier centered on the Pineview Reservoir. It would be inappropriate to route a backcountry trail through this settled valley if it can be avoided. Third, the trail must cross Interstate 84 in this section. This is a major road with four lanes of high-speed traffic that cannot be safely crossed at grade by any trail user. Additionally, Interstate 84 parallels the Weber River, which is large enough to require a bridge crossing for safety.

The proposed solution for the divergent routes in this area is to route the WMT along the environmentally preferable route. This solution has several advantages. First, while this route mostly crosses private lands it is the shortest of the four alternatives, which may make it easier to accept for private landowners who may be considering giving permission for a trail corridor over their land. Additional leverage may be gained with private landowners by using the environmentally preferable alternative as it will ensure as little damage to their land as possible. Second, this route is defined at its northern and southern ends by existing trails. This means that less new trail needs to be constructed, which can reduce costs and may be an incentive for private landowners to acquiesce to the construction of the trail as it will have clear destinations at either end. Third, this route crosses I-84 and the Weber River in a safe and economical manner by utilizing an existing underpass on a minor road to cross the interstate and using a vehicular bridge on a minor road to cross the river. This will eliminate the need to construct trail-specific crossings for either the road or the river which would each constitute a significant expense.
Fourth, this route passes within sight of Devil’s Slide, a unique geological formation that may hold interest for many trail users. Finally, this route avoids having to cross Highway 39 more than once, which would not be the case with the socially preferable corridor.

**Fourth divergence area.** The fourth area of divergence occurs along the border of the central and southern sections of the range. It is shown in Figure 69. More than any other, this section shows a diverse amount of alignment between the proposed corridors. Additionally, this area is home to four wilderness areas which are nearly contiguous, providing a unique opportunity in the range for extended travel in designated wilderness. Challenges particular to this section include several major highways (including an interstate) and two major rivers (though both can be bypassed if the trail is routed far to the eastern side of the range).

The solution proposed for this section is to follow the socially preferable route for a majority of the main trail while simultaneously offering a wilderness bypass. Following the socially preferable route will provide trail users with a route across all four designated wilderness areas in this part of the range. Those sections of this route that are not in designated wilderness remain almost entirely on public land. Additionally, this route passes in close proximity to Timpanogos Cave National Monument, the only NPS facility in the range. It passes directly adjacent to the base of the trail that provides access to the cave. This route also has both a preferable crossing for the American Fork River (an existing bridge) and a preferable crossing for Highway 92 (a crosswalk). Further, this route would expose trail users to some of the highest and most impressive peaks in the range by weaving between highpoints. Existing trails provide access to some of these peaks, and additional side trails could be constructed to others. It also passes below the location of the former Timpanogos Glacier, which currently exists only
Figure 69. Fourth divergence area.
as ice underneath a talus field but was formerly an impressive ice sheet with numerous crevasses. This route also must cross the Provo River and Highway 189 (East Provo Canyon Road), however this can be accomplished safely and efficiently using an existing bridge and underpass that are on minor roads. The crossings would bring the trail in close proximity to Bridal Veil Falls, a 600’ waterfall and a unique natural attraction in the range. This route also passes adjacent to three ski areas.

The proposed wilderness bypass trail in this section should (from the north) begin on the wilderness alternative, follow portions of the environmentally preferable, economically preferable, and aesthetically preferable routes, as well as sections of the wilderness alternative route. This proposal will have all the benefits discussed earlier for the wilderness bypass in the first area of divergence. In addition, the bypass route will come in close proximity or on the border of three ski areas, providing additional access to the trail from those existing recreational facilities. Further, this bypass avoids the potential costs of having to cross either Highway 92 or the American Fork River. While this route does necessitate crossing a formidable road (Highway 189) and a sizeable river (the Provo River) it does so in a safe and economical manner. The route runs below the Deer Creek Dam, crossing Highway 189 via an underpass and crossing the Provo River via a vehicular bridge on a minor road.

Fifth divergence area. The fifth area of divergence occurs in the southernmost section of the range (Figure 70). All four corridors are in alignment for much of the northern section of this area, but diverge upon approaching the Mount Nebo Wilderness. The socially and environmentally preferable routes pass through the wilderness area, while the wilderness
Figure 70. Fifth divergence area.
alternative, economically, and aesthetically preferable routes remain largely in alignment to the east.

The proposed solution to this section is to follow the environmentally preferable corridor throughout the area while also creating a wilderness bypass trail. The environmentally preferable route in this section has several significant advantages. First, it largely follows established trails. This reduces the cost of constructing new trail and reduces the environmental impact of trail construction. Second, this section requires a crossing of Highway 89 and the Spanish Fork River, which this route does admirably. There are no underpasses or overpasses on this section of Highway 89, but the crossing of the road is accomplished where a large area has been cleared for trucks to pull off the road. There are long, clear lines of vision in both directions. The river is crossed on a small vehicular bridge on a minor road. Third, this trail enters the Mount Nebo Wilderness and passes a side trail that leads to the summit of Mount Nebo, the tallest mountain in the range. Both the designated wilderness and the peak could be strong attractors for trail users.

The wilderness bypass should follow the alignment of the wilderness, aesthetic, and economic alternatives. As is the case with the previous wilderness bypasses, this would give mountain bikers a route to continue on the trail and give other users an option of which trail to follow. This route follows existing trails for part of its length. Additionally, it directly passes a number of water sources and reconnects to the main trail quickly.
Proposed Corridor

The final proposed corridor for the Wasatch Mountain Trail was delineated based on sections of alignment between the preferred alternative routes and the decisions made in the previous section regarding the areas of divergence. Additional precision has been added to the proposed corridor to respond more closely to details of topography, road and river crossings, interactions with existing trails, etc. through the use of three-dimensional modeling in Google Earth. The proposed corridor is shown in Figure 71. The length of the main WMT route is 396.8 miles and the wilderness bypass routes total 82.1 miles. In all, a total of 478.9 miles of trail are proposed to constitute the Wasatch Mountain Trail.

A brief text description of the corridor from north to south, along with illustrative maps, is presented in the following sections.

Proposed corridor in the Bear River Range. The northern terminus of the proposed Wasatch Mountain Trail is at the end of Second Bridge Road just outside of Soda Springs, Idaho (Figure 72). The trail briefly follows the southern edge of the Alexander Reservoir before ascending to the ridge above. After gaining the ridge, the trail turns south and runs along the height-of-land. To avoid roads, the trail contours lower on the western side of the ridge, proving views over Grace, Idaho and northern Cache Valley. The trail continues south, paralleling the ridge, passing Sherman Peak to the east (Figure 73) and crossing Idaho 36, a paved road, near Emigration Campground. The trail contours to the east following a valley between low mountains before turning west to climb past Midnight Mountain and to the crest of the Bear River Range. The trail turns south again, meandering among peaks along the crest
Figure 72. Proposed WMT corridor northern terminus.
Figure 73. Proposed WMT corridor Midnight Mountain area.
until it passes Franklin Basin and descends just north of the Idaho/Utah state line. As the trail climbs up Boss Canyon a junction is met between the main trail and the Mount Naomi Wilderness bypass. The main trail continues to climb until it reaches the ridge ahead, then turns south on that ridge, entering the designated wilderness and ascending several peaks including Doubletop Mountain (Figure 74). The trail descends off the ridge just north of Mount Gog and rejoins the wilderness bypass just to the east of that mountain (the bypass route parallels the main route at a lower elevation, outside of the Wilderness area). The trail passes near to White Pine Lake and meanders along the southern border of the Mount Naomi Wilderness until reaching Tony Grove Lake. Just past the lake another bypass route heads south to the Jardine Juniper and eventually rejoins the main trail at Wood Camp in Logan Canyon. The main trail climbs back into the Mount Naomi Wilderness, ascends Mount Elmer, and skirts along the ridge south towards Beirdneau Peak. The trail descends from the peak, emerging at the bottom of Logan Canyon at Tab Hollow near Wood Camp. The Logan River is crossed on a vehicular bridge giving access to the Jardine Juniper/Wood Camp trailhead. Highway 89 is crossed at a right angle and the trail climbs out of the canyon in a series of switchbacks until it reaches a small mesa and passes Little Cottonwood Spring. The trail descends into Ricks Canyon, crosses the Right Fork of the Logan River, and makes its way up Steel Hollow (Figure 75). Heading southeast, the trail follows minor canyons and crosses small forest roads (as well as paved Highway 39/Monte Cristo Road) on the eastern side of the range before descending to the Causey Reservoir and entering the North Wasatch.

**Proposed corridor in the North Wasatch.** The trail descends to Dry Bread Hollow and the northern tip of the Causey Reservoir where it briefly joins dirt roads to circle the western
Figure 74. Proposed WMT corridor Mount Naomi area.
side of the water body. The trail leaves the road and heads along the eastern arm of the reservoir in Skullcrack Canyon before turning south again to ascend to the Weber/Morgan county line. The trail contours along the east side of Bybee Knoll before dropping into Dry Fork Canyon and descending to Interstate 84 and the Weber River in the bottom of Weber Canyon (Figure 76). The trail maneuvers around a quarry and has excellent views of the Devil’s Slide rock formation before crossing under the interstate and over the river on a minor road. The trail ascends through private property up Powder Hollow on a dirt road. After leaving the road and contouring to the west of Redrock Peak the trail drops down Redrock Canyon, crosses Highway 66 and East Canyon Creek below the East Canyon Dam, then climbs south along the ridge towards Big Mountain. The trail continues along the Morgan/Salt Lake county line as it becomes the Salt Lake/Summit county line, then descends to Parley’s Canyon and Interstate 80 west of Summit Park. The trail goes under the interstate at Lambs Canyon and enters the Central Wasatch (Figure 77).

**Proposed corridor in the Central Wasatch.** After crossing under the interstate the trail ascends the northern side of Mount Aire before descending to the Mount Aire Trailhead. After crossing Mill Creek Canyon Road, the trail splits and a wilderness bypass route leads east and south to avoid four wilderness areas. This bypass follows Mill Creek Canyon, crosses Highway 190/Big Cottonwood Canyon Road at Spruces Campground, then stays to the east of the Reed and Benson Ridge until reaching the top of Little Cottonwood Canyon opposite Alta Ski Resort. The bypass ascends the canyon between Honeycomb Cliffs and Mount Wolverine, passes Twin Lakes Reservoir, Lake Mary, Lake Martha, and Lake Catherine on the edge of the Brighton Ski Resort, then follows the ridge south towards Ant Knolls. The bypass trail
Figure 77. Proposed WMT corridor Big Cottonwood Canyon area.
continues south, slowly descending into Thomas Canyon with Mill Canyon Peak to the west (Figure 78). The bypass crosses the South Fork of Deer Creek then drops to cross Highway 189/Provo Canyon Road via an underpass and the Provo River (Deer Creek) on a bridge just below the Deer Creek Dam (Figure 79). After contouring on the western slopes of the Wallsburg Ridge the bypass rejoins the main trail just east of Bald Knoll.

From the north junction with the wilderness bypass, the main trail climbs from Mill Creek Canyon into the Mount Olympus Wilderness, reaching the shoulder of Mount Raymond, before descending into Big Cottonwood Canyon, crossing Highway 190/Big Cottonwood Canyon Road at the Lake Blanche Trailhead. The trail parallels the Mill B South Fork as it climbs into the Twin Peaks Wilderness. Passing Lake Florence and Lake Blanche, the trail climbs over the shoulder of Mount Superior, jogs east, and then descends into Little Cottonwood Canyon, crossing Highway 210/Little Cottonwood Canyon Road at Snowbird Ski and Summer Resort. The trail climbs as it heads west through the canyon, entering the Lone Peak Wilderness and ascending to Red Pine Lake. Above the lake the trail switchbacks up to the ridge, then begins to descend to the saddle between White Baldy and Box Elder Peak (Figure 78). The trail contours along the east side of Box Elder Peak and enters the South Wasatch.

**Proposed corridor in the South Wasatch.** Entering the South Wasatch, the trail descends into American Fork Canyon, leaving the Lone Peak Wilderness as it reaches Highway 92/Alpine Loop Scenic Byway and the American Fork River. The river is crossed on a vehicular bridge and the highway is crossed on a crosswalk, both directly opposite to the Timpanogos Cave National Monument visitor center. The trail turns east and parallels the road and river until reaching Burned Canyon, where a steep ascent up switchbacks leads into the
Figure 78. Proposed WMT corridor Mount Timpanogos area.
Figure 79. Proposed WMT corridor Provo Peak area.
Mount Timpanogos Wilderness. The trail climbs up into the Timpanogos Basin and passes Emerald Lake as it skirts to the east of Mount Timpanogos. The trail traverses the mountains above the Sundance Ski Resort and leaves the wilderness area, descends into Provo Canyon, and comes to Highway 189/Provo Canyon Road and the Provo River at Bridal Veil Falls (Figure 79). The trail crosses the river on a bridge and the road via an underpass before turning east to head up the canyon. Ascending via switchbacks the trail leaves Provo Canyon west of Vivian Park. The trail reaches the low point on the ridge between Cascade Mountain and Provo Peak, then turns east to slowly descend past Bald Knoll to the junction with the wilderness bypass trail. Continuing south on eastern side of Rattlesnake Mountain, the trail slowly curves back west after passing Red Pine Knoll. The trail descends the left fork of Maple Canyon before turning abruptly south to enter the right fork of Maple Canyon as it heads up to the shoulder of Spanish Fork Peak (Figure 80). After descending to Sterling Hollow in Spanish Fork Canyon the trail crosses Highway 89/6/Grand Army of the Republic Highway at a truck rest stop and then takes a vehicular bridge over the Spanish Fork River. The trail briefly follows Covered Bridge Drive through private property before ascending Thurber Ridge, making its way south towards Santaquin Peak, which the trail summits. The trail descends down the south shoulder of Loafer Mountain then passes the Payson Lakes as it heads towards its final leg through the Mount Nebo Wilderness. The trail passes below Twin Knolls to the east and bifurcates at another wilderness bypass (Figure 81). The main trail climbs up into the wilderness, passing the trail that leads to the summit of Mount Nebo, and traverses the eastern side of the massif before descending to reunite with the bypass. The bypass jogs east from where it leaves the main trail, passing through foothills as it bends around to cross the Nebo Loop Road and climb back to the main
Figure 80. Proposed WMT corridor Spanish Fork Area.
trail. The final section of the trail descends from the mountains to Utah Highway 132 and the trail’s southern terminus.

**Proposed Trail Performance Outcomes**

In order to ascertain the functionality of the proposed trail route, the following sections report how successful the corridor is at meeting the goals set forth following the completion of the trail study section of this research. Both the main and the bypass trails are considered together in all performance evaluations. An infographic relating the proposed trail performance in comparison with the trail study sections and the stated goals can be found in Figure 82a and Figure 82b. The full results of the features examined for the proposed WMT corridor can be found in Appendix E: Wasatch Mountain Trail Features Data.

