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Illuminating Perceptions of Social-Ecological Complexity for More Holistic Management of Parks and Protected Areas

Michael Patrick Blacketter
Clemson University, michaelblacketter@gmail.com

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ILLUMINATING PERCEPTIONS OF SOCIAL-ECOLOGICAL COMPLEXITY FOR MORE HOLISTIC MANAGEMENT OF PARKS AND PROTECTED AREAS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Parks, Recreation and Tourism Management

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by
Michael P. Blacketer
May 2020

Accepted by:
Dr. Matthew Brownlee, Committee Chair
Dr. Elizabeth Baldwin
Dr. Brenda Bowen
Dr. Robert Powell

ABSTRACT

This dissertation focuses on illuminating human perceptions in a social-ecological system (SES) through three studies: (1) revealing human perceptions of the influence of social network structure on social dynamics in an SES; (2) understanding human perceptions of biophysical and social change related to a SES, and (3) exploring how key stakeholder groups might perceive social-ecological reciprocities in an SES. To achieve these endeavors, this dissertation advances analytical tools that have yet to be widely used in natural resource management to understand stakeholders' perceptions of social-ecological complexity—social network models, perceptions of change, and fuzzy logic cognitive mapping. These tools represent a combination of objective social analysis, inquiry into subjective perceptions, and subjective mental modeling, all of which may be useful for natural resource managers who need or desire to engage in SES thinking. The three studies herein thus apply these tools to the complex social-ecological system known as the Bonneville Salt Flats (BSF) in western Utah (USA).

DEDICATION

Although I have been interested in many of the concepts explored and described in this dissertation for many years, I find that the inspiration to pursue these things through doctoral education came from my wife, Stacia Bourne.

Stacia, we have followed one another across the country five times over fourteen years in pursuit of various forms of higher education. I thought I was finished with academia after completing my master's degree. In fact, it never occurred to me to pursue a PhD; such an achievement never seemed like a possibility to me. Who did that? Well, you did—courageously, tenaciously, and inspiringly.

You shared with me so many things that you were learned in the course of your studies. Much of what you shared with me stimulated long-dormant thoughts in my head that eventually opened my mind up to the possibility of pursuing a doctorate . . . and it has turned out to be an amazing adventure. Even while you were in the throes of your own doctoral studies, you supported me however you could and reassured me and encouraged me when I had doubts.

For your example, for your support, for your kindness, and for your kindness and understanding in this journey (and the largest one), I thank you, Stacia. We are a great team.

ACKNOWLEDGEMENTS

First and foremost, I would like to offer my thanks and acknowledgement to the U.S. National Science Foundation for funding this research. The dissertation studies herein are part of a larger interdisciplinary effort to evaluate the social and biophysical reciprocity in the changing Bonneville Salt Flats, for whom the principal investigator is Dr. Brenda Bowen from the University of Utah. Entitled *CNH-L: Adaptation, mitigation, and biophysical feedbacks in the changing Bonneville Salt Flats (Award No. 1617473),* this overall research represents a collaboration among the National Science Foundation, University of Utah, Clemson University, and the Bureau of Land Management. The statements, findings, conclusions, and recommendations herein are specifically my own, and do not necessarily reflect the views of the U.S. National Science Foundation. I am incredibly lucky to have been given the opportunity to participate in such a meaningful, consequential body of research.

I would also like to acknowledge all of the people who have helped and guided me on my doctoral journey. You have given me more than you know.

Dr. Ed Ruddell, your infuriatingly valuable essay assignments returned me to writing and inspired me think expansively about a great many things. The recollection and reflection necessary for that writing brought a great many forgotten but formative experiences to light through the act of excavating numerous layers of my own personal history. Those revelations allowed me to see the impact of certain experiences on my ways of thinking about and responding to the world. Recognizing the influence of so many events has allowed to put many of past injuries to rest. For that, Ed, I thank you sincerely.

Dr. Matt Brownlee, you addressed my earliest questions about graduate school and eventually took me on as a research assistant. In doing so you, you gave me numerous opportunities to travel for research and have experiences that I would not have had otherwise. Your friendship, humor, insight, and guidance has been immensely helpful to me on this doctoral journey. The enthusiasm with which you approach your work is inspiring, and your compassion and concern for the well-being of others—including lowly graduate students (who you strive to lift up)—is the mark of not only a great mentor, but a truly good human being.

Dr. Bob Powell, your curious juxtaposition of consummate researcher and dirtbag adventure guide shatters all stereotypes about people who pursue lives of high adventure. Your genuineness in both of these identities is inspirational and utterly disarming. Thank you for the talks and the clarity with which you've fueled my studies.

Dr. Brenda Bowen, thank you for your willingness to join my dissertation committee and advise me from afar. Your enthusiasm for the Bonneville Salt Flats and your probing questions for me about the value of the BSF have helped reshape large portions of my thinking about natural resources and the people who love them.

Dr. Betty Baldwin, your openness to engage in discussion with me about qualitative research, collective identity, the meaning of stakeholders, and much, much more has helped connect many ides in my mind and infinitely contributed to the synthesis

I’ve achieved in regard to many of my research topics. Thank you for all of this, and thank you, too, for your kind demeanor, approachability, and general guidance.

Many other friends and family members have been tremendous sources of encouragement, support, decompression, and levity throughout my journey. If I’ve even mentioned to you that I was in school (again!?), you have provided me with all of these things and more. You know who you are—so thank you, from the bottom of my heart.

Lastly, I’d be remiss (and I’d regret it later) if I didn’t mention the five corgi fur kids that Stacia and I have shared out lives with over the years: Willamina, Tucker, Harriet, Derby, and Banks. These ridiculous, amazing little creatures have been an endless source of delight, contemplation, affection, and fulfillment. Such wonderful friends you’ve all been. ☺

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CHAPTER 1[1]

Introduction

Protected areas (PAs) are geographically prescribed locations that are granted protection in recognition of their natural, ecological or cultural values (Dudley, 2008). Highly beneficial for preserving and building biodiversity, PAs are classified by the International Union for Conservation of Nature (IUCN) into seven categories based on their level of protection in accordance with nation-specific laws and/or the regulations of the international organizations involved. These categorical designations specify distinct allowances for levels and types of human use and management—from strict reserves with little-to-no human presence, to parks with high visitation, and to other areas conserved specifically for the natural resources that they provide (Dudley, 2008). Since parks and other protected areas (PPAs) are important components of global ecosystem health, it is crucial that they be managed as sustainably as possible to ensure their continued ecological resilience and value.

Disconcertingly, many of the Millennium Ecosystem Assessment's global sustainability goals are suspected to be unachievable without improving our knowledge of the dynamic interactions and feedbacks between social and ecological systems (Mastrangelo et al., 2019). The relationship between the natural world and human society is, however, increasingly recognized to be dynamic and fraught with complex non-linear relations between continuously changing entities (Folke, 2002). This relationship is made

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[1] For a list of commonly used terms in this dissertation and their definitions, please see Appendix 1.

even more complex through synergistic stresses and shocks in systems that result in significant discontinuities and levels of uncertainty. Thus, building knowledge of social-ecological complexity is imperative—and may not be possible without developing truly transdisciplinary methodologies (Schoon & van der Waal, 2015) to forge a more robust approach to conservation that addresses its numerous and diverse challenges (Game, Meijaard, Sheil, & McDonald-Madden, 2013).

Such challenges are likely familiar to natural resource managers—and by extension, parks and protected area management (PPAM) practitioners—who continually confront many issues that are neither simple nor exclusively ecological or social in nature in the course of their work (Miller, et al., 2017). For this reason, people charged with managing natural resources such as PPAs employ a likewise diverse array of approaches to understand the complexity, resilience, and reciprocity of human and ecological variables (Berkes, Colding, & Folke, 2002). This is in part due to the fact that the integration of human social processes with ecological systems in these realms of management necessitates acknowledging natural resources (e.g. PPAs) as *social-ecological systems*[2] (SESs; Berkes, 2017).

Furthermore, due to SESs' varying degrees of complexity, uncertainty, and non-linear behaviors among system components, such an acknowledgement often requires managers to engage in *SES thinking*. This practice entails making management processes flexible, able to engage uncertainty, and building various capacities to adapt to social and

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[2] Social-ecological systems (SESs) represent integrated 'bio-geo-physical units' and their concomitant human social actors and institutions (Glaser, Krause, Ratter, & Welp, 2008).

ecological dynamics (Berkes, Colding, & Folke, 2003). Traditionally speaking, however, park and protected area management (PPAM)—has often narrowly focused on specific management objectives, desired conditions, and outcomes (Holling & Meffe, 1996; Meffe, Nielsen, Knight, & Schenborn, 2002).

Although SES concepts have indeed been applied to the sustainable management of specific places and resources, a broad application of the questions and concepts used in SES research has seen limited usage to PPAM, especially in the United States. And while much PPAM in the United States has been arguably successful, it nonetheless has been philosophically predicated on historic practices for natural resource extraction (Meffe, Nielsen, Knight, & Schenborn, 2002). It through the extractive activities of forestry and mining that natural resource management developed as a body of sciences—and this was not ill-fitting considering that the historic mindset of natural resource managers was characterized by the dominion of humankind over nature. As this mindset has fallen out of favor to some extent in regard to protected areas—which are protected for their global ecological value as opposed to their local or commodified monetary value—the traditional dominion model can no longer be successfully applied to sustainable PPAM.

Historic PPA practices were neither designed with social-ecological complexity in mind, nor can they respond to the ways in which many social and ecological entities change (Berkes, Colding, & Folke, 2002). Thus, my dissertation suggests that a more holistic approach that applies SES science and thinking may be extremely advantageous for PPA managers to better understand and henceforth think in terms of social-ecological complexity. To do this, however, managers need new tools for addressing the dynamic interactions among ‘human-social’ and ‘natural-ecological’ components that are inextricably intertwined in protected areas; these represent the complex social-ecological systems we know as PPAs.

One way for PPA managers to bolster social-ecological comprehension is to take cues from the field of systems science. Specifically, it is sometimes necessary to account for—and thus plan for—the many linkages and reciprocities between social and ecological entities that comprise any specific resource. While this accounting is potentially an immense undertaking, it can be approached incrementally.

Akin to an act of mosaic artwork in which numerous small tiles coalesce into a greater, cohesive image, the illumination of SES complexity can be done one small tile at a time. Because it is typically neither desirable nor feasible to assess ecological or social systems—whether independently or jointly—at a single scale and/or resolution (Scholes, Reyers, Biggs, Spierenburg, & Duriappah, 2013), performing SES research at different scales might even be construed as building a mosaic with differently sized tiles to capture complexity’s many facets and nuances. It is thus necessary in this potential mosaic approach to justify and logically frame the scale of inquiry into any sub-system component of SES complexity (Berkes, Colding, & Folk, 2003). Each of this dissertation’s three academic studies uniquely focuses a bit of light through the lens of human perceptions to bring small parts of an SES mosaic into focus.

Because human actors—via their direct relationships, perceptions, and relative understanding of complexity related to a resource—are immensely influential in the management and use of PPAs, my dissertation focuses on illuminating certain human components of social-ecological complexity. The three, solid steps toward such illumination I offer henceforth (a) reveal perceptions related to how social networks may influence social dynamics in SESs; (b) to understand human perceptions of social and ecological change related to an SES, and (c) to explore how key stakeholder groups might similarly or differently understand the social-ecological reciprocities—and thus social-ecological complexity in general—that shape a resource's social and biophysical components.

Ultimately, I argue that as our understanding of the intricately integrated nature of social and ecological systems advances, PPA managers and researchers must likewise continue to broaden their understanding of PPAs as SESs. In doing so, my research presented in the following chapters seeks to contribute to global sustainability goals that Mastrangelo, et al. (2019) assert cannot be achieved without improving knowledge of feedbacks between social and ecological systems. The application and refinement of tools for understanding and describing relationships within complex systems is therefore my dissertation's contribution to PPA scholarship. It is my hope that PPA researchers and managers might wield these tools to better anticipate, prepare, and perhaps avert certain systemic shocks and stresses—social, ecological, and social-ecological—that might negatively impact resources' ecological health and function as well as their sustainable human use and management.

My dissertation thus advances analytical tools that have yet to be widely used in park and protected area management to understand stakeholders' perceptions of social-ecological complexity—social network models, perceptions of change, and fuzzy logic cognitive mapping. These tools represent a combination of (a) objective social analysis, (b) inquiry into subjective perceptions, and (c) subjective mental modeling, all of which may be useful for PPA managers who need or desire to engage in systems thinking. The three studies I present in Chapters II, III, and IV apply these tools to the complex, social-ecological system known as the Bonneville Salt Flats (BSF) in western Utah, USA.

Despite its notoriety as one of the world's foremost venues for setting land speed records, the BSF is also increasingly recognized as a complex system in which numerous biophysical elements interact with human stakeholders[3] who fall into distinct and occasionally overlapping groups. The fairly sparse social and biophysical processes that link elements of this system—unlike those of more biophysically and socially diverse PPAs—provide relatively simplified conditions in a living laboratory that are useful for exploring the relationships that play out among social and ecological actors.

Problem Statement

Failure to understand whether and how people perceive complexity in social-ecological systems such as parks and protected areas may impede managers' ability to accurately anticipate systemic shocks or stresses in a system as well all preclude the accurate prediction of events—e.g. behaviors, function, or reciprocities—that result from management actions.

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[3] Stakeholders referred to in this study are members of one of several *a priori* groups associated with the Bonneville Salt Flats. Deeper, more theory-based stakeholder definition, identification, or selection was not part of this study. More about stakeholders is included in Part 3 of Appendix 1: Definitions.

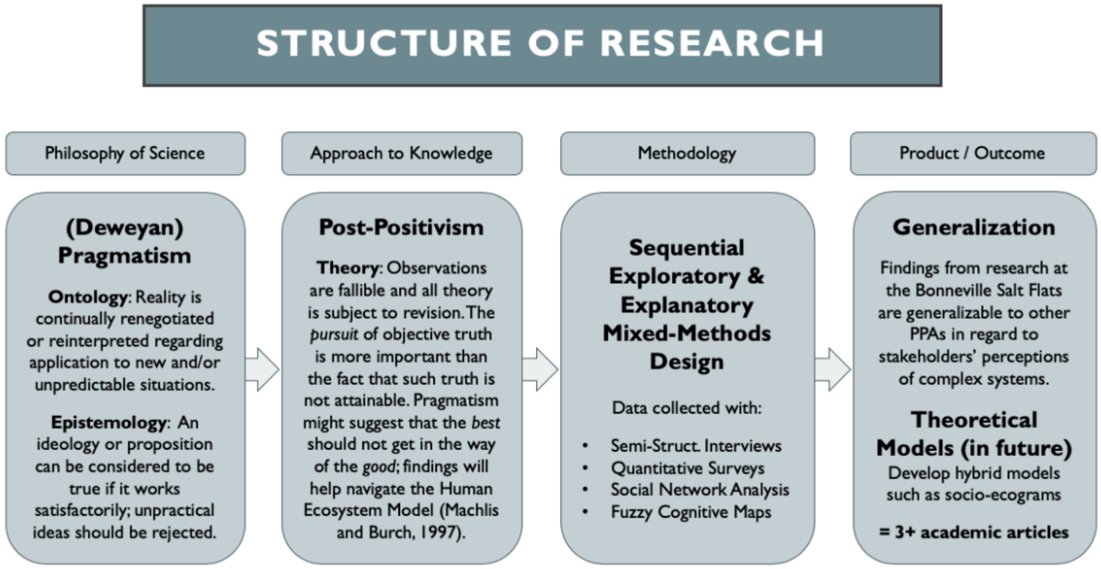
Purpose Statement

This dissertation's primary purpose is to illuminate how people perceive complex social-ecological systems. It addresses this purpose via three mixed-methods inquiries: (1) a social network analysis of stakeholder groups coupled with qualitative inquiry regarding the social network influence on SES social dynamics, (2) a quantitative questionnaire—generated from qualitative inquiry—that probes people's perceptions of social and biophysical change in an SES, and (3) cognitive mapping performed through qualitative inquiry to illustrate mental models of stakeholder groups' perceptions of SES complexity. Each of these studies herein applies those inquires to the living laboratory of the Bonneville Salt Flats.

Research Paradigm

The studies I present in this doctoral dissertation are predicated on a specific path that I have charted through ontology, epistemology, theoretical perspective, methodology, and methods (see Figure 1.1). I believe that communicating this path is important because it expresses not only the way that I see myself, both in relation to my research as well as in relation to the knowledge revealed therein. Furthermore, my paradigmatic path is equally important to keep in mind regarding the strategies used to reveal and ultimately apply that knowledge.

The three studies in Chapters II, III, and IV of my dissertation apply Deweyan Pragmatism through post-positivist methods to illuminate stakeholder perceptions of complex systems. This paradigm is action-oriented in its intentions but nonetheless recognizes that although researcher bias is undesirable, it is also likely inevitable. In exploring stakeholders' perceptions of complexity in social-ecological systems, the research operates from Charles Sanders Pierce's (1902) position that each human mind 'reflects' reality differently and so the construction of knowledge is therefore a social phenomenon (Ormerod, 2006). My mixed-methods research thus uses pragmatic sequential processes to apply quantitative inquiry that informs qualitative inquiry—and vice-versa—through semi-structured interviews, quantitative surveys, social network analysis, and cognitive mapping. Each of these approaches endeavors to reveal and generalize the significance of stakeholders' perceptions of complex social-ecological systems. Appendix 12 presents additional, in-depth discussion of my research philosophy and the rationale and implications of the pragmatic paradigm.



STRUCTURE OF RESEARCH

Philosophy of Science

(Deweyan) Pragmatism

Ontology: Reality is continually renegotiated or reinterpreted regarding application to new and/or unpredictable situations.

Epistemology: An ideology or proposition can be considered to be true if it works satisfactorily; unpractical ideas should be rejected.

Approach to Knowledge

Post-Positivism

Theory: Observations are fallible and all theory is subject to revision. The *pursuit* of objective truth is more important than the fact that such truth is not attainable. Pragmatism might suggest that the *best* should not get in the way of the *good*; findings will help navigate the Human Ecosystem Model (Machlis and Burch, 1997).

Methodology

Sequential Exploratory & Explanatory Mixed-Methods Design

Data collected with:

- Semi-Struct. Interviews
- Quantitative Surveys
- Social Network Analysis
- Fuzzy Cognitive Maps

Product / Outcome

Generalization

Findings from research at the Bonneville Salt Flats are generalizable to other PPAs in regard to stakeholders' perceptions of complex systems.

Theoretical Models (in future)

Develop hybrid models such as socio-ecograms

= 3+ academic articles

Figure 1.1. Paradigmatic structure of this dissertation's research including ontology, epistemology, methodology, methods, outcomes and potential products

The Human Ecosystem Model as Inspiration

The Human Ecosystem Model (HEM; see Figure 1.2) describes many key variable categories for identifying, analyzing, and working with human ecosystems (Machlis, Force, & Burch, 1997; Burch, Machlis, & Force, 2017). Defined by these authors as "a coherent system of biophysical and social factors capable of adaptation and sustainability over time—and bearing striking similarity to the definition of *social-ecological system*s—the HEM illustrates potential flows of resources that, for better or for worse, can ripple or cascade through systems in the wake of disturbance.

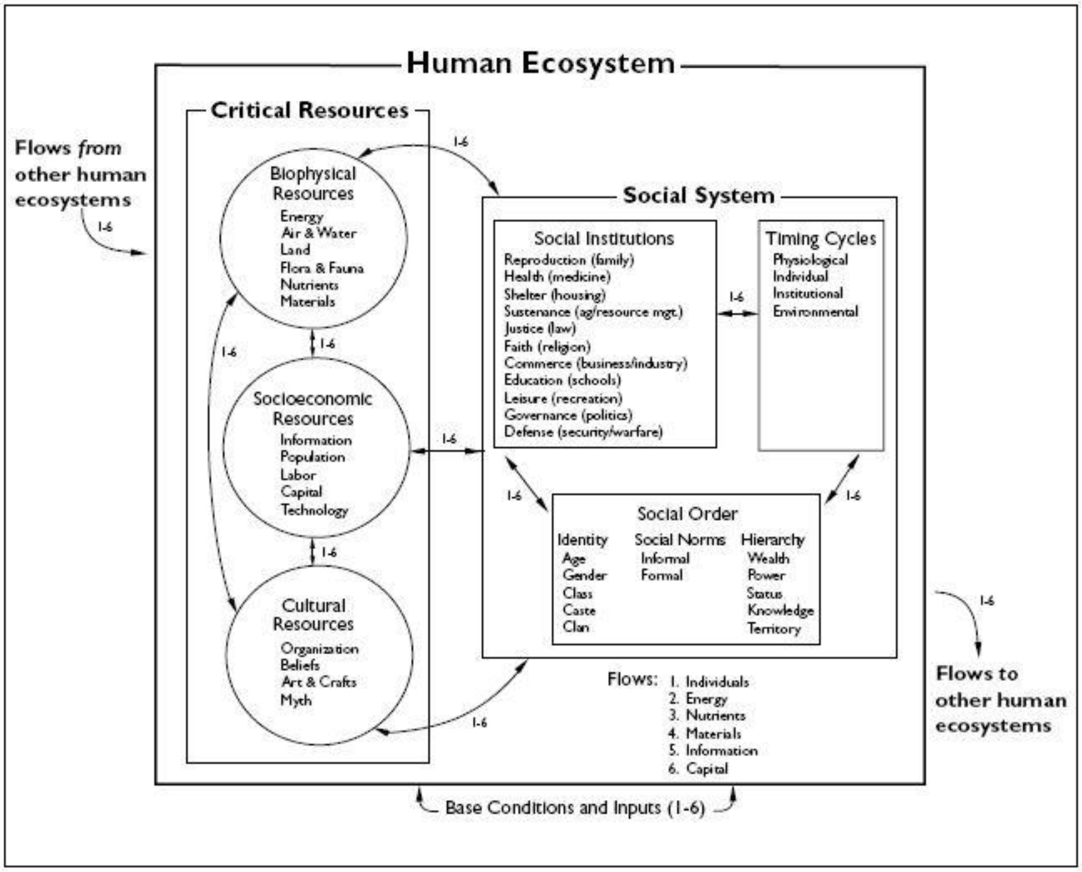


Figure 1.2. The Structure of Human Ecosystems Model (Machlis, Burch, & Force, 2017) is useful for planning scenarios in which social and ecological actions cascade through different realms of coupled systems.

Originally intended to introduce the human ecological sciences to current and future ecosystem managers, the HEM can also serve as a basic teaching tool regarding social-ecological cascades. Through its description, analysis, application, and associated critique or debate, HEM-related activities can help bridge courses, departments, and faculties involved in ecosystem management education (Machlis, Force, & Burch,1997); the model's utility in scenario-building is limited only by ignorance or uncertainty related to specific social and ecological reciprocities.

Because of the similarities between "human ecosystems" and "social-ecological systems," using the HEM to trace resource flows and cascades has the potential to be extremely useful for scenario-building in SESs. That is, the HEM can be applied to SESs to predict and plan for system stresses and shocks that may upset sustainability—or more specifically *resilience,* as discussed later—and may therefore be very helpful for planners, manager, and researchers to address how they might look across social, temporal, biological, and spatial scales to identify components that may inhibit or bolster system resilience.

The first step in the aforementioned "action-oriented" aspect of my research—which ultimately endeavors to contribute to the holistic and sustainable management of other PPAs—was originally to use the HEM for scenario building related to the BSF. Ultimately, however, it proved awkward to wrap around the three dissertation studies. Despite this, the HEM served as inspiration for developing a novel, conceptual model for a hybrid social-ecogram (SEG) that I hope can help to simultaneously visualize resource attributes, values attached to those attributes, and the human stakeholders who seek to acquire those various types of value.

By exploring the influence of a) social network structure, b) perceptions of change, and c) cognitive maps of social-ecological complexity, I hoped to reveal how people related to a resource—broadly speaking, through work or recreation—think about the about the complex systems of which they are an integral part. Furthermore, I hope my findings may be useful for illuminating potential cascades of social and ecological phenomena—such as potential conflicts and misunderstandings as well as opportunities for better communication and collaboration—for the sake of improved PPA management.

The three studies in my dissertation are potentially applicable to scenario building along specific paths through the HEM as well as for applying the new conceptual social-ecogram (SEG) model presented in Chapter V. The HEM served as an organizing framework for my ideas during the course of my three dissertation studies and ultimately inspired me to develop my idea for the SEG. Through describing and discussing that new model in Chapter V, I will synthesize the overall values of Studies 1, 2, and 3. That also considers the study findings through the lens of the Panarchy concept (Gunderson, 2001) to expand SES thinking across temporal, spatial, social, and ecological scales.

Research Questions

This dissertation as a whole seeks to contribute to the means by which researchers and managers can reveal various aspects of complex social-ecological reciprocities in PPAs and in doing so, foster more holistic and sustainable PPA management. While the primary endeavor of inquiry is thus to illuminate how stakeholders perceive complexity, the individual studies in Chapter II, II, and IV will seek to contribute to that understanding by exploring the utility of (a) social network analysis, (b) quantitative analysis of perceptions, and (c) semi-quantitative cognitive maps of perceived SES complexity. While, secondary research questions for each study are presented in relevant chapter, the primary overarching question and the three foci of the following studies' inquiries are as follows:

Overarching Research Question for Dissertation

How do stakeholders perceive complex systems and social-ecological complexity?

Research Question for Study 1: Social Network Analysis of BSF Stakeholders

1. *What is the structure of the Bonneville Salt Flats stakeholder social network?*
2. *Who are the potentially influential people in the BSF social network?*
3. *How do star actors perceive the influence of the BSF social network on overall BSF social dynamics?*

Research Question for Study 2: Perceptions of Change at the BSF

1. *What social and ecological phenomena do Racers and Spectators at land speed racing events perceive to be changing at the BSF and to what degree?*
2. *How do Racers' and Spectators past use history with the BSF influence their perceptions of change?*

Research Question for Study 3: Fuzzy Cognitive Mapping of BSF Stakeholders

1. *How does the structure of stakeholders' mental models—and therefore fuzzy cognitive maps—of the BSF differ?*
2. *Do stakeholder groups agree on correlations between important BSF concepts?*

3. *Are stakeholder group representatives confident that their fuzzy cognitive maps accurately portray the perception of typical members of their community?*

Dissertation Format

This dissertation consists of five chapters represented in Figure 1.3. In Chapter I, this introduction, I provide background information that guided the dissertation's development, the purpose of the overall study, all research questions, and the definitions of terms used herein (a more extensive list of which is presented in Appendix 1). The three studies presented in Chapters II, III, and IV are formatted as research articles with their own introduction, methods, results, discussion, and reference sections. Finally, Chapter V consists of a summary and synthesis of findings derived from those three studies, followed by recommendations for further research that were determined during the overall course of my dissertation's research and syntheses.

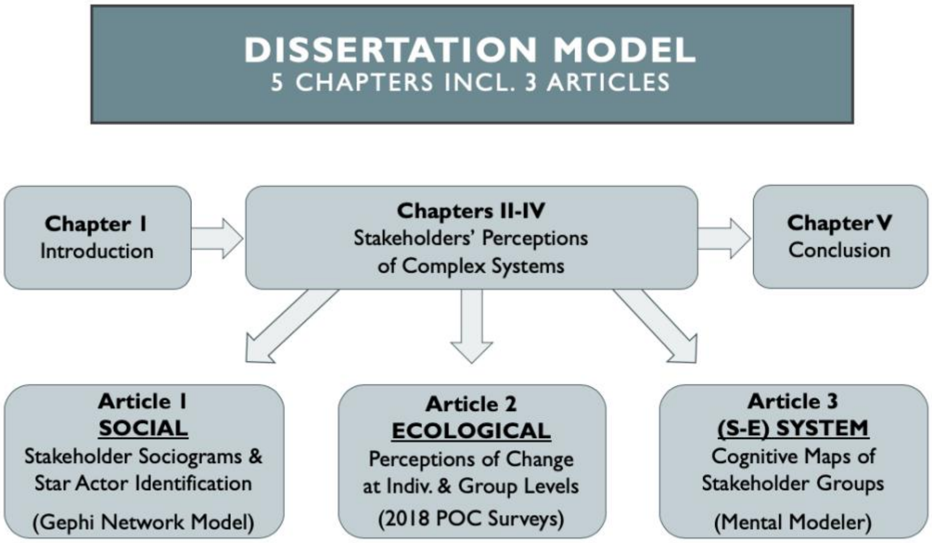


Figure 1.3. Model of dissertation's five-chapter structure, including three primary articles.

Delimitations

In Study 1, social network survey recipients frequently failed to complete the quarterly questionnaires in part or in full. Non-response is very common in social network analysis, and due to anecdotal evidence garnered in pre-SNA interviews as well as evidence in academic literature (e.g. Huisman, 2000; Kossinets, 2008), a low response rate was expected in this study. Non-response resulted in only 91 out of potential hundreds of BSF stakeholders for whom I had hoped to capture social interaction data. Nonetheless, I pushed forward—in addition to switching from focusing on an aggregated, individual (actor)-level SNA, the study culminated in a stakeholder group-level model for which I member-checked the measured social interactions with influential network actors revealed in the SNA. These actors thus served as proxies for their stakeholder communities and also provided me with a second round of qualitative interviews through which I was able to elicit salient philosophical points about the influence of their social network on the social dynamics in the SES that the BSF represents.

In Study 2, missing data was also problematic. Beginning with 553 paper surveys that were hard-won while walking the salt at the peak of summer 2018, the number of usable surveys was whittled down to 419 after I excluded numerous dramatically incomplete participant responses. Despite this setback, several significant effects related to group affiliation and past use history emerged, and while these effects were smaller than I had actually expected, I am confident that they nonetheless represent the perceptions of the sample. Again, in the face of data difficulty, I was able to modify my approach to render what I hope are useful findings of the study. In this particular study, I also learned several lessons regarding instrument development that, while frustrating at the time, did not greatly hinder progress.

In Study 3, missing data was less of a problem. There were, however, several aspects of the social and biophysical concepts that caused specific issues. Addressed in the article, these issues included a lack of clarity in regard to scale, definition, and nested-ness of certain social and biophysical concepts. Luckily, these concerns became apparent early in the interview process, and I was able to make and hold to certain decisions to guide the mental modeling process consistently with all 11 participants (who were the same social network actors revealed in the Study 1 SNA). This is yet another example of my pragmatic approach to generating useable research in the face of adversity and uncertainty.

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CHAPTER II

Social Network Analysis in a Social-Ecological System and Star Actors' Perceptions of Social Network Influence

Abstract

In this study, I applied social network analysis to a body of stakeholder groups with a vested interest in Utah's Bonneville Salt Flats (BSF), herein posited as a complex social-ecological system (SES). The study had two primary purposes: (1) to identify potentially influential individuals—herein described as *star actors*[4]—in the BSF SES, and (2) to solicit these actors' perceptions of how their social network may be influential in regard to the BSF's social dynamics. The study produced social network models—i.e. sociograms—at the individual actor level as well as at the stakeholder group level. I shared these sociograms with star actors during individual conversations to discuss findings regarding BSF-related social interactions gathered over the course of the study year—which was intended as an act of 'member checking' the data. These discussions informed the subsequent inquiry into the social network's influence on the BSF's social dynamics. Star actors shared practical ideas as well as introspective exploration of concepts related to the influence of authority, social network evolution, the influence of research on the social network, and self-reflection.

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[4] **Sociometric stars** are recipients of numerous and frequent selection by others (Moreno, 1934 in Scott, 2017) indicating their popularity. This study extends the concept and defines **star actors** as individuals who are both (a) recipients of numerous and frequent selection and (b) themselves report numerous and frequent interactions with others, resulting in their high centrality and degree scores.

Keywords

Social network analysis, Bonneville Salt Flats, stakeholders, social network theory, sociograms, social-ecological systems, complexity, natural resource management, reciprocity, systems thinking, park and protected area,

Introduction

As a type of complex adaptive system, social-ecological systems (SESs) are comprised of many human and natural elements and processes that change or learn as they interact through reciprocal linkages (Levin, et al., 2013; Biggs, Schluter, & Schoon, 2015). As such, they represent 'bio-geo-physical units' along with their associated social actors and institutions, all of which are delimited by spatial or functional boundaries that are embedded in particular ecosystems and their context problems (Glaser, Krause, Ratter, and Welp (2008). Furthermore, the numerous reciprocities among social and ecological actors and actions in SESs means that they are fraught with uncertainties and non-linear relationships (Werner & McNamara, 2007; Allen & Garmestani, 2015), requiring most SES research to target smaller, nested systems with *a priori* boundaries intended to help to focus inquiry and analysis (Schluter, Hinkel, Cox, Schluter, Binder, & Falk, 2014).

Such reduction is not antithetical to systems thinking—if pursued strategically, various sub-system components of complex systems can be independently revealed to bring larger scales or visualizations of a system into focus (Holling, 2001). Similar to an act of creating a mosaic from smaller fragments, ever-larger bodies of social-ecological knowledge can therefore be constructed from even the smallest social, ecological, and social-ecological pieces. With enough of these smaller pieces of the mosaic put into context, the greater picture gains clarity and meaning. Similarly, as various aspects of a complex system are illuminated, its overall character may become increasingly apparent. Furthermore, performing SES research at different scales might be construed as building a mosaic with differently sized tiles to capture complexity's many facets and nuances.

It is typically neither desirable nor feasible to assess ecological or social systems—whether independently or jointly—at a single scale and/or resolution (Scholes, Reyers, Biggs, Spierenburg, & Duriappah, 2013). It is thus necessary in the suggested mosaic approach to justify and logically frame the scale of inquiry (Berkes, Colding, & Folk, 2003). For this reason, choosing a unit of analysis is imperative. Stakeholders[5] associated with a natural resource represent human actors in social networks within a larger social-ecological system. Therefore, this study focuses on the role of a social network associated with a specific natural resource. It achieves this endeavor by applying social network analysis (SNA) to explore how influential stakeholders in the social-ecological system known as the Bonneville Salt Flats may perceive the influence of their social network on the resource's overall social dynamics.

Background

Social Network Analysis

Social network analysis (SNA) is a research method that identifies patterns in social relationships among members of a population through the use

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[5] Stakeholders in this study are members of several *a priori* groups associated with the Bonneville Salt Flats. Deeper, theory-based stakeholder definition, identification, or selection was not part of this study.

of networks and graph theory (Scott, 2017). In doing so, SNA can also be used to examine both the availability and exchange of resources—e.g. information or other social goods—between these actors (Wellman & Berkowitz, 1988). Ultimately, SNA endeavors to understand a network of drawn-together individuals by quantitatively and graphically mapping their connective relationships.

Social network theory (SNT; Prell, Hubacek, & Reed, 2009), on the other hand, focuses on the roles that social relationships perform in conveying information, channeling personal or media influence, and facilitating attitudinal or behavioral change (Liu, Beacom, Sidhu, & Valente, 2017). Underlying SNT is the fundamental notion that social structure is significant because it quantifies both interactional patterns as well as the relationships involved in those patterns (Sih, Hanser, & McHugh, 2009). Social interactions have the potential to influence how new information or behaviors are transmitted throughout groups; thus, human behaviors both affect and are affected by the presence and behavior of others within their social networks (Makagon, McCowan, & Mench, 2012). In this regard, SNT suggests that the co-creation of stakeholder knowledge is at least in part facilitated by certain actors who are centrally located in the network and through whom many interactions occur. Understanding the genesis or propagation of such behaviors therefore has many potential applications in regard natural resource management, wherein managers must oversee both ecological and human social aspects of a resource.

Together, SNA and SNT are useful for revealing social network structure and the implications of that structure in regard to the entity or phenomenon responsible for bringing a network together. Furthermore, Mbaru and Barnes (2017) suggest that 'key players'—e.g. *star actors*—in networks are likely to be best positioned to successfully implement four distinct conservation objectives: (1) rapid diffusion of conservation information, (2) diffusion between disconnected groups, (3) rapid diffusion of complex knowledge or initiatives, or (4) widespread diffusion of conservation information or complex initiatives over a longer time period. Identifying these star actors is therefore potentially valuable for understanding various aspects of stakeholder knowledge-building related to the SES of which they are an integral part. For this reason, these star actors are potentially quite valuable in terms of the sustainable management of natural resources.

Data for SNA are typically gathered in interviews or through questionnaires, wherein researchers solicit reports of who participants interact with socially, either in general or in regard to a specific phenomenon or entity. The resultant data can be used to both graphically and mathematically model a social network at the heart of research inquiries. A key strength of SNA lies in its employment of standardized mathematical methods to calculate various measures of sociality across individual, group, and population levels (Makagon, McCowan, & Mench, 2012, citing Freeman, 1984; Sih et al., 2009; McCowan et al., 2011). As such, SNA necessarily sets distinct analytical boundaries around a body of human interactions related to something specific, such as a community center, natural resource, festival, school, etc.

To reveal one component of social-ecological complexity, this study analyses a social network comprised of key stakeholders to produce graphic representations (i.e. sociograms) of social linkages within a social network. The sociograms derived from this analysis depict social relationships in terms of *nodes* representing individual people (i.e. actors) or groups and the *edges* (i.e. *links* or *ties)* that connect those nodes to form a network of relationships. These sociograms can thus be studied to understand not only the qualities of specific relationships—by enumerating actors' connections and therefore potential influence in regard to other actors—as well as general characteristics of the social network as a whole.

The Bonneville Salt Flats

The social network data herein pertains to stakeholders with a vested interest in the one of the Unites States' most iconic western landscapes. Part of the state of Utah's enormous West Desert, the Bonneville Salt Flats (BSF) is approximately 125 miles west of Salt Lake City on Interstate 80. This unique landscape is characterized by a 30,000-acre salt pan that represents some of the mineral remnants of the Pleistocene Lake Bonneville as well additional solids from evaporated groundwater brine (Bowen, Kipnis & Raming, 2017; Oviatt, 2015; Turk, 1973). At its largest historic expanse, Lake Bonneville was approximately 325 miles long, 135 miles wide, and had a maximum depth of over 1,000 feet. The solutes historically held by that immense volume of water—now long since evaporated from this terminal system—are now accumulated as crystallized salt both on the playa floor as well as dissolved in associated brine aquifers.

The BSF is overseen by the United States Bureau of Land Management and is managed as a Special Recreation Management Area for (1) dispersed and unconstrained recreation including automotive land speed racing, rocketry, foot races, cycling, and diverse artwork, as well as for (2) corporate resource extraction in the form of (a) potash—used for manufacturing synthetic fertilizer—and (b) both culinary and industrial salt production. These recreational and extractive human relationships with the BSF have a long history. In fact, land speed racing and mineral extraction have been practiced at the BSF for over 100 years (Mason & Kipp, 1997).

However, in recent decades impacts to the natural processes that produce and sustain the salt crust have fueled tension between certain stakeholder groups. Due partially to this tension as well as to mandated quasi-decadal salt crust assessment (Bowen, Kipnis, & Pechmann., 2018), an extensive multidisciplinary research endeavor based at the University of Utah set out to measure the volume of the salt crust as part of a much larger research endeavor[6] to study the BSF as a complex system full of social-ecological reciprocities. The SNA study herein is one of several aspects of that overall inquiry into the BSF as an SES.

Research Purpose, Questions, and Scholarly Contributions

Without understanding social network structure, the role of stakeholder networks in social-ecological systems remains a mystery. This shortcoming has implications for natural resource and PPA management wherein managers may need to understand the influence of social networks to predict and respond to social dynamics and social-ecological reciprocities. Thus, the purpose of this study is to use SNA as a tool for

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[6] Entitled *CNH-L: Adaptation, mitigation, and biophysical feedbacks in the changing Bonneville Salt Flats* (Award No. 1617473), this overall research endeavor represents a collaboration among the National Science Foundation, the University of Utah, Clemson University, and the Bureau of Land Management.

revealing perceptions of social dynamics to better understand and perhaps leverage relevant social structures in social-ecological systems.

To this end, the study herein addresses three primary research questions: (1) "What is the structure of the BSF stakeholder social network?", (2) Who are the potentially influential people (i.e. star actors) in the BSF social network?", and lastly, (3) "How do star actors perceive that their social network may influence social dynamics in the larger BSF social-ecological system? "

Methods

This study used an explanatory sequential mixed-methods approach (Creswell & Plano Clark, 2017) with an additional exploratory component to reveal important structural characteristics of the BSF stakeholder community. Data collection consisted of: (1) four seasonal quantitative surveys to gather social network data from BSF stakeholders to (a) reveal social network structure and (b) to identify star actors in the BSF community; and (2) qualitative interviews with star actors for the purpose of (a) member checking the study's quantitative SNA findings and (b) investigating star actors' perceptions of the social network's influence on the BSF social-ecological system.

Participant Sampling

I identified initial participants by their recorded attendance at a BSF-related summit at the University of Utah in the fall of 2015. The list of these individuals—

wherein each person was identified with a BSF-related stakeholder group[7]—was compiled by the CHN-L project's primary investigator and later shared with me. These groups included: (1) the Academic/Scientific research community, (2) the Land Speed Racing community, (3) the Land Management community, (4) citizens of the city of Wendover and greater Tooele County, Utah, and (5) the Media community. The Mining and Industry community —a sixth group—also shows up in this study through referral and post-data collection interviews, despite its non-participation in SNA surveys.

I then utilized a snowball-sampling approach to solicit these individuals and their referrals to participate in the SNA survey. Next, I distributed the individual-level SNA online survey using the Qualtrics Research Suite (see Appendix 6) four times during 2018. Using a modified Dillman (Hoddinott & Bass, 1986) approach, this step of the sampling process captured a full year of BSF-related social interactions among participants. Initial telephone solicitation of 20 stakeholders for SNA survey participation yielded participant referral of 74 additional BSF-affiliated individuals. Ultimately, this resulted in a list of 94 total names from which survey participants could select to identify with whom they interacted each quarter.

Instrumentation

The surveys contained three questions pertaining to 'significant' BSF-related interactions—i.e. conversations, meetings, email, or phone calls lasting approximately

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[7] Stakeholders referred to in this study are members of one of several *a priori* groups associated with the Bonneville Salt Flats. Deeper, more theory-based stakeholder definition, identification, or selection was not part of this study. More about stakeholders is included in Part 3 of Appendix 1: Definitions.

two minutes or longer—that each participant had with other individuals during the previous three months. These questions requested that participants: 1) select the individuals with whom they had regular contact regarding the BSF during the previous three months from the expanded list of names, and 2) quantify those interactions with each individual in terms of (a) total number, (b) average duration in minutes; and (c) average importance on a seven-point Likert-type scale (1 = 'very low importance' to 7 = 'very high importance'). In summary, each SNA survey asked participants to provide the same data regarding BSF-related interactions with other stakeholders: 1) who they interacted with, and the 2) frequency, 3) duration, and 4) perceived importance of those interactions over the course of one year.

Data Formatting and Analysis

I used Excel to clean and restructure the Qualtrics data to make it compatible with *Gephi 0.9.2*—an open-source software package used for network visualization and analysis. I then used IBMs SPSS (version 26) to perform a multiple imputation of missing interaction values attributed to SNA survey incompletion (Huisman, 2000). These imputed values comprised 82 interaction counts, 107 interaction durations, and 71 ratings of interaction importance. The total number of imputed data values (260) comprised approximately 16% of the total data. With imputation complete, I proceeded to calculate *edge weight* for BSF-related social interactions. This edge weight communicates the relative 'value' of a BSF-related social interactions between actor pairs for the purpose of semi-quantitatively comparing these interactions at both individual and group levels (see Figure 2, below). Edge weight was also used to calculate *weighted* *degree,* wherein the edge weight is multiplied by an actor's *total degree*—a measure of the number of direct connections an actor has with other actors, regardless of their group affiliation. Weighted degree is thus useful for comparing the relative influence that certain actors may have in a social network compared to others.

Edge Weight = Frequency × Ave. Duration × Importance

wherein

Frequency = Number of Interactions per Quarter
Duration = Percent of One Hour
Importance = 1-7 on Likert-Type Scale

Figure 2.1. Calculating edge weights

After calculating edge weights, I imported the restructured data as an *edge table* into Gephi. This table contained all reported interactions as well as weighted edge values representing the three measures of each of those interactions.

RQ 1: Sociograms and Network Structure

Using the final, completed dataset, I used Gephi to construct several sociograms for the data collection year, including: (a) an unweighted and undirected network model at the actor level, (b) a model that shows the structural results of removing potentially influential actors, and (c) a weighted and directed network model at the group level.

The sociograms revealed the basic structure of the network at the individual and group levels. Analytically, I used Gephi's Force-Atlas algorithm, which treats the distance between any two actor nodes as a function of the strength of the edge connecting them. Force-Atlas is often used with weighted network data to show the attractive forces within groups. Ultimately, Force Atlas arranges the network into communities with strong relationships that emerge as a product of repeated interactions among actors during the data collection year despite being unweighted by interaction frequency, duration, or importance. These relationships are therefore reinforced by multiple reports of pairwise interactions between individuals. When one actor reports an interaction with another actor, an edge relationship is established; if that second actor also names the first, the strength edge is thus doubled, and group cohesion is easily rendered by the algorithm.

RQ2: Identifying Star Actors

To address Research Question 2 (*Who are the star actors in the BSF network?*), I used three centrality scores (closeness, betweenness, and eigenvector) and both (a) weighted and (b) total degree scores from SNA data to identify star actors. Next, I selected the two actors from each of the six *a priori* stakeholder groups who had the highest *degree* and *centrality* scores. As network *nodes* with many *edges*, these star actors appeared in the sociograms as points with numerous rays connecting them to other points, thus resembling a star (as per Bavelas, 1950). Resulting from their central positions, star actors potentially wield structural influence in the social network due to the frequency, duration, and importance of BSF-related social interactions that include them.

RQ3: Social Network Influence on BSF Social Dynamics

To address Research Question 3 (*How does the BSF social network influence social dynamics?*), I used the Zoom meeting platform to conduct audio-recorded, semi-structured internet interviews (Seidman, 2013) and member-checking (Creswell, 1994) with star actors. The purpose of the interviews was to corroborate the SNA's preliminary structural results as well as provide insight into how the social network potentially influences social dynamics from the perspective of interviewees. Upon star actors' agreement to participate in an interview, I provided a visual of the unweighted and undirected BSF sociogram, in which they were identified individually by a numbered, anonymous node in the social network (see Figure 2.2).

During the interview, I verbally described and visually displayed the structural characteristics of the sociogram. Analysis of the interview data confirmed the SNA structure and helped identify inductive emergent themes (Creswell & Plano Clark, 2017) related to Research Question 3 through of open coding.

Results

SNA survey participants selected individuals with whom they had BSF-related social interactions during the data collection year. In total, 37 unique individuals supplied survey responses that encompassed 556 BSF-related social interactions.

Structure of the BSF Social Network (RQ1)

The sociogram in Figure 2.2 shows clustering of six *a priori* stakeholder groups in this study. Whether in regard to internal or external communication, the Academic and Land Speed Racing communities reported the highest number of BSF-related social interactions. The abundance of these interactions is influenced by these two communities (a) having many individuals and (b) the highest level of SNA survey participation in the study. Showing few actor nodes, Industry, Media, and Wendover/Tooele stakeholders are least represented due to these groups' low SNA survey participation.

The final tally of stakeholders represented in the BSF social network totaled 91 individuals who engaged in 375 person-to-person social interactions related to the

Bonneville Salt Flats. By percentage, 49.5% of these individuals represented the Land Speed community (orange nodes), 30.8% represented Academia (red nodes), 7.8% represented Land Managers (green nodes), 4.4% represented Mining/Industry (yellow nodes), 4.4% represented Media (blue nodes), and 3.3% represented the local Wendover-Tooele community (purple nodes).

Table 2.1. *Network structure metrics for individual-level sociogram (with weights) of BSF stakeholders across data collection year*

Metric	**Oct 2017-July 2018**
Number of Participants	37
Nodes (Actors)	91
Edges (Interactions)	375
Average Degree (per actor)	4.12
Ave. