# Are we on the same page? Informing adaptive management of outdoor rock climbing using document analysis and cognitive mapping

Thesis

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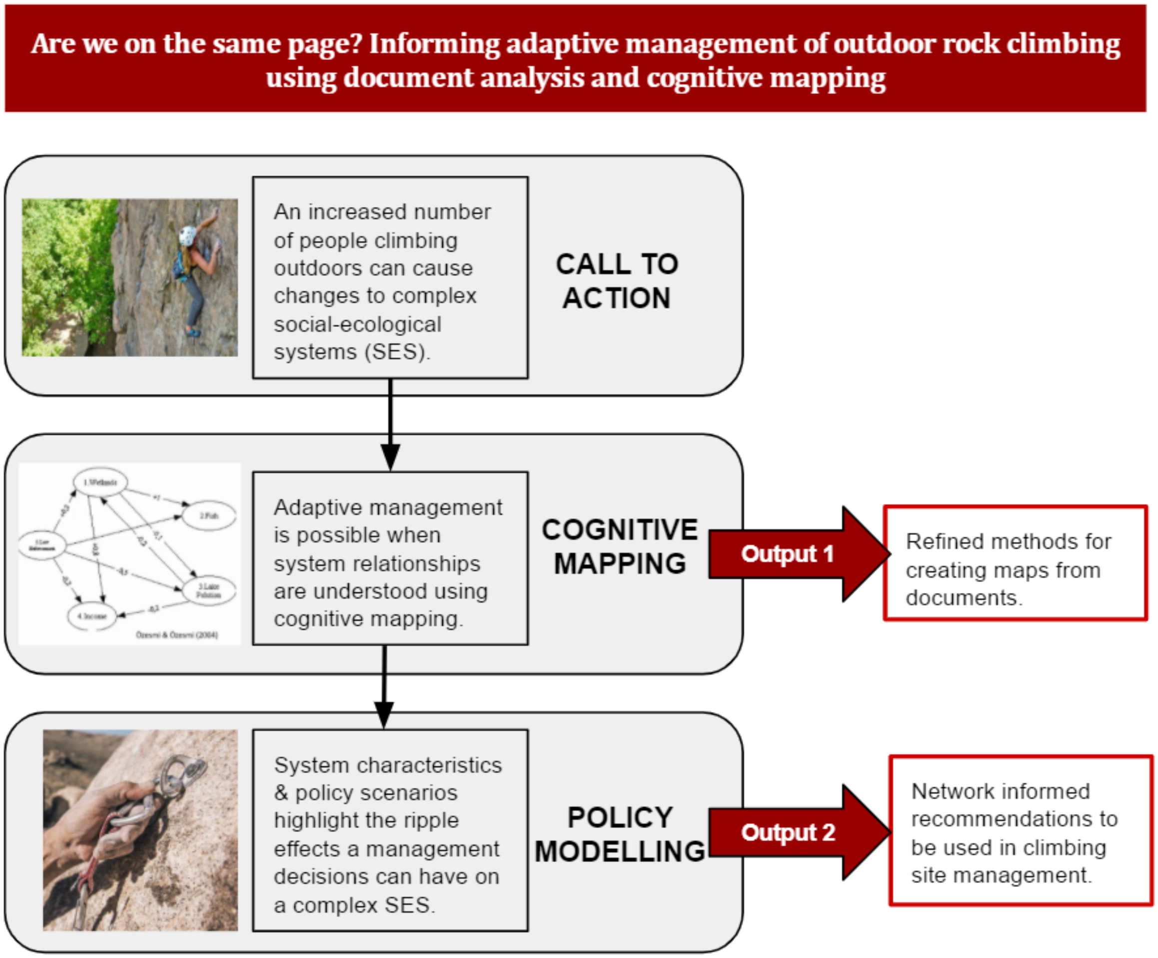
Abstract

Growth in outdoor climbing recreation has resulted in social and ecological impacts to the complex systems in which the activity occurs, necessitating adaptive management strategies that address the impacts and respond to changing conditions. Use of the Adaptive Management Framework (AMF) can aid land managers in developing policies that reach desired social and ecological outcomes (Williams & Brown, 2014). An assessment of current policies and a representative model of the social-ecological system in which climbing occurs could help land managers conduct systems-informed policy planning as part of the AMF. This study uses text to data analysis to identify and compare how social and ecological variables are described by existing climbing management plans (CMPs) across six land manager groupings (International, National Park, Forest Service, State, Coop/coalition, and Local/private). Causal link statements derived from collected CMPs were then analyzed to construct a cognitive map of the system to test 5 different policy scenarios. Results indicated the outdoor climbing system consists of 31 variables and 99 relationships among all variables. No significant difference was found across policy scenarios tested, suggesting a need for further development of the model through the refinement of the state of variables and the degree of relationship they have over other variables in the system. By establishing a model of the outdoor climbing system for policy planning, this study lays a foundation for the incorporation of systems thinking to the adaptive management of outdoor climbing.

Graphical Abstract



# Dedication

I dedicate this document to my grandpa Carl James.

Grandpa,

You have always believed in me and my dreams. The sacrifices you have made, like stepping away from completing you graduate studies to dedicate yourself to your growing family, paved a path for your future generations to thrive. While you may not have been able to finish your master's degree, if not for all that you have done for our family, I would not have known how far I could grow with hard work, dedication, and the support of loved ones. From dance lessons and milkshakes to career planning and travel sharing, you have always sparked joy, confidence, and adventure in my soul.

Thank you for helping me to become the person I am today.

With love,

tiger

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# Vita

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## Field of Study

Major Field: Environment and Natural Resources

Environmental Social Science specialization

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# Chapter 1. Introduction

Annually, 10 million Americans participate in outdoor climbing recreation (The Outdoor Foundation, 2017). The number of outdoor climbers is estimated to grow upwards of 86% by the year 2060 (Cordell, 2012). As engagement in the sport of rock climbing increases, so too have impacts on the social and environmental attributes associated with the places where climbing occurs (Attarian & Keith, 2008). The primary focus of existing scientific research on rock climbing and locations where the sport occurs has been on assessing impacts of outdoor climbing to the landscape (e.g., the rock face, social trials) and recommending management practices that protect specific species or resources, such as archaeological, biological, or social (Attarian & Pyke, 2000). These studies typically assume a cause-effect relationship that overlooks the dynamic interplay of social and ecological variables that constitute the overall outdoor climbing system.

This study aimed to extend the practice of studying outdoor climbing impacts from topic specific to system-wide to inform management of the locations in which climbing occurs. Systems thinking allows for a more complete understanding of how system attributes and actors interact (Bodin, 2017). Outdoor climbing systems include a wide variety of social and ecological *attributes*, such as vegetation, wildlife, natural soundscapes, and fixed safety anchors (Attarian & Keith, 2008). Likely *actors* involved in the outdoor climbing system include land managers, climbing specific coalitions, other climbing affiliated non-governmental organizations (NGOs), and individual climbers. The term 'land manager' here denotes anyone (or entity) who has the authority to design policies that affect a given climbing site. Coalitions and other NGOs consist of collectives of individuals acting to influence the actions of land managers regarding a climbing site or region. Individual climbers are predominately identified here by their recreational interest in and use of a landscape, though they may have some influence on policies created by land managers when actively engaged in decision-making processes. These actor types may not always be mutually exclusive as coalitions and/or NGOs may own and develop policies regarding climbing on their land. All these actors, alongside the ecological and social components affected by or affecting outdoor climbing, comprise the outdoor climbing system. Increasing understanding of the outdoor climbing system has the potential to further inform decision making processes to achieve desired management outcomes.

Outdoor climbing is largely managed through the shared adoption of the recommendations of two key outdoor education and advocacy actors: The Leave No Trace Center for Outdoor Ethics (LNTCOE) and Access Fund. The U.S. Forest Service (USFS), Bureau of Land Management (BLM), United State (U.S.) Fish & Wildlife Service (FWS), and the National Park Service (NPS) all formally partnered with the LNTCOE and adopted leave no trace (LNT) principles in 1994. These land managers in the U.S. later formalized the LNT principles with a Memorandum of Understanding (MOU) during the year 2000 (Clark, 2017). These principles have guided management for decades, though alone are not enough to manage the multitude of actors and impacts of the climbing management system.

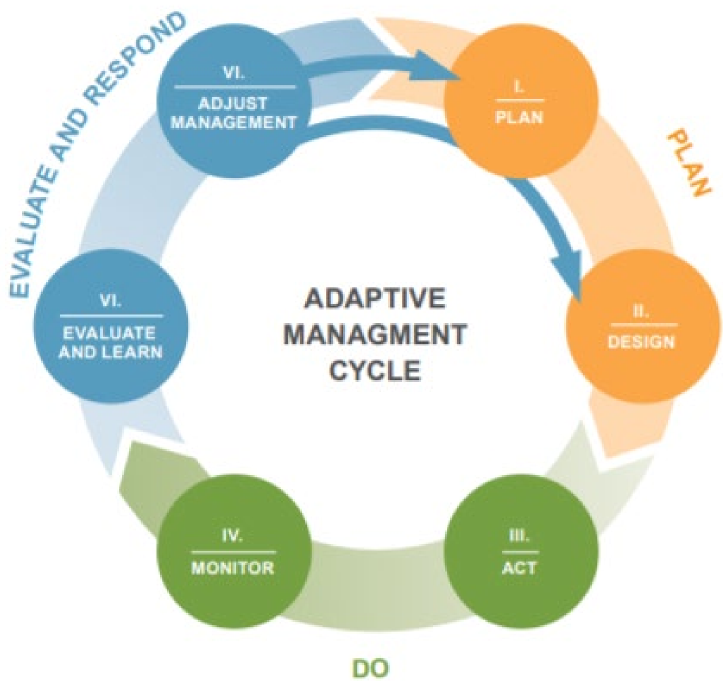
In response to the impacts of climbing on local areas, many organizations at different levels (e.g., state, federal) initiated climbing management plans (CMPs; McHugh, 2019). A CMP is a recreation specific management plan that acts as collection of system related policies for the management of climbing recreation users and site-related dimensions including physical infrastructure advancements, species protection, and climbing route development. Informal influence for the management of outdoor climbing is drawn from partnerships with the Access Fund, a non-profit organization focused on access and advocacy to outdoor climbing in the U.S., and their endorsed document outlining the process of constructing a management plan for outdoor climbing (Attarian & Keith, 2008). This informative document by Attarian and Keith (2008) does not address the complex, interconnectedness of system variables involved in the management of climbing sites and instead segments portions of the greater system out into six digestible chunks: the approach, staging area, the climb, the summit, the descent, and the camping. While reviewing the system in segments may help with understanding its components, managers run the risk of applying policies believed to have positive outcomes on one attribute that can have unexpected reciprocal or delayed impacts elsewhere in the system without considering all segments in the entire system during decision making (Cummings et al., 2016).

When considering the outdoor climbing landscape, management of the recreation activity is inconsistent across land management type and, at times, entirely absent (Murdock, 2019). Some sites lack a formal CMP, whereas other sites' CMPs were drafted before modern advancements such as bolted safety anchors and are now being re-evaluated based on the current management demands and associated impacts (McHugh, 2019). Murdock (2019) makes the argument that national climbing recreation management policies need further development to support the growing prevalence of climbing. The adaptive management framework (AMF) provides the further development needed to manage outdoor climbing systems.

The AMF is a proactive approach to management that approaches system related decision making in a "learn by doing" fashion and provides a means to achieve clear objectives using knowledge gleaned from iterative applications of informed policy planning, design, monitoring, and adjustment (Williams & Brown, 2014; Walters, 1997). Adaptive management is a way to achieve resilience in the management of complex SES who's social and ecological variables are undergoing consistent change due to external agents or relationships with other system variables (Williams & Brown, 2014). In this way, the adaptive management is appropriate for the outdoor climbing system due to its many complex relationships. For example, an increase in climbers can lead to a decrease in vegetation which can in turn lead to cliff base soil instability (McHugh, 2019).

Kovács et al. (2014) outlines adaptive management as a three stage cycle: 1) plan, 2) do and 3) evaluate and respond. The three stages of adaptive management allow for a scientific approach to policies that encourages learning and adjustment to meet the continual changes in a system. Rather than acting on assumptions of how a system will respond to human interventions, the planning stage of adaptive management involves goal development and system representation to inform management approach (Kovács et al., 2014). Dynamic modeling can help land managers as part of system representation by increase understanding of system variables and their relationships to inform management policies (Kovács et al., 2014).

Figure 1.1 Adaptive Management Cycle (Kovács et al., 2014).




This study aims to advance the potential application of the AMF to outdoor climbing by modeling the system through a review of established climbing management plans (CMPs). Specifically, this study will 1) conduct a comparative analysis of system representation across CMPs, 2) produce an outdoor climbing system model for future policy planning, and 3) use the developed model to test the impacts of hypothetical policy scenarios. A comparative analysis of CMPs will help to identify variation in management approaches across land manager groups, as well as identify the relationships that form the basis of the system model. Because there is limited knowledge surrounding outdoor climbing as a system, a document-derived cognitive map will be used to model the outdoor climbing system (Baker et al., 2018). Cognitive mapping is an approach to representing a system that build on the qualitative, static perceptions of key variables and their interconnections to produce dynamic models for policy testing (Gray et al., 2013). The constructed dynamic system model of outdoor rock climbing will then be used to understand impacts across the system following the targeted management of selected variable(s) in the form of policy scenarios. The ability to pre-test policies before implementation in the real world aids in predicting unforeseen effects and can highlight areas of uncertainty to target further planning prior to implementation (Baker et al., 2018; Cumming et al., 2016).

## 1.1 Research Objectives

The research has the following five overarching objectives:

1. Assess the content of publicly-available CMPs.
2. Identify causal link statements (CLS) within the CMPs denoting system variables and relationships to model the study system.
3. Develop a system model outlining key variables both social and ecological in nature.
4. Utilize the developed model to test policy scenarios.
5. Provide land management and stakeholder co-management recommendations for future climbing management policies.

## 1.2 Research Questions

This research focuses on constructing a system model of outdoor climbing for application in the adaptive management planning stages to select policies that align with desired management outcomes. The general research questions guiding this study are adapted from the management recommendations for climbing as a renewable economic resource outlined by Eric Murdock, policy director of the Access Fund, in his March 14, 2019 address to Chairman Murkowski, Ranking Member Manchin, and the U.S. Committee on Energy and Natural Resources (see:

https://static1.squarespace.com/static/54aabb14e4b01142027654ee/t/5ca22bba652dea11eadee173/1554131899094/AF+Testimony+ENR+Rec+Oversight+Hearing+032719.pdf).

The general research questions answered by this study include:

- What similarities and differences exist in the present policies on the social and/or ecological attributes of climbing across existing CMPs?
- Which variables affect the greatest change across the system?
- How do various policy scenarios affect the system?

## Chapter 2. Literature Review

### 2.1 The State of Outdoor Climbing

The modern form of rock climbing as a recreational activity consists of climbing a rock face from bottom to top and stems from the vertical climbing elements of mountaineering (McHugh, 2019). The rock climbing grew in popularity in the early 1990s as more youth gained access through the advancement of safety equipment such as bolted safety anchors and the development of indoor gyms (McHugh, 2019). Today, nearly 10 million Americans engage in the sport annually and roughly 60% of rock climbing development is located on public lands (The Outdoor Foundation, 2017, "THIS LAND IS OUR LAND: Climbing on Public Lands," 2016). Ecological attributes that can be impacted by climbing activity can include vegetation, soil stability, natural soundscape, water quality, and wildlife. Social attributes affected by, or stemming from, climbing include site aesthetics, pets, pollution, litter, guiding and commercial services, parking and transportation, risk management, and financial contributions to local economies (Attarian & Keith, 2008; Maples et al., 2017).

The growing prevalence of outdoor rock climbing has created a call to action to protect the social and ecological attributes of these systems and develop environmental stewards out of recreation users (Murdock, 2019). When considering the state of individual climber behaviors, it is known that increased access to knowledge about a place through information provisions and a greater time spent in the place can lead an individual to act responsibly toward the environment (Halpenny, 2010; Thompson et al., 2008). No significant difference exists in the environmental ethics of an outdoor climber based on how they were introduced to the sport of climbing (indoors, outdoors, formally, or informally) (Stuessy et al., 2009). A significant difference does exist by group in the preferred communication approaches to motivate environmental behaviors. Climbers who were introduced to the sport outdoors typically favored language that provoked biocentric values, where equal value is given to all living things. While those who began as indoor climbers favored behavior motivation messaging that incorporated anthropocentric values which place humans as the most valuable organism (Stuessy et al., 2009). Further, climbers are a heterogenous group whose can have varied expectations of land management. Schuster, Thompson, and Hammit (2001) surveyed climbers (n = 400) from 13 different locations in the United States and found that all surveyed climbers held reservations towards the practices of management entities and believe climbing was not adequately understood but had varied attitudes regarding the appropriate degree of involvement. Further, the study suggests conflict could arise when land managers act in favor with one group of climbers while going against the wishes of other climbers or other recreationist groups' attitudes. Understanding social impacts and acting to reduce them may prevent conflicts between climbers and other recreation user groups. For example, Zeppel (2009) highlights conflicts that have arisen between climbers and other user groups when managing the natural space of Devils Tower National Monument, WY. The geologic feature is considered a sacred sight to Plains Indians (Lakota, Eastern Shoshone, Kiowa, Kiowas-Apache, Comanche, Crow, Cheyenne, and Arapaho) whose motivations for visiting (vision quests, sun dances, prayer offerings, and fasting) may be compromised by motivations of climbers who visit to experience diverse range of difficulties in climbs available and breathtaking views upon summiting. Zeppel (2009) stresses the importance of considering the different values of a site (physical, personal, and spiritual) when working to manage the outdoor climbing because of the potential for mismatched motivations and resulting conflict. The variation across climbers' preferences and the perceptions of management decisions underscores the importance of considering across and within user group motivations when managing the outdoor climbing system.

In response to the impacts (both social and ecological) of climbing on local areas, many organizations at different levels (e.g., state, federal) initiated climbing management plans (CMPs (McHugh, 2019). According to Eagles et al. (2014) a good management plan should provide a public participation document that outlines key features and values, establishes management objectives to be met, and provides outlined actions to be taken to achieve such objectives. While some sites are still without formal CMPs, other sites whose CMPs and Wilderness Stewardship plans (WSPs) were drafted early in the development of outdoor climbing are now being re-evaluated based on the current management demands and associated impacts (McHugh, 2019).

McHugh (2019) assessed the specific ecological variables that should be considered in plans, as well as the appropriate methods of incorporating national level initiatives into local level action. McHugh's research demonstrated limitations to field-based research (i.e., time intensive and financially demanding) and underscored a need for new methods to understand the impacts of climbing on the ecology of climbing areas. Murdock (2019) makes the argument that national climbing recreation management policies need further development to support the growing prevalence of climbing. However, limitations to studying the system presented by McHugh (2019) need to be addressed to ensure policies developed are representative of the complex social ecological system (SES) for which they manage.

## 2.2 Social Ecological Systems

Landscapes have served as a canvas for people to paint their many needs for millennia, lending these places as representations of the balance between society and the environment (Sluis et al., 2019). In this way, landscapes are dynamic and can be viewed from a variety of spatial, temporal, and functional scales to show different relationships across the systems. These scales can present mismatches that affect management outcomes when not accounted for during decision making processes (Cumming et al. 2006). An example mismatch (spatial) is the administrative and political boundaries within the Big Cottonwood Canyon, Utah which are being impacted from increasing recreation use, including rock climbing. While the land is managed by the U.S. Forest Service, much of the canyon's water rights are owned by Salt Lake City. This can preset scale mismatches and subsequent complications to producing policies for managing water quality impacts arising from a lack of restroom facilities available to recreationalists (Associated Press, 2019). Because of SES' complex nature and potential for scale mismatches, research promotes the need for governance that is adaptive in nature, involves a variety of stakeholders, and accounts for interactions between system variables (Sluis et al. 2019; Buizer et al. 2011).

Policies that manage SES, and the varied human behaviors therein affecting natural and social resources, need be appropriate for both the ecosystem interdependencies and the institutions that regulate these systems. Example policies affecting the outdoor climbing system can include fixed safety anchor and bolt moratoriums (see: Sammartino, 2020), route closures for raptor nesting or vegetation restoration, the development of a paved parking area or trails for access to climbing sites and partnering with a local climbing coalition for education projects such as signage or informational sessions that target develop desired behaviors in site visitors.

The varying ability of a policy to account for critical pieces of a SES refers to its overall fit (Bodin et al., 2016). A well-suited policy will achieve both horizontal fit (aligning ties within the studied system) and vertical fit (across interconnected systems). Ties within systems can be actor to actor (within the social system), resource-to-resource (within the ecological system), and actor-to-resource (across the social and ecological system) (Bodin et al., 2016). For CMPs to achieve horizontal fit, the policies should account for the system's social and ecological features and connections. Regarding vertical fit, a CMP should align with other documents within the recreation planning hierarchy (Figure 2.1). While CMPs focus on climbing recreation, the systems they manage may host a variety of other user groups and interests. For instance, 34% of climbing is located on U.S. Forest Service (USFS) land ("THIS LAND IS OUR LAND: Climbing on Public Lands," 2016). USFS sites can boast diverse recreation user groups such as backpackers, day hikers, anglers, and off-highway vehicle users, as well as be used for economic interests such as logging and fish hatcheries.

Figure 2.1 Recreation planning hierarchy (Eagles et al., 2014).


When considering policy fit, it is also important to account for this system embeddedness. Embeddedness refers to a policy's role in the greater hierarchy of rules and guiding practices. CMPs may be embedded alongside several similar user group and interest specific policies. These policies also fall under state and national legislation, agency specific, and regional specific land use planning policies. Each new proposed policy is impacted by potential legacy effects of prior or current practices and has the potential to affect existing rules in place. Therefore, new policies need to account for past and present relevant policy in the planning stages (Carlsson & Berkes, 2005). Further, for a CMP to achieve vertical fit it should uphold all levels of relevant policy. To uphold related policies, CMPs can reference them directly or more simply ensure the policies therein are in alignment to more general regulations in place. For example, climbing sights on federally designated wilderness land, as designated by the Wilderness Act of 1964, are subject to regulations such as the prohibited use of motorized equipment like hand drills commonly used to install fixed safety anchors and their CMPs should therefore address the prohibited use and adaptation within its policies.

2.3 Modeling SES for Adaptive Management.

As part of the planning stage of the AMF, system variables and their relationships need to be understood to inform policy decisions. A diverse number of frameworks and modeling techniques exist to understand SES.

Available frameworks for analyzing SES include Driver, Pressure, State, Impact, Response (DPSIR); Earth Systems Analysis (ESA); Ecosystem Services (ES); Human Environment Systems framework (HES); Material and Energy Flow Framework (MEFA); Social Ecological Systems Framework (SESF); Sustainable Livelihood Approach (SLA); The Natural Step (TNS); and The Vulnerability Framework (TVUL) (Binder et al., 2013). The SESF is appropriate for application in policy planning and is the only framework that treats social and ecological system variables with near equal depth (Binder et al., 2013). The SESF can be used as a tool to begin to ask important questions about systems including who the key actors and resources are and how the resource and governance structures set conditions for the system (McGinnis & Ostrom, 2014). The SESF provides a theoretical foundation to inform the view of complex systems, as well as the environment in which decision making and governance occurs with respect to outdoor climbing by informing where within the system further understanding is necessary. Such an approach is important in the study system since impacts within SES can span political boundaries and have varied effects across temporal and spatial scales (Bodin, 2017).

Known system variables, elicited through framework applications or participatory methods, can be transformed into a system representation, or model, to help predict outcomes of implemented policies (Ostrom, 2011). Possible approaches to modeling SES can include 1) knowledge acquisition using interviews, surveys, or focus groups, 2) system conceptualization using causal loop diagrams, decision tree analyses, or concept mapping, 3) conceptual quantification using social network analysis or fuzzy cognitive mapping (FCM), or 4) aggregated representation using Bayesian models or agent based models (Voinov et al., 2018). When it comes to selecting a best fit approach to modeling a system, the intended use for the model is the determiner. Further, cognitive mapping and causal loop diagrams are used when conceptualizing interactions based primarily on data obtained through qualitative approaches (e.g., interviews, focus groups). These options can help inform researchers on how actors interact and perceive their surroundings (Jones et al., 2011). Using semi-quantitative methods, FCMs blend cognitive and pooled knowledge in developing system maps. The more quantitative systems diagramming approaches, such as agent based models, are primarily computationally driven. Computational models use real world deduction to generate model tests and simulation-based data to construct the test system (An, 2012).

### 2.3.1 Fuzzy Cognitive Mapping.

Because this study's objectives include representing the system and testing 'what if' policy scenarios, a conceptual quantification of the system is preferred. FCMs are the best-suited approach for the mapping of the complex SES of outdoor climbing because they present near accurate representations despite limited scientific understanding of the system. This capacity to create a near-accurate system model rely on "wisdom of the crowd" and fuzzy computational science. The wisdom of the crowd phenomena proposes that the pooled knowledge of heterogenous groups will produce near accurate depictions of a topic or a system (Galton, 1907). This long-established phenomenon is utilized in FCM creation by converting incomplete system representations from many data sources into a collective adjacency matrix that represents the values and relationships of system variables. A simple demonstration of this phenomenon can be seen in carnival guessing games during which participants guess the number of candies in a jar. While it is unlikely any one individual will guess the correct number of candies, the collective average of responses will generate a near accurate guess corresponding to the true number of candies in the jar. In such a way, FCM does not require the reliance on expert understanding or in-field experimentation. Instead, FCM promotes the incorporation of many voices to "fuzzily" classify relationships within a system. Fuzzy classifications utilize computational variance by defining variables in an unknown area rather than an exact measurement.

More generally, FCMs are a form of mental modeling. A mental model can be defined as "a cognitive structure that forms the basis of reasoning, [and] decision making (...) based on … personal life experiences, perceptions, and understanding of the world" (Jones et al., 2011, p. 1). Further, mental models represent the reasoning mechanisms that support an individual's working memory of a given system (Jones et al., 2011). FCMs expand on traditional mental models through the inclusion of relationships between variables as perceived values of influence. These values can be either positive or negative and range from [-1,1]; typically, with varying degrees rated as low (+/- 0.2), medium (+/- 0.5), or high (+/- 0.8). There exist three main approaches to the construction of FCMs: 1) from an expert, 2) from a pooling of many different stakeholder models, and/or 3) documents. Data needed to produce FCMs can be gathered from questionnaires, linguistic analysis, written tests, available quantitative data, or directly from subjects' drawings (Gray et al., 2014). Combined methods are often employed to construct a robust map to be used for system models. A more robust model will reduce the uncertainty of outcomes derived in the policy testing stage (Baker et al., 2018). Gray et al. (2012) and Özesmi and Özesmi (2004) provide thorough introductions to the use of FCMs to model complex SES.

An additional strength of using FCMs for adaptive management planning of the outdoor climbing system is that FCMs can be used as dynamic tools for the pre-testing policy scenarios (Gray et al., 2013). Running policy scenarios with a FCM can highlight gaps in stakeholder knowledge, characteristics of a system, potential areas for conflict, and the effectiveness of policy to achieve desired management outcomes that address both social and ecological impacts (Doukas & Nikas, 2020; Sluis et al., 2019; Samarasinghe & Strickert, 2013; Gray et al., 2012). Samarasinghe and Strickert (2013) use of FCMs identified existing power struggles between stakeholders in the context of natural hazard mitigation in ski area management in New Zealand and Canada. Their testing of different policies demonstrated how to work with groups to bolster positive social arrangements rooted in collective and adaptive capacity. Doukas and Nikas (2020) evaluated the presence of FCM modeling in climate policy literature to demonstrate the adaptability of FCMs as a method for policy evaluation, project selection, risk assessment, scenario analysis, and technology assessment across policy sectors including agriculture, buildings, environment, industry, power, and transportation. Their assessment determined that the use of FCM in policy planning process is well suited for assessing near-optimal policy portfolios to produce a list of best fit policies. Mourhir et al. (2015) highlight the ease of utilizing FCMs to run a variety of both independent and combined policy efforts to show how cross discipline tradeoffs exist within policy regimes and that aggregated policies produce different outcomes than simply combining the results of independent policy scenarios. Another advantage to FCM is its “quick and dirty” capacity of this method to provide system representation from limited field data without the need for intensive pre-research prior to testing stages (Mourhir et al., 2015). This is important in this study considering complications in collecting in field data (McHugh, 2019).

# Chapter 3. Methods

## 3.1 Document Collection

Climbing management plans (CMPs) were sourced during calendar year 2020 using Google's search engine on April 11, June 15, and September 6 and 10. The two search days in September focused on collecting plans for climbing areas absent from the plans already collected as determined by geographic region/state (those areas included the Midwest and South Central states). Throughout the collection process, plans and any relevant documents[1] collected were stored in Zotero (Version 5.0.93; a free and open-source reference management). Initially, the generic search phrase: "climbing management plan" was used to collect documents, followed by specific management agency searches, for example "blm climbing management" (representing Bureau of Land Management climbing management), and then, lastly, specific climbing area searches for example "rockwoods climbing management plan" (Appendix A). Specific climbing area searches were done for states absent from the collected plans using MountainProject (www.mountainproject.com; a climbing website that organizes national climbing locations by state). Once climbing locations within a given state were identified, specific sites were then searched within Google's search engine using the location name and similar search phrases as were used in the initial collection process.

[1] *"Relevant documents" included any materials related to the construction of a CMP such as a FONSI (Finding of No Significant Impact), letters to landowners, public comments, etc. However, these additional documents were not used in the research reported here.*

### 3.2 Document Classification

All plans and supplemental materials collected were given identification names to be used throughout the study to ensure documents remained identifiable over generic titles common to CMPs (Appendix B). For example: “Rock Climbing Guidelines” was the title of the CMP for the city plans for both Scottsdale, Arizona and Sandstone, Minnesota. The identification name used in this work included three abbreviated delineations: Organization, followed by State/Sub Organization, and then Document Type. An example identification name is “NPS-CA/JTNP-CMP” which reads as Organization: National Park Service, State/Sub Organization: California/Joshua Tree National Park, and Document Type: Climbing Management Plan.

### 3.3 Document Coding

#### 3.3.1 Document Coding Dictionary

The collected CMPs were then coded based on a confirmatory approach using an *a priori* code dictionary. A confirmatory approach is one that begins with a list of key variables that are likely to be included in the document being processed (Carley & Palmquist, 1994). This approach helped to prevent a sprawling list of codes that could otherwise occur if taking an exploratory approach due to the large data size of the documents. The confirmatory list, also referred to as the code dictionary, was constructed based on general visitor tourism and “park” policies identified in Eagles et al. (2014) and both the social and ecological impacts Attarian and Keith (2008) discussed all climbing management plans should address. Definitions were written for all variables as they pertain to outdoor climbing. In addition to these, code categories for general document details and causal link statements (CLS) were constructed. CLS include segments of text within a given narrative that utilize a causal connecter phrase to connect two different concepts, also referred to herein as system variables (Nadkarni & Shenoy, 2004). CLS codes included statements about system variables that either directly or indirectly affected one another.

### 3.3.2 Document Coding Process

The text to data analysis software MaxQDA (Version 12.3.9) was used to code the CMPs. All text within the main CMP (title through the final policy segment; not including appendices) was linked to a minimum of a single code in the form of code segments, though as many codes as relevant could be linked. All code segments were comprised of complete sentences but were not limited to single sentences since multiple continuous sentences or even paragraphs may have applied to a given code. For example, the segment "Temporary closures may be used to protect nesting raptors during critical phases of the courtship, nesting, and fledging periods." (S-CO/PP-CMP) was given the codes 'WILD', 'ROCK', and 'CLS' to denote the presence of content on developed routes, wildlife and an expressed relationship. In this coding process, the codes outlined in the code dictionary accounted for a variety of words or topics within a given theme. This practice was selected over coding each sentence independently since the MaxQDA software would merge continuous codes segments that shared the same codes - even if manually coded as separate segments.

## 3.4 Causal Statement Coding

Once causal statements were identified within the documents, these segments were further coded using Microsoft Excel. Themes within the causal statements were first converted into codes using an exploratory approach (without a preexisting code hierarchy). Since a conclusive list of outdoor climbing system variables did not previously exist, an exploratory approach was used to allow for an organic code hierarchy to form as if these statements were elicited from an interview (Carley & Palmquist, 1994). Following the initial coding of the causal statements, similar terms were combined to create a simplified group of codes to be used as a word bank. For example, ‘braided trails’, ‘tracks’, ‘unsanctioned trails’, and ‘social trails’ all represented the same system variable dubbed *social trails*. Each code within the word bank was given a number to aid in the next stage of identifying relationships from the causal statements. Each causal statement was coded with two numbers separated by a comma to signify the direction of the relationship: the first number represented the independent variable acting on the second number, the dependent variable. For instance, the CLS “Temporary or permanent closures of individual routes or specific climbing areas may occur to protect the natural resources or for visitor safety” (CI-AZ/MSP-RCG) was coded into two system relationships, 27,18 and 27,29; denoting route closures (27) impacted natural resources (18) and safety (29). The type of relationship expressed in the CLS was also determined as either a positive (+1) or negative (-1) at this stage. Positive relationships were those in which an increase in the affecting variable led to an increase in the state of the affected variable. Negative relationships are those in which an increase to the affected variable would lead to a decrease to the affected variable. Once each the relationship type was determined, these values transcribed into an adjacency matrix.

### 3.5 Code Hierarchy Analysis

Code hierarchy analysis was conducted in MaxQDA and Microsoft Excel by document and across land manager groupings. Percentage coverage by code category and frequency of code appearance by document and grouping were studied. ANOVA tests were run to understand if a significant difference existed between plans and by code group (general visitor and tourism variables, GVTV; climber social variables, CSV; climber environmental variables, CEV). If ANOVA tests revealed a significant difference existed within a code group (GVTV, CSV, CEV), paired two sample t-tests and Pearson's correlation tests were conducted to assess difference and correlation values between the mean code representation by plan group.

## 3.6 Cognitive Mapping

The modeling software *Mental Modeler* was used to construct a cognitive map of the study system based on the contents of the CMPs coded. The causal statement adjacency matrix was uploaded as a comma-separated value (CSV) file to *Mental Modeler*. The software then utilized the matrix to construct the cognitive map of the system. *Mental Modeler* was used for this stage of the study, as opposed to other platforms such as *R*, to ensure the map remained easily applicable to work in settings outside academia since the platform provides simplified visualization and real time policy pre-testing.

## 3.7 System Analysis

To understand interactions among variables and their importance in the system, concept-level calculations were conducted on the adjacency matrix (Table 3.1). Calculation included: outdegree [od(vi)], indegree [id(vi)], centrality [td(vi)], classification (receiver, ordinary, or transmitter), driverness (d), density (D), complexity (c) and hierarchal index (h). See Appendix J for related equations.

