RECREATION SUITABILITY MAPPING AND RECREATIONAL CONFLICT WITHIN THE WILDLAND-URBAN INTERFACE

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

The Lake Mountains is the Bureau of Land Management (BLM) – Salt Lake Field Office's (SLFO) largest management area within the wildland-urban interface. According to Radeloff, Hammer, Stewart, Fried, Holcomb, and McKeefry, the wildland-urban interface (WUI) is "the area where houses meet or intermingle with undeveloped wildland vegetation." The Lake Mountains is a set of mountains bordered on the east by the town of Saratoga Springs and to the north and west by Eagle Mountain City. Due to its accessibility and proximity to residential areas, the Lake Mountains provide an opportunity for different recreational activities, ranging from target shooting, hiking, mountain biking, hunting, camping, bird watching, and viewing cultural resources. Most notably, the Lake Mountains receive 20,000 to 50,000 visitors per year with associated impacts that include public safety hazards, increased potential of wildfire, cultural resource damage, and property damage (e.g., bed post being shot through window), and litter. Currently, the BLM is conducting a Land Use Plan Amendment for 8,124 acres of the Lake Mountains to help mitigate these impacts. Therefore, the purpose of this study was to assist the BLM with their plan amendment, as well as the overall management of the Lake Mountains by addressing three objectives: 1) to analyze user preferences for terrain and infrastructure in the Lake Mountains area; 2) to display visitor preferences through recreation suitability maps; and 3) to determine adequate recreation zones based on the data to prevent and reduce recreational conflict within the WUI. I used a mixed-

methods approach involving semistructured interviews (n = 20) and survey questionnaires (n = 405) distributed onsite to a representative sample of Lake Mountains recreationists. The preference ratings for variables contained in the questionnaire were indexed, mapped, and analyzed using traditional recreation suitability mapping (RSM) techniques. The findings showed that target shooters and OHV riders had similar preferences to each other. Moreover, campers and hikers shared similar preferences to each other in this study.

TABLE OF CONTENTS

LIST OF FIGURES

Figures

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CHAPTER 1

INTRODUCTION

Thesis Format

This thesis is written in an article format containing three chapters. Chapter 1 is an introduction to the thesis, containing the overall purpose of the research, and an introduction to the literature. Chapter 2 is a journal article that was prepared for submission to *Landscape and Urban Planning*, and consists of a thorough literature review, research questions, results, and discussion. Chapter 3 provides additional recommendations for managers, and also contains my challenges, accomplishments, and revelations resulting from this research.

Introduction to the Problem and Overall Significance

Previous research indicates that the wildland-urban interface is a half-mile from where "houses meet or intermingle with undeveloped wildland vegetation" (Radeloff, Hammer, Stewart, Fried, Holcomb, & McKeefry, 2005, p. 799). However, previous literature has not addressed recreational conflict within the wildland-urban interface. Therefore, there is a gap in the research literature to further understand recreational conflict in the WUI.

Recreational conflict has been studied widely and it has been observed that "resource conflicts often occur when demand for space (e.g., multiple-use recreation) exceeds actual space" due to outdoor recreation being a "'spatially conditioned process' – meaning there is a direct relationship between space and experience" (Beeco, Hallo, & Brownlee, 2014, p.136). Nonetheless, the BLM is a multiple-use agency and provides recreational opportunities for multiple types of recreation. However, identifying specific locations and terrain to accommodate a range of activities such as OHV riding, target shooting, camping, and hiking, while trying to limit recreational conflict, is a challenging task for land managers.

Social-spatial mapping techniques, like Recreation Suitability Mapping (RSM), assists in determining and displaying visitor's terrain preferences through recreation suitability maps for competing outdoor recreational activities (Beeco, et al., 2014). In utilizing RSM, researchers work to identify specific terrain features or infrastructure preferences that may adequately facilitate outdoor recreational experiences (Beeco, et al., 2014). Furthermore, utilizing RSM in a planning process can help demonstrate and identify relationships between social and ecological conditions, landscape features, and elements of the outdoor experience (Albritton & Stein, 2011; Beeco, et al., 2014; Kliskey, 2000; Saqalli, Caron, Defourny, & Issaka, 2009; Silberman & Rees, 2010; Snyder, Whitmore, Schneider, & Becker, 2008; Wyman & Stein, 2010).

The relationships between OHV riders, target shooters, hikers, and campers within a WUI are not well understood, nor have they been mapped for a land management agency using traditional RSM techniques. This research aimed to contribute to this knowledge gap by investigating the relationship between the four types of outdoor recreationists' and the terrain and infrastructure preferences of the Lake Mountains area.

The four types of recreation were chosen because the BLM felt that they were the most dominant activities occurring at the Lake Mountains and infrastructure improvements are needed to better support these four activity groups. To accomplish this objective, the researcher employed a mixed method approach involving semistructured interviews (n = 20), quantitative questionnaires (n = 405), and traditional RSM techniques to map the relationships between the four types of outdoor recreationists' terrain and infrastructure preferences (e.g., dirt roads, vegetation, washes). Quantified values were weighted and analyzed using SPSS 22.0, and mapped using ArcMap 10.2.2.

Overall Research Questions

This research addressed the following questions and, where appropriate, related hypotheses:

RQ1: What terrain features and infrastructure were most and least preferred by target shooters, OHV users, hikers, and campers?

Hypothesis one: Target shooters will prefer high sloping terrain juxtaposed to long flat terrain

Hypothesis two: OHV users will prefer areas with existing roads and trails

Hypothesis three: Hikers will prefer areas with connected trails and lots of vegetation

Hypothesis four: Campers will prefer areas of higher elevation at the Lake Mountains

RQ2: How does RSM inform management decisions regarding recreational conflict prevention and reduction in the WUI?

Hypothesis five: RSM will inform management decisions regarding zoning an area for differing recreational opportunities.

Hypothesis six: The zones that result from RSM will help prevent and mitigate

recreational conflict by separating activities.

RQ3: Methodologically, what are the best RSM techniques for indexing, weighting, and mapping recreational zones in the WUI?

CHAPTER 2

RECREATION SUITABILITY MAPPING AND RECREATIONAL CONFLICT WITHIN THE WILDLAND-URBAN INTERFACE

Abstract

The Lake Mountains area is the Bureau of Land Management (BLM) – Salt Lake Field Office's (SLFO) largest management area within the wildland-urban interface (Pallette, 2015). The wildland-urban interface (WUI) is "the area where houses meet or intermingle with undeveloped wildland vegetation" (Radeloff, Hammer, Stewart, Fried, Holcomb, & McKeefry, 2005, p. 799). The Lake Mountains are bordered on the east by the town of Saratoga Springs and to the north and west by Eagle Mountain City. Due to its accessibility and proximity to residential areas, the Lake Mountains area provides opportunities for different recreational activities, ranging from target shooting, hiking, mountain biking, hunting, camping, bird watching, and viewing cultural resources. Most notably, the Lake Mountains receive 20,000 to 50,000 visitors per year with associated impacts that include public safety hazards, increased potential of wildfire, cultural resource damage, property damage, and litter (Pallette, 2015). Currently, the BLM is conducting a Land Use Plan Amendment for 8,124 acres of the Lake Mountains area to help mitigate these impacts. The purpose of this study was to assist the BLM with their plan amendment, as well as the overall management of the Lake Mountains by addressing

three objectives: 1) to analyze user preferences for terrain and infrastructure in the Lake Mountains area; 2) to display visitor preferences through recreation suitability maps; and 3) to determine adequate recreation zones based on the data to prevent and reduce recreational conflict within the WUI. I employed a mixed method approach involving semistructured interviews (n = 20) and quantitative questionnaires (n = 405). Quantified values were weighted and analyzed using SPSS 22.0, and mapped with ArcMap 10.2.2. The preference ratings for variables contained in the questionnaire were indexed, mapped, and analyzed using traditional recreation suitability mapping (RSM) techniques.

Introduction

Urban growth contributes to human encroachment on undeveloped wildlands, which is known as a wildland-urban interface (WUI). WUIs are "where houses meet or intermingle with undeveloped wildland vegetation" (Radeloff, et al., 2005, p.799), and are areas that local populations depend on for recreation, such as wildlife viewing, exercise, and solitude (Kil, Stein, & Holland 2014). Recreational conflict is now a concern for WUI managers because residents increasingly live close to WUIs, increased use of public land is occurring, and the public uses the area for varying recreational activities. Recreational conflict has been defined as "any physical, social or psychological obstruction arising with or between participants and their recreation goals" (p. 216) resulting from competition for physical, social, or psychological space during the same period (Lindsay, 1980).

Due to the increases of encroachment on undeveloped wildlands, it is imperative for land managers to study, understand, and properly manage WUIs and the recreational conflict that occurs within them. WUIs present considerable challenges for land

managers because of the adjacent infrastructure to the wildlands, which contributes to increased human-environmental conflicts, and recreation-related conflicts. Because resource conflict typically occurs when demand for space exceeds actual space (e.g., multiple use recreation within a WUI), we need to move beyond traditional approaches of understanding WUIs (Beeco et al., 2014). One technique that can address recreational conflict within the WUI is Recreation Suitability Mapping (RSM), which aims to identify specific terrain features or infrastructure preferences that can adequately facilitate outdoor recreational experiences. Coupling RSM with traditional conflict mitigation approaches, such as public meetings and focus groups, may help decrease resource damage and recreation conflict, and contribute to knowledge about effectively managing the WUI.

However, there is limited literature that focuses on using RSM within WUIs to address recreational conflict. With spatial demands for public land increasing, determining areas of potential conflict and segmenting use (e.g., activity zoning) based on spatial patterns, and terrain and infrastructure preferences may be effective in reducing recreational conflict (Beeco, Hallo, & Brownlee 2014). Zoning recreational activities by spatial preferences is a management strategy proven effective when resource protection and open space access goals conflict (Monz, Roggenbuck, Cole, Brame, & Yoder, 2000). Using RSM in this context added to the literature, making it available for future research endeavors that aim to investigate spatially conditioned processes for WUI management.

RSM applications in the WUI context make sense because spatial data can help integrate knowledge from scientific disciplines, such as social sciences, natural resourcemanagement, visitor use management, and ecology. Understanding the spatial aspects of visitor use is crucial for public land management because the distribution and

density of visitor use greatly affects biophysical and experiential conditions (Beeco, et al., 2014; D'Antonio, et al., 2010; Hammitt & Cole, 1998). Additionally, land managers find it useful to know how many visitors frequent an area, their spatial patterns, and their behavior in order to reduce resource damage (Manning, 2011).

Literature Review

The purpose of this literature review is to explain the three main concepts used in this research. First, the researcher discusses the literature available on WUIs. Second, the researcher reviews recreational conflict and the multiple definitions that exist in the literature. Finally, RSM is explained because it is the methodological foundation of the study.