**Proposed corridor environmental outcomes.** The proposed WMT corridor responds well to the environmental constraints present in the Wasatch Range. The proposed WMT route meets or exceeds all six of the environmental feature goals set.

The goal for trail length through habitat areas of threatened and endangered species was 5% or less. Only 3.7% (17.7 mi) of the proposed trail passes through likely habitat for threatened or endangered species. The two significant species’ habitats that the corridor travels through are 6 miles of greater sage-grouse habitat and 10.9 miles of Canada lynx habitat. Restricting trail users from leaving the trail tread in these areas (particularly by restricting dispersed camping) could help to reduce the negative impact the trail might have on these species.
Figure 82. Trail performance comparisons A.
Figure 83. Trail performance comparisons B.
The goal for trail length through sensitive wetland and alpine tundra regions was 5% or less. This goal was reached: only 4.0% (19.2 mi) of the proposed trail passes through these areas.

Trail length through landform slopes of 10-70% was deemed preferable and a goal of at least 80% of the total trail on these slopes was set. This goal was met with 83.3% (398.9 mi) of the trail length on slopes of 10-70%. Only 2.7% (12.9 mi) of the trail length falls on exceeding steep slopes of 70% or greater, with the remaining 14.0% (67.1 mi) on gentle slopes of 10% or less.

The goal for the grade of the trail itself was to maximize length of trail at grades of 15% or less with an average trail slope of less than 10%. This goal was met, with a total of 78.6% (376.4 mi) of the trail at less than a 15% grade and an average grade of 6.4%. More than a third of the trail (39.8% or 190.6 mi) is at grades under 5% and a majority (62.6% or 299.8 mi) falls under 10%. Additionally, the maximum slope of the proposed trail is 64%, significantly less than was discovered on the AT, CDT, or PCT study sections which had maximum slopes of 92%, 85% and 69.7%, respectively.

The goal for routing the trail on south, southeast, or southwest aspects was 50% or more of the total length. This objective was achieved: 53.8% (257.6 mi) of the trail has such exposures.

The recommendation for routing the proposed trail along existing trails was to use those trails that follow the general direction of the proposed trail where possible. There are an abundance of these trails in the Wasatch Range and the proposed WMT corridor utilizes a significant number of them. A total of 40.4% (193.5 mi) of the entire length of the corridor is on
existing trails. An additional 1.3% (6.2 mi) of the corridor is routed on existing roads while 1.2% (5.7 mi) follows current USFS roads. A total of 57% (273.0 mi) of the proposed trail route will require new trail to be constructed.

**Proposed corridor economic outcomes.** The proposed trail is successful at meeting four of the six goals pertaining to economic design features. Of the two goals that were not met, one, trailhead location, requires additional study, and the second, land ownership, is currently impossible to meet. Trail signage and branding for the WMT have already been discussed and are not spatially explicit. Therefore they are omitted from consideration in this section on trail performance.

The goal for highway crossings was to ensure that they were as minimal as possible with an average of 1 every 45 miles or more being preferable. This goal is met by the proposed route. The Wasatch Range is completely crossed by six highways, with five others partially crossing it. Therefore, regardless of the route chosen, any trail must cross at least six highways. The proposed route crosses eleven highways (ten on the main route and one on bypass routes), which means that, on average, one highway is crossed every 43.5 miles, which meets the stated goal. Of these crossings, four take place on an underpass (including both crossings of interstate highways) and one takes place on a crosswalk. The remainder cross at grade where there are long sightlines in both directions. These locations will require signage for both motorists and trail users to maximize safety. An additional 16 crossings of minor roads also occur on the proposed route, or an average of 1 every 29.9 miles.

The recommendation for trailhead locations was to place them where the trail crosses major roads, with one on average every 5-15 miles. The proposed route does not meet this
goal. Although trailheads have been proposed at all major road crossings, this only amounts to one every 25.3 miles, on average. Additional research beyond the scope of this study must be undertaken to better understand the relationship of trailheads to long-distance trails to ascertain if the goal objective should be revised or if additional trailhead locations must be identified on this route.

The stated goal for river crossings is to make them at safe points and to rely primarily on fords, a goal that is met by the proposed route. The proposed route recommends fords at all crossings aside from where the trail must span one of the range’s major rivers. These major rivers would be unsafe to ford in most conditions and locations. Of these rivers, the proposed trail crosses six (the Logan, Weber, American Fork, Provo (once on the main route, once on a bypass route), and Spanish Fork Rivers). All of these crossings are facilitated through the use of existing bridges on minor roads.

The goal for existing recreation facilities is to incorporate them into the trail design, with an average of one every 10-25 miles. Ski areas were identified as being especially preferable existing recreation locations so as to attract trail users who are already utilizing those popular areas. The proposed route meets this goal by passing through or very near to 27 existing recreation facilities including campgrounds, day use areas, and existing trailheads. This is an average of 1 every 18.1 miles. Within that number are included five major ski resorts: Solitude, Brighton, Alta, Snowbird, and Sundance.

The goal for connections to other trails is to average 1 every 1.5-4 miles. This goal is achieved by the proposed route which has 128 trail connections, an average of one every 3.7 miles. This proposed trail would greatly increase the connectivity of existing trails in the
Wasatch Range and allow trail users to access the WMT from myriad locations and not only from designated WMT trailheads.

The goal of routing the trail 100% on public land has not been met. There is no corridor through the Wasatch Range that can meet that goal due to the fact that public land does not run contiguously from one end of the range to the other. The proposed route runs for 82.1% (393.2 mi) of its length on public land (77.3% or 370.2 mi on USFS property, 4.3% or 20.6 mi on state owned property, 0.5% or 2.4 mi on BLM property, and 0.1% or 0.5 mi on NPS property) while the remainder (17.9% or 85.7 mi) falls on private land. It will be necessary to receive permission from private landowners to route the trail over private land, but this task should be ameliorated by the fact that much of the proposed trail on private land runs on previously existing trails that presumably have already received landowner assent. Additionally, a campaign to purchase or procure easements for land on and adjacent to the trail corridor should be undertaken so that the trail can be established in perpetuity.

**Proposed corridor social outcomes.** The proposed trail is successful at meeting 4.5 out of 5 of the social design feature goals. The goal that was not entirely met, that of providing reliable water sources regularly along the trail, will require additional study to determine the nature of each water source passed along the route. The consideration of side trails or existing trails that may lead to other water sources should also be undertaken in order to provide trail users with smaller gaps between sources.

The goal for proximity to points of interest was to maximize trail user exposure with an average of 1 point every 2-8 miles. This objective was met by the proposed route which passes 82 points of interest (74 highpoints, 7 unique natural attractions, and 1 cultural site) for an
average of one every 5.8 miles. Ultimately, a variety of as yet unknown points are likely to be discovered.

The goal for routing through designated wilderness was to maximize trail length in such areas wherever possible while providing alternative routes for mountain bikers and other trail users. This goal was met by routing the trail through portions of all six wilderness areas in the range while providing four wilderness bypass sections that allow all users a continuous experience from one end of the range to the other. A total of 17.4% of the proposed corridor lies within designated wilderness areas (not including wilderness bypass sections).

The goal for permitted trail use was to maximize non-motorized use to 100% of the trail length and prohibit motorized use wherever possible. The proposed trail succeeds in meeting this goal: 100% of the trail would permit foot traffic and equestrian use. Outside of wilderness areas, 100% of the trail would permit mountain bikes, with wilderness bypasses to allow mountain bikes to avoid the areas where they are prohibited. Motorized use would be restricted to 2.6% (12.5 mi) of the trail and would be allowed only on the portions that coincide with existing roads and forest service roads.

The goal for camping was to maximize dispersed camping availability, with camping allowed in 60% or more of the area surrounding the trail. The proposed trail meets this goal: 61% of the area surrounding the trail allows dispersed camping. This number would likely increase as efforts are made to decrease the length of trail on private land, or if private landowners would agree to allow dispersed camping on their properties.

The goal for exposure to water sources was to maximize exposure to them, with an average of one source every five miles or less preferable. In addition, the maximum distance
between perennial sources should be 10 miles or less. This goal is difficult to measure, because no data is available as to the nature of most water sources in the Wasatch Range; lengthy observation of each spring would be required to adjudicate between seasonal and perennially sources. However, the average distance between water sources on the proposed trail is only 3.1 miles, significantly less than the 5 mile maximum recommended, which means that it is likely that the proposed trail meets that half of this goal. However, the longest stretch of trail without any water sources is 23.2 miles in southern Idaho, significantly more than the goal of 10 miles or less. This means that trail users will need to carry their own water supply for a greater distance than is preferred, or make detours off of the main trail to find water at alternative sources.

**Proposed corridor aesthetic outcomes.** The proposed corridor meets the single aesthetic design feature goal. Trail construction materials for the WMT have already been discussed and are not spatially explicit. Therefore they are omitted from consideration in this section on trail performance.

The goal for trail viewsheds of developed lands and roads was to minimize them wherever possible and preferably restricting them to 3% of the total viewshed or less. The proposed corridor meets this goal, restricting unwanted views to just under 3.0% of the total viewshed.
CHAPTER V
DISCUSSION

This section of the study restates the research and project goals and highlights the key results that were achieved. Limitations to the methodologies utilized are also reviewed in order to clarify the validity of results and identify areas of weakness that would benefit from additional research. Finally, this section concludes by outlining several areas of further research that could prove fruitful to future investigations into the planning and design of long-distance non-motorized backcountry recreation trails in general and the proposed Wasatch Mountain Trail specifically.

Study Goals and Achievements

The basis for this study is the empirical proof that physical, affective, and cognitive benefits are derived from experiences in the backcountry, and that those benefits can be augmented by prolonging one’s activity and exposure in that setting. Research has shown that non-motorized recreation on trails is the primary avenue by which individuals access the backcountry and expose themselves to settings that are favorable to the promotion of health and well-being. This study, therefore, examines long-distance non-motorized backcountry recreation trails because they can be considered an excellent catalyst for achieving the aforementioned health benefits. Explorations of the planning and design of such landscapes of movement is essential to understanding and shaping relationships of trail users with the natural
environment in order to facilitate individuals’ physical, affective, and cognitive development and growth.

In order to achieve this goal, this study was divided into two major focus areas: research into existing features of well-known long-distance non-motorized backcountry recreation trails and the application of that research to the planning and design of such a trail in the Wasatch Range. The research goals of the first half of this study were to identify suitable long-distance non-motorized backcountry recreation trails, identify and analyze the various trail features that can be manipulated through planning and design, and to use those features to form recommendations for future trail planning. The project goals of the second half of this study were to apply the information produced by the first half to a study of the constraints and opportunities within the Wasatch Range for a long-distance non-motorized backcountry trail, to propose various alternative corridors for such a trail through the range, to select an amalgamation of those corridors to serve as a proposed corridor, and to refine that corridor to produce a proposed trail route. Finally, this route was measured by performance indicators to assess its suitability for the landscapes through which it passes.

This study succeeded in its research goals by identifying long-distance trails to pursue as models for study based on their prominence, diversity, availability of information, and familiarity to the researcher. By using a case study approach, the research was able to follow an established pattern of investigation to explore all three trail study sections. The study was also successful in identifying key design features of the trails and categorizing them in a helpful and efficient manner. The analysis of these features provides a defensible precedent for others seeking to quantify various aspects of existing trails, and provides a set of design
recommendations that require accountability and establish performance minimums for future trail designs.

This study succeeded in its project goals by applying the information gathered in the research portion towards the creation of a trail route in the Wasatch Range. The trail and landscape features identified and analyzed proved to be essential constituent parts of trail design while simultaneously forming the structure of a defensible and repeatable design process. The comparison of competing trail corridors helped to identify and highlight strengths and weaknesses among the four routes, while the assimilation of the various paths into a single corridor allowed the researcher to exercise discretion, intuition, and experience into a final product that is also rational and defensible. By comparing the final outcome with pre-established performance metrics the study reinforced the expanding possibilities of landscape performance measurements in a recreation setting while further proving the viability of the proposed corridor.

Ultimately, this study has provided a detailed and contemporary approach to the planning and design of long-distance non-motorized backcountry trails that was previously unavailable among the landscape architecture, environmental planning, and natural resource management disciplines. By providing such an approach, this study seeks to increase the accessibility of trail design for academics and professionals who can then be more effective in their advocacy for such trails, increasing the positive influence that considered landscape and recreation design can have on society. Particularly, this study hopes to influence recreational trail design so as to increase the numbers of trail users on long-distance non-motorized backcountry trails which in turn could produce significant health benefits for individuals and society as a whole.
Study Limitations

Despite the achievements noted above, this study is also subject to shortcomings and limitations. These limitations fall into two categories: data accuracy and availability, and methodological weakness.

The issues of data availability and accuracy are ubiquitous in landscape architecture and environmental planning, especially when reliance on GIS forms a core resource for the research. First, landscapes are incredibly complex interactions of natural and human-influenced systems. These systems often contain multifaceted components and involve intricate relationships that elude even the most experienced researcher and cannot be easily understood. There are also logistical limitations to research that determine which data will be considered and which must be set aside. While this study attempted to be comprehensive in its approach it has not been able to find and utilize all the data that would be necessary to address all of the natural or human factors that affect outcomes in trail planning and design. There are likely to be additional features or even categories of features that this study failed to identify but that could prove crucial to comprehensive trail design. Second, the data used in this research was limited by its form and content. Accuracy of GIS data suffers for several reasons, one of which is the issue of resolution. For example, elevation data with a resolution of 30 meters, such as was used to model the terrain of the Wasatch Range, is not precise enough to account for all the complex topographies that can and should influence trail design. Another aspect of GIS inaccuracy is that it represents a landscape in a particular time in the past rather than a consistently changing system. Therefore data on, for example, landcover, may have been accurate when it was
produced, but may not reflect existing conditions as they have changed over time. Thus the location of wetlands used in this study may not represent their actual locations as they exist today. Furthermore, some of the data used in this study rely on previous research and models that were not able to be verified by the researcher. For example, the likely habitat for greater sage-grouse in the Wasatch is doubtless the result of a complex habitat model that itself was based on assumptions and data with varying degrees of precision and accuracy. Such data was used at face value during this research and, while assumed to be the best data available, may grandfather in certain errors or omissions.

The second limitation of this study, that of methodological shortcomings, is centered on the structure of this research as a rational, expert-driven approach. While configuring the research in this way produces measurable outcomes, quantifiable data, and defensible decisions, it lacks the inclusion of all voices aside from that of the researcher. Due to logistical constraints, the opinions of other trail users, managers, landowners, and stakeholders were omitted from this study. A more socially inclusive approach to the project may have yielded much different conclusions and have resulted in other positive outcomes such as private landowner acceptance, constituency building, and volunteer donations of time and/or money to realize the project.