Table 3.1 Concept-level calculations (Levy, 2017; Özesmi & Özesmi, 2004; Sandell, 1996).

| Type | Definition |
|---|---|
| Variable outdegree [od(vi)] | The number of causal effects on other concepts calculated by the row sum of the absolute values of a variable in the adjacency matrix which shows the cumulative strength of connections exiting a variable. Where *y* represents the matrix row number of the variable and *N* is the total number of variables in the matrix, and *x* is the cell value. |
| Variable indegree [id(vi)] | The number of causal effects on the concepts calculated by the column sum of the absolute values of a variable in the adjacency matrix which shows the cumulative strength of the connections entering the variable. Where *z* represents the matrix column number of the variable in question and *N* is the total number of variables in the matrix, and *x* is the cell value within the matrix location. |
| Variable centrality [td(vi)] | An assessment of a variable's cumulative strength within the system calculated by the summation of the variable's outdegree and indegree. |
| Variable type: | Identification of system variables as one of three types to understand its predominant role as determined by whether its outdegree and indegree: |
| 1. Receiver (R) | Variable classification characterized solely by incoming connections; zero outdegree, od($v_i$), and positive indegree, id($v_i$). |
| 2. Ordinary (O) | Variable classification characterized by both incoming and outgoing connections; positive outdegree, od(vi), and positive indegree, id(vi). |
| 3. Transmitter (T) | Variable classification characterized by outgoing connections; positive outdegree, od(vi), and zero indegree, id(vi). |
| Variable driverness (d) | A calculation of a variables' balance of incoming and outgoing connections; bounded between 0 and 1 and symmetrical around 0.5. High driverness (0) indicates the variable has a strong effect on others but is minimally affected by others (cause) while low driverness (1) indicates a high degree of influence from others (effect). The logistic function was used with variables with no incoming or outgoing ties. |
| Map density (D) | A calculation of the connectivity. Where C is the number of connections and N is the number of variables. |
| Map Complexity (c) | A calculation of the degree of receiver connections versus transmitter connections (R/T). Testing complexity can help to inform whether the system provides greater utility. |
| Map Hierarchy Index (*h)* | A calculation of the system structure. When h equals 1 then the system is fully hierarchical or domination in style, while those with an h equal to 0 is democratic. A democratic hierarchal index means the system is highly interconnected as opposed to stemming from a select few key variables as is the case in hierarchal systems. |

### 3.8 'What-If' Scenario Testing

Once constructed, the cognitive map was utilized as a system model to run 'what if' scenarios representing hypothetical conditions of potential management policies. The selection of hypothetical conditions was informed by reoccurring practices highlighted in the analysis of CMPs, as well as based on the driverness of system variables. All scenario testing was completed in Microsoft Excel.

To use the cognitive map for policy testing, the system's steady state values were calculated to ensure policies were tested from equilibrium. A state value represents the value of a concept during a snapshot of time, typically between 0 (low) and 1 (high). The steady states of system concepts are their state values once the system and its many interconnected variables carry out all possible effects on one another and reach an equilibrium (Kok, 2009). To determine the steady state value for system variables iterative vector calculations, or loop calculations, were performed by multiplying the system adjacency matrix and state values of the variables. Initial loop calculations should be applied 2 X N (number of system variables) times to ensure the system has reached a true equilibrium as opposed to imploding, exploding, or sinusoidal patterns (Kok, 2009). Further, the logistic function ($f(x) = (1/ (1 + e\hat{}(-x)))$) was applied to the values for an impact range of [0,1] (Gray et al., 2012). Because no known starting state values existed for the outdoor climbing system variables, all variables were given the neutral value of 0.5 to perform the steady state calculations. Through initial loop calculations between the adjacency matrix and initial state vectors (0.5), it was determined that the system coalesced to an equilibrium and could, in turn, be used for policy testing that compares initial steady state values to those resulting from manufactured state values.

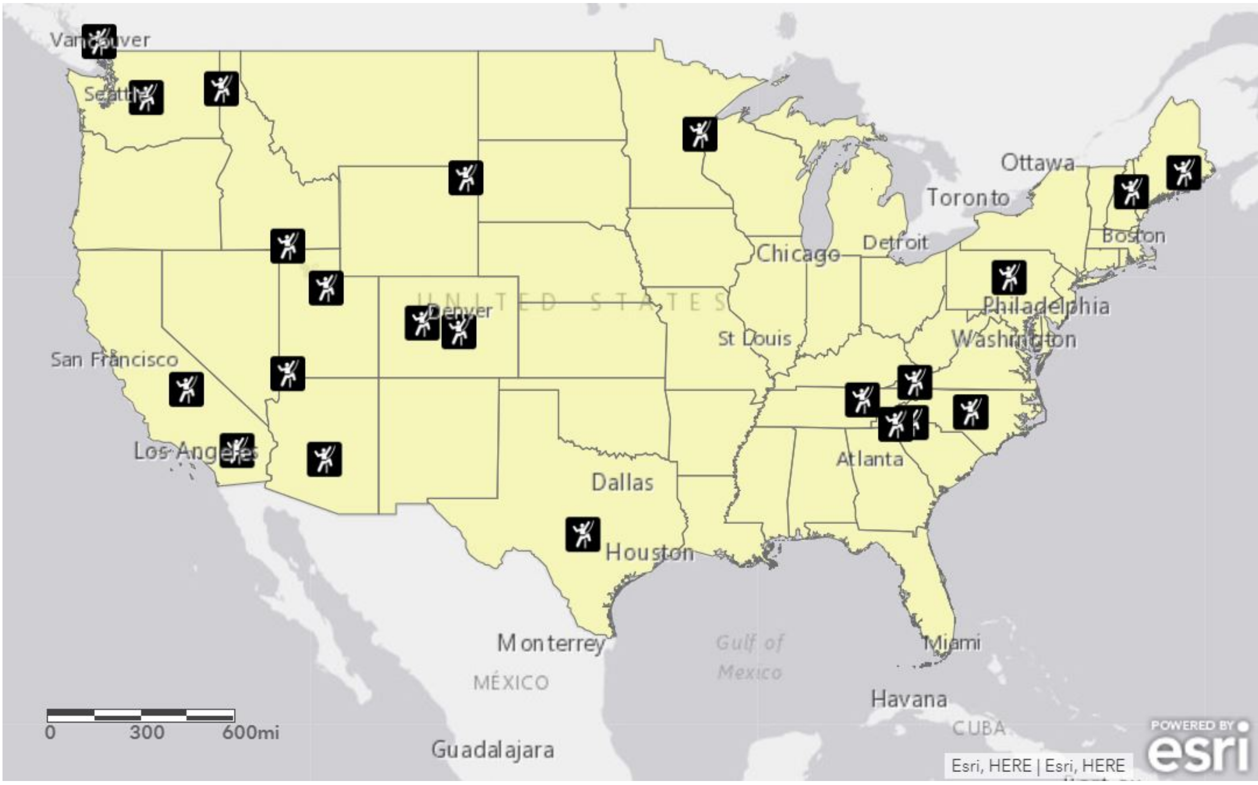
The loop calculation process described for the calibration of steady state values was applied for policy testing. Starting state values for scenario tests were again 0.5 for all variables except those with manufactured conditions which were instead either increased to 1 or decreased to -1 based on the scenario conditions. Variables whose conditions were manufactured were ‘clamped’ during the calibration of the scenario’s steady state value. Clamping requires manufactured variables’ states to be adjusted back to the manufactured value prior to each loop calculation to maintain the variables effect on the system throughout the policy pre-test (Kok, 2009).

# Chapter 4. Results

## 4.1 Collected Documents

In total, 36 CMPs were located and 26 were analyzed (Appendix C). These plans included policy for climbing in 19 different states and 4 different countries (Figure 4.1). The ten plans identified but excluded from analysis had document quality too poor for coding, included broader forms of recreation than climbing, or were collected after the three documents minimum for each of the document groupings outlined below and area was achieved. Plans spanned a timeline of 28 years with the earliest plan published during 1992 and the most recent during 2020. Six total document groupings were identified *posteriori* based on the jurisdictional level of the organizations responsible for the documents (number of plans for each grouping listed in parentheses): International (3), National Park Service (4), Forest Service (3), State (8), Coop/coalition (3) and Local and Private (4). The International grouping includes plans whose jurisdiction fall on non-U.S. soil. The National Park Service grouping includes plans for areas located on U.S. National Park Service land. The Forest Service grouping includes plans for areas located on U.S. Forest Service land. The State grouping consists of plans for climbing areas managed by state government authorities. The Coop/Coalition grouping consists of climbing area managed by a group(s) of climbing representatives. The Local and Private grouping consists of plans that were created by city or private landowners who manage the land on which climbing occurs.

Figure 4.1 Spatial distribution of climbing management plans.




*Note.* Place markers not pictured here, but represented in document system include Hawaii, United States; Peninsula Mountain, South Africa; Victoria, Australia.

## 4.2 Identified Codes

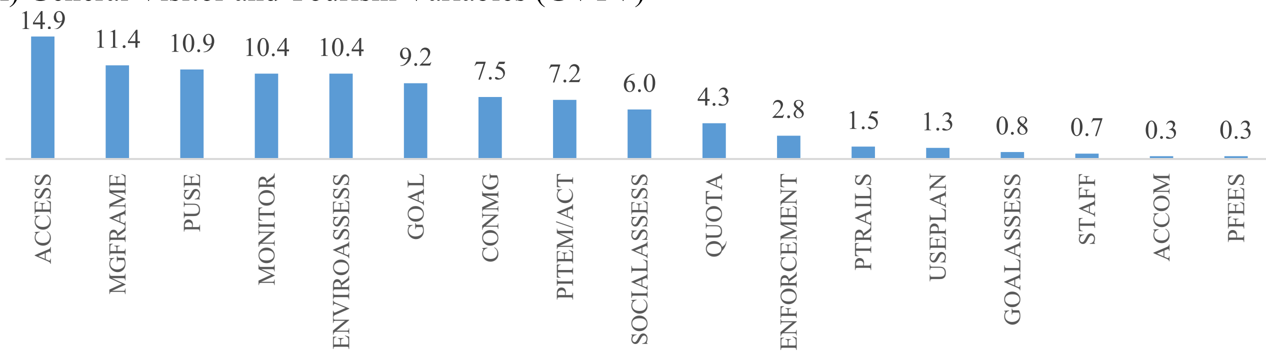
In total, there were 2,264 coded segments across the 26 documents. These coded segments represented a grand total of 40 codes (see Appendix D for a full list and definitions). The codes generally fell into 3 categories (Figure 4.2): general visitor and tourism variables (GVTV, n = 17), climber social variables (CSV, n = 14), and climber ecological variables (CEV, n = 9). Plans on average covered 21 of the 40 code variables across 87 coded segments. The 10 *most* coded variables as measured by frequency (versus percent document coverage) included: "CSV\FIXED" (286), "CSV\CLIMB" (165), "CEV\ROCK" (146), "CSV\MOU" (128),

"CEV\VEG" (123), "CSV\RM" (121), "GVTV\ACCESS" (114), "CSV\CULTURAL" (106), "CEV\WILD" (100), and "CSV\EDU" (79). The 5 *least* coded variables as measured by frequency included: "CSV\ECON" (7), "GVTV\GOALASSESS" (5), "GVTV\STAFF" (3), "GVTV\PFEES" (2), and "GVTV\ACCOM" (2). Documents within the Forest Service group had the highest average coded segments (127) followed by International plans (118), and then National Park plans (109). When assessing code appearance across all documents within the group, the National Park group had the most and Coop/coalition the fewest (See Appendix E). However, when assessing code appearance as measured by the average across documents, the Forest Service grouping had the most and Coop/coalition the fewest (See Appendix F).

There was a significant difference in code appearance by group at the $p < 0.05$ level for the six groupings when considering all codes (GVTV, CSV, and CEV) [$F(5,234) = 4.38$, $p = 0.001$]. For example, the Forest Service group had an average of 3.18 appearances of each code while the Local/private group only had 0.98 appearances of each code. When considering code groups, there was a significant difference at the $p < 0.05$ level for the six grouping when considering just the GVTV code [$F(5,96) = 2.93$, $p = 0.017$] and CEV code [$F(5,48) = 2.87$, $p = 0.024$]. There was not a significant difference at the $p < 0.05$ level for the six groupings when considering just the CSV code [$F(5,78) = 1.06$, $p = 0.387$). Table 4.1 presents the correlation values and significant difference findings of the combined and GVTV tests.

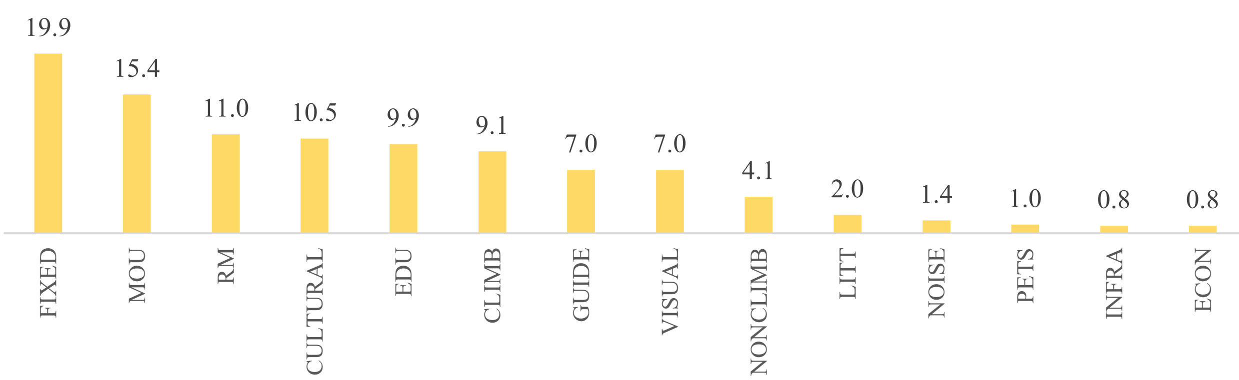
Figure 4.2 Percentage of codes across all CMPs by code category.

A) General Visitor and Tourism Variables (GVTV)




B) Climber Environmental Variables (CEV)


C) Climber Social Variables (CSV)




*Note.* See Appendix C for related code dictionary.

Table 4.1 Means, standard deviation, and correlation of average code appearance by group.

| Group | *n* | *M* | *SD* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Combined Variable | | | | | | | | |
| 1. International | 3 | 2.95 | 3.14 | | | | | |
| 2. National Park | 4 | 2.73 | 2.41 | 0.77 | | | | |
| 3. Forest Service | 4 | 3.18 | 3.28 | 0.77 | 0.74 | | | |
| 4. State | 8 | 2.29 | 2.70 | 0.67 | 0.85 | 0.76** | | |
| 5. Coop/coalition | 3 | 1.43 | 2.79 | 0.38** | 0.58** | 0.47*** | 0.80** | |
| 6. Local/private | 4 | 0.93 | 1.20 | 0.50*** | 0.65*** | 0.63*** | 0.89*** | 0.82 |
| General Visitor Tourism Variable (GVTV) | | | | | | | | |
| 1. International | 3 | 1.84 | 1.62 | | | | | |
| 2. National Park | 4 | 1.90 | 1.68 | 0.53 | | | | |
| 3. Forest Service | 4 | 2.02 | 2.00 | 0.79 | 0.67 | | | |
| 4. State | 8 | 1.38 | 1.35 | 0.50 | 0.72 | 0.79 | | |
| 5. Coop/coalition | 3 | 0.76 | 1.27 | 0.08* | 0.50*** | 0.47*** | 0.83** | |
| 6. Local/private | 4 | 0.51 | 0.61 | 0.22** | 0.57*** | 0.56** | 0.86*** | 0.82 |
| Climber Environmental Variable (CEV) | | | | | | | | |
| 1. International | 3 | 3.00 | 2.35 | | | | | |
| 2. National Park | 4 | 2.89 | 2.39 | 0.64 | | | | |
| 3. Forest Service | 4 | 4.33 | 2.69 | 0.75 | 0.77* | | | |
| 4. State | 8 | 2.31 | 2.61 | 0.28 | 0.92 | 0.86** | | |
| 5. Coop/coalition | 3 | 1.26 | 1.41 | 0.28 | 0.55* | 0.66** | 0.73 | |
| 6. Local/private | 4 | 0.73 | 0.97 | 0.35* | 0.59* | 0.69*** | 0.73 | 0.90 |

*Note. n, M* and *SD* are used to represent number of plans, mean and standard deviation, respectively. * = $p < .05$ (2-tailed test). ** = $p < .01$ (2-tailed t-test). *** = $p < .001$ (2-tailed t-test). CSV specific table not present because ANOVA test detected no significant differences.

### 4.2.1 International CMP Codes

The average length of an International plan was 31 pages with a standard deviation of 21.91. The most prevalent codes included cultural resources (CSV\CULTURAL; 39), fixed anchors (CSV\FIXED; 32), rock climbers (CSV\CLIMB; 29), collaboration (CSV\MOU; 28) and wildlife (CEV\WILD; 19). International CMPs collectively covered all but 6 of the 40 codes (excluded: GVTV\PITEM/ACT, GVTV\PFEES, GVTV\ACCOM, GVTV\STAFF, CSV\PETS, CSV\NOISE).

### 4.2.2 National Park CMP Codes

The average length of a National Park plan was 28 pages with a standard deviation of 16.98. National Park plans were some of the most comprehensive and covered all but 2 of the 40 codes (excluded: GVTV\PFEES and GVTV\PTRAILS). The most prevalent codes included fixed anchors (CSV\FIXED; 40), rock climbers (CSV\CLIMB; 29), cultural resources (CSV\CULTURAL; 27), rock (CEV\ROCK; 26), and education (CSV\EDU; 24).