Wildland-Urban Interface

Historically, the wildland-urban interface (WUI) has been discussed in relation to the dangers wildfires impose on those living near public wildland. A WUI is an "area where houses meet or intermingle with undeveloped wildland vegetation" (Radeloff, et al., 2005, p. 799). Urban sprawl continues to encroach on natural ecosystems while recreational use of wildlands simultaneously increases (Kil, et al., 2012). A WUI is a natural area that is in close proximity to urban development, making these areas a critical location that nearby communities depend on for outdoor recreation opportunities. This dependency come with associated adverse effects, such as ecological degradation, urban growth, suburban development, and recreational conflict (Kil, et al., 2014).

Urbanized environments that abut wildlands are getting more attention due to associated adverse effects, such as habitat loss (Theobald, 2001), wildlife disturbance

(Soule, 2008), biodiversity declines (McKinney, 2002), and recreational conflict (Kil, et al., 2012). Impacts such as these decrease biodiversity and ecological integrity, but also impact social values or the recreational quality of the area (Dwyer & Childs, 2004; Kil, et al., 2012). Research has documented that easy access to WUIs leads to higher recreational use levels, and local residents tend to regularly use WUIs at high rates (Kil, et al., 2012; Stein, et al., 2005).

Since neighboring communities depend on WUIs for outdoor recreational opportunities, the public might be sensitive to management decisions. Consequently, land managers need to account for public opinion because management decisions regarding WUIs likely influence the meanings visitors and residents ascribe to these areas (Kil, et al., 2012). Increasingly, alterations in how WUIs are managed can affect the publics' place-based connections (Warzecha & Lime, 2001).

Few studies have attempted to assess recreational conflict within WUIs to maintain quality resources, minimize conflict, and provide exceptional outdoor recreation experiences. Therefore, this research augments the existing literature related to managing recreational activities in the WUI. Furthermore, this research provides important information to managers overseeing WUIs and the Lake Mountains area.

Recreational Conflict

Recreational conflict has been studied widely and it has been observed that "resource conflicts often occur when demand for space (e.g., multiple-use recreation) exceeds actual space" due to outdoor recreation being a "'spatially conditioned process' – meaning there is a direct relationship between space and experience" (Beeco, et al., 2014, p.136). Traditionally, recreational conflict has been defined as goal interference in a

recreationist's experience and is influenced by activity, place, mode of experience, and tolerance of lifestyle diversity (Jacob & Shreyer, 1980). These four factors are used to predict the intensity of the conflict. The intensity of recreational conflict is also determined by population of outdoor recreational groups, size of area being used, and rate or speed of the activity (Jacob & Shreyer, 1980).

Activity style, regarding recreational conflict, refers to various personal meanings associated with an activity by individuals (Schneider & Hammitt, 1995). This includes the intensity of participation, status in the activity, and range of activity experiences. Resource specificity refers to the importance of using a specific resource or place and varies with the range of experience, possessive feelings for, and relationship with the resource. Mode of experience "is a continuum of environmental focus determined by the recreation activity itself: those involved in activities where movement precludes detailed examination of the scenery are unfocused and those able to concentrate on the detail are focused" (Schneider & Hammitt, 2009, p. 224). Finally, tolerance for lifestyle diversity is the willingness to share resources with members of other lifestyle groups. This varies with the technology that is associated with the activity and the resource consumption that occurs from and with the activity (Schneider & Hammitt, 2009). Jacob and Schreyer's (1980) original definition of recreational conflict is not the only model that exists in the literature. As their model was being conceptualized, Lindsay (1980) was developing a spatial model for conflict. In this model, conflict is defined as "any physical, social or psychological obstruction arising with or between participants and their recreation goals" (p. 216) resulting from competition for physical, social, or psychological space during the same period of time (Lindsay, 1980). This model is present in the crowding and social carrying capacity literature (e.g., Vaske, Donnelly, & Heberlein, 1980). The Lindsay

(1980) model notes that a single recreational sphere is available for outdoor recreational activities, but conflict potential increases when other activities fill in the space (Schneider & Hammitt, 2009).

A third model of recreation conflict was proposed by Bury, Holland, and McEwen (1983). This model defines recreational conflict as the condition "whenever incompatible activities occur" (Bury, et al., 1983; Schneider & Hammitt, 2009). In this model, recreational activities are conceptualized as a grid where the amount of environmental dominance and dependence on technology is reflected for each activity. The grid helps predict conflict by the distance between recreation activities; activities that are distant from each other on the grid are less compatible compared to activities that are more proximal (Schneider & Hammitt, 2009).

All three models have contributed to the recreational conflict literature. They all have similarities, including goal interference, definitions of conflict, and why conflict occurs. For the purposes of this study, the researcher was focused on the Lindsay (1980) model of recreational conflict because of its spatial model, inclusive of physical, social, or psychological obstruction. Furthermore, physical, social, and psychological obstructions exists at the Lake Mountains area (Pallette, 2015) making the spatial method, RSM, appropriate for the study.

Recreation Suitability Mapping

Related to the Lindsay (1980) model, space demand and space utility are extremely important to understand in areas such as WUIs. Consequently, balancing the demands of society and maintaining the health of ecosystems is of vital importance. One method to study space utility and space demand is RSM, which spatially displays visitor

use preferences through recreation suitability maps for competing outdoor recreational activities, and assists with activity zoning of competing recreational activities (Beeco, et al., 2014). The RSM technique uses ArcGIS software to "quantify terrain quality by using recreation attributes considered important to the recreation user" (Kliskey, 2000, p. 35).

The RSM technique is a four-step process. The first step is to create a base map of existing recreational use zones and infrastructure (e.g., trails). Secondly, the researcher identifies and measures suitability variables using social preference data from questionnaires. Within the third step, the researcher weights and scales variables in the spatial model depending on their importance. Finally, the fourth step consists of the researcher mapping and analyzing all variables to determine the suitability of an area for outdoor recreation (Beeco, et al., 2014; Gabriela, 2006; Kliskey, 2000).

User preferences, determined within the RSM process, provided information for a plan to accommodate the needs of each selected user group within the Lake Mountains area. This is because RSM aims to identify specific terrain features or infrastructure that facilitate recreational experiences. Moreover, RSM may offer unique advantages to protected areas where enforcement of recreational policies is difficult to implement because of monetary or staffing constraints (Kilskey, 2000). Designating areas that are suitable for various recreational activities may coerce visitors to instinctively follow recreational management designations and zoning. Additionally, identifying specific terrain preferences for distinct recreational activities may reduce resistance to other types of management strategies (e.g., direct and indirect) because user groups will be zoned to the specific areas they naturally prefer (Kliskey, 2000). Furthermore, two RSM methodologies currently exist in the literature. This study uses the traditional RSM

technique, where the method is used at a landscape level (Beeco, et al., 2014; Kliskey, 2000). The alternate RSM method is used in a confined corridor (e.g., trail) to conduct social-spatial mapping (Peterson, 2016).

Although there is an abundance of literature available on recreational conflict and WUIs, studies that focus on recreational conflict within a WUI are extremely limited. As discussed, WUI literature mainly consists of urban encroachment, water quality damage, habitat fragmentation, and wildfire dangers, but there is an increasing need for understanding how to effectively manage recreational conflict within the WUI. Therefore, the purpose of this study was to assist the BLM with making informed management decisions and add to the limited literature of recreational conflict within a WUI.

Research Questions

The following research questions guided the investigation of the relationships between the terrain and infrastructure preferences of OHV riders, hikers, campers, and target shooters. The aim is to assist the BLM with visitor use management, as well as the overall management of the Lake Mountains by addressing four objectives: 1) to analyze user preferences for terrain and infrastructure in the Lake Mountains area; 2) to display visitor preferences through recreation suitability maps; 3) to determine adequate recreation zones based on the data to prevent and reduce recreational conflict within the WUI; 4) to advance RSM research by identifying advantageous methods to index, map, and analyze relationships within the WUI.

1. What terrain features and infrastructure are most and least preferred by target shooters, OHV users, hikers, and campers?

2. Does RSM inform management decisions regarding recreational conflict prevention and reduction in the WUI?
3. Methodologically, what are the best RSM techniques for indexing, weighting, and mapping recreational zones in the WUI?

Study Area

The Lake Mountains area is located in Utah County, Utah of the United States of America, bordered on the east by Saratoga Springs City and on the north and west by Eagle Mountain City (Figure 1). It is the SLFO's largest WUI, with an estimated 20,000 to 50,000 visitors per year using the area for a wide variety of outdoor recreation opportunities, including target shooting, hiking, camping, OHV riding, and mountain biking (Pallette, 2015). The BLM manages the majority of the Lake Mountains, in conjunction with the State of Utah School and Institutional Trust Lands Administration.

Methods

I chose an exploratory mixed methodology (Clark & Creswell, 2011) as a guiding framework for the study, which consisted of three phases. In Phase 1, I conducted interviews with recreationists from the four activity groups being studied (i.e., target shooters, OHV riders, hikers, and campers), to identify the most important terrain and infrastructure features. The four types of activities were chosen by administering an internal BLM staff survey to SLFO employees about what activities are in the most need of management at the Lake Mountains area. In Phase 2, I developed and administered a questionnaire for recreationists using the Lake Mountains area. In Phase 3, I indexed, weighted, analyzed, and displayed relationships between terrain and infrastructure

preferences for OVH riders, target shooters, hikers, and campers at the Lake Mountains. Terrain and infrastructure preferences were displayed using ArcMap software. This three phase process was chosen because a) not all quantitative measures for the investigation were available, b) some variables were unknown, and c) due to the originality of the investigation, limited frameworks or theories were applicable (Clark & Creswell, 2011; Morgan, 1998).

Phase 1 – Initial Interviews

I conducted semistructured in-person interviews with recreationists that use(d) the Lake Mountains, using a modified Seidman (2012, p. 21) approach during June of 2016 (*n = 20)*. I used a snowball sampling approach to identify and contact participants. The sample consisted of 12 males and 8 females ranging from age 14 – 66 years old. The purpose of the interviews were to establish the 12 terrain and infrastructure preferences used in the questionnaire. A list of 50 preferences were shown to Lake Mountains recreationists and the top-selected preferences were used in the questionnaire (see Appendix B).

Phase 2 – Instrument Development and Data Collection

Using Phase 1 results and appropriate literature, I developed quantitative measurement items that captured terrain and infrastructure preferences of OHV riders, target shooters, hikers, and campers at the Lake Mountains. Following procedures outlined by Beeco and others (2014), I used a) 7-point Likert scales to assess the terrain and infrastructure preferences of the Lake Mountains for each activity group (1 = do not prefer; 7 = strongly prefer), and b) rank order questions (1 = most preferred; 5 = fifth

most preferred) to identify the most preferred terrain and infrastructure features for Lake Mountains area recreationists. In addition to these measures, I used standard demographics (U.S. Census Bureau, 2015). The researcher combined these instruments into a five page questionnaire.

I administered the survey questionnaire on-site, using systematic random probability sampling (Vaske, 2008) within the Lake Mountains area from July to August 2016. My goal was to administer at least 20 questionnaires per sampling period. Times and days of sampling was randomized, with me traveling throughout the Lake Mountains area until the sampling quota was hit. I administered questionnaires to recreationists, inclusive of OHV riders, target shooters, hikers, and campers using the Lake Mountains area. Furthermore, OHV riders were intercepted at Five-Mile Pass due to the proximity of location and similar terrain conditions to the Lake Mountains. Five-Mile Pass was used to intercept OHV riders because it is adjacent to the Lake Mountains area and consists of similar terrain. Five-Mile Pass is managed for OHV use, and the Lake Mountains area is not extremely popular for OHV riding due to the amount of target shooting that takes place.

Phase 3 – Indexing Variables and Mapping

First, I used standard calculations for leverage, kurtosis, and skewness to identify statistical outliers and to verify univariate and multivariate normality of the data (Tabachnick, Fidell, & Osterlind, 2001). Next, I used two steps in the social-spatial mapping process: 1) weighting variables in SPSS 22.0, and 2) mapping and analyzing variable relationships in ArcMap 10.2.2. Specifically, weighting procedures were adapted from Beeco and others (2014) and Kliskey (2000). Essentially, terrain and

infrastructure preferences received scores from each participant, and variables were mapped and analyzed with procedures described below.

Weighting Variables

The researcher adapted previous weighting procedures described by Beeco and others (2014) and Kliskey (2000). The weight (W) captured recreationists' terrain and infrastructure preferences for trails less than a 15% slope, trails greater than 15% slope, paved roads, more than 5 miles of connected trails, dirt roads, clear shooting lane, single track trails, proximity to washes, parking, at least one-half mile from buildings, vegetation, and wide open spaces. For example, hikers may prefer an area with lots of vegetation and trails with at least a 15% slope where OHV riders might prefer trails with at least 15% slope and wide open spaces. The following equation was used to produce W:

$W = \bar{M}_{pref} + \%\ 1^{st}$ ranking, where

$\bar{M}_{pref}$ = the group mean preference for the specific terrain or infrastructure

$\%\ 1^{st}$ ranking = the percent of the group sample that ranked the specific terrain or infrastructure preference as their most preferred.

Overall, these weighting procedures produced scores that allowed terrain and infrastructure to be ranked based on preference for OHV riders, target shooters, hikers, and campers using or intending to use the Lake Mountains.

Mapping

I imported preference weights into ArcMap 10.2.2 along with the base map of the Lake Mountains (Figure 1). Next, a map was made for each activity group using the cell

statistics tool in ArcMap 10.2.2 to spatially examine terrain and infrastructure preferences. The final map included weighted layers for each recreational activity's terrain and infrastructure preferences aggregated into a single map.

Results

Description of the Sample

During sampling, 405 recreationists (e.g., 100 target shooters, 101 campers, 102 hikers, 101 OHV riders) completed the questionnaire with a response rate greater than 90%, yielding a confidence interval of 3.26% at the 95% confidence level. All of the respondents reported residing in the United States (100%), specifically within the Mountain Standard Time Zone. The average age of target shooters was 40 years old, campers 42 years old, hikers 42, and OHV riders 41 years of age. The majority of the sample population was male (82%) with limited differences in respect to race (92% self-identified as white).

The sample had differing educational backgrounds: 33% of campers, 50% of hikers, 56.4% of OHV riders, and 35.6% of target shooters reported earning a 4-year college degree. Additionally, 8% of campers, 7.8% of hikers, 5% of OHV riders, and 17.8% of target shooters reported earning a graduate degree. 31% of campers and 34.3% of hikers reported making $75,000 to $99,000 in household income annually. A total of 28.7% of OHV riders reported making $100,000 to $149,000 and 29.7% of target shooters reported making $50,000 to $74,999 in household income annually.

Furthermore, 83.2% of camping respondents reported using the Lake Mountains for their primary activity, 97.1% of hikers reported using the Lake Mountains for their primary activity, 61.4% of OHV riders reported using the Lake Mountains for their

primary activity, and 96% of shooters reported using the Lake Mountains for their primary activity.

Results of Relationships Between Variables

Results addressing Research Question 1 (What terrain features and infrastructure are most and least preferred by target shooters, OHV users, hikers, and campers?) and Research Question 2 (How may RSM inform management decisions regarding recreational conflict prevention and reduction in the WUI?) are displayed by the mean preference values in Table 1.

Trails Less Than 15% Slope

OHV riders had a M_{pref} of 3.91, % 1st ranking of 0, and weight of 3.91. Shooters had a M_{pref} 2.84, % 1st ranking of 6.9, and a weight of 9.74. Hikers had a M_{pref} 4.89, a % 1st ranking of 6.9, and a weight of 11.79. Campers had a M_{pref} of 3.34, a % 1st ranking of 2, and a weight of 5.34 (Table 1). The mean difference across all recreational activities is statistically significant except for target shooters and campers.

Trails Greater Than 15% Slope

OHV riders had a M_{pref} of 6.24, % 1st ranking of 12.9, and weight of 19.14. Shooters had a M_{pref} 3.37, % 1st ranking of 5, and a weight of 8.37. Hikers had a M_{pref} 5.62, a % 1st ranking of 14.7, and a weight of 20.32. Campers had a M_{pref} of 3.64, a % 1st ranking of 3, and a weight of 6.64 (Table 1). The mean difference across all recreational activities is statistically significant except for target shooters and campers.

Paved Roads

OHV riders had a M_{pref} of 2.21, % 1st ranking of 1, and weight of 3.21. Shooters had a M_{pref} of 3.64, % 1st ranking of 4, and a weight of 7.64. Hikers had a M_{pref} 2.96, a % 1st ranking of 1, and a weight of 3.96. Campers had a M_{pref} of 3.89, a % 1st ranking of 2, and a weight of 5.89 (Table 1). The mean difference across all recreational activities is statistically significant except for target shooters and campers.

More Than 5 Miles of Connected Trail

OHV riders had a M_{pref} of 6.42, % 1st ranking of 24.8, and weight of 31.22. Shooters had a M_{pref} of 2.98, % 1st ranking of 0 , and a weight of 0. Hikers had a M_{pref} 5.66, a % 1st ranking of 12.7, and a weight of 18.36. Campers had a M_{pref} of 4.4, a % 1st ranking of 1, and a weight of 5.4 (Table 1). The mean difference across all recreational activities is statistically significant.

Dirt Road

OHV riders had a M_{pref} of 6.29, % 1st ranking of 4, and weight of 10.29. Shooters had a M_{pref} of 4.65, % 1st ranking of 1, and a weight of 5.65. Hikers had a M_{pref} 4.89, a % 1st ranking of 1, and a weight of 5.89. Campers had a M_{pref} of 5.56, a % 1st ranking of 3, and a weight of 8.56 (Table 1). The mean difference across all recreational activities is statistically significant.

Clear Shooting Lanes With Backstop

OHV riders had a M_{pref} of 3.82, % 1st ranking of 2, and weight of 5.82. Shooters had a M_{pref} of 6.27, % 1st ranking of 26.7, and a weight of 32.97. Hikers had a M_{pref} 3.63,

a % 1st ranking of 1, and a weight of 4.63. Campers had a M_{pref} of 3.47, a % 1st ranking of 2, and a weight of 5.47 (Table 1). The mean differences for camping, hiking, and OHV riding are not statistically significant, but the mean difference for target shooting is statistically significant.

Single Track Trails

OHV riders had a M_{pref} of 5.45, % 1st ranking of 17.8, and weight of 23.25. Shooter had a M_{pref} of 2.58, % 1st ranking of 0, and a weight of 2.58. Hikers had a M_{pref} 5.29, a % 1st ranking of 2, and a weight of 7.29. Campers had a M_{pref} of 4.04, a % 1st ranking of 1, and a weight of 5.04 (Table 1). The mean difference across all recreational activities is statistically significant.

Close to Washes

OHV riders had a M_{pref} of 4.91, % 1st ranking of 2, and weight of 6.91. Shooters had a M_{pref} of 4.15, % 1st ranking of 4, and a weight of 8.15. Hikers had a M_{pref} 3.04, a % 1st ranking of 0, and a weight of 3.04. Campers had a M_{pref} of 4.64, a % 1st ranking of 9.9, and a weight of 14.54 (Table 1). The mean differences for camping, target shooting, and OHV riding are not statistically significant, but the mean difference for hiking is statistically significant.

Parking

OHV riders had a M_{pref} of 5.5, % 1st ranking of 9.9, and weight of 15.4. Shooters had a M_{pref} of 4.67, % 1st ranking of 1, and a weight of 5.67. Hikers had a M_{pref} 4.88, a % 1st ranking of 13.7, and a weight of 18.58. Campers had a M_{pref} of 4.94, a % 1st ranking

of 5.9, and a weight of 10.84 (Table 1). The mean differences for camping, hiking, and target shooting are not statistically significant, but the mean difference for OHV riding is statistically significant.

At Least ½ Mile Away From Buildings

OHV riders had a M_{pref} of 6.51, % 1st ranking of 12.9, and weight of 19.41. hooters had a M_{pref} of 6.1, % 1st ranking of 14.9, and a weight of 21. Hikers had a M_{pref} of 4.28, a % 1st ranking of 7.8, and a weight of 12.08. Campers had a M_{pref} of 5.76, a % 1st ranking of 12.9, and a weight of 18.66 (Table 1). The mean difference for camping and target shooting is not statistically significant, but the mean difference for hiking and OHV riding is statistically significant.

Lots of Trees and Vegetation

OHV riders had a M_{pref} of 4.66, % 1st ranking of 0, and weight of 4.66. Shooters had a M_{pref} of 4.13, % 1st ranking of 10.9, and a weight of 15.03. Hikers had a M_{pref} 6.64, a % 1st ranking of 38.2, and a weight of 44.84. Campers had a M_{pref} of 6.36, a % 1st ranking of 57.4, and a weight of 63.76 (Table 1). The mean difference for camping and hiking is not statistically significant, but the mean difference for OHV riding and target shooting is statistically significant.

Wide-open Space

OHV riders had a M_{pref} of 5.37, % 1st ranking of 14.9, and weight of 20.27. Shooters had a M_{pref} of 5.31, % 1st ranking of 25.7, and a weight of 31.01. Hikers had a M_{pref} 2.73, a % 1st ranking of 0, and a weight of 2.73. Campers had a M_{pref} of 2.23, a %

1st ranking of 2, and a weight of 4.23 (Table 1). The mean difference across all recreational activities is statistically significant.

Similarities and Differences

Weight similarities are present with recreational groups and preferences. The most profound differences exist in preferences for campers and hikers vs. OHV riders and target shooters. For example, campers (W = 63.26) and hikers (W = 44.84) had a high preference for lots of trees, where OHV riders (W = 20.27) and target shooters (W = 31.01) had a high preference weight for wide-open spaces (Table 1).

Hikers (W = 20.32) and OHV riders (W = 19.14) had the highest weight ranking for having a preference for trails with a slope greater than 15%, while campers and target shooters had low suitability weights for terrain slope (Table 1). Furthermore, OHV riders (W = 23.25) had the highest preference for single-track trails and campers (W = 14.54) had the highest preference of being in close proximity to washes.

No two recreational groups had "0" for %1st ranking in the same terrain and infrastructure preference. However, there were multiple preferences where one "0" was present for %1st ranking (Table 1). For example, OHV riders reported 0 as their %1st ranking for lots of trees and target shooters reported 0 as their %1st ranking for single track trails (Table 1).

RSM Map Results

Results addressing Research Question 1 (What terrain features and infrastructure are most and least preferred by target shooters, OHV users, hikers, and campers?) are displayed in Figures 2-5. The RSM maps give land managers a spatial view of

recreationists' terrain and infrastructure preferences at the Lake Mountains area. For example, campers (Figure 4) and hikers (Figure 5) have high suitability values for the "lots of vegetation" preference (Table 1). Furthermore, campers prefer to be at least ½ mile from developed buildings or residences (Figure 4; Table 1), while hikers prefer trails with a slope greater than 15% (Figure 5; Table 1). It is assumed that campers and hikers prefer areas with more vegetation because it provides shade. Vegetation, such as trees, is scarce at the Lake Mountains making exposure to the sun a common occurrence.

OHV riders had high preference values for more than 5 miles of connected trails, single track trails, wide open spaces, and being at least ½ mile away from buildings or residences (Figure 2). Target shooters shared similar terrain preferences because they prefer wide-open spaces and being at least one-half mile away from building or residences (Figure 3). Target shooters differ from OHV riders because they preferred clear shooting lanes, and terrain that is less than a 15% slope. Weights for the preferences are displayed in Table 1.

Hikers had high preference for vegetation, trails greater than 15% slope, more than 5 miles of connected trails, and parking areas (Figure 5). Moreover, hikers had relatively low preference for paved roads, clear shooting lanes, being close to washes, and wide open spaces. Paved roads are not a major concern because Highway 68 is the only paved road in the Lake Mountains project boundary (Figure 5).

Hikers and campers both highly preferred areas with lots of vegetation (Figure 4-6). When zoning the Lake Mountains area, it is not expected that hikers and campers will have much recreational conflict between each group because both activities are nonmotorized. The Lake Mountains area is not a designated wilderness area so hikers or campers should not expect an experience that consists of solitude when visiting.

However, when zoning for hiking and camping, managers should look at areas with lots of vegetation, in the center of the Lake Mountain's geographical area, which is greater than 15% slope.

OHV riders preferred areas with single-track trails, more than 5 miles of connected trails, and in wide-open spaces. Generally, this terrain exists on the out-skirts of the Lake Mountains. It would be wise for land managers to zone around the Lake Mountains area, at least ½ mile away from where campers and hikers prefer (Figure 6). OHV riding can disrupt hiking and camping in many ways, including noise, pollution, dust, and public safety. Limiting OHV riding to at least ½ mile away from where campers and hiker prefer could dramatically reduce the chances of recreational conflict occurring between groups.

Target shooters preferred to shoot at least ½ mile away from urban development and where clear shooting lanes exist. Urban development is noted by the dark orange line (Figure 6) and the surrounding area in white is a ½ mile buffer. It would be wise for managers to limit target-shooting activities to the southern end of the Lake Mountains near where the Soldier Pass Shooting Range will be constructed. Furthermore, target shooting could be accommodated to the east of the Soldier Pass shooting range where OHV riding terrain is not preferable (Figure 6).

Discussion

Although researchers have explored preferences for different terrain based on activities with traditional RSM techniques in the past, researchers have not conducted RSM to explore how to prevent or reduce recreational conflict within a WUI through activity zoning. This research addressed the knowledge gap by evaluating the

relationships between terrain and infrastructure preferences of OHV riders, target shooters, campers, and hikers. Traditional RSM techniques were used in this study, and appear to offer an effective technique in WUI management. The methods and results have implications for public land managers interested in spatially assessing and addressing recreational conflict within WUI areas. Additionally, this discussion addresses Research Question 3 (Methodologically, what are the best RSM techniques for indexing, weighting, and mapping recreational zones in the WUI?).

GIS Techniques for Indexing and Mapping

RSM techniques were advanced from Beeco, et al. (2014) and Kliskey 2000. The RSM methods developed for this study advance knowledge for WUI management, on the traditional RSM landscape scale. The one-weight method employed in this research was crucial in properly understanding the quantitative questionnaire data. The weight gave priority to the '1' "most preferred to the '5' "fifth most preferred" feature results (Appendix D). The resulting information, after applying the weight, suggested what terrain and infrastructure preferences were preferred by the four types of recreationists. For example, campers had the highest weighted score for lots of trees (63.76). This preference result tells land managers that campers in the Lake Mountains prefer to be by vegetation. Moreover, if the BLM is planning to build a campground within the Lake Mountains area, being near vegetation is the most important terrain preference for campers.

These traditional RSM techniques are transferrable to other recreational landscapes within WUI's once terrain and infrastructure preferences are quantified with questionnaires. For example, these methods would transfer to other recreational

landscapes within a WUI, such as the North Oquirrh Mountains Management Area (Utah), by first identifying recreational groups using the area, identifying terrain and infrastructure preferences, and quantifying and measuring the relationships between terrain and infrastructure preferences with the differing recreational groups.

Further, the same method could be used for recreational landscapes not in a WUI. Moreover, the method could be adapted for recreational corridors, such as hiking trails like the Wasatch Crest Trail (Utah). Again, once recreational groups, terrain, and infrastructure preferences are identified, the information could be mapped, producing values for the preferences that can be used for recreational zoning. Although this study evaluated relationships between the terrain and infrastructure preferences of OHV riders, target shooters, hikers, and campers, the relationships of any outdoor recreational group could be evaluated with this method. For example, backpackers in a heavily forested area may prefer to camp in open meadows with hiking trails that have less than a 15% slope, which are both preferences that can be mapped. Using the weighting procedure described in this study would allow land managers to identify area where primitive campgrounds could be constructed and managed. Also, if the same area was popular for OHV riders that prefer riding through thick timber on trails greater than a 15% slope, those preferences could be mapped and compared. Land managers could use the resulting data to reduce recreational conflict between the two groups.

Management Implications

The RSM maps give land managers a spatial view of recreationists' terrain and infrastructure preferences at the Lake Mountains. For example, campers (Figure 4) and hikers (Figure 5) had high suitability values for the "lots of vegetation' preference (Table

1). Furthermore, campers preferred to be at least ½ mile from developed buildings or residences (Figure 4; Table 1), while hikers preferred trails with greater than a 15% slope (Figure 5; Table 1). Land managers could use these results for site improvement projects at the Lake Mountains. Constructing campgrounds near vegetation that is at least ½ mile away from buildings or residences would suit the campers who use the Lake Mountains.

A trail system would be suitable (red lines through elevation on Figure 5) to accommodate the two highest terrain and infrastructure preferences for hikers. Also, the third highest preference hikers had were "more than 5 miles of connected trails." According to the scale of the RSM map, the red line is longer than 5 miles (Figure 5). Constructing a hiking trail in the recommended area would accommodate hikers' top 3 preferences. Thus, the Lake Mountains would have a formal hiking route, opening up the area to many other types of recreationists. To further accommodate hikers, it would be recommended to construct developed parking areas. This would consist of significant site hardening, but two parking areas could be installed at the north and southwest ends of the Lake Mountains area where terrain is less than a 15% slope (Figure 5).

Hikers and OHV riders both had a high preference value for slope greater than 15%. Luckily, that is the only preference value they share high values with. Conflict between these two user groups can come in many forms (e.g., noise, dust, safety). When considering recreational use zones for these two groups, vegetation is key. Hikers (Figure 5) preferred lots of vegetation and OHV riders preferred wide-open spaces (Figure 2), meaning that where there is lots of vegetation and terrain greater than 15% would be a good use zone for hikers. Compare this to OHV riders, where wide-open spaces with terrain greater than 15% would be highly suitable and preferred.

Recreational conflict between target shooters and OHV riders could be avoided

by being cognizant of what preferences are combined with creating an activity zone within the wide-open space preference. Target shooters identified having a high preference value for areas with clear shooting lanes (Figure 3; Table 1). These have been identified in the base map and are well known areas in the Lake Mountains. Making OHV riding prohibited near these clear shooting lanes could reduce the level of conflict between the two user groups.

The combined RSM feature map (Figure 6) is a visual tool that managers can refer to when making activity zones for the Lake Mountains area. Campers and hikers preferred areas with lots of vegetation, and zoning for these two activities in the middle of the Lake Mountains where vegetation exists, slope is greater than 15%, and infrastructure for a hiking trail is present is highly recommended. The Lake Mountains is not a wilderness area so campers and hikers should not expect solitude when recreating there. In fact, hikers and campers shared a lot of the same suitability preferences for terrain and infrastructure (Figure 4-5), and zones for the two activities should have more similarities than differences.

Campers' and target shooters' mean difference for terrain greater than 15% was not statistically significant (Table 1). The result may mean there is the possibility of conflict over this one variable. Land managers need to be cognizant of this and that is why it is recommended for target shooting not to be allowed in the center of the Lake Mountains, where campers have high suitability (Figure 6). Furthermore, target shooters prefer areas that are at least ½ mile away from urban development and where clear shooting lanes exist. Terrain and infrastructure best suit target shooters at the south end of the Lake Mountains near the Soldier Pass Shooting Range (Figure 6).

Finally, OHV riders preferred trails that are connected by more than 5 miles, wide

open spaces, and terrain greater than 15% (Figure 2; Figure 6). It is recommended to keep OHV riding to the outside edge of the Lake Mountains, and not allow it in the center where hiking and camping can be concentrated. Land managers should consider turning existing informal dirt-roads into OHV riding trails. The route going from vegetation polygon to vegetation polygon (Figure 6) should be zoned for hiking only. Keeping hiking trails and OHV trails separate could dramatically reduce the recreational conflict between the two user groups.

Conclusion

Recreation Suitability Mapping (RSM), used in this study, demonstrates how social-spatial data could be incorporated in outdoor recreation planning at multiple scales. Additionally, RSM contributed to thoroughly understanding recreational groups' preferences and suitable terrain and infrastructure for the specific recreation activities. This method was of particular importance because the study area experiences high spatial demand and potential conflict between user groups. Furthermore, it demonstrated its usefulness in addressing recreational conflict within a Wildland-Urban Interface (WUI). This study served as a foundation for public land managers and researchers to advance and contribute to the method.