**Further Research**

To build upon the achievements and address the limitations of this study, several recommendations for further research are made. First, further efforts must be made to establish
the validity of the trail features identified and the trail design recommendations that evolved from analyzing those features in the research portion of this study. Other trail sections must be examined to ascertain whether the patterns visible in the three sections presented in this study are present in other trail sections. This may influence the recommendations for future trail design by augmenting them with additional information or changing the underlying assumptions.

Second, as mentioned earlier in this study, additional research must be done regarding trailheads and water sources in the Wasatch Range. The patterns of locating trailheads derived from this study appear to be somewhat contradictory and unclear. Also, the nature of each water source along the proposed corridor is not clear from the available GIS data but is crucial to locating the trail where it will provide users with reliable drinking water.

Third, a concerted effort should be made to explore socially inclusive avenues of planning and design for the proposed Wasatch Mountain Trail. By combining the largely rational approach presented here with further work with the publics who are stakeholders in such a project both the plan and the outcome are likely to improve drastically. Such efforts could include public meetings, group charrettes, the establishment of a non-profit trail group, partnerships with the USFS, the NPS, influential agencies and organizations, and others. Without such involvement this project is doomed to remain an academic exercise that will never see completion.

Fourth, the arduous but necessary task of ground-truthing the proposed corridor must be undertaken. Although GIS and 3D modeling provide incredible data and details, the proposed trail corridor must be examined by people on the ground in order to establish where the final tread should be located. This requires walking the length of the corridor with a GPS unit that
can accurately locate the best places for switchback turns, adjust the tortuosity of the trail to accommodate vegetation and other obstacles, and otherwise enhance the details of the trail location.

Finally, connections between the proposed corridor and other destinations should be considered. For example, side trails to water sources, camping areas, highpoints, and other locations could be valuable amenities for trail users. Where such trails are located and which points of interest they lead to must be examined. In addition, connections between the proposed WMT and other long-distance trails in the region must also be explored. Two of the most promising such connections are the Highline Trail in the Uinta Mountains and the Idaho Centennial Trail. The Highline Trail runs east-west through the Uinta Mountains, which are largely contained within the Uinta National Forest. The trail is nearly 100 miles long in total and its western terminus lies within 50 miles of the proposed WMT corridor. When complete, the Idaho Centennial Trail will run for about 900 miles north-south through the entire state of Idaho. By connecting with either or both of these trails the WMT would increase regional connectivity for non-motorized trails and encourage trail users to continue their journeys beyond the confines of the Wasatch Range.
REFERENCES


Marion, J. L. (2006). *Assessing and understanding trail degradation: Results from Big South Fork National River and recreational area*. USGS Patuxent Wildlife Research Center, Cooperative Park Studies Unit.


Appendix A. Trail Study Environmental Features Data
### Threatened and Endangered Species' Habitats

<table>
<thead>
<tr>
<th>Trail</th>
<th>Species/Habitat</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
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<tr>
<td><strong>AT</strong></td>
<td><em>Isotria medeoloides</em></td>
<td>15.1</td>
<td>10.0%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>15.1</strong></td>
<td><strong>10.0%</strong></td>
</tr>
<tr>
<td><strong>CDT</strong></td>
<td><em>Centrocercus minimus</em></td>
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<td>4.4%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>5.8</strong></td>
<td><strong>4.4%</strong></td>
</tr>
<tr>
<td><strong>PCT</strong></td>
<td><em>Anaxyrus canorus</em></td>
<td>7.5</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td><em>Ovis canadensis sierra</em></td>
<td>18.8</td>
<td>12.6%</td>
</tr>
<tr>
<td></td>
<td><em>Rana sierrae</em></td>
<td>34.7</td>
<td>23.2%</td>
</tr>
<tr>
<td></td>
<td><em>Rana muscosa</em></td>
<td>50.3</td>
<td>33.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>92.3</strong></td>
<td><strong>61.7%</strong></td>
</tr>
</tbody>
</table>

(Some species habitat overlaps)

### Length of Trail Through Sensitive Habitats

<table>
<thead>
<tr>
<th>Trail</th>
<th>Habitat</th>
<th>Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AT</strong></td>
<td>Alpine Tundra</td>
<td>28.8</td>
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</tr>
<tr>
<td></td>
<td>Wetland</td>
<td>1.0</td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>29.6</strong></td>
<td><strong>19.5%</strong></td>
</tr>
</tbody>
</table>

(.2 mi (.1%) are crossed on bridge or puncheon)

| **CDT** | Alpine Tundra | 7.6 | 5.7% |
|         | Wetland       | 2.7 | 2.0% |
| **Total** |             | **10.3** | **7.8%** |

| **PCT** | Alpine Tundra | 1.0 | 0.7% |
|         | Wetland       | 6.8 | 4.5% |
| **Total** |             | **7.8** | **5.1%** |
### Landform Slope

<table>
<thead>
<tr>
<th>Trail</th>
<th>Percent Grade</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
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<tr>
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<td>0-10%</td>
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<td>16.3%</td>
</tr>
<tr>
<td></td>
<td>10-70%</td>
<td>123.7</td>
<td>81.7%</td>
</tr>
<tr>
<td></td>
<td>70%+</td>
<td>3.1</td>
<td>2.0%</td>
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<tr>
<td>CDT</td>
<td>0-10%</td>
<td>39.5</td>
<td>29.7%</td>
</tr>
<tr>
<td></td>
<td>10-70%</td>
<td>93.3</td>
<td>70.2%</td>
</tr>
<tr>
<td></td>
<td>70%+</td>
<td>0.1</td>
<td>0.1%</td>
</tr>
<tr>
<td>PCT</td>
<td>0-10%</td>
<td>30.5</td>
<td>20.4%</td>
</tr>
<tr>
<td></td>
<td>10-70%</td>
<td>118.3</td>
<td>79.1%</td>
</tr>
<tr>
<td></td>
<td>70%+</td>
<td>0.7</td>
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</table>

### Trail Slope

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<thead>
<tr>
<th>Trail</th>
<th>Percent Grade</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>0-5%</td>
<td>43.2</td>
<td>28.5%</td>
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<tr>
<td></td>
<td>5-10%</td>
<td>33.5</td>
<td>22.2%</td>
</tr>
<tr>
<td></td>
<td>10-15%</td>
<td>13.3</td>
<td>8.8%</td>
</tr>
<tr>
<td></td>
<td>15%+</td>
<td>61.4</td>
<td>40.1%</td>
</tr>
<tr>
<td></td>
<td>Average Slope</td>
<td>15.3%</td>
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</tr>
<tr>
<td></td>
<td>Maximum Slope</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>CDT</td>
<td>0-5%</td>
<td>55.5</td>
<td>41.8%</td>
</tr>
<tr>
<td></td>
<td>5-10%</td>
<td>23.9</td>
<td>18.0%</td>
</tr>
<tr>
<td></td>
<td>10-15%</td>
<td>17.9</td>
<td>13.5%</td>
</tr>
<tr>
<td></td>
<td>15%+</td>
<td>35.6</td>
<td>26.8%</td>
</tr>
<tr>
<td></td>
<td>Average Slope</td>
<td>11.1%</td>
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</tr>
<tr>
<td></td>
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<td>31.5%</td>
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<td>5-10%</td>
<td>29.0</td>
<td>19.4%</td>
</tr>
<tr>
<td></td>
<td>10-15%</td>
<td>22.6</td>
<td>15.1%</td>
</tr>
<tr>
<td></td>
<td>15%+</td>
<td>50.9</td>
<td>34.1%</td>
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<tr>
<td></td>
<td>Average Slope</td>
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<tr>
<td></td>
<td>Maximum Slope</td>
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### Trail Aspect