### 4.2.3 Forest Service CMP Codes

The average length of a Forest Service plan was 13 pages with a standard deviation of 5.56. The most prevalent codes included rock climbers (CSV\CLIMB; 41), fixed anchors (CSV\FIXED; 34), collaboration (CSV\MOU; 30), vegetation (CEV\VEG; 29), and rock (CEV\ROCK; 23). Forest service CMPs presented all but 4 of the 40 codes across documents (excluded: GVTV\USEPLAN, GVTV\PFEES, GVTV\STAFF, CSV\ECON).

### 4.2.4 State CMP Codes

The average length of a State plan was 11 pages with a standard deviation of 5.51. The most prevalent codes included fixed anchors (CSV\FIXED; 103), rock (CEV\ROCK; 60), risk management (CSV\RM; 59), rock climbers (CSV\CLIMB; 53), and vegetation (CEC\VEG; 44). State plans discussed all but 4 codes (excluded: GVTV\PTRAILS, GVTV\ACCOM, GVTV\GOALASSESS, and CEV\WATER).

### 4.2.5 Coop/coalition CMP Codes

The average length of a Coop/coalition plan was 7 pages with a standard deviation of 4.50. The top discussed code was fixed anchors (CSV\FIXED) which covered roughly a third of the total coded segments (50 total occurrences across documents). The remain 4 of 5 most frequent codes included access (GVTV\ACCESS; 14), rock climbers (CSV\CLIMB; 14), commercial operations (CSV\GUIDE; 14), and risk management (CSV\RM; 12). Across all 3 plans, 6 of the 9 CEVs were discussed (excluded: CEV\SOIL, CEV\WILDERNESS, and CEV\WATER). Similarly, most of the CSVs (11 of 14) were in at least one of the documents reviewed; CSV\NOISE, CSV\LITT, and CSV\ECON were excluded. Further, CMPs from this grouping discussed just 7 of the 17 GVTVs (excluded: GVTV\PTRAILS, GVTV\PFEES, GVTV\ENFORCEMENT, GVTV\ACCOM, GVTV\STAFF, GVTV\MONITOR, GVTV\ENVIROASSESS, GVTV\SOCIALASSESS, GVTV\GOALASSESS, and CEV\WILDERNESS).

### 4.2.6 Local/private CMP Codes

The average length of a Local/private plan was 5 pages with a standard deviation of 3.38. The most abundant codes across documents included fixed anchors (CSV\FIXED; 27), risk management (CSV\RM; 19), rock (CEV\ROCK; 15), collaboration (CSV\MOU; 14), and access

(GVTV\ACCESS; 12). Within GVTV, 14 of the 17 codes were included when considering all plans in this grouping (excluded: GVTV\PFEES, GVTV\ACCOM, GVTV\STAFF, and GVTV\GOALASSESS). Of the CEV, 3 of the 9 were absent including CEV\WILDERNESS, CEV\CAMP, and CEV\SOIL. Finally, when considering CSV, all but 3 of the 14 were present; CSV\NOISE, CSV\LITT, and CSV\ECON were not featured.

### 4.3 Identified Causal Link Statements

A total of 169 causal link statements (CLS) were found. National Park plans had the most CLS (59), followed by State (42), International (34), Forest Service (17), Local/private (13) and Coop/coalition (4). CLS did not contain expressed degrees of relationship (low, medium, or high) to achieve fuzzy relationship values. Therefore, the relationships were limited to binary values (-1 or +1) as determined by relationship type (negative or positive). This limitation to the collected CLS prevented the incorporation of fuzzy relationship values and thus limited subsequent outcomes to a cognitive map, as opposed to the initially sought after FCM.

Table 4.2 Causal link statements (CLS) frequency by document and group.

| | CLS | GROUP TOTAL | DOC. AVG. | |
|---|---|---|---|---|
| INT/AU-VIC-CMP | 16 | 34 | 11.3 | International |
| INT/ZAF-SANP-EMP, CMP | 11 | | | |
| INT/CAN-BC/BCP-RCS | 7 | | | |
| NPS-TN/OWSR-CMP | 4 | 59 | 14.8 | National Park |
| NPS-CA/SKCNP-CMP, D, EIS | 7 | | | |
| NPS-WY/DTNM-CMP | 28 | | | |
| NPS-CA/JTNP-CMP | 20 | | | |
| FS-UT/LC-CMP, T | 7 | 17 | 4.3 | Forest Service |
| FS-CO/PP-CMP | 6 | | | |
| FS-NH/RR-CMP | 4 | | | |
| FS-NH/WMNF-CMD | 0 | | | |
| SP-NCSP-CMG | 6 | 42 | 5.3 | State |
| SP-WA/FS-CMP | 0 | | | |
| SP-TX/ERSNA-CMP, PC | 12 | | | |
| SP-NC/CR-CMP | 1 | | | |
| SP-ID/CRSP-CMP | 7 | | | |
| SP-HI-CMP, D | 3 | | | |
| SP-PA/DCNR-CMG, FP | 1 | | | |
| SP-UT/SCSP-CMP | 12 | | | |
| CO/CCC-NC/HV-CMP | 1 | 4 | 1.3 | Coop/coalition |
| CO/CCA-ME/EB-CMP | 1 | | | |
| CO/CCC-NC/LK-CMP | 2 | | | |
| COPU-CO/PCOST-CMP | 3 | 13 | 3.3 | Local/private |
| CO-ID/QP-GB, CMP | 1 | | | |
| CI-MN/RPS-CMP, D | 6 | | | |
| CI-AZ/MSP-RCG | 2 | | | |

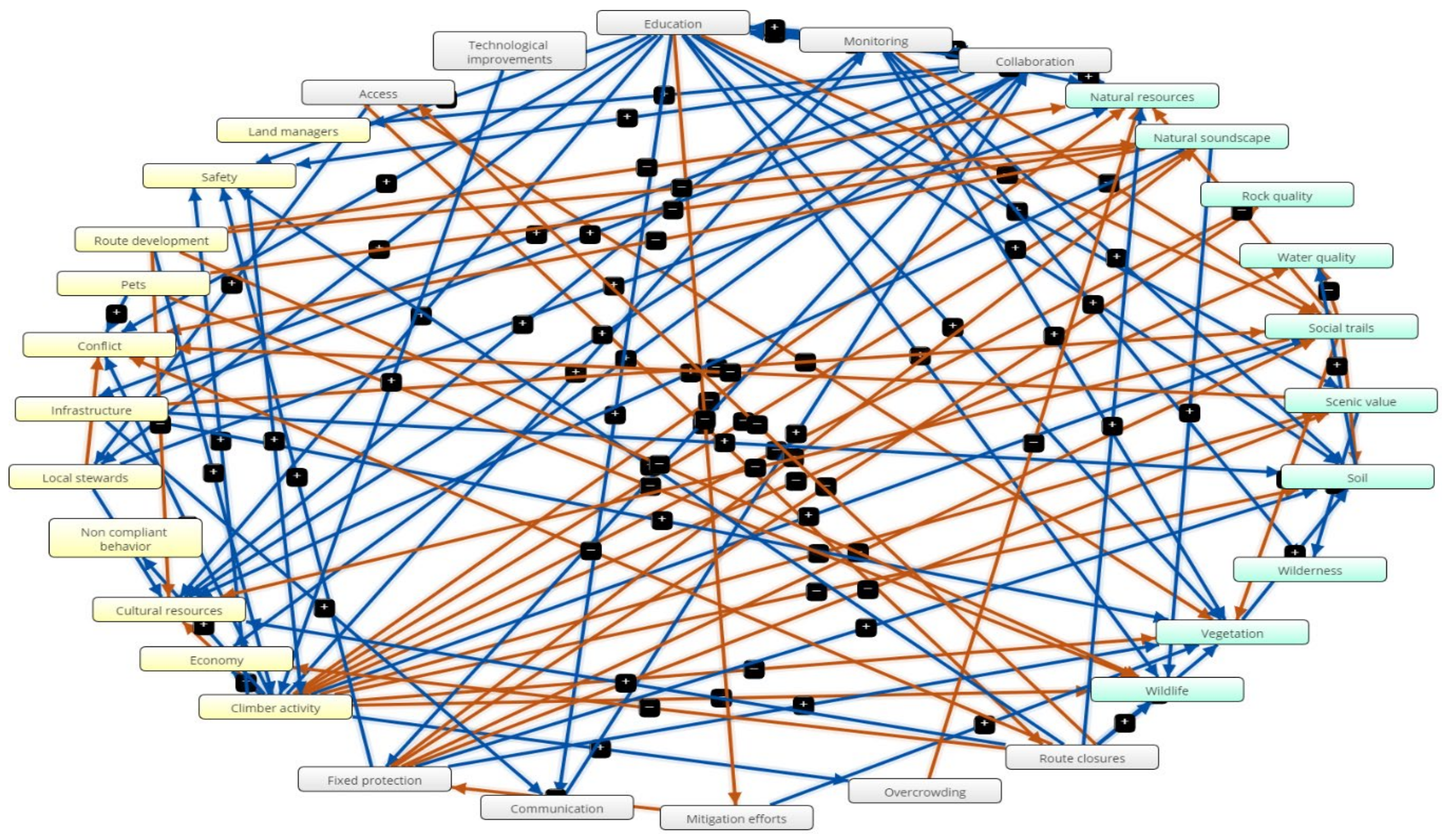
## 4.4 System Characteristics

In total, 99 unique relationships were incorporated into the system's adjacency matrix from the CLS (Appendix G), and the resulting model is visualized in Figure 4.3. Of the 31 system variables, 10 are classified as receiver variables, 3 are transmitter variables, and 18 are ordinary variables (Appendix H). On average, each variable had 3.19 connections. The three most connected variables included climber activity (21), education (15), and collaboration (14). System drivers, as identified by variable driverness, include local stewards (0.400), mitigation efforts (0.333), monitoring (0.300), collaboration (0.286), access (0.250), fixed protection (0.222), climber activity (0.190), infrastructure (0.167), education (0.133), and route closures (0.111). The system had a complexity of 3.333 and a density of 0.103. The hierarchy index of the system is 0.120, which is indicative of a "democratic system" (Table 4.3). The term democratic as used here refers to an interconnected system structure (Özesmi & Özesmi, 2004).

Table 4.3 Summary of system characteristics.

| | |
|---|---|
| No. of variables | 31 |
| No. of connections | 99 |
| No. of receiver variables | 10 |
| No. of transmitter variables | 3 |
| No. of ordinary variables | 18 |
| Connections/variable | 3.19 |
| Complexity | 3.333 |
| Density | 0.103 |
| Hierarchy Index, *h* | 0.120 |

Figure 4.3 Outdoor climbing system cognitive map.




**LEGEND:**

GVTSV : General Visitor and Tourism System Variable (GVTSV; gray box)

CSSV : Climber Social System Varaible (CSSV; yellow box)

CESV : Climber Environmental System Variable (CESV; green box)

: Positive relationship (blue line)

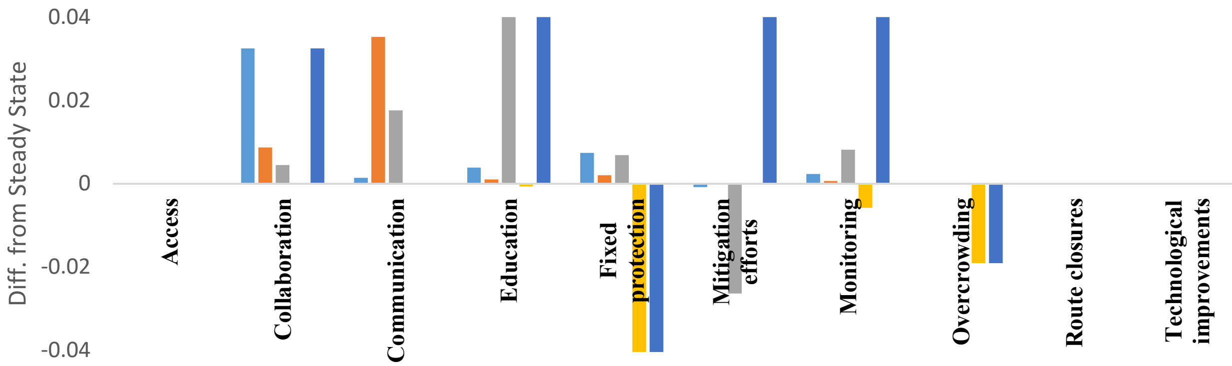
: Negative relationship (orange line)

4.5 'What If' Scenario Outcomes

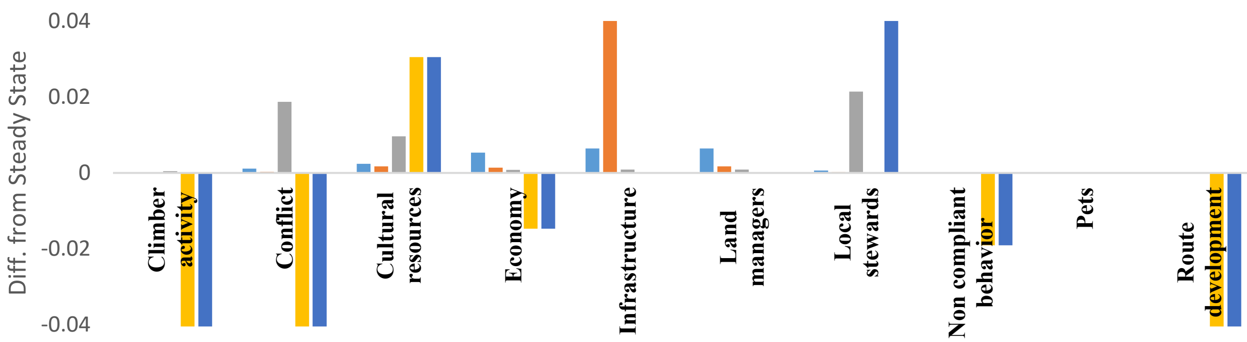
Five different policy what-if scenarios were tested from variables with high driverness. The first three scenarios, entitled "Collaboration", "Infrastructure", and "Education", all focused on maximizing a single system variable, delineated in the scenario names, by clamping the target variable at 1 throughout the steady state calculation. The fourth scenario called "Bolt Ban" aimed to mimic the recently employed management approaches in both Ten Sleep, Wyoming and Bitterroot, Montana, among other locations, of placing a moratorium on the addition of fixed anchors and route development by clamping both variables at 0 (for further details on 'bolt bans' see: Sammartino, 2020). The fifth scenario combined five of the system drivers (collaboration, education, local stewards, mitigation efforts, and monitoring) and clamped them at 1 to act as if these variables were maximized. The fifth scenario is called "Rose-colored glasses", a reference to an English idiom that means the individual only sees the good in a situation – at times to an unrealistic extreme (*Rose-Colored Glasses*, n.d.). Similarly, this final scenario's concoction of variables maintained at high levels may be considered unrealistic, but for the purpose of research were combined here to test the outcome of maximizing these possible management best practices. When compared to the steady state values of the system ($M=0.63$; $SD=0.257$), the outcomes of all five scenarios did not produce statistically significant change to the system; scenario 1 ($M=0.64$; $SD=0.26$; $t=-0.037$; $p=0.970$), scenario 2 ($M=0.64$; $SD=0.26$; $t=-0.133$; $p=0.895$), scenario 3 ($M=0.64$; $SD=0.27$; $t=-0.166$; $p=0.869$), scenario 4 ($M=0.61$; $SD=0.28$; $t=0.308$; $p=0.759$), and scenario 5 ($M=0.65$; $SD=0.29$; $t=-0.229$; $p=0.820$). Further, there was no significant difference to steady state from the scenario application [$F$ (4,150) =0.087, $p=0.986$] (Figure 4.4).

Figure 4.4 Comparison of scenarios’ difference from steady state.

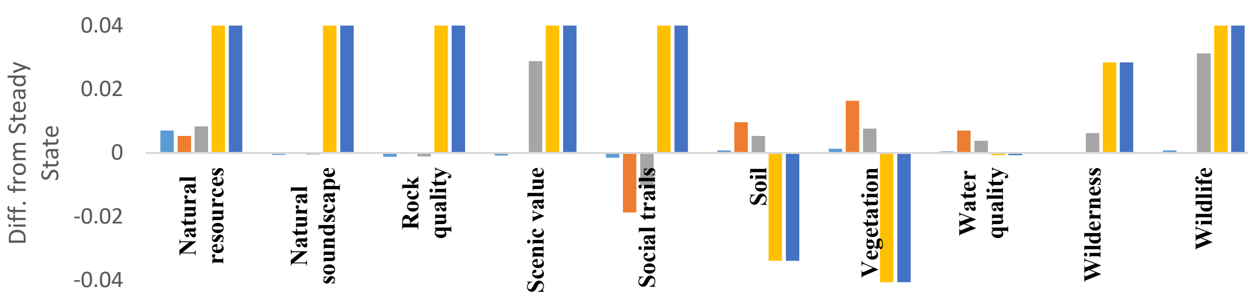
A) General Visitor and Tourism System Variables (GVTSV)




B) Climber Social System Variables (CSSV)




C) Climber Environmental System Variables (CESV)




*Note*. The scale of the y-axis was reduced to 0.04 and -0.04 for purposes of visibility. Thus, some variables that appear to stop at 0.4 or -0.4 had much greater or lesser values than depicted.

# Chapter 5. Discussion

The findings of this research expand upon the limited knowledge available on the outdoor climbing system to help propel the adaptive management planning process towards meeting desired management outcomes and balancing climber motivations. Through the investigation of climbing management plans (CMPs), this study sheds light on the implications of system thinking on the management of outdoor climbing. The thematic results within and across groups, system characteristics, and policy scenarios all provide considerations for adaptive management that begins with informed policy planning.

## 5.1 Decoding the System

The thematic foci of the CMPs present considerations for the future of each outdoor climbing land group manager group and the collective management of the outdoor climbing landscape. Existing gaps in the inclusion of policy content relating to the assessment of general visitor and tourism attributes could suggest a need for increased use of goal development and assessment. Additionally, clear communication of route development policies may need further developement to reduce social conflict. Further, ensuring heterogeneity in the creation of CMPs allows for general visitor and tourism, ecological, and social attributes to be represented throughout policy perpetuity.

### 5.1.1 Policy Clarity for Conflict Prevention

The CMPs assessed here demonstrated a shared commitment to safe infrastructure practices. Within the variables relating to the social system (CSV), nearly 20% of the CSV code discussed fixed anchors and bolting practices for installation and replacement. While bolts and fixed anchors are vital to the safety of climbers, the hardware and its installation can be disruptive, affect the visual aesthetics and natural soundscape, as well as leave lasting impacts on the rock faces. To complicate the impacts of bolts and fixed anchors further, there exist a wide range of perspectives within the community of climbers on the ethics of their use. The conflicting perspectives and impacts (both positive and negative) surrounding bolts and safety anchors result in between and within user group conflict. For example, a lack of clear guidelines for fixed protection installation and replacement in Ten Sleep, WY during 2019 led to verbal altercations, acts of vandalism, and removal of bolts in prominent climbing sites that affected visitor experience and safety. Land managers closed the entirety of the greater Big Horn National Forest to bolt installation until formalized rules were established (Sammartino, 2020).

While fixed anchors were highly represented within the CMPs studied, it is important that land managers continue to ensure that not only are such regulations in place but supported by the community. Community support for policy may be achievable by building on the social capital of stakeholders. Social capital consists of trust and norms of reciprocity that can build or further cooperative relationships (Henry et al., 2011). In the context of climbing plans, social capital may be fostered or understood during public comment periods, participatory planning methods (such as focus groups, interviews with community leaders, and modeling workshops), clear communication of anticipated decisions with feedback opportunities, and advisory groups. Several CMPs already incorporated such practices. For example, SP-ID/CRSP-CMP outlined that policies be reviewed annually by park staff and a developed advisory group called CRAG (Climbing Resource Advisory Group). This plan showed that the inclusion not only helped to incorporate alternative perspectives, but aided land managers in understanding ever evolving outdoor climbing industry standards. In one notable instance, an international plan even included a walkthrough with the indigenous land caretakers to ensure their perspectives were considered in the policy planning process (INT/AU-VIC-CMP; see: https://vicclimb.files.wordpress.com/2020/09/victorian-climbing-management-guidelines-v04.pdf). As the original land caretakers, the respectful inclusion of indigenous perspectives into plan creation may provide further insights and prevention of social conflict regarding indigenous rights and sovereignty.

Potential applications of the use of cognitive mapping exists for conflict prevention purposes within the outdoor climbing system. Samarasinghe and Strickert (2013) showed that fuzzy cognitive maps (FCMs) developed from a variety of stakeholders can be effective in highlighting potential areas of conflict between stakeholders and prompt communication around circumventing such conflict prior to policy implementation through informed policy planning. As such, future research could develop FCMs from outdoor climbing stakeholder groups to promote policies that negate conflict within and across stakeholders.

### 5.1.2 Harnessing the Potential for Technical Learning

Few CMPs acknowledged a need to assess (i.e., evaluate) general visitor and tourism variables (GVTV). While roughly 9.2% of the GVTV code centered around goals, less than 1% focused on the assessment of outlined goals. As such, explicitly outlined procedures do not exist within most CMPs for the revisitation of goals. It is important that frequent revisitation of goals occurs to allow for adjustments to be made to policies to ensure desired management outcomes are being achieved (Williams & Brown, 2014). This process of evaluation and adjustment of polices to ensure they align with goals is known as technical learning (William & Brown, 2014).

At 10%, monitoring was one of the most represented features of the GVTV codes, suggesting there is more consistency, as compared to goal assessment, on the importance of monitoring. Monitoring used here is the collection of data regarding recreation behavior and the state of nearby resources. This can be conducted through a variety of direct and indirection observations and measurement. Assessment, on the other hand, is used here to denote the review and study of available data on behaviors and resources to inform management decisions. Plans who included policies relating to monitoring focused on various social and environmental system attributes, including cultural resources such as cliff dwellings or petroglyphs, visitor use levels at varied cliff faces within a given climbing area, the presence of cliff-nesting raptors, and the abundance of cliff base plant communities. The presence of monitoring in the plans could suggests that there are existing data collection processes occurring that which can be used, and expanded upon, to conduct assessments of the outdoor climbing system. For starters, goal assessment could benefit from existing monitoring pathways by exploring if measurable outcomes are being achieved.

The acronym SMART (specific, measurable, achievable, realistic, and time bound) provides a framework for developing goals (Wood, 2011). The Convention on Biological Diversity (CBD) conducted analysis on the inclusion of SMART goal setting in the production of actionable policies for social ecological systems (SES). CBD found a strong basis for the application of the SMART goal framework to the sustainable use of landscapes and that it allowed for target areas to be consistently interpreted and effectively applied (Green et al., 2019). The SMART goal framework can be incorporated into the AMF, where goals are monitored and evaluated in terms of whether they are achieved. As an illustration, setting a deadline (i.e., time) by which a goal should be achieved can spur action to complete the goal or reflection on what part of the process needs to change if deadlines are not being met.

### 5.1.3 Not All Plans are Created Equal

Significant differences in code presence across groups provides initial insight into the variation in system representation within existing CMPs. International, National Park, Forest Service, and State plans were found to be significantly more representative of system variables than Local/private and Coop/coalition drafted plans. Based on the assumption that a greater code representation translates to greater system representation in the policies, this finding could suggest that processes involved in the governmental and international plan creation capture a greater representation of the outdoor climbing system. U.S. governmental plans frequently include an environmental and social assessment to inform the plan such as an environmental impact statements (EIS), finding of no significant impact (FONSI), and/or public comment periods. These rigorous approaches to system assessment to inform policies may lead to more heterogenous system representation due to the inclusion of multiple approaches to learning and the engagement of many voices in the decision making setting. Local/private and Coop/coalition plan drafters should evaluate if their approach to informing CMPs captures all necessary considerations pertaining system attributes and stakeholder interests. It is important CMP content reflects the interests of all impacted stakeholders to minimize conflict and promote collaboration on social and environmental issues (promoting actor to actor social system horizontal fit; Bodin et al., 2016). However, further research is needed to compare the level of stakeholder engagement and environmental assessment involved in existing CMP creation and how varying forms of knowledge production translate into measurable positive policy outcomes on the system.

## 5.2 Characterizing the System

One of the strengths of cognitive mapping is that the system model created can be used as is or be built upon to characterize and make predictions regarding the outdoor climbing system. Land managers can guide stakeholder expectations and align management policies to meet desired outcomes using system characteristics and policy scenario outcomes (Game et al., 2018).

### 5.2.1 Community Consensus or an Absence of Creative Approach?

Considering the theoretical maximum number of connections for each variable is 31 and that this system has an average of 3.2 connections for each variable, the system is sparsely connected. Further, the system has a low density (0.1 out of a maximum of 1.0). Density score is relative. Therefore, to draw conclusions as to whether the density score of the cognitive map derived from the CMPs' is relatively low or high, further research is needed. Research comparing community maps (aggregated individual maps for stakeholder groups such as climbers, non-climber user groups, academics, land managers, or scientists) could be used to understand if the system, and subsequent means for intervention, are being fully represented. For instance, Gray et al. (2014) found that in coastal management setting local stakeholders perceived a greater number of possible interventions, as determined by FCMs with a higher density, compared to scientist and land managers. The authors suggest that scientists and policy makers may be quicker to see untraditional interventions as impractical or politically unpalatable.

Because density scores equate to entry points for management intervention as perceived by model influencers, if the CMP map's density is lower than that of other stakeholders this may suggest the CMPs used to inform the model present limited variation in perceived system relationships identified within causal link statements (CLS) (Gray et al., 2014). Further, the low system density of the cognitive map developed from CLS in the studied CMPs could suggests those involved in the plan creation process may perceive there to be a limited number of ways to measure change in the outdoor climbing system (management interventions; Özesmi & Özesmi, 2004). The map's low density could also result from an absence of creative thinking around policies to achieve desired outcomes within the outdoor climbing system (Gray et al., 2014). Alternatively, low system density could result from a consensus among those involved in CMP creation about the main forms of system intervention. Specific comparison of the characteristics of the outdoor climbing system using community maps could help refine system density, identify alternative means of management, and identify areas for knowledge coproduction. Aside from the potential to capture a more complete system representation, comparison of community maps helps identify gaps in knowledge between groups and provide target areas for timely and tailored consensus building (Gray et al., 2014; Gray et al., 2012).

### 5.2.2 Ripple Effects of a Policy

Due to the high degree of variable interconnectedness, land managers could act under the understanding that adjustments to any system variable, particularly those that have outward impact (ordinary or transmitter variables), will likely have impacts to the whole system (Özesmi & Özesmi, 2004). As such, a land manager's choice to value or undervalue any one system variable should be informed by model outcomes that align with desired management goals. For example, policies that include variables with high driverness (e.g., pets, route development, and technological improvements) will have the greatest impacts across the system, as seen in the bolt ban and rose-colored glasses scenarios. The impacts of managing other variables can be best understood by studying the cognitive map's characteristics and assessing the spheres of influence of any given variable (Berlow, 2010). Variables within the 1st degree of influence will have direct relational influence while more nuanced relationships may be many degrees of influence out from the focal variable. Understanding and acting based on these scales of influence could empower decision makers who face conflicting causal relationships or varying stakeholder interests (Vasslides & Jensen, 2016; Game et al., 2018).

In building local level awareness of the system's capacity for change, land manager and coalitions have the potential to motivate climbers and non-climber groups to abide by policies in place and to collaborate on stewardship and safety initiatives such as trail building, graffiti removal, and safety bolt replacement fundraising. If stakeholders perceive systems as within their capacity to change, they may also be more likely to act in favor of protecting the social and ecological variables for continued access. This could be a point of focus for land managers to build social capital in the form of normative beliefs and behaviors, as well as within and between group trust of management goals (Henry et al., 2011). Ways to develop social capital could include between group and within group approaches such as networking opportunities, the development of associations around shared interests, conducting community impact assessments or running educational interventions (Henry et al., 2011). For instance, Maples et al. (2017) conducted an economic impact assessment that found climbers spent an estimated $12.1 million dollars in the rural town of Slade, KY in 2018. By quantifying the role climbers had on the greater system in this way, Maples et al. (2017) helped communicate the impacts climbing had on the community and engaged a wider range of stakeholders to value areas geologic features and subsequent climbing recreation opportunities as an influential part of the region's resources.

#### 5.2.3 Scenario Synthesis

The policy scenarios demonstrated how lags can influence the perceived outcome of any given management action (Kok, 2009). While a given policy may result in an initial decrease in the targeted impact or behavior, there may be a very different outcome as the system reaches equilibrium due to potential feedback loops and ripple effects throughout the system. For instance, infrastructure advancements (scenario 3) resulted in an initial decrease in economic stability of the system, yet economic balance later improved due to its connections within the system. The ability to pre-test policies is an advantage of cognitive mapping methods, so long as there is heterogenous representation, because such maps allow for the conceptualization of variable roles and possible pathways for future decision making (Gray et al., 2014; Baker et al., 2018).

### 5.3 Limitations of Findings

Limitations to this research can be identified throughout the methods. First, by using Google, a search engine familiar with my previous searches and general cookies, there is a proclivity for the search engine's algorithm to promote content aligned with previous search history. Therefore, over each subsequent search for CMPs there was likely a greater chance that the promoted search outcomes aligned with previous CMP downloads and my general search history as a recreational rock climber. If this process were to be replicated in the future, this potential source of bias could be reduced by using multiple search engines (Bing, Ecosia, Google, etc.) and by using an incognito browser that does not track cookies or use an algorithm to identify search outcomes or their order.

Second, both in the initial document coding process and in the analysis of causal link statements, there was the potential for the coder's own experiences and degree of knowledge on the locations or topics to influence outcomes (Carley & Palmquist, 1992). This potential for error was managed using a code dictionary where possible and aggregated coding dates in which procedures were likely similar (Carley & Palmquist, 1992). Additionally, as this research was conducted by a single coder, there was a chance that results may not be reliable and were subject to the bias the coder has towards the content of the research. The primary coder had a familiarity with the topic from academic specializations, professional accreditations, and employment, as well as personal engagement in the form of recreation. This level of involvement in the topic while potentially advantageous for content discerning certainly has potential for confirmation bias on preconceived notions of the system and variable interactions. These limitations could be addressed if future iterations of this research are conducted using multiple coders and intercoder reliability testing. Further, it is important all coders share a consensus for how terms are to be applied and refine unclear definitions if intercoder reliability tests identify inconsistencies (Deegan, 2009).

Third, limitations of the cognitive map developed herein include the absence of detailed relationship values, uncertainty regarding the map's representativeness, as well as the technical knowhow necessary for model construction (Cumming et al., 2006). Because the CLS included only directionality (+/-) and not degree (Low, Medium, or High), this system model lacks a stepped relational characteristic (Özesmi & Özesmi, 2004). Absence of these values limit the capacity of the model to produce near accurate equilibrium values when testing policy outcomes. Future research should engage experts and diverse stakeholder voices to validate and build upon the system model presented here through the addition of fuzzy relational values.

Finally, the variables and represented relationships of a cognitive map are subject to uncertainty (Mourhir et al., 2015). Further, the system model is only as accurate as the perceptions that shape its construction (Jones et al., 2011). Because the cognitive map was created from a limited number of CLS from a narrow selection of CMPs, it is important to address the potential for misrepresentation based on false relationship perceptions within these documents. There is opportunity to reduce this uncertainty through the map's validation. Map validation can be conducted through the triangulation of methods using interviews or participatory methods to elicit comparative cognitive maps of the study system. By comparing and pooling knowledge from a variety of sources, there is potential to validate, or update, the model created here. At a local level, land managers can use the model constructed herein as a starting point to elicit the cognitive maps, or even fuzzy cognitive maps (FCM), of those intimately connected to the study system. Fortunately, readily accessible platforms like Mental Modeler are available to assist in this elicitation process by reducing potential technical barriers for land managers interested in this approach (see Gray et al., 2013 or visit mentalmodeler.org).

## 5.4 Significance of Findings

All study objectives were met and in doing so directly responded to the main study questions. For starters, this study was interested in outlining similarities and differences that existed in CMPs. Significant differences were found to be present in the inclusion of policies relevant to general visitor and tourism attributes and climber environmental variables of the system. Advancements to the goal development and assessment process can begin to address inconsistencies across sites to ensure appropriate system representations across land managers and the outdoor climbing landscape. Through the collection and mapping of CLS, the shared variables of the study systems were isolated and represented. In testing variable driverness and centrality, the most influential system variables were identified by centrality, variable type, and driverness and most notably included the variables: pets, route development, and technological improvements. And lastly, in testing various policy scenarios, it was determined that policies that involve the combined management of multiple high driverness variables will have the greatest effect on the system. However, policies with the greatest system effect will likely not be the best for balancing user motivations and achievement management goals. It is therefore important that the limitations of the current model be addressed to advance the pre-testing capacity to inform the policy planning as part of the adaptive management of the outdoor climbing system.

Beyond achieving system-relevant goals that motivated the research, this combined-method approach of this study advances the ability to represent complex SES. In support of the use of cognitive mapping, this research provides a case-study into the use of mapping methods to conceptualize a system that may otherwise have limited available knowledge and produce a model for pre-testing policy scenarios.

## 5.5 Next Steps

### 5.5.1 CMP Content Comparison

Future research can build upon the across group comparison conducted here to produce more detailed comparisons of the existing CMPs managing the outdoor climbing system. Segment specific content within code categories was not analyzed. The possibilities for future comparison of this data can be conducted by specific policy topic, plan, regions date, or most other specified scales. Specific anticipated next steps based on findings put forth here include a comparative review of themes and approaches expressed around CMP goals, assessment approaches, stakeholder engagement practices, sources of conflict, and monitoring practices in place.

### 5.5.2 Future Map Refinement

To achieve a FCM of the study system, next steps for modeling the outdoor climbing system could include stakeholder group engagement on the perceived degree of relation between system variables and judgement as to whether all variables included are appropriate and if any additional variables should be added (Obiedat, 2013). Fundamentally, FCMs are only as accurate as the representation of the system within the minds of the map creators (Mourhir et al., 2015). The pooled knowledge of stakeholders through individual FCMs and subsequent community FCMs can be used to develop the relational data, as well as to identify potential points of conflict among stakeholder groups and assess knowledge gaps (Freitag et al., 2019; Gray et al., 2014). Once sources of potential conflict and knowledge gaps are identified, they may be more readily resolvable where appropriate through deliberation, collaboration, education, and/or outreach.

# Chapter 6. Conclusion

*"(...) learning what we don't know isn't a dead end - in fact, it can provide a clear path forward, illuminating the steps required to make an open and transparent decision."*

Quote from Baker et al. (2018) about the utility of fuzzy cognitive mapping

This research presents a case study application of cognitive mapping with methodological emphasis in linguistic analysis and document data mining. This research also provides a comparative analysis of the state of climbing management policies, as well as a network model that can be used to inform adaptive management. Potential applications of these outcomes will depend upon the influence given actors have within their system to change it and the state of management within said system. Therefore, study findings have been translated here into general recommendations for key actors.