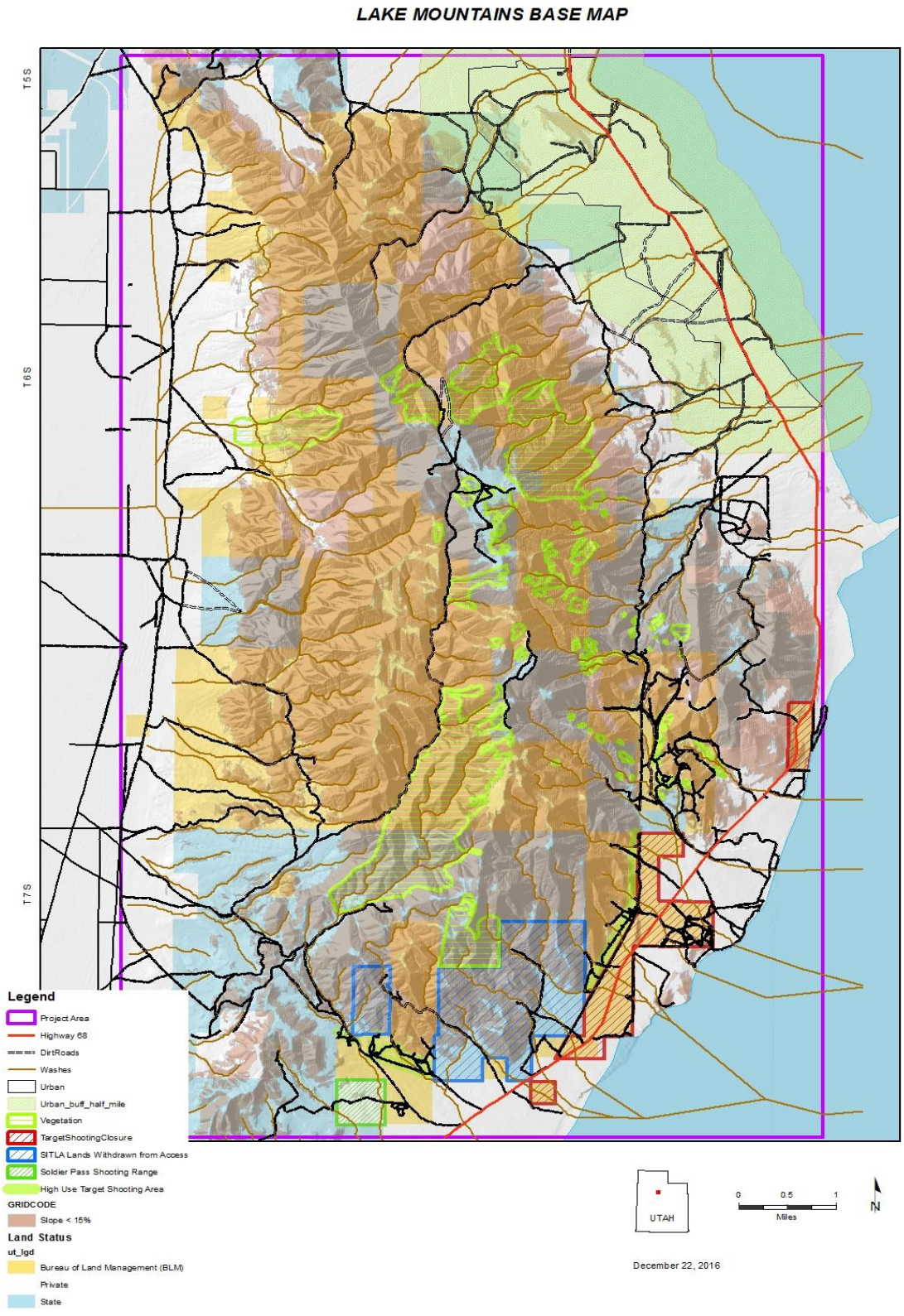

Figure 1. Base map of the Lake Mountains project area

Table 1. *Preference values of each activity*

Preferences		OHV	Shooters	Hikers	Campers	F-value
Trails < 15%	M_{pref} (sd)	3.91 (2.16)^a	2.84 (2.16)^b	4.89 (1.69)^c	3.34 (1.83)^b	20.2**
	% 1st ranking	0	6.9	6.9	2	-
	Weight	3.91	9.74	11.79	5.34	-
Trails > 15%	M_{pref} (sd)	6.24 (1.01)^a	3.37 (2.09)^b	5.62 (1.50)^c	3.64 (2.19)^b	65.6**
	% 1st ranking	12.9	5	14.7	3	-
	Weight	19.14	8.37	20.32	6.64	-
Paved roads	M_{pref} (sd)	2.21 (1.66)^a	3.64 (1.92)^b	2.96 (2.00)^c	3.89 (2.25)^b	14.9**
	% 1st ranking	1	4	1	2	-
	Weight	3.21	7.64	3.96	5.89	-
Dirt roads	M_{pref} (sd)	6.29 (1.01)^a	4.65 (1.65)^b	4.89 (1.32)^c	5.56 (1.02)^d	33.4**
	% 1st ranking	4	1	1	3	-
	Weight	10.29	5.65	5.89	8.56	-
Clear shooting lanes	M_{pref} (sd)	3.82 (2.11)^a	6.27 (1.15)^b	3.63 (2.35)^a	3.47 (2.19)^a	43.8**
	% 1st ranking	2	26.7	1	2	-
	Weight	5.82	32.97	4.63	5.47	-
Single track trails	M_{pref} (sd)	5.45 (1.71)^a	2.58 (1.69)^b	5.29 (1.53)^c	4.04 (1.92)^d	60.3**
	% 1st ranking	17.8	0	2	1	-
	Weight	23.25	2.58	7.29	5.04	-
Close to washes	M_{pref} (sd)	4.91 (1.68)^a	4.15 (1.90)^a	3.04 (1.74)^b	4.64 (1.94)^a	20.9**
	% 1st ranking	2	4	0	9.9	-
	Weight	6.91	8.15	3.04	14.54	-
Parking	M_{pref} (sd)	5.5 (1.39)^a	4.67 (1.71)^b	4.88 (1.70)^b	4.94 (1.78)^b	4.5**
	% 1st ranking	9.9	1	13.7	5.9	-
	Weight	15.4	5.67	18.58	10.84	-
½ mile away from buildings	M_{pref} (sd)	6.51 (0.90)^a	6.1 (1.43)^b	4.28 (1.97)^c	5.76 (1.39)^b	43.9**
	% 1st ranking	12.9	14.9	7.8	12.9	-
	Weight	19.41	21	12.08	18.66	-
Lots of trees	M_{pref} (sd)	4.66 (1.83)^a	4.13 (1.88)^b	6.64 (0.65)^c	6.36 (1.10)^c	72.8**
	% 1st ranking	0	10.9	38.2	57.4	-
	Weight	4.66	15.03	44.84	63.76	-
Wide open spaces	M_{pref} (sd)	5.37 (1.78)^a	5.31 (1.77)^b	2.73 (1.59)^c	2.23 (1.58)^d	98.8**
	% 1st ranking	14.9	25.7	0	2	-
	Weight	20.27	31.01	2.73	4.23	-
More than 5 miles of connected trails	M_{pref} (sd)	6.42 (2.22)^a	2.98 (1.89)^b	5.66 (1.20)^c	4.4 (2.22)^d	85.6**
	% 1st ranking	24.8	0	12.7	1	-
	Weight	31.22	2.98	18.36	5.4	-

Note. Mean values scaled from '1' (not preferable) to '7' (highly preferable); mean values with different superscripts within a row indicate statistical significance at $p < 0.05$; ** $p < 0.01$

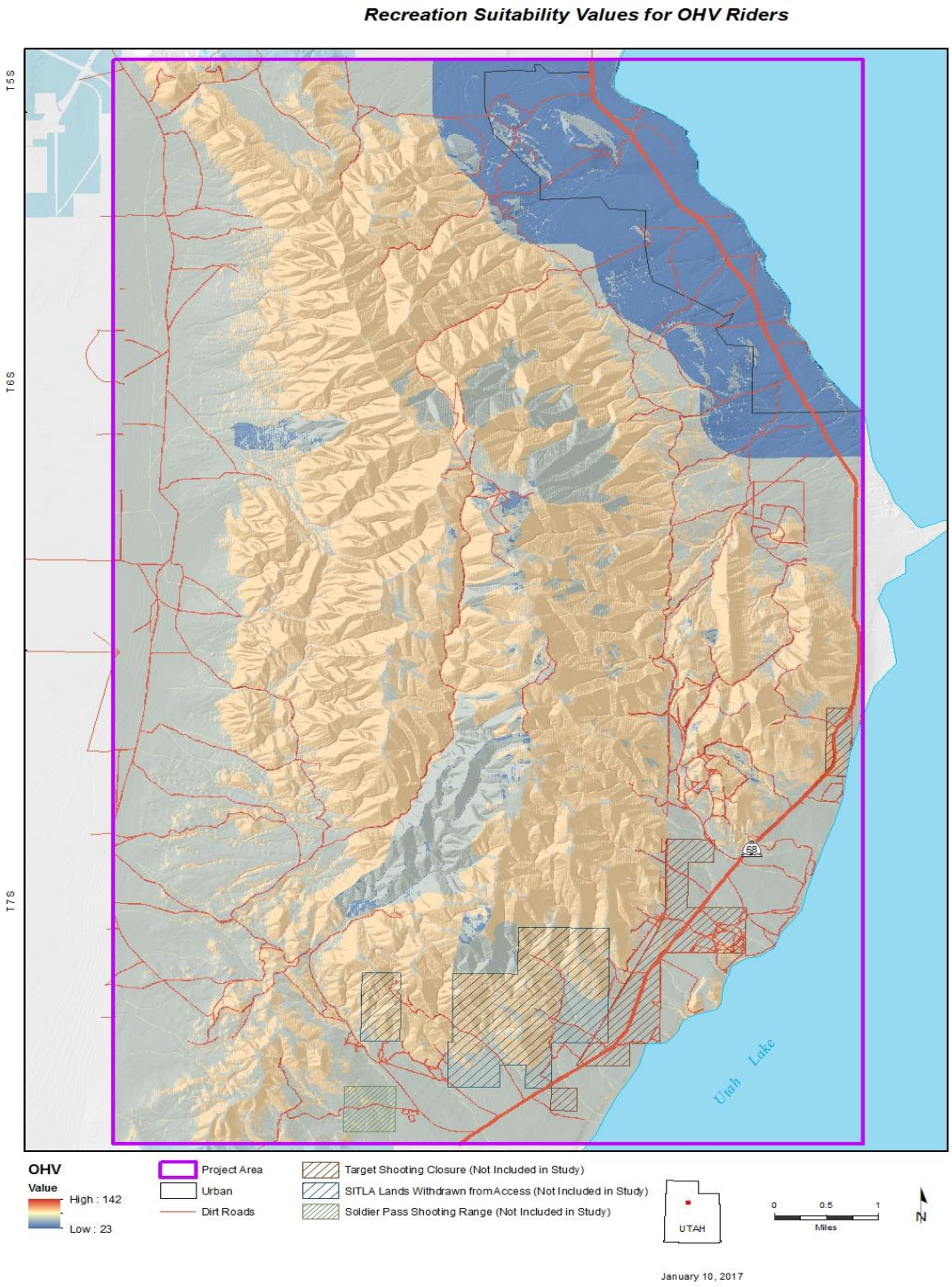

Figure 2. Map layer of OHV suitability. Suitability values ranged from '23' to '142.'