<table>
<thead>
<tr>
<th>Trail</th>
<th>Exposure Direction</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
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<tbody>
<tr>
<td>AT</td>
<td>SE, S, SW</td>
<td>55.8</td>
<td>36.7%</td>
</tr>
<tr>
<td>CDT</td>
<td>SE, S, SW</td>
<td>48.6</td>
<td>36.6%</td>
</tr>
<tr>
<td>PCT</td>
<td>SE, S, SW</td>
<td>82.7</td>
<td>55.3%</td>
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</table>

### Length of Trail on Existing Trails or Roads

<table>
<thead>
<tr>
<th>Trail</th>
<th>Surface Type</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
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<tbody>
<tr>
<td>AT</td>
<td>Preexisting Trails</td>
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<td>20.1%</td>
</tr>
<tr>
<td></td>
<td>Old Road/RR Grade</td>
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<td>5.4%</td>
</tr>
<tr>
<td></td>
<td>Current Roads</td>
<td>2.9</td>
<td>1.9%</td>
</tr>
<tr>
<td></td>
<td>Current FS Roads</td>
<td>0.1</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>41.5</strong></td>
<td><strong>27.4%</strong></td>
</tr>
<tr>
<td>CDT</td>
<td>Preexisting Trails</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Old Road/RR Grade</td>
<td>8.3</td>
<td>6.2%</td>
</tr>
<tr>
<td></td>
<td>Current Roads</td>
<td>4.8</td>
<td>3.6%</td>
</tr>
<tr>
<td></td>
<td>Current FS Roads</td>
<td>24.2</td>
<td>18.2%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>37.3</strong></td>
<td><strong>28.1%</strong></td>
</tr>
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<td>PCT</td>
<td>Preexisting Trails</td>
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<td>Unknown</td>
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<td>Old Road/RR Grade</td>
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<td>0.3%</td>
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<td>Current Roads</td>
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<td></td>
<td>Current FS Roads</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
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<td><strong>0.3%</strong></td>
</tr>
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</table>
Appendix B. Trail Study Economic Features Data
### Trailheads, Road and River Crossings, and Existing Recreational Facilities

<table>
<thead>
<tr>
<th>Trail Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AT Trailheads</strong></td>
<td>24</td>
<td>6.3</td>
</tr>
</tbody>
</table>

#### Road Crossings
- **Highway (1 via underpass)**: 3, 50.5 mi
- **Local Road**: 13, 11.7 mi
- **Railroad**: 2, 75.7 mi
- **Total**: 18, 8.4 mi

#### River Crossings
- **Ford**: 10, 15.1 mi
- **Highway Bridge**: 3, 50.5 mi
- **Road Bridge**: 2, 75.7 mi
- **Suspension Bridge**: 1, 151.4 mi
- **Foot Bridge**: 9, 16.8 mi
- **Total**: 25, 6.1 mi

#### Recreational Facilities
- **Ski Area**: 4, 37.9 mi
- **Visitor Center/Headquarter**: 4, 37.9 mi
- **Campground**: 3, 50.5 mi
- **Other**: 2, 75.7 mi
- **Total**: 13, 11.7 mi

| CDT Trailheads | 10     | 13.3          |

#### Road Crossings
- **Highway**: 1, 132.9 mi
- **Local Road**: 2, 66.5 mi
- **Total**: 3, 44.3 mi
<table>
<thead>
<tr>
<th>Trail</th>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
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<tr>
<td></td>
<td><strong>CDT River Crossings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ford</td>
<td>4</td>
<td>33.2</td>
</tr>
<tr>
<td></td>
<td>Road Bridge</td>
<td>5</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Foot Bridge</td>
<td>1</td>
<td>132.9</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>10</td>
<td><strong>13.3</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Recreational Facilities</strong></td>
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</tr>
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<td></td>
<td>Ski Area</td>
<td>2</td>
<td>66.5</td>
</tr>
<tr>
<td></td>
<td>Campground</td>
<td>3</td>
<td>44.3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
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<td><strong>26.6</strong></td>
</tr>
<tr>
<td></td>
<td><strong>PCT Trailheads</strong></td>
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<td>149.6</td>
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<tr>
<td></td>
<td><strong>Road Crossings</strong></td>
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<td></td>
<td>Local Road</td>
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<td>37.4</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td>4</td>
<td><strong>37.4</strong></td>
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<tr>
<td></td>
<td><strong>River Crossings</strong></td>
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<td></td>
<td>Ford</td>
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<td>3.9</td>
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<td></td>
<td>Suspension Bridge</td>
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<td>149.6</td>
</tr>
<tr>
<td></td>
<td>Foot Bridge</td>
<td>5</td>
<td>29.9</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
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<td><strong>3.4</strong></td>
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<td><strong>Recreational Facilities</strong></td>
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<td><strong>Total</strong></td>
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</table>
### Corridor Ownership

<table>
<thead>
<tr>
<th>Trail</th>
<th>Owner</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AT</strong></td>
<td>USFS</td>
<td>134.8</td>
<td>89.0%</td>
</tr>
<tr>
<td>State</td>
<td>14</td>
<td>9.2%</td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>2.6</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Public Total</strong></td>
<td></td>
<td><strong>151.4</strong></td>
<td><strong>99.9%</strong></td>
</tr>
<tr>
<td>Private</td>
<td>0.1</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td><strong>CDT</strong></td>
<td>USFS</td>
<td>128.6</td>
<td>96.8%</td>
</tr>
<tr>
<td>BLM</td>
<td>2.3</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Public Total</strong></td>
<td></td>
<td><strong>130.9</strong></td>
<td><strong>98.5%</strong></td>
</tr>
<tr>
<td>Private</td>
<td>2</td>
<td>1.5%</td>
<td></td>
</tr>
<tr>
<td><strong>PCT</strong></td>
<td>NPS</td>
<td>96.4</td>
<td>64.5%</td>
</tr>
<tr>
<td>USFS</td>
<td>52.9</td>
<td>35.4%</td>
<td></td>
</tr>
<tr>
<td><strong>Public Total</strong></td>
<td></td>
<td><strong>149.3</strong></td>
<td><strong>99.9%</strong></td>
</tr>
<tr>
<td>Private</td>
<td>0.2</td>
<td>0.1%</td>
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</table>
Appendix C. Trail Study Social Features Data
## Points of Interest

<table>
<thead>
<tr>
<th>Trail</th>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Highpoints</td>
<td>33</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Unique Natural Attraction</td>
<td>7</td>
<td>21.6</td>
</tr>
<tr>
<td></td>
<td>Cultural Sites</td>
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<td>21.6</td>
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<td></td>
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<td>CDT</td>
<td>Highpoints</td>
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<tr>
<td></td>
<td>Unique Natural Attraction</td>
<td>6</td>
<td>22.2</td>
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<tr>
<td></td>
<td>Cultural Sites</td>
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<td>132.9</td>
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<td></td>
<td><strong>Total Points of Interest</strong></td>
<td><strong>17</strong></td>
<td><strong>7.8</strong></td>
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<td>PCT</td>
<td>Highpoints</td>
<td>56</td>
<td>2.7</td>
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<td></td>
<td>Unique Natural Attraction</td>
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<td></td>
<td>Cultural Sites</td>
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<td>NA</td>
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<td></td>
<td><strong>Total Points of Interest</strong></td>
<td><strong>72</strong></td>
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</table>

## Areas of Designated Wilderness

<table>
<thead>
<tr>
<th>Trail</th>
<th>Wilderness Name</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Wild River</td>
<td>8.4</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td>Great Gulf</td>
<td>8.7</td>
<td>5.8%</td>
</tr>
<tr>
<td></td>
<td>Pres. Dry River</td>
<td>9.9</td>
<td>6.5%</td>
</tr>
<tr>
<td></td>
<td>Pemigewasset</td>
<td>30.3</td>
<td>20.0%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>57.3</strong></td>
<td><strong>37.8%</strong></td>
</tr>
<tr>
<td>CDT</td>
<td>Weminuche</td>
<td>0.3</td>
<td>0.2%</td>
</tr>
<tr>
<td></td>
<td>La Garita</td>
<td>20.1</td>
<td>15.1%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>20.4</strong></td>
<td><strong>15.3%</strong></td>
</tr>
</tbody>
</table>
### Trail Lengths

<table>
<thead>
<tr>
<th>Trail</th>
<th>Wilderness Name</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCT</td>
<td>Domeland</td>
<td>3.2</td>
<td>2.1%</td>
</tr>
<tr>
<td></td>
<td>South Sierra</td>
<td>18.5</td>
<td>12.4%</td>
</tr>
<tr>
<td></td>
<td>Golden Trout</td>
<td>28.4</td>
<td>19.0%</td>
</tr>
<tr>
<td></td>
<td>Sequoia &amp; Kings Canyon</td>
<td>96.4</td>
<td>64.4%</td>
</tr>
<tr>
<td></td>
<td>John Muir</td>
<td>&lt;0.1</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>146.5</strong></td>
<td><strong>97.9%</strong></td>
</tr>
</tbody>
</table>

### Permitted Trail Uses

<table>
<thead>
<tr>
<th>Trail</th>
<th>Trail Use</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Footpath</td>
<td>151.4</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Mountain Bike</td>
<td>2.9</td>
<td>1.9%</td>
</tr>
<tr>
<td></td>
<td>Equestrian</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Motorized</td>
<td>2.9</td>
<td>1.9%</td>
</tr>
<tr>
<td>CDT</td>
<td>Footpath</td>
<td>132.9</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Mountain Bike</td>
<td>112.8</td>
<td>84.9%</td>
</tr>
<tr>
<td></td>
<td>Equestrian</td>
<td>132.9</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Motorized</td>
<td>29</td>
<td>21.8%</td>
</tr>
<tr>
<td>PCT</td>
<td>Footpath</td>
<td>149.6</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Mountain Bike</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Equestrian</td>
<td>149.6</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Motorized</td>
<td>0</td>
<td>0.0%</td>
</tr>
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</table>

### Campsites, Shelters, and Water Sources

<table>
<thead>
<tr>
<th>Trail</th>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
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<tbody>
<tr>
<td>AT</td>
<td>Fee Shelter</td>
<td>18</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>No Fee Shelter</td>
<td>12</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>5</strong></td>
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<tr>
<td></td>
<td>Fee Campsites</td>
<td>9</td>
<td>16.8</td>
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<td>No Fee Campsites</td>
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<td>37.9</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
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<td><strong>11.6</strong></td>
</tr>
<tr>
<td>Trail</td>
<td>Feature</td>
<td>Number</td>
<td>Average Interval (mi)</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------</td>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td>AT</td>
<td>Perennial Water Sources</td>
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<td>1.9</td>
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<td></td>
<td>Seasonal Water Sources</td>
<td>21</td>
<td>7.2</td>
</tr>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>99</strong></td>
<td><strong>1.5</strong></td>
</tr>
<tr>
<td></td>
<td>Longest Distance Between Perennial Sources</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>CDT</td>
<td>Fee Shelter</td>
<td>1</td>
<td>132.9</td>
</tr>
<tr>
<td></td>
<td>No Fee Shelter</td>
<td>1</td>
<td>132.9</td>
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<td><strong>66.4</strong></td>
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<td>Fee Campsites</td>
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<td>NA</td>
</tr>
<tr>
<td></td>
<td>No Fee Campsites</td>
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<td>NA</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
<td><strong>NA</strong></td>
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<td></td>
<td>Perennial Water Sources</td>
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<td>4.7</td>
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<td>Seasonal Water Sources</td>
<td>11</td>
<td>12.1</td>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>39</strong></td>
<td><strong>3.4</strong></td>
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<td></td>
<td>Longest Distance Between Perennial Sources</td>
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</tr>
<tr>
<td>PCT</td>
<td>Fee Shelter</td>
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<td>NA</td>
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<td></td>
<td>No Fee Shelter</td>
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<td>149.6</td>
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<td></td>
<td><strong>Total</strong></td>
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<td><strong>149.6</strong></td>
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<tr>
<td></td>
<td>Fee Campsites</td>
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<td>NA</td>
</tr>
<tr>
<td></td>
<td>No Fee Campsites</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
<td><strong>NA</strong></td>
</tr>
<tr>
<td></td>
<td>Perennial Water Sources</td>
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<td></td>
<td>Seasonal Water Sources</td>
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<td>8.3</td>
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</table>
### Dispersed Camping

<table>
<thead>
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<th>Trail</th>
<th>Feature</th>
<th>Square Miles</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>500 Foot Buffer</td>
<td>32.8</td>
<td>NA</td>
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<td></td>
<td>Camping Not Allowed</td>
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<td>87.5%</td>
</tr>
<tr>
<td></td>
<td>Camping Allowed</td>
<td>4.1</td>
<td>12.5%</td>
</tr>
<tr>
<td>CDT</td>
<td>500 Foot Buffer</td>
<td>24.3</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Camping Not Allowed</td>
<td>9.9</td>
<td>40.1%</td>
</tr>
<tr>
<td></td>
<td>Camping Allowed</td>
<td>14.4</td>
<td>59.3%</td>
</tr>
<tr>
<td>PCT</td>
<td>500 Foot Buffer</td>
<td>27.3</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Camping Not Allowed</td>
<td>8.1</td>
<td>29.7%</td>
</tr>
<tr>
<td></td>
<td>Camping Allowed</td>
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<td>70.3%</td>
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</table>
Appendix D. Trail Study Aesthetic Features Data
### Trail Viewshed

<table>
<thead>
<tr>
<th>Trail</th>
<th>Feature</th>
<th>Square Miles</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
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<td>1551.9</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Developed Area in Viewshed</td>
<td>41.3</td>
<td>2.7%</td>
</tr>
<tr>
<td></td>
<td>Roads in Viewshed</td>
<td>5.2</td>
<td>0.3%</td>
</tr>
<tr>
<td></td>
<td><strong>Total Developed Viewshed</strong></td>
<td><strong>46.5</strong></td>
<td><strong>3.0%</strong></td>
</tr>
<tr>
<td>CDT</td>
<td>Total Viewshed</td>
<td>1630.4</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Developed Area in Viewshed</td>
<td>1.3</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td></td>
<td>Minor Roads in Viewshed</td>
<td>1.5</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td></td>
<td>Major Roads in Viewshed</td>
<td>4.5</td>
<td>0.3%</td>
</tr>
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<td><strong>Total Developed Viewshed</strong></td>
<td><strong>7.3</strong></td>
<td><strong>0.4%</strong></td>
</tr>
<tr>
<td>PCT</td>
<td>Total Viewshed</td>
<td>706.1</td>
<td>NA</td>
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<td>Developed Area in Viewshed</td>
<td>0.2</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td></td>
<td>Minor Roads in Viewshed</td>
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<td>&lt;0.1%</td>
</tr>
<tr>
<td></td>
<td>Major Roads in Viewshed</td>
<td>&lt;0.1</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td></td>
<td><strong>Total Developed Viewshed</strong></td>
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Appendix E. Wasatch Mountain Trail Features Data
Environmental

Threatened and Endangered Species' Habitats

<table>
<thead>
<tr>
<th>Species</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Grus americana</em></td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td><em>Spiranthes diluvialis</em></td>
<td>0.7</td>
<td>0.1%</td>
</tr>
<tr>
<td><em>Primula maguirei</em></td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td><em>Centrocercus urophasianus</em></td>
<td>6</td>
<td>1.3%</td>
</tr>
<tr>
<td><em>Lynx canadensis</em></td>
<td>10.9</td>
<td>2.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17.6</strong></td>
<td><strong>3.7%</strong></td>
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</tbody>
</table>

Sensitive Habitats

<table>
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<th>Habitat</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine Tundra</td>
<td>17.2</td>
<td>3.6%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>1.9</td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19.1</strong></td>
<td><strong>4.0%</strong></td>
</tr>
</tbody>
</table>

Landform Slope

<table>
<thead>
<tr>
<th>Percent Grade</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10%</td>
<td>67.5</td>
<td>14.0%</td>
</tr>
<tr>
<td>10-70%</td>
<td>398.9</td>
<td>83.3%</td>
</tr>
<tr>
<td>70%+</td>
<td>13.2</td>
<td>2.7%</td>
</tr>
</tbody>
</table>
### Trail Slope

<table>
<thead>
<tr>
<th>Percent Grade</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5%</td>
<td>195</td>
<td>39.8%</td>
</tr>
<tr>
<td>5-10%</td>
<td>111.7</td>
<td>22.8%</td>
</tr>
<tr>
<td>10-15%</td>
<td>78.4</td>
<td>16.0%</td>
</tr>
<tr>
<td>15%+</td>
<td>106.3</td>
<td>21.7%</td>
</tr>
</tbody>
</table>

Average Slope = 6.4%
Maximum Slope = 64%

### Trail Aspect

<table>
<thead>
<tr>
<th>Exposure Direction</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE, S, SW</td>
<td>257.6</td>
<td>53.8%</td>
</tr>
</tbody>
</table>

### Length of Trail on Existing Trails or Roads

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preexisting Trails</td>
<td>193.7</td>
<td>39.5%</td>
</tr>
<tr>
<td>Old Road/RR Grade</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Current Roads</td>
<td>6.4</td>
<td>1.3%</td>
</tr>
<tr>
<td>Current FS Roads</td>
<td>5.9</td>
<td>1.2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>206</strong></td>
<td><strong>43.0%</strong></td>
</tr>
</tbody>
</table>
Economic

Trailheads, Road and River Crossings, and Existing Recreational Facilities

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
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</thead>
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<tr>
<td>Trailheads</td>
<td>19</td>
<td>25.8</td>
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</tbody>
</table>

Road Crossings

<table>
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<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway (4 via underpasses, 1 )</td>
<td>11</td>
<td>44.5</td>
</tr>
<tr>
<td>Local Road</td>
<td>16</td>
<td>30.6</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>18.1</td>
</tr>
</tbody>
</table>

River Crossings

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Bridges</td>
<td>6</td>
<td>81.7</td>
</tr>
</tbody>
</table>

Recreational Facilities

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ski Area</td>
<td>5</td>
<td>98.0</td>
</tr>
<tr>
<td>Campground</td>
<td>22</td>
<td>22.3</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>18.1</td>
</tr>
</tbody>
</table>

Trail Intersections

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersections with other trails</td>
<td>128</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Corridor Ownership

<table>
<thead>
<tr>
<th>Owner</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS</td>
<td>0.3</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>USFS</td>
<td>378.7</td>
<td>77.3%</td>
</tr>
<tr>
<td>BLM</td>
<td>2.5</td>
<td>0.5%</td>
</tr>
<tr>
<td>State</td>
<td>21.1</td>
<td>4.3%</td>
</tr>
<tr>
<td>Total Public</td>
<td>402.6</td>
<td>82.1%</td>
</tr>
<tr>
<td>SITLA</td>
<td>3.9</td>
<td>0.8%</td>
</tr>
<tr>
<td>Private</td>
<td>82.3</td>
<td>16.8%</td>
</tr>
<tr>
<td>Total Private</td>
<td>86.2</td>
<td>17.6%</td>
</tr>
</tbody>
</table>
### Social

#### Points of Interest

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highpoints</td>
<td>74</td>
<td>6.5</td>
</tr>
<tr>
<td>Unique Natural Attractions</td>
<td>7</td>
<td>68.4</td>
</tr>
<tr>
<td>Cultural Sites</td>
<td>1</td>
<td>478.9</td>
</tr>
<tr>
<td><strong>Total Points of Interest</strong></td>
<td><strong>82</strong></td>
<td><strong>5.8</strong></td>
</tr>
</tbody>
</table>

#### Areas of Designated Wilderness

<table>
<thead>
<tr>
<th>Wilderness Name</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt Naomi</td>
<td>9.8</td>
<td>2.5%</td>
</tr>
<tr>
<td>Twin Peaks</td>
<td>7.4</td>
<td>2.0%</td>
</tr>
<tr>
<td>Mount Timpanogos</td>
<td>14.6</td>
<td>4.0%</td>
</tr>
<tr>
<td>Mount Olympus</td>
<td>8.5</td>
<td>2.1%</td>
</tr>
<tr>
<td>Mount Nebo</td>
<td>8.3</td>
<td>2.0%</td>
</tr>
<tr>
<td>Lone Peak</td>
<td>20.3</td>
<td>5.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>68.9</strong></td>
<td><strong>17.4%</strong></td>
</tr>
</tbody>
</table>

(Does not include bypass mileage)

#### Permitted Trail Uses

<table>
<thead>
<tr>
<th>Trail Use</th>
<th>Trail Length (mi)</th>
<th>Percent of Trail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footpath</td>
<td>489.9</td>
<td>100.0%</td>
</tr>
<tr>
<td>Mountain Bike</td>
<td>419.4</td>
<td>85.6%</td>
</tr>
<tr>
<td>Equestrian</td>
<td>489.9</td>
<td>100.0%</td>
</tr>
<tr>
<td>Motorized</td>
<td>12.3</td>
<td>2.6%</td>
</tr>
</tbody>
</table>
### Water Sources

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number</th>
<th>Average Interval (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Sources</td>
<td>157</td>
<td>3.1</td>
</tr>
<tr>
<td>Longest Distance Between Sources</td>
<td>23.2 mi</td>
<td></td>
</tr>
</tbody>
</table>

### Dispersed Camping

<table>
<thead>
<tr>
<th>Feature</th>
<th>Square Miles</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 Foot Buffer</td>
<td>83.2</td>
<td>NA</td>
</tr>
<tr>
<td>Camping Not Allowed</td>
<td>32.5</td>
<td>39.1%</td>
</tr>
<tr>
<td>Camping Allowed</td>
<td>50.7</td>
<td>60.9%</td>
</tr>
</tbody>
</table>

### Aesthetic

### Trail Viewshed

<table>
<thead>
<tr>
<th>Feature</th>
<th>Square Miles</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Viewshed</td>
<td>19894.9</td>
<td>NA</td>
</tr>
<tr>
<td>Developed Area in Viewshed</td>
<td>591.8</td>
<td>3.0%</td>
</tr>
<tr>
<td>Minor Roads in Viewshed</td>
<td>0.3</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>Major Roads in Viewshed</td>
<td>1.5</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td><strong>Total Developed Viewshed</strong></td>
<td><strong>593.6</strong></td>
<td><strong>3.0%</strong></td>
</tr>
</tbody>
</table>