For land managers, this study demonstrates how the use of alternative methods -- specifically cognitive mapping and document analysis -- can improve understanding of outdoor climbing management, as well as provides a comparative analysis of current climbing management policies. Further, this study identified how available information ('wisdom of the crowd') can lead to greater understanding of the system and reduce barriers (e.g., cost, technical knowledge, extended time in field) common to studying outdoor climbing (McHugh, 2019). In doing so, this research created a baseline model of the system to be considered in the adaptive management of outdoor climbing recreation. Land managers can use the cognitive map constructed here or build upon its skeleton to create more site-specific system representations. By representing their system, land managers can incorporate a system thinking approach to addressing impacts facing the social and environmental variables of their system (Baker et al., 2018). If cognitive mapping methods outlined in this document appeal to land managers, varying forms of participatory engagement processes and levels of technological approaches can be used to construct site specific fuzzy cognitive map (FCMs) to build upon the presented work. The online program *Mental Modeler* can provide land managers a user friendly platform to begin modeling and policy analysis (Gray et al., 2013). If the barrier to employing modeling is based on limited experience applying such methods, land managers can consider alternative forms of system representation through other forms of participatory engagement to elicit an array of perceptions using physical cognitive map drawing, focus group conversations, or even individual stakeholder interviews (Voinov et al., 2018). Knowledge sharing can be bolstered through collaboration between land managers and local organizers. Partnerships with local or regional coalitions and NGOs with dedicated advocacy members can help reduce barriers towards protecting the spaces they use (Murdock, 2019). Local organizers can be identified through the AAC chapter chairs (https://americanalpineclub.org/regions) or Access Fund regional directors (https://www.accessfund.org/inside-access-fund/staff). By building on the human capital of these pre-existing organizations, land managers can work to build social capital with local level coalitions who can assist in reaching management goals (Coleman, 1988). Further, the comparative qualitative data highlighted herein can be used by land managers to understand the focus of existing management policies. By understanding trends in current policies, land managers can identify gaps in topic coverage to address during the evaluation and redesign of outdoor climbing system-related policy development. Social learning, the uptake and incorporation of knowledge across different groups on policy successes and failures for future planning, can be maximized by collaborating with others who have previously managed or studied related variables to better inform policy planning and the greater adaptive management of outdoor climbing (William & Brown, 2014).

Coalitions can incorporate the findings of this research to help build upon their existing relationships and connections to promote adaptive management of system(s). Begin by developing an understanding of system variables and their interconnectedness. Understanding the complexity of one's system can help coalitions to focus their resources, which at times could be limited in capacity, on system variables whose relationships are most influential on desired outcomes. For example, if there is a desire for increased communication, the system model developed herein suggests targeting education will result in more favorable outcomes as compared to increasing collaboration. This example highlights the importance of understanding and incorporating system relationships into decisions because complex systems may not always operate in obvious ways nor be consistent with assumptions made about variable interactions. Additionally, coalitions can work to build or bolster relationships with land managers and, in some cases, develop shared management responsibilities over the local outdoor climbing to assist in building social capital to designing and achieving shared goals for the system. Shared management practices can include the organizing of clean up events, dedicated MOUs for specific management tasks such as safety bolt replacement, and active roles in decision making spaces through individual or group advisory positions.

Lastly, individuals engaged in outdoor climbing can apply the findings of this study by first familiarizing oneself with the system(s) they are actors within. Further, identify if a CMP exists for the system, what other policies affect outdoor climbing, who owns the land, and if a local coalition is working to maintain access and reduce impacts. By understanding the key actors and impacts affecting a given system, climbers can begin to play an informed role in the stakeholder engagement process. Participating in stakeholder engagement helps to ensure individual motivations for visiting a site are represented in management policies. Engagement can look different depending on the person. For some it can be as simple as promoting Leave No Trace ethics when out with peers and for others it can be volunteering to conduct monitoring work, host clean-ups or trail building events, or involving themselves in local politics.

Whatever one's role within climbing, it is important that it be understood that actions taken have ripple effects across a system. As such, actor behaviors and policies alike need be rooted in informed, adaptive approaches to ensure climbing management considers the complex relationships between the social and ecological attributes of the system, as well as the varied interests of actors. Climb on.

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Appendix

Appendix A. Document Search Phrases

The following key terms were entered into Google's search engine to source climbing management plans for this research:

- "climbing management plan"
- "mad river gorge" "climbing management plan"
- "mad river gorge" "climbing management"
- "mad river gorge" "management"
- Ableman's Gorge climbing management plan
- acadia climbing management plan
- acadia climbing management plan pdf
- Access Fund Comments to Management Plans for the Indian Creek and Shash Jáa Units of Bears Ears National Monument
- alabama hills management plan
- alabama hills management plan comments
- alaska climbing management plan
- apache leap
- approved ROCK CLIMBING GUIDELINES 4 ROBINSON PARK CITY OF SANDSTONE
- arches climbing management plan
- arkansa climbing management plan
- arkansas climbing management plan
- backcountry management plan grand canyon national park
- black canyon climbing management plan
- black canyon interim climbing management plan
- blacktail butte climbing
- blca interim climbing management plan
- blm climbing management
- british columbia
- carolina climbers coalition climbing "management"
- carolina climbers coalition climbing management
- city of post falls
- city of rocks national reserve
- CLIFTON CLIMBERS ALLIANCE CLIMBING MANAGEMENT PLAN FOR EAGLE BLUFF
- Climbing and Natural Resources Management AN ANNOTATED BIBLIOGRAPHY
- climbing in custer state park
- climbing management plan
- climbing management plan auburn state recreation area
- climbing Management Plan for Great Falls, VA
- coalition owned climbing areas

Appendix A. Continued.

- cochise stronghold climbing management plan
- cochise stronghold southern arizona climbing
- dardanelle climbing management plan
- devils lake climbing management plan
- devil's lake climbing management plan
- Draft Management Plan for the Peter's Kill Area of Minnewaska State Park Preserve
- Effective Recreation Visitor Communication Strategies: Rock Climbers in the Bitterroot Valley, Montana
- eldorado canyon climbing management plan
- ENCHANTED ROCK
- finalised draft climbing management plan devils tower
- Forest Resource Management Plans: A Sustainability Approach Front cover image for Forest Resource Management Plans: A...
- forks of the sky climbing
- grampians-climbing-management-plan
- grandad bluff climbing management plan
- gunks climbing management plan
- hidden valley climbing management plan
- illinois climbing management plan
- iowa climbing management plan
- joshua tree climbing management plan
- Land and Resource Management Plan for the Daniel Boone National Forest: Appendices to final environmental impact stat...
- laurel knob climbing
- laurel knob climbing management
- lincoln lake climbing management plan
- mad river gorge
- Michigan climbing management plan
- minnesota rock climbing
- minnesota rock climbing management plan
- missouri climbing management plan
- mohonk preserve climbing
- mohonk preserve climbing management
- mohonk preserve climbing management plan
- national-level management guidelines for climbing NPS
- new river gorge climbing management plan
- non operating management plans
- oak creek canyon climbing management plan
- obed
- obed climbing
- obed wild and scenic river climbing management plan
- ohio climbing management plan

Appendix A. Continued.

- poshe stronghold southern arizona climbing
- red rock canyon management plan
- roadside climbing management plan
- robinson park city of sandstone
- ROCK CLIMBING GUIDELINES 4 ROBINSON PARK CITY OF SANDSTONE
- Rock Climbing Rules and Regulations Daniel Boone National Forest
- rockwoods climbing management plan
- Rocky Mountain National Park Commercial Services Strategy for Guided Climbing and Technical Mountaineering
- South Platte Area Climbing Management Plan
- South Platte Area Climbing Management Plan for Pike National Forest Prepared in cooperation with The Access Fund and ...
- south platte naTIONAL FOREST COLORADO
- Sunset Rock Final Climbing Management Plan
- this land is our land: climbing on public lands
- torrent of falls climbing management plan
- wall climbing management plan
- WILDERNESS ROCK CLIMBING INDICATORS AND CLIMBING MANAGEMENT IMPLICATIONS IN THE NATIONAL PARK SERVICE by Katherine Y....
- WISCONSIN climbing management plan

Appendix B. Document Identifications Dictionary

| Organization Abbreviation | Full Name |
|---|---|
| FS | Forest Service |
| NPS | National Park Service |
| BLM | Bureau of Land Management |
| AF | Access Fund |
| CAN | Canada |
| SP | State Parks/Public Land Manager |
| COPU | County Owned Public |
| COPR | County Owned Private |
| WCC | Washington Climbers Coalition |
| FIC | Friends of Indian Creek |
| AAC | American Alpine Club |
| ED | Any Relevant University Publications |
| ZAF | South Africa |
| CO | Co-op/Coalition |
| ETCC | Eastern Kentucky Climbers Coalition |
| INT | International |
| AU | Australia |
| CI | City Owned |
| CCA | Clifton Climbers Association |

| State/Sub.Org. Abbreviation | Full Name |
|---|---|
| BC/BCP | British Columbia, BC Parks |
| CO/RMNP | Colorado, Rocky Mountain National Park |
| NY/MNSPP | New York, Minnewaska |
| AZ/AL | Arizona, Apache Leap |
| K/GP | Quebec, Gatineau |
| CA/JTNP | California, Joshua Tree NP |
| CO/PP | Colorado, Pikes Peak |
| WY/DTNM | Wyoming, Devils Tower NM |
| CO/PCOST | Colorado, Pitkin County Open Space and Trails |
| WA | Washington |
| TN/OWSR | Tennessee, Obed Wild and Scenic River |
| UT/IC | Utah, Indian Creek |

Continued.

Appendix B. Continued.

State/Sub.Org. Continued.

| Abbreviation | Full Name |
|---|---|
| AZ/GCNP | Arizona, Grand Canyon NP |
| NH/WMNF | New Hampshire, White Mountain NF |
| TX/ERSNA | Texas, Enchanted Rocks State Natural Area |
| WA/BRSP | Washington, Beacon Rock State Park |
| ID/CRSP | Idaho, Castle Rock SP |
| AK/CSP | Arkansas, Chugach SP |
| UT/ANP | Utah, Arches NP |
| KY/DBNF | Kentucky, Daniel Boone NF |
| PA/DCNR | Pennsylvania, Department of Conservation & Natural Resources |
| MN/TSP | Minnesota, Tettegouche SP |
| SANP | South African National Parks |
| NC/NPFP | North Carolina, Nantahala-Pisgah Forest Partnership |
| NC/LK | North Carolina, Laurel Knob |
| NCSP | North Carolina State Park |
| UT/SCSP | Utah, Snow Canyon SP |
| VIC | Victoria, AU |
| AZ/MSP | Arizona, McDowell Sonoran Preserve |
| ID/COR | Idaho, City of Rocks |
| HI | Hawaii |
| CO/LSP | Colorado, Lory State Park |
| CA/ASRA | California, Auburn State Recreation Area |
| CA/SKCNP | California, Sequoia Kings Canyon National Park |
| WA/FS | Washington, Forks of the Sky |
| NH/RR | New Hampshire, Rumney Rock |
| ID/QP | Idaho, Q’emiln Park |
| UT/LC | Utah, Logan Canyon |
| MN/RPS | Minnesota, Robinson Park City of Sandstone |

Document Type

| Abbreviation | Full Name |
|---|---|
| PC | Public Comments |
| EM | Educational Materials |
| BPG | Best Practices Guide |
| TR | Technical Report |
| CSS | Commercial Services Strategy |
| CS | Case Study |
| CMP | Climbing Management Plan |

Continued.

Appendix B. Continued.

Document Type Continued.

| Abbreviation | Full Name |
|---|---|
| FP | Federal Policy |
| M | Media |
| BMP | Backcountry Management Plan |
| I | Interim |
| D | Draft |
| FONSI | Finding of No Significant Impact |
| CCMP | Climbing & Canyoneering Management Plan |
| EMP | Environmental Management Program |
| CMG | Climbing Management Guide |
| RCG | Rock Climbing Guidelines |
| CMS | Climbing Management Strategy |
| EIS | Environment Impact Statement |
| CMD | Climbing Management Direction |
| GB | Guidebook |
| T | Thesis |

Appendix C. Code Dictionary

| CATEGORY | DEFINITION | FULL TITLE | ABBREVIATION |
|---|---|---|---|
| Document Details | N/A | Document Title | Title |
| | N/A | Climbing Location | Location |
| | The date of approval into policy where applicable. Otherwise, any date of creation or signature. | Date Published | Date |
| | Any names or reference to advisees on the CMP | Involved Parties | Involved Parties |
| | Names, emails, addresses of involved parties | Contact Information | Contact Info |
| | Parts of the document that state definitions or facts that are supplemental to CLS or policies | Definition | Definition |
| | Portions of the document that discuss history or background on the location that are supplemental to the policies | Area History | Area History |
| | Any included table | Table | Table |
| | Any included image | Image | Image |
| | Any inclusion of additional documents considered or tied to the CMP. | Reference to Parent and/or Additional Management Plan Document | Ref to Parent + Additional MP Doc |

| | | | |
|---|---|---|---|
| CLS | Statements that suggest a relationship (+/-) between two given variables. These statements need not be factual- it is just what the author states and all should be coded as CLS with associated codes for the relationship values when applicable. CLS example: Hats tend to create hat hair to those who wear them. | Causal Link Statement | CLS |

| | | | |
|---|---|---|---|
| General Visitor and Tourism "Park" Policy Categories adapted from Eagles et al. 2014 (GVTV) | Policies on: overall goals for the management plan that direct the management approach | Goals or Objectives of Management Plan | GOAL |
| | Policies on: an overall, clearly identified, strategy to guide visitor use management | Visitor Use Plan | USEPLAN |
| | Policies on: the use of an established visitor management framework that provides directives for visitor management (such as Limits of Acceptable Use and Visitor Impact Management) | Established visitor management framework | MGFRAME |

Continued.

Appendix C. Continued.

| | | | |
|---|---|---|---|
| General Visitor and Tourism "Park" Policy Categories adapted from Eagles et al. 2014 (GVTV) | Policies on: permissible/encouraged activities and visitor numbers that conform with park goals and objectives (such as low impact recreational and interpretation activities) | Permitted and encouraged visitor levels and uses | QUOTA |
| | Policies on conflict that many arise in the park (such as, between visitors and managers, between recreationists, and between recreation and non-recreational activities) | Conflict Management | CONMG |
| | Policies on: trails and markings within the park (such as signs and trails for education and enforcement purposes) | Trails and markings | PTRAILS |
| | Policies on: restricted items withing the park (such as firearms) | Restricted Items | PITEM |
| | Policies on: land use zoning within the park (such as allowable and timing of activities) | Land use zoning and temporary area restrictions | PUSE |
| | Policies on: the provisions of accessible programming, services, and facilities for persons with disabilities) | Accessibility | ACCESS |
| | Policies on: dates and hours of operation for the park as a whole, as well as for specific facilities (such as visitor center, restaurant), and specific services (such as boat tour, educational program) | Dates and hours of operations | OPPHRS |
| | Policies on: length of stay for visitation in the park (such as seasonal restrictions and campsite use) | Length of stay | MAXSTAY |
| | Policies on: fees and pricing for park entry, facilities, and services (such as considering different park seasons, locations, and visitor types) | Fees and pricing | PFEES |
| | Policies on: enforcement of rules and laws within park boundaries (such as preventing illegal, dangerous, or unwarranted activity) | Enforcement of rules and laws | ENFORCEMENT |
| | Policies on: park accommodations (such as accommodation type, location, facilities) | Accommodation | ACCOM |
| | Policies on: the number, type, qualifications, and training of park human resources (such as skilled workers, temporary workers, and volunteers) for specified roles and for specified times (seasonal, special projects, full time) | Human resources required for visitation | STAFF |

Continued.

Appendix C. Continued.

| | | | |
|---|---|---|---|
| General Visitor and Tourism "Park" Policy Categories adapted from Eagles et al. 2014 (GVTV) | Policies on: a program to measure visitor use and numbers into and within the park | Visitors use monitoring | MONITOR |
| | Policies on: visitor satisfaction (such as creating a certain degree of visitor satisfaction that can encourage visitors spending or repeat visitation) | Visitor satisfaction | SATISFACTION |
| | Policies on: the use of an environmental assessment tool to inform the CMP/GMP | Environmental impact assessment | ENVIROASSESS |
| | Policies on: the use of a social assessment tool to inform the CMP/GMP | Social impact assessment | SOCIALASSESS |
| | Policies on: a program to measure whether the park plan policies have been attained | Assessment of objectives attainment | GOALASSESS |

| | | | |
|---|---|---|---|
| Policy Categories Specific to Environmental System Variables *Adapted from Attarian and Keith 2008 (CEV) | Policies on: the formation and lasting upkeep of rock face base areas referred to commonly as "staging areas" and access trails to general and specific climbing areas | Climber Trails/Staging Areas | CTRAILS |
| | Policies on: backcountry trips (such as permissible activities and visitor numbers) | Bivouac/backcountry camping | CAMP |
| | Policies on: the regulations around human litter and fecal disposal in the vicinity of the climbing area | Human waste | HUWASTE |
| | Policies on: rock face and surrounding area vegetation | Vegetation | VEG |
| | Policies on: the impact on water (ground & surface) | Water resources | WATER |
| | Policies on: wildlife including but not limited to birds, mammals, insects, amphibians, reptiles | Wildlife | WILD |
| | Policies on: soil compaction, degradation, erosion, and other possible impacts | Soil | SOIL |
| | Policies on: actions relating to the rock quality and erosion | Rock Face/Geological Resources | ROCK |
| | Polices on: the specific land designation of "wilderness" | Wilderness Areas | WILDNESS |

| | | | |
|---|---|---|---|
| Policy Categories Specific to Social System Variables *Adapted from | Policies on: impacts to indigenous, cultural, & historical items | Cultural Resources | CULTURAL |
| | Policies on: the recreation group be managed for including rappelling, sport climbing, bouldering, ice/mixed climbing, and traditional climbing | Climber Users | CLIMB |

Continued.

Appendix C. Continued.

| | | | |
|---|---|---|---|
| Policy Categories Specific to Social System Variables *Adapted from Attarian and Keith 2008 (CSV) | Policies on: recreational space users who do not include climbers or general visitor comments | Non-climber Users | NONCLIMB |
| | Policies on: the scenic value of the landscape and potential impacts | Visual Impacts | VISUAL |
| | Policies on: the bolts, "glue-ins", anchors, rappel rings, fixed gear, route development, pitons, bolt replacement | Fixed Hardware | FIXED |
| | Policies on: climber or non-climber users' animals | Pets | PETS |
| | Policies on: the natural soundscape and potential impacts | Noise | NOISE |
| | Policies on: trash | Litter | LITT |
| | Policies on: rented, group, guided, or other commercial applications of climbing on the land | Commercial Activity | GUIDE |
| | Policies on: human made dimensions of the climbing locations including but not limited to buildings, trail markers, signage, parking lots, restrooms | Infrastructure | INFRA |
| | Policies on: safety, search and rescue, emergency services, and other risk related services or impacts | Risk Management | RM |
| | Policies on: collaboration, stakeholder engagement, and other partnerships between land managers and community members | Partnerships & Memorandums of Understanding | MOU |
| | Policies on: efforts to inform visitors including but not limited to trailhead messages, programs, signage, brochures | Educational Materials/Programs | EDU |
| | Policies on: the financial contributions including but not limited to jobs, local sales | Local Economy | ECON |

Appendix D. Document Identifications

| Plan Title by Document Group | ID Code | Date | # of pages |
|---|---|---|---|
| **International** | | | |
| Victorian Climbing Management | INT/AU-VIC-CMP | 2020 | 61 |
| Environmental Management Programme for Climbing | INT/ZAF-SANP-EMP, CMP | 2000 | 21 |
| Rock Climbing Strategy | INT/CAN-BC/BCP-RCS | 1999 | 10 |
| **National Park** | | | |
| Climbing Management Strategy | NPS-CA/SKCNP-CMP, D, EIS | 2014 | 11 |
| Final Climbing Management Plan | NPS-TN/OWSR-CMP | 2002 | 24 |
| Final Climbing Management Plan and FONSI | NPS-WY/DTNM-CMP | 1995 | 56 |
| Climbing Management Plan | NPS-CA/JTNP-CMP | 1993 | 20 |
| **Forest Service** | | | |
| Logan Canyon Climbing Management Plan | FS-UT/LC-CMP, T | 2017 | 21 |
| South Platte Area Management Plan | FS-CO/PP-CMP | 2015 | 11 |
| Rumney Rocks Climbing Management Plan | FS-NH/RR-CMP | 2015 | 8 |
| **State** | | | |
| Rock Climbing Management Guidelines | SP-NCSP-CMG | 2019 | 15 |
| Technical Rock Climbing Management Plan | SP-WA/FS-CMP | 2017 | 7 |
| Rock Climbing Management Plan | SP-TX/ERSNA-CMP, PC | 2017 | 22 |
| Chimney Rock Climbing Management Plan | SP-NC/CR-CMP | 2016 | 5 |
| Climbing Management Plan | SP-ID/CRSP-CMP | 2016 | 12 |
| Hawaii Rock Climbing Management Plan | SP-HI-CMP, D | 2014 | 11 |
| Rock Climbing, Rappelling, and Bouldering Management | SP-PA/DCNR-CMG, FP | 2008 | 4 |
| Climbing Management Plan | SP-UT/SCSP-CMP | 1997 | 13 |
| **Coop/coalition** | | | |
| Hidden Valley Climbing Management Plan | CO/CCC-NC/HV-CMP | 2017 | 7 |
| Climbing Management Plan | CO/CCA-ME/EB-CMP | 2014 | 2 |
| Laurel Knob Climbing Management Plan | CO/CCC-NC/LK-CMP | 2006 | 13 |
| **Local/private** | | | |
| Melrose Mountain Climbing Management Plan | CO/CCC-NC/MM-CMP | 2019 | 6 |
| Gold Butte Climbing Management Plan | COPU-CO/PCOST-CMP | 2015 | 11 |
| Climbing Management | CO-ID/QP-GB, CMP | 2014 | 1 |
| Rock Climbing Guidelines 4 | CI-MN/RPS-CMP, D | 2014 | 6 |
| Rock Climbing Guidelines | CI-AZ/MSP-RCG | 2011 | 3 |

Appendix E. Code Frequency by Document Group.

| | International | National Park | Forest Service | State | Coop/coalition | Local/private | SUM |
|---|---|---|---|---|---|---|---|
| GVTV\GOAL | 9 | 8 | 7 | 19 | 5 | 2 | 50 |
| GVTV\MGFRAME | 10 | 17 | 6 | 19 | 1 | 3 | 56 |
| GVTV\USEPLAN | 2 | 3 | | 1 | | 1 | 7 |
| GVTV\QUOTA | 3 | 1 | 7 | 10 | 3 | 2 | 26 |
| GVTV\CONMG | 4 | 9 | 6 | 17 | 2 | 7 | 45 |
| GVTV\PTRAILS | 6 | | 2 | | | 1 | 9 |
| GVTV\PITEM/ACT | | 14 | 3 | 15 | 8 | 3 | 43 |
| GVTV\PUSE | 5 | 7 | 12 | 25 | 6 | 6 | 61 |
| GVTV\ACCESS | 10 | 20 | 18 | 40 | 14 | 12 | 114 |
| GVTV\PFEES | | | | 2 | | | 2 |
| GVTV\ENFORCEMENT | 7 | 3 | 1 | 4 | | 2 | 17 |
| GVTV\ACCOM | | 1 | 1 | | | | 2 |
| GVTV\STAFF | | 2 | | 1 | | | 3 |
| GVTV\MONITOR | 18 | 10 | 18 | 14 | | 1 | 61 |
| GVTV\ENVIROASSESS | 12 | 17 | 15 | 16 | | 1 | 61 |
| GVTV\SOCIALASSESS | 5 | 16 | 6 | 4 | | 2 | 33 |
| GVTV\GOALASSESS | 3 | 1 | 1 | | | | 5 |
| CEV\WILDERNESS | 1 | 11 | 7 | 2 | | | 21 |
| CEV\CTRAILS | 16 | 8 | 17 | 10 | 6 | 9 | 66 |
| CEV\CAMP | 6 | 4 | 7 | 4 | 5 | | 26 |
| CEV\HUWASTE | 3 | 2 | 5 | 1 | 2 | 1 | 14 |
| CEV\VEG | 20 | 21 | 29 | 44 | 5 | 4 | 123 |
| CEV\WATER | 1 | 1 | 8 | | | 1 | 11 |
| CEV\WILD | 19 | 26 | 15 | 35 | 2 | 3 | 100 |
| CEV\SOIL | 7 | 5 | 6 | 10 | | | 28 |
| CEV\ROCK | 8 | 26 | 23 | 60 | 14 | 15 | 146 |
| CSV\CULTURAL | 39 | 27 | 10 | 27 | 1 | 2 | 106 |
| CSV\CLIMB | 29 | 29 | 41 | 53 | 2 | 11 | 165 |
| CSV\NONCLIMB | 4 | 9 | 5 | 5 | 4 | 5 | 32 |
| CSV\VISUAL | 5 | 13 | 7 | 19 | 2 | 5 | 51 |
| CSV\FIXED | 32 | 40 | 34 | 103 | 50 | 27 | 286 |
| CSV\INFRA | 7 | 7 | 10 | 17 | 5 | 10 | 56 |
| CSV\PETS | | 2 | 1 | 2 | 2 | 1 | 8 |
| CSV\NOISE | | 5 | 1 | 2 | | | 8 |
| CSV\LITT | 3 | 5 | 3 | 5 | | | 16 |
| CSV\GUIDE | 6 | 7 | 5 | 29 | 14 | 10 | 71 |
| CSV\RM | 9 | 18 | 4 | 59 | 12 | 19 | 121 |
| CSV\EDU | 14 | 24 | 11 | 21 | 4 | 5 | 79 |
| CSV\MOU | 28 | 15 | 30 | 38 | 3 | 14 | 128 |
| CSV\ECON | 3 | 3 | | 1 | | | 7 |
| SUM | 354 | 437 | 382 | 734 | 172 | 185 | 2264 |
| AVG PER DOCUMENT | 118 | 109 | 127 | 92 | 57 | 37 | 87 |
| CODE APPEARANCE | 34 | 38 | 36 | 36 | 24 | 30 | 40 |

Appendix F. Code Frequency by Document.

| | NPS-TN/OWSR-CMP | NPS-CA/SKCNP-CMP, ... | NPS-WY/DTNM-CMP | NPS-CA/JTNP-CMP | FS-UT/LC-CMP, T | FS-CO/PP-CMP | FS-NH/RR-CMP | SP-NCSP-CMG | SP-WA/FS-CMP | SP-TX/ERSNA-CMP, PC | SP-NC/CR-CMP | SP-ID/CRSP-CMP | SP-HI-CMP, D | SP-PA/DCNR-CMG, FP | SP-UT/SCSP-CMP | CO/CCC-NC/MM-CMP | COPU-CO/PCOST-CMP | CO-ID/QP-GB, CMP | CI-MN/RPS-CMP, D | CI-AZ/MSP-RCG | CO/CCC-NC/HV-CMP | CO/CCA-ME/EB-CMP | CO/CCC-NC/LK-CMP | INT/AU-VIC-CMP | INT/ZAF-SANP-EMP ... | INT/CAN-BC/BCP-RCS | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GVTV\GOAL | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 | 1 | | 1 | 1 | 21 |
| GVTV\MGFRAME | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | 1 | | 1 | | 1 | | | | 1 | 1 | 1 | 1 | 18 |
| GVTV\USEPLAN | | | | 1 | | | | | | | | 1 | | | | | | | 1 | | | | | | 1 | | 4 |
| GVTV\QUOTA | 1 | | | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | 1 | | 1 | 1 | | | 15 |
| GVTV\CONMG | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 | 1 | 21 |
| GVTV\PTRAILS | | | | | | 1 | | | | | | | | | | | 1 | | | | | | | | | 1 | 3 |
| GVTV\PITEM/ACT | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | 1 | 1 | | 1 | | 1 | | 1 | 1 | 1 | | 1 | | | | 15 |
| GVTV\PUSE | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | | 18 |
| GVTV\ACCESS | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 22 |
| GVTV\PFEES | | | | | | | | 1 | | | | 1 | | | | | | | | | | | | | | | 2 |
| GVTV\ENFORCEMENT | | 1 | | 1 | | 1 | | 1 | 1 | 1 | | | | 1 | | | 1 | 1 | | | | | | | 1 | 1 | 11 |
| GVTV\ACCOM | | | 1 | | | | 1 | | | | | | | | | | | | | | | | | | | | 2 |
| GVTV\STAFF | | | 1 | | | | | | | | | | | | 1 | | | | | | | | | | | | 2 |
| GVTV\MONITOR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | | 1 | | 1 | | | | | | | 1 | 1 | 1 | 15 |
| GVTV\ENVIROASSESS | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 | 1 | | 1 | | | | | | | 1 | 1 | 1 | 16 |
| GVTV\SOCIALASSESS | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | | | | | 1 | | | | 1 | | | | | 1 | 1 | 1 | 13 |
| GVTV\GOALASSESS | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | | 1 | 3 |
| CEV\WILDERNESS | | 1 | | 1 | | 1 | 1 | | | | | 1 | | 1 | | | | | | | | | | 1 | | | 7 |
| CEV\CTRAILS | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 21 |

Continued.

Appendix F. Continued.

| | NPS-TN/OWSR-CMP | NPS-CA/SKCNP-CMP… | NPS-WY/DTNM-CMP | NPS-CA/JTNP-CMP | FS-UT/LC-CMP, T | FS-CO/PP-CMP | FS-NH/RR-CMP | SP-NCSP-CMG | SP-WA/FS-CMP | SP-TX/ERSNA-CMP… | SP-NC/CR-CMP | SP-ID/CRSP-CMP | SP-HI-CMP, D | SP-PA/DCNR-CMG, FP | SP-UT/SCSP-CMP | CO/CCC-NC/MM-CMP | COPU-CO/PCOST-CMP | CO-ID/QP-GB, CMP | CI-MN/RPS-CMP, D | CI-AZ/MSP-RCG | CO/CCC-NC/HV-CMP | CO/CCA-ME/EB-CMP | CO/CCC-NC/LK-CMP | INT/AU-VIC-CMP | INT/ZAF-SANP-EMP, CMP | INT/CAN-BC/BCP-RCS | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CEV\CAMP | | | 1 | 1 | 1 | 1 | | | 1 | | | | 1 | | 1 | | | | | | 1 | | 1 | 1 | | 1 | 11 |
| CEV\HUWASTE | 1 | 1 | | | 1 | 1 | 1 | | | | | | | | 1 | | 1 | | | | 1 | | 1 | 1 | 1 | | 11 |
| CEV\VEG | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 23 |
| CEV\WATER | | | 1 | | 1 | 1 | | | | | | | | | | | | | 1 | | | | | 1 | | | 5 |
| CEV\WILD | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | | | 1 | | 1 | 1 | 1 | 20 |
| CEV\SOIL | | 1 | 1 | 1 | 1 | 1 | | | | 1 | | 1 | 1 | 1 | 1 | | | | | | | | | 1 | 1 | | 12 |
| CEV\ROCK | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | 1 | 1 | 1 | 23 |
| CSV\CULTURAL | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | | 1 | | | 1 | | | 1 | | 1 | 1 | 1 | 17 |
| CSV\CLIMB | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 24 |
| CSV\NONCLIMB | 1 | | 1 | 1 | | 1 | | 1 | | | 1 | 1 | | | 1 | 1 | 1 | | | | 1 | | 1 | 1 | | 1 | 14 |
| CSV\VISUAL | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | | | 1 | 1 | | 18 |
| CSV\FIXED | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 26 |
| CSV\INFRA | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | 1 | | 1 | 20 |
| CSV\PETS | 1 | | | 1 | | 1 | | | | | | 1 | 1 | | | | 1 | | | | 1 | | 1 | | | | 8 |
| CSV\NOISE | | 1 | 1 | 1 | | 1 | | | | | | | 1 | 1 | | | | | | | | | | | | | 6 |
| CSV\LITT | 1 | 1 | 1 | | 1 | 1 | | | | | | | 1 | 1 | 1 | | | | | | | | | 1 | | | 9 |
| CSV\GUIDE | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | | | 1 | | 1 | 1 | | 1 | 19 |
| CSV\RM | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 24 |
| CSV\EDU | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 21 |
| CSV\MOU | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 25 |
| CSV\ECON | | | 1 | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | 3 |
| SUM | 25 | 25 | 29 | 31 | 28 | 33 | 26 | 25 | 16 | 21 | 15 | 29 | 23 | 17 | 28 | 18 | 20 | 12 | 17 | 9 | 19 | 8 | 20 | 29 | 22 | 23 | 568 |
| AVG PER GROUP | 28 | | | | 29 | | | 22 | | | | | | | | 15 | | | | | 16 | | | 25 | | | 22 |

Appendix G. System Adjacency Matrix.

| | Access | Climber activity | Collab… | Comm… | Conflict | Cultural … | Economy | Education | Fixed … | Infrastructure | Land … | Local … | Mitigation … | Monitoring | Natural r… | Natural s… | Non-comp… | Overcrowding | Pets | Rock quality | Route c… | Route d… | Safety | Scenic … | Social … | Soil | Tech… | Vegetation | Water … | Wilderness | Wildlife |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Access | | | | | | | | | | | | 1 | | | | | | | | | -1 | | | | | | | -1 | | | |
| Climber activity | | -1 | | | 1 | -1 | 1 | | | | | | | 1 | -1 | -1 | 1 | 1 | | -1 | | | 1 | -1 | 1 | -1 | | -1 | -1 | | -1 |
| Collaboration | | | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | | | | | | | | 1 | | | | | | | | |
| Communication | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Conflict | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cultural resources | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Economy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Education | | | 1 | 1 | 1 | 1 | | | | | | 1 | -1 | 1 | | | | | | | | | 1 | 1 | -1 | 1 | | 1 | | | 1 |
| Fixed protection | | | | | | | | | | | | | | | | -1 | | | | -1 | | | 1 | -1 | -1 | 1 | | 1 | | | |
| Infrastructure | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | -1 | 1 | | 1 | | | |
| Land managers | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Local stewards | | | | | -1 | 1 | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| Mitigation efforts | | | | | | | | | -1 | | | | | | | | | | | | | | | | | | | 1 | | | |
| Monitoring | | | | | | 1 | | 1 | | | | | | | 1 | | | | | | | | | | -1 | 1 | | 1 | | 1 | |
| Natural resources | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Natural soundscape | | | | | -1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Non-compliant behavior | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overcrowding | | | | | | | | | | | | | | | -1 | | | | | | | | | | | | | | | | |
| Pets | | | | | 1 | | | | | | | | | | | -1 | | | | | | | | | | | | | | | -1 |
| Rock quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Route closures | -1 | | | | -1 | 1 | -1 | | | | | | | | 1 | | | | | | | | 1 | | | | | 1 | | | 1 |
| Route development | | 1 | | | | -1 | | | | | | | | | -1 | -1 | | | | | | | | | | | | | | | -1 |
| Safety | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scenic value | | | | | -1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| Social trails | | | | | | -1 | | | | | | | | | -1 | | | | | | | | | | | -1 | | -1 | -1 | | |
| Soil | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Tech. improvements | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Vegetation | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| Water quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wilderness | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wildlife | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Appendix H. Variable Characteristics

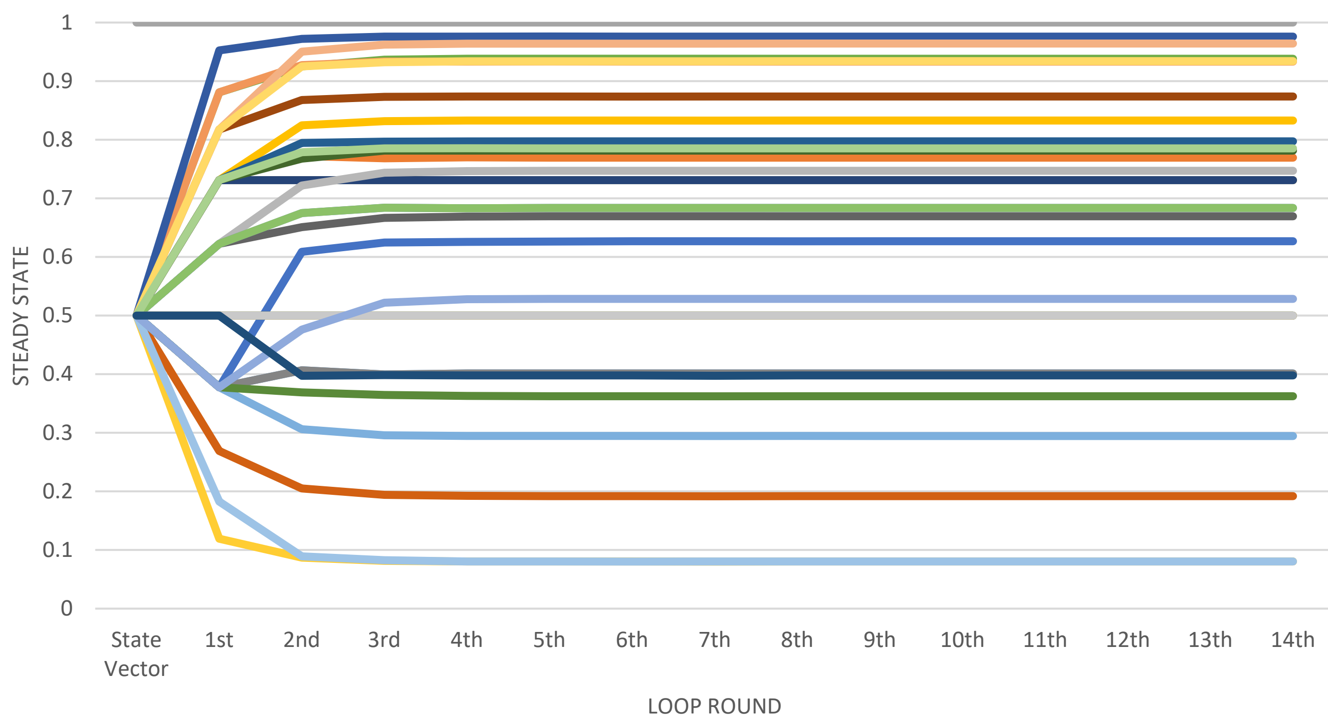
| | Variable Outdegree [od(vi)]: | Variable Indegree [id(vi)]: | Variable Centrality [td(vi)]: | Variable Classification: | Variable Driverness [d]: |
|---|---|---|---|---|---|
| Pets | 3 | 0 | 3 | Transmitter | 0 |
| Route development | 5 | 0 | 5 | Transmitter | 0 |
| Tech. improvements | 1 | 0 | 1 | Transmitter | 0 |
| Route closures | 8 | 1 | 9 | Ordinary | 0.111 |
| Education | 13 | 2 | 15 | Ordinary | 0.133 |
| Infrastructure | 5 | 1 | 6 | Ordinary | 0.167 |
| Climber activity | 17 | 4 | 21 | Ordinary | 0.19 |
| Fixed protection | 7 | 2 | 9 | Ordinary | 0.222 |
| Access | 3 | 1 | 4 | Ordinary | 0.25 |
| Collaboration | 10 | 4 | 14 | Ordinary | 0.286 |
| Monitoring | 7 | 3 | 10 | Ordinary | 0.3 |
| Mitigation efforts | 2 | 1 | 3 | Ordinary | 0.333 |
| Local stewards | 3 | 2 | 5 | Ordinary | 0.4 |
| Overcrowding | 1 | 1 | 2 | Ordinary | 0.5 |
| Social trails | 5 | 5 | 10 | Ordinary | 0.5 |
| Natural soundscape | 3 | 4 | 7 | Ordinary | 0.571 |
| Scenic value | 2 | 3 | 5 | Ordinary | 0.6 |
| Communication | 1 | 2 | 3 | Ordinary | 0.667 |
| Land managers | 0 | 1 | 1 | Receiver | 0.731 |
| Non-compliant behavior | 0 | 1 | 1 | Receiver | 0.731 |
| Safety | 1 | 5 | 6 | Ordinary | 0.833 |
| Soil | 1 | 7 | 8 | Ordinary | 0.875 |
| Rock quality | 0 | 2 | 2 | Receiver | 0.881 |
| Wilderness | 0 | 2 | 2 | Receiver | 0.881 |
| Vegetation | 1 | 9 | 10 | Ordinary | 0.9 |
| Economy | 0 | 3 | 3 | Receiver | 0.953 |
| Water quality | 0 | 3 | 3 | Receiver | 0.953 |
| Wildlife | 0 | 6 | 6 | Receiver | 0.998 |
| Conflict | 0 | 7 | 7 | Receiver | 0.999 |
| Natural resources | 0 | 8 | 8 | Receiver | 1 |
| Cultural resources | 0 | 9 | 9 | Receiver | 1 |

Appendix I. What-if Policy Scenarios.

Variable Legend:

Access
Climber activity
Collaboration
Communication
Conflict
Cultural resources
Economy
Education
Fixed protection
Infrastructure
Land managers
Local stewards
Mitigation efforts
Monitoring
Natural resources
Natural soundscape
Non compliant behavior
Overcrowding
Pets
Rock quality
Route closures
Route development
Safety
Scenic value
Social trails
Soil
Technological improvements
Vegetation
Water quality
Wilderness
Wildlife

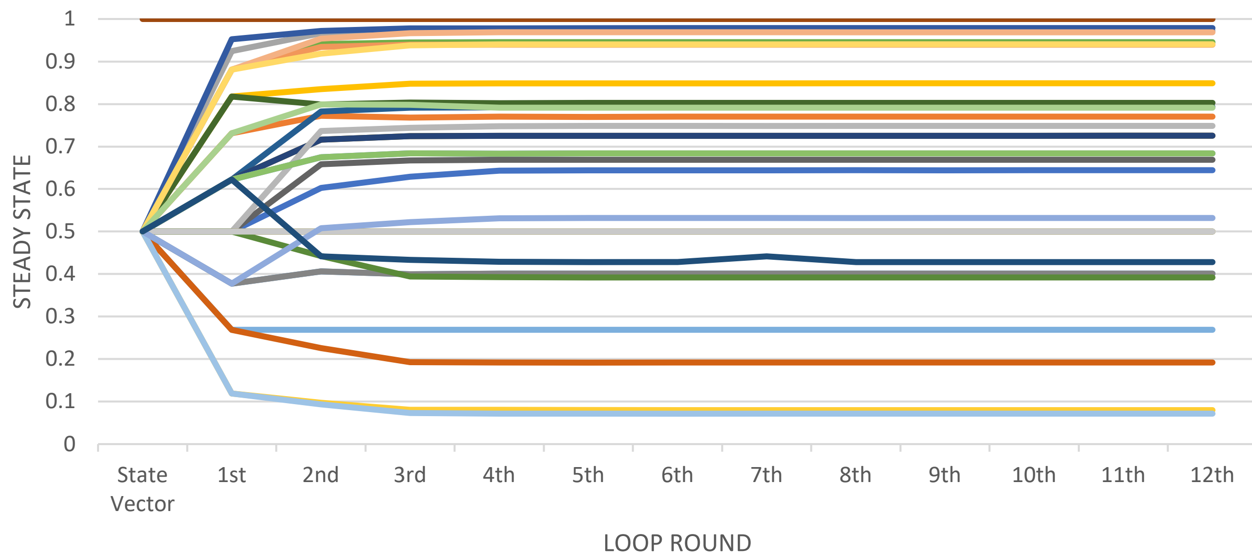
Scenario 1: Collaboartion (collaboration clamped at 1).



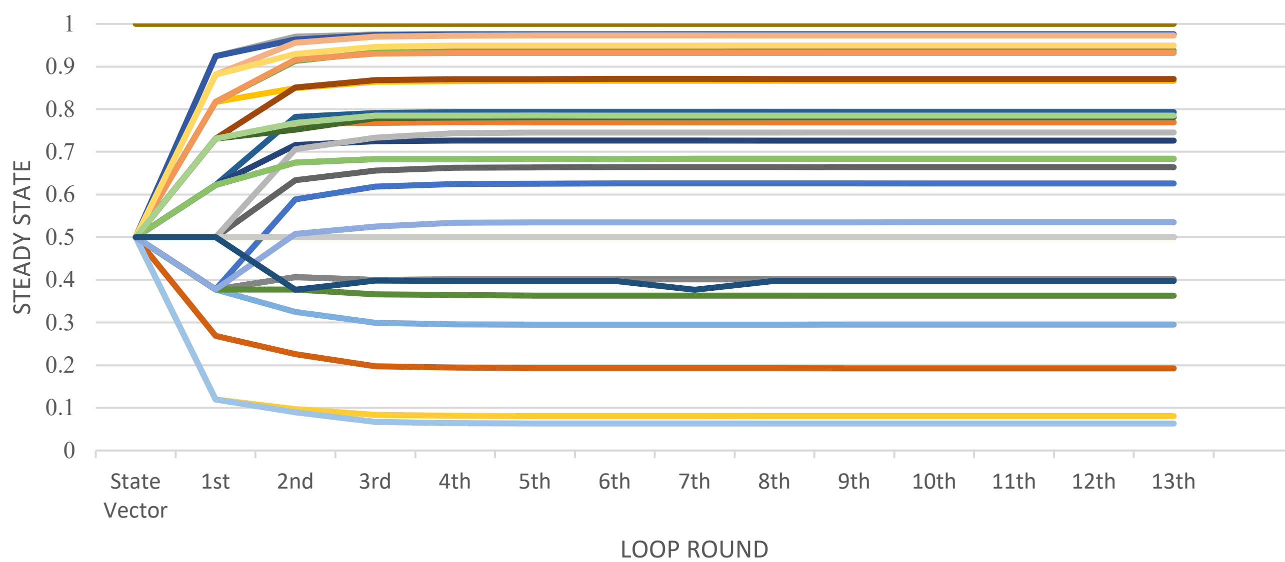

Continued.

Appendix I. Continued.

Scenario 2: Education (education clamped at 1).



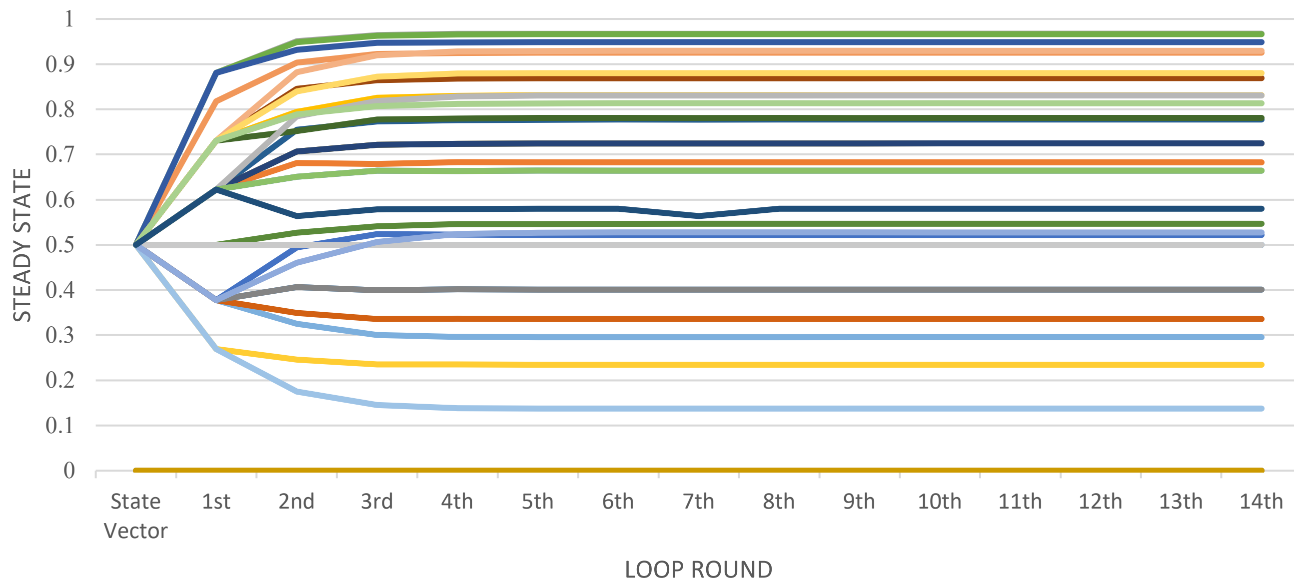

Scenario 3: Infrastructure (infrastructure clamped at 1).



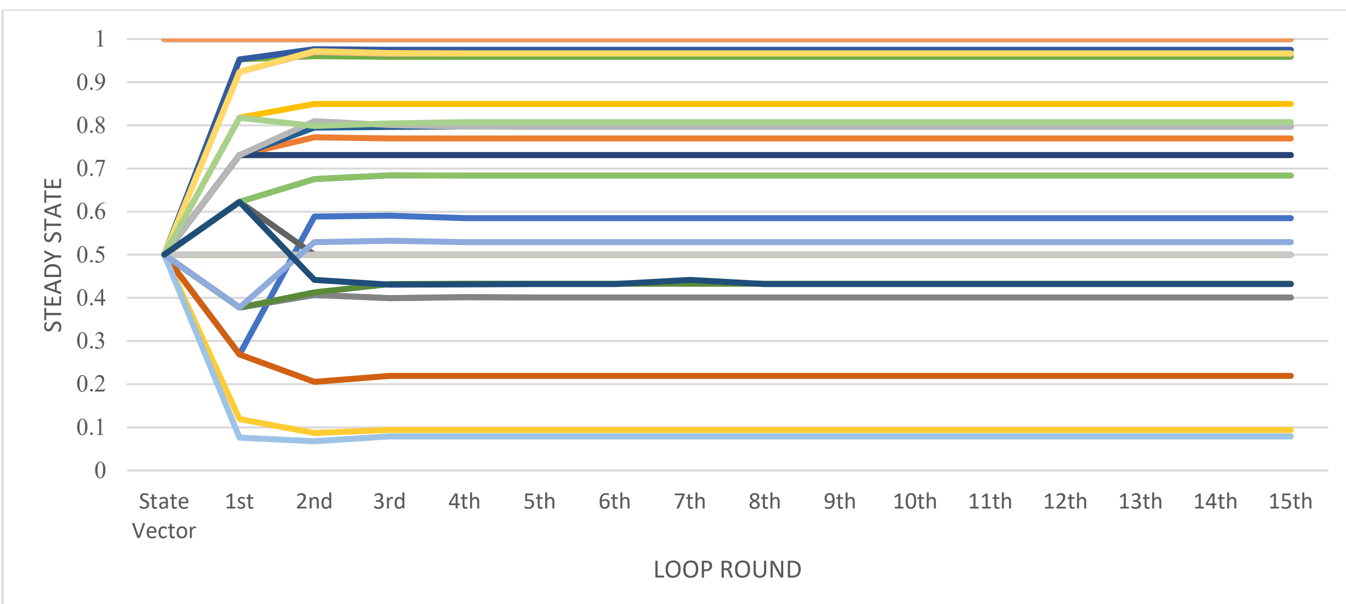

Continued.

Appendix I. Continued.

Scenario 4: Bolt Ban (route development and fixed anchors clamped at 0).




Scenario 5: "Rose-colored Glasses" (collaboration, education, local stewards, mitigation efforts, and monitoring all clamped at 1).



Appendix J. System Calculation Equations

| Calculation | Equation |
| --- | --- |
| Variable outdegree [od(vi)] | $\mathrm{od}(vi) = \sum_{y:1}^{y:N} \lvert x \rvert$ |
| Variable indegree [id(vi)] | $\mathrm{id}(vi) = \sum_{1:z}^{N:z} \lvert x \rvert$ |
| Variable centrality [td(vi)] | $\mathrm{td}(v_i) = \mathrm{od}(v_i) + \mathrm{id}(v_i)$ |
| Receiver (R) | $\mathrm{od}(v_i) = 0 \cap \mathrm{id}(v_i) > 0$ |
| Ordinary (O) | $\mathrm{od}(v_i) > 0 \cap \mathrm{id}(v_i) > 0$ |
| Transmitter (T) | od(vi) > 0 ∩ id(vi) = 0 |
| Variable driverness (d) | $\mathrm{d} = \dfrac{\frac{\mathrm{id}(vi)}{\mathrm{od}\ (vi)}}{1 + \left(\frac{\mathrm{id}(vi)}{\mathrm{od}(vi)}\right)}$ |
| Map density (D) | D = C / N-2 |
| Map Complexity (c) | c = R / T |
| Map Hierarchy Index (*h*) | $h = \dfrac{12}{(N-1)N(N+1)} \sum_i \left[\dfrac{od(vi) - (\sum od(vi))}{N}\right]^2$ |