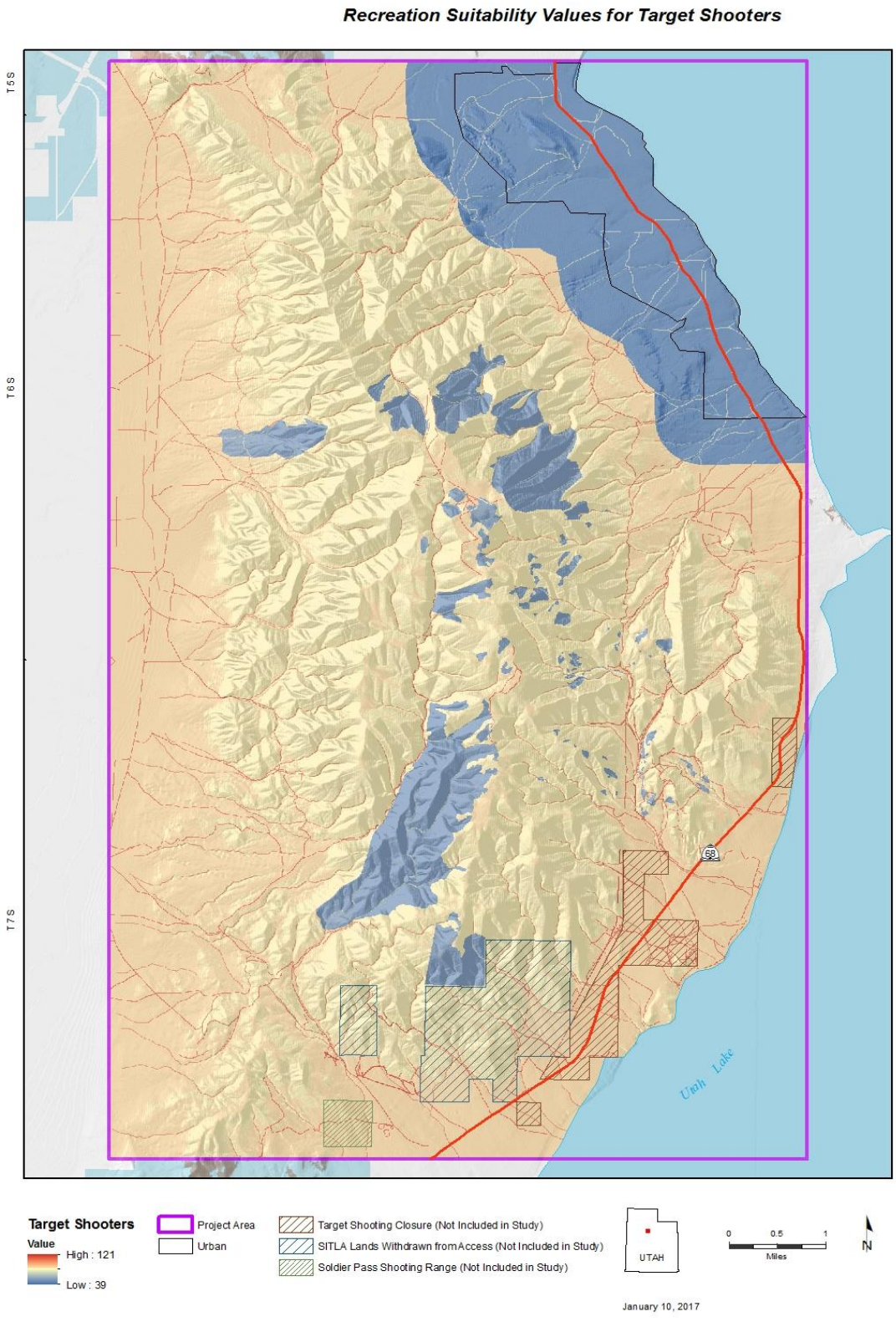

Figure 3. Map layer for Target Shooting suitability. Scores ranged from '30' to '121.'

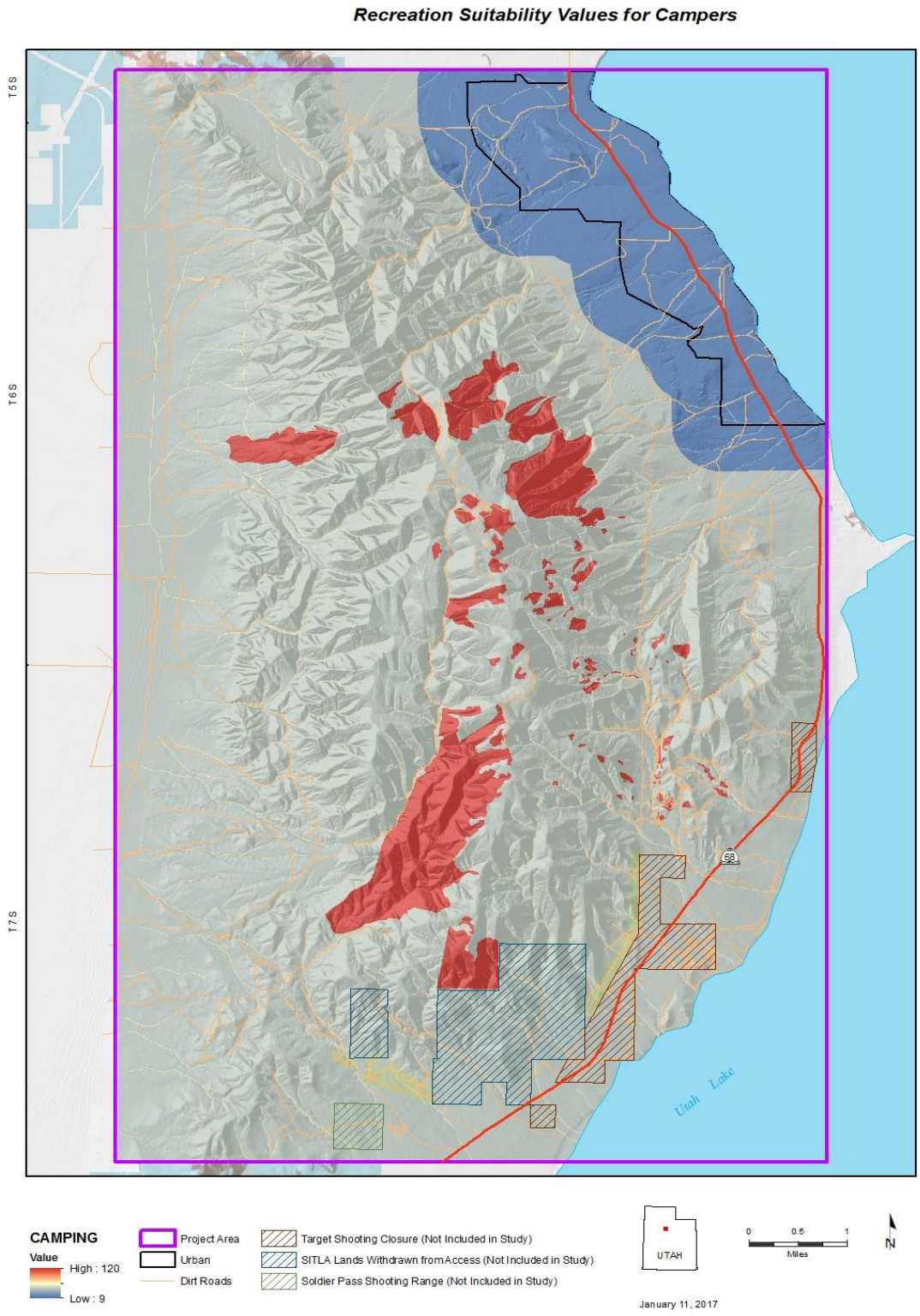

Figure 4. Map layer for Campers suitability. Scores ranged from '9' to '120.'

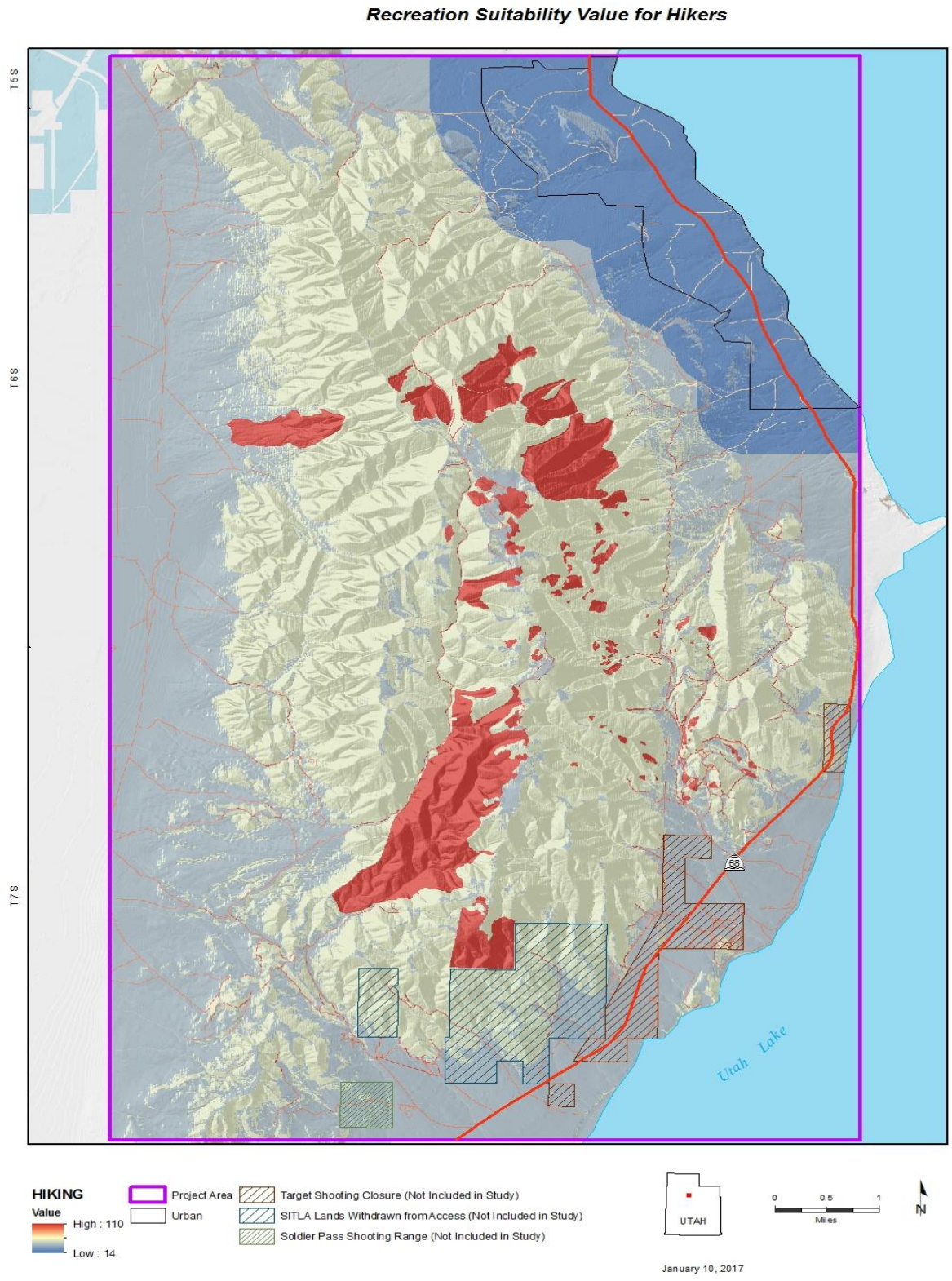

Figure 5. Map layer for Hiking suitability. Scores ranged from '14' to 110.'

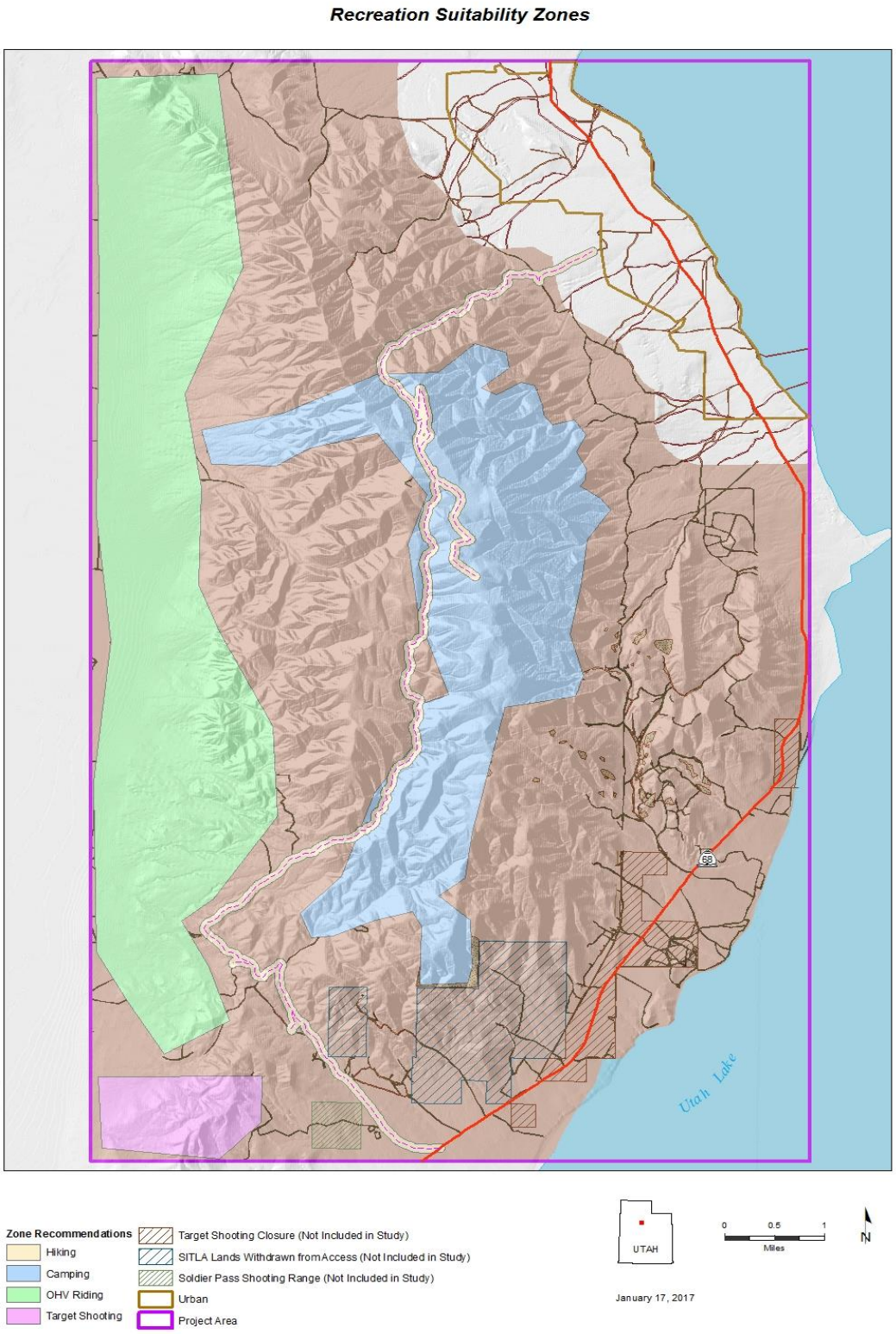

Figure 6. Map layer for combined suitability preference.

CHAPTER 3

SUMMARY AND CONCLUSIONS

Reflections on Learning

Introduction

The purpose of this chapter is to review the thesis experience and discuss the difficulties, adversity, successes, and discoveries that were uncovered during the process, as well as offer advice to future students. The complete thesis progression is accounted for in the 'reflections on learning' section. The insights on successes and failures, as well as what I have gained and learned about conducting research, technical writing, and myself during the process is discussed in subsequent paragraphs.

Challenges

Challenges began at the very beginning of my master's program because I was honestly not sure if I wanted to study the social science side of natural resource management or ecology. I began my master's program while working at the BLM. I was very excited to be there and soon learned from work experience that social science and human dimensions expertise is very much needed in public land management. However, working full-time and doing a master's program full-time is an exhausting task, and I would not recommend it to anyone.

I started my master's program with so many interests related to public land management, and immediately realized I needed to narrow them to develop a thesis project. After many discussions and meetings with my advisor, a project for my BLM office was selected. We set up a meeting with BLM managers to form research questions that would further the management of the Lake Mountains, and that I was interested in.

Working for the BLM, I realized that incorporating GIS into a project was a wise choice because GIS is used frequently for land management projects. A concern for me was the limited experience I had in creating my own project and applying GIS techniques to it. While completing my master's course work, I also completed a graduate certificate in Urban Planning. Part of the curriculum was a 'GIS in Planning' course. This class proved to be very beneficial because it gave me basic GIS knowledge and educated me on GIS terminology. With this new information, I started to coordinate with the GIS specialist in my BLM office. Luckily, she was very supportive and a great mentor in GIS techniques and applications.

Challenges arose with questionnaire distribution at the Lake Mountains. At first, the goal was to distribute some of the questionnaires via an online format. When that did not work out, I prepared to distribute questionnaires with the help of two seasonal park rangers at my office. When we were about to begin, one of the field office managers informed me that I could no longer use the seasonal rangers because the federal employee Paper Reduction Act prohibits federal employees from administering paper questionnaires to the public. I then proceeded with data collection and administered 405 questionnaires at the Lake Mountains by myself. Luckily, there were days that I could do it as part of my work duties, but other days, I had to go after work or on the weekends to administer questionnaires.

Finally, one of the greatest challenges to this thesis work was the insanely tight deadline at the end. I was extremely fortunate to be offered a job from the National Park Service, but first needed to complete all graduate work. I had already started writing a good portion of my thesis, but I needed to condense my final analysis and writing into roughly a 2-week period. There were moments of extreme stress, fatigue, and frustration, but in the end, it proved to be one of the most rewarding accomplishments of my life.

Successes

My critical thinking and problem solving skills were improved tremendously from the thesis process. I can recall multiple times that problems arose, mainly GIS ones, and I was forced to think through them. It quickly became apparent that I needed to address the problem at once instead of putting them off. Seeking help consisted of calling my advisor for discussions and asking the SLFO GIS specialist for assistance. This opened my eyes and helped me to stop procrastinating with certain areas of life.

The mental strain of completing a thesis is something that is not regularly discussed. I definitely built up mental toughness skills due to this process. Being able to bounce back from adversity is a skill that helps one deal with failure. There were many low points where I felt like giving up, but persistence and passion for public land management pulled me through. Taking shortcuts was very tempting, but I knew if I did this, my work would not be the absolute best that I could make it. Having the constant support of my committee inspired me to want to do the best work possible.

Discoveries

The major finding of the study is where the overall learning of the process was discovered. Doing a thesis project for an actual problem area was very exciting because the research can be used in real life, and not set on an academic shelf to collect dust. Writing about possible management implications is a joy because it is the first step towards making positive management decisions that contribute to the overall management of public land. Furthermore, intentional WUI management is needed and will be extremely important with an increasing population.

Other discoveries were also made during the process. For example, time management is a skill that can always be improved. Balancing work, thesis work, and my personal life was extremely difficult and I would not have been able to do it without actively working on my time management skills. Making detailed schedules and holding myself accountable to the deadlines is a life skill that can be applied to many life situations. Another discovery was that open communication is key to a successful project. Keeping my advisor and graduate committee up-to-date on my thoughts, experiences, and deadlines is essential to success.

Advice

One of the biggest pieces of advice I can offer to students is to wisely pick their graduate committee. They really do make or break the experience of a graduate education, and I can honestly say that my graduate committee was an absolute joy to work with. Also, select a topic that you are passionate about because there will be many late nights and social events missed. Being passionate about the topic will ease the frustration that stems from the lack of sleep, and not spending time with family and

friends.

Putting an individual ego aside is another piece of advice that I will offer. There are times when I had good days and bad days. Sometimes on the bad days, I would ask questions that were very basic, but since I was having a bad day, the question seemed difficult. This will happen to anyone completing a graduate degree, and having the willingness to ask questions will alleviate a lot of stress and wasted time. Do not be afraid to make mistakes because they are inevitable.

My final piece of advice would be to enjoy the experience. At first, 2 years seems like a long time, but in the end, it seems like graduate school was a blink of an eye. A graduate education is so different from an undergraduate education because the relationships formed are on a deeper level, and how much more in-depth subjects are covered is not even comparable. Taking a few moments to realize that graduate school is a unique experience and to enjoy it more is something I wish I would have known. The relationships built and the education gained is something that will stay with me for a lifetime.

APPENDIX A

INITITIAL INTERNAL SURVEY

The initial survey was intended to see what four types of recreation occur at the Lake Mountains. It was administered internally at the BLM SLFO to all field office employees.

Initial Questionnaire

1. All of these activity groups are potential users of Lake Mountains. How important is managing for:

Not Important **Extremely Important**
1 **7**

OHV Riders
Bird Watchers
Campers
Hikers
Target Shooters
Mountain Bikers
Trail Runners
Rock Art Viewers
Hunters
Wildlife Viewers

2. From the list above, please select the four activities that are most important to manage at the Lake Mountains. (1 = most important)

1
2
3
4

APPENDIX B

SEMISTRUCTURED INTERVIEW QUESTIONS

The initial interview was designed using a modified Seidman Approach (Seidman, 2012). The interview is administered orally to 5 participants in each group of recreation studied.

Purpose: To finalize the top 10 preferences used in the quantitative questionnaire used at the Lake Mountains.

Interview Script

The investigator used a modified Seidman Approach (Seidman, 2013, p. 20) to structure the interview process. This process involved two sequential categories that allow respondents' to share there top ten terrain and infrastructure preferences. The first step involved me explaining the study and why I need to narrow down a list of 32 terrain and infrastructure preferences to ten. Next, I distributed a form for respondents' to circle and rank order their top ten preferences.

Initial question

1. Did you have a chance to read the consent form that we emailed you? If not, would you mind reading a hard copy before continuing?

Focused History

1. Please start by telling us about how you recreate at the Lake Mountains area?
2. How long have you been recreating at the Lake Mountain?
3. In a given year, how often do you visit the Lake Mountain?
4. Please describe your typical visit to the Lake Mountains.

Perceptions, insights, and experiences

1. It is thought that the Lake Mountains are primarily used for target shooting. Do you agree with this? Why or why not?
2. Does the Lake Mountains, being located in close proximity to urban areas, influence your decision to recreate there? Why or why not?
3. What are the key challenges, if any, that you have experienced while recreating at the Lake Mountain?

Reflection and meaning

1. What do you think will happen in the future with the Lake Mountains?
2. How has your interaction(s) with other types of recreationists at the Lake Mountains been?

3. We are interested in speaking to other target shooters, hikers, campers, and OHV riders who hold diverse experiences and opinions about the area. Who else do you recommend we contact? Why?

PLEASE INDICATE YOUR TOP 10 PREFERENCES AND IDENTIFY ANY NOT ON THE LIST

Terrain and Infrastructure Preferences

1. Tree density
2. Slope of road
3. Slope of trail
4. Paved road
5. Dirt road
6. Gravel road
7. OHV trail
8. Single track trail
9. Trail that is deeply incised
10. Connectivity of trails
11. Proximity to urban area
12. Bulletin boards with signing
13. Signing with rules and regulations
14. Signing with management presence (BLM land)
15. Management not present (areas with no signing or boundaries)
16. Fences
17. Potable water location
18. Proximity to parking area
19. Developed parking lot
20. Slope for proper shooting backstop
21. Clear shooting lanes
22. Presence of vegetation (e.g., cheat grass)
23. Pinyon Pine present
24. Juniper Trees present
25. View of Utah Lake
26. Proximity to cultural resources
27. Proximity to urban infrastructure
28. Proximity to washes
29. Trails with high rugosity
30. Groomed trails
31. Proximity to houses
32. Opportunity to see wildlife
33. Distance of trails

Write any preferences not listed:

APPENDIX C

IRB STATEMENT

INSTITUTIONAL REVIEW BOARD
THE UNIVERSITY OF UTAH

75 South 2000 East Salt Lake City, UT 84112 | 801.581.3655 | IRB@utah.edu

IRB: IRB_00093462

PI: Arben Kraja

Title: Questionnaire - Recreation Suitability Mapping to address Recreational Conflict within the Wildland-Urban Interface

Date: 7/10/2016

The above-referenced protocol has received an IRB exemption determination and may begin the research procedures outlined in the University of Utah IRB application and supporting documents.

EXEMPTION DOCUMENTATION

Review Type: Exemption Review
Exemption Category(ies): Category 2
Exemption Date: 7/10/2016

Note the following delineation of categories:

- Categories 1-6: Federal Exemption Categories defined in 45 CFR 46.101(b)
- Categories 7-11: Non-Federal Exemption Categories defined in University of Utah IRB policy in Investigator Guidance Series, Exempt Research

You must adhere to all requirements for exemption described in University of Utah IRB policy in (Investigator Guidance Series, Exempt Research). This includes:

- All research involving human subjects must be approved or determined exempt by the IRB before the research is conducted.
- All research activities must be conducted in accordance with the Belmont Report and must adhere to principles of sound research design and ethics.
- Orderly accounting and monitoring of research activities must occur.

Ongoing Submissions for Exempt Projects

- **Continuing Review:** Since this determination is not an approval, the study does not expire or need continuing review. This determination of exemption from continuing IRB review only applies to the research study as submitted to the IRB. You must follow the protocol as proposed in this application
- **Amendment Applications:** Substantive changes to this project require an amendment application to the IRB to secure either approval or a determination of exemption. **Investigators should contact the IRB Office if there are questions about whether an amendment consists of substantive changes.** Substantive changes include, but are not limited to
  - Changes to study personnel (to secure Conflict of Interest review for all personnel on the study)
  - Changes that increase the risk to participants or change the risk:benefit ratio of the study
  - Changes that affect a participant's willingness to participate in the study
  - Changes to study procedures or study components that are not covered by the Exemption Category determined for this study (listed above)
  - Changes to the study sponsor
  - Changes to the targeted participant population
  - Changes to the stamped consent document(s)
- **Report Forms:** Exempt studies must adhere to the University of Utah IRB reporting requirements for unanticipated problems and deviations: http://irb.utah.edu/submit-application/forms/index.php
- **Final Project Reports for Study Closure:** Exempt studies must be closed with the IRB once the research activities are complete: http://irb.utah.edu/submit-application/final-project-reports.php

SUPPORTING DOCUMENTS

Informed Consent Document
Updated Consent

Surveys, etc.
Thesis Questionnaire

Click IRB_00093462 to view the application.

Please take a moment to complete our customer service survey. We appreciate your opinions and feedback.

APPENDIX D

QUESTIONNAIRE

Visitors' Infrastructure and Terrain Preferences at the Lake Mountains

Important questions for Potential Lake Mountain Users

The purpose of this project is to evaluate recreationists' terrain and infrastructure preferences for the Lake Mountains with the intent of informing planning decisions

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Conducted by

Outdoor Recreation, Education, & Tourism Lab
COLLEGE OF HEALTH | THE UNIVERSITY OF UTAH

Researcher use only:

Questionnaire Number: _____ Staff (first initial/last name):_____

Site (#): _____ Date (mm/dd): _____ / _____ Time (am/pm): _____

Activity: _____

Notes:_____

_____

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1. From the list below, what do you consider your primary recreational activity? *(please select one)*

   - ❑ Camping
   - ❑ Hiking
   - ❑ OHV Riding
   - ❑ Target Shooting

2. Please tell us about *your past experience* as a camper, hiker, OHV riders, or target shooter.

   a. Including today, approximately how many days in the last year (12 months) did you engage in your primary recreational activity?_____

   b. Including today, approximately how many days in the last month (30 days) did you engage in your primary recreational activity?_____

   c. Including today, how many days in the last week (7 days) did you engage in your primary recreational activity? (*check only one*)

   ❑ 1 day ❑ 2 days ❑ 3 days ❑ 4 days

   ❑ 5 days ❑ 6 days ❑ 7 days

   d. On average, how much time do you spend during each outing for your primary activity?

   ❑ less than one hour ❑ 1 hour ❑ 2 hours ❑ 3 hours

   ❑ 4 hours ❑ 5 hours ❑ 6 hours ❑ 7 hours

   ❑ 8 hours ❑ 9 hours ❑ 10 hours ❑ 11 + hours

3. Please tell us about *your past experience* at the Lake Mountains area. Before answering the questions below, please refer to the map provided with this questionnaire.

   a. Have you ever used or visited the Lake Mountains area for recreation? *(please select one)*

      - ❑ Yes (please complete the questions below, 3b – 3e)
      - ❑ No (please skip to Question # 4)

   b. Including today, approximately how many days in the last year (12 months) did you engage in recreational activities at the Lake Mountains area?_____

   c. Including today, approximately how many days in the last month (30 days) did you engage in recreational activities at the Lake Mountains area?_____

d. Including today, how many days in the last week (7 days) did you engage in recreational activities at the Lake Mountains area? (*check only one*)

❑ 1 day	❑ 2 days	❑ 3 days	❑ 4 days
❑ 5 days	❑ 6 days	❑ 7 days	

e. On average, how much time do you spend during each outing at the Lake Mountains area? (*check only one*)

❑ less than one hour	❑ 1 hour	❑ 2 hours	❑ 3 hours
❑ 4 hours	❑ 5 hours	❑ 6 hours	❑ 7 hours
❑ 8 hours	❑ 9 hours	❑ 10 hours	❑ 11 + hours

4. We would like to know which terrain and infrastructure features you prefer related to potential Lake Mountain outdoor experiences. A rating of "1" indicates that you 'do not prefer' the terrain and infrastructure features and "7" means that you 'strongly prefer' the terrain and infrastructure features. *Circle one number for each row*

"In order to use a recreation area for my primary activity, I prefer an area…."	Do not prefer at all ←						→ Strongly prefer
that has trails less than a 15% slope	1	2	3	4	5	6	7
that has trails greater than a 15% slope	1	2	3	4	5	6	7
with paved roads	1	2	3	4	5	6	7
that has more than 5 miles of connected trails	1	2	3	4	5	6	7
with dirt roads	1	2	3	4	5	6	7
that has clear shooting lanes with a backstop	1	2	3	4	5	6	7
with single track trails	1	2	3	4	5	6	7
that is close to washes	1	2	3	4	5	6	7
with a developed parking lot and close proximity to parking	1	2	3	4	5	6	7
that is at least a one-half mile away from buildings or residencies	1	2	3	4	5	6	7
with lots of trees and vegetation	1	2	3	4	5	6	7
with wide open spaces with no trees or vegetation	1	2	3	4	5	6	7

Do not prefer at all ← → Strongly prefer

5. Please rank your **top five** most preferred terrain features and infrastructure features by writing a 1, 2, 3, 4, or 5 next to five of the rows below. Writing a "1" next to a terrain or infrastructure feature indicates that it is your "most preferred" feature and a "5" indicates that it is your "fifth most preferred" feature. Since you are ranking only the top five, some terrain features and infrastructure features will be left blank.

"In order to use a recreation area for my primary activity, I prefer an area…."

that has trails less than a 15% slope	____
that has trails greater than a 15% slope	____
with paved roads	____
that has more than 5 miles of connected trails	____
with dirt roads	____
that has clear shooting lanes with a backstop	____
with single track trails	____
that is close to washes	____
with a developed parking lot or close proximity to parking	____
that is at least a one-half mile away from buildings or residencies	____
with lots of trees and vegetation	____
with wide open spaces with no trees or vegetation	____

6. What is the zip code of your primary residence? _____

7. What year were you born? _____

8. What is your gender? *(select one)* ❑ Male ❑ Female ❑ Other

9. What is the highest level of school you have completed? *(select one)*

❑ Less than high school
❑ Some high school
❑ High school graduate
❑ Some college
❑ Two-year college graduate
❑ Four-year college graduate
❑ Graduate or professional degree
❑ Do not wish to answer

10. What is your race? *(select all that apply)*

❑ American Indian or Alaska Native
❑ Asian
❑ Black or African American
❑ Hawaiian or Pacific Islander
❑ Hispanic or Latino/Latina
❑ White
❑ Other
❑ Do not wish to answer

11. Which category best describes your total household income in U.S. dollars during 2015 before taxes? *(select one)*

❑ Less than $24,999
❑ $25,000 to $34,999
❑ $35,000 to $49,999
❑ $50,000 to $74,999
❑ $75,000 to $99,999
❑ $100,000 to $149,999
❑ $150,000 to $199,999
❑ $200,000 or more
❑ Do not wish to answer

12. Below, please provide any additional comments about the Lake Mountains area that could help managers.

Thank you for your help with this survey!
Please return it to the person who gave it to you.

Thank you for your help! If you have questions regarding this study, please contact:
Matthew Brownlee, Ph.D. | matthew.brownlee@hsc.utah.edu | 801-585-7239 | University of Utah

Outdoor Recreation, Education, & Tourism Lab
COLLEGE OF HEALTH | THE UNIVERSITY OF UTAH

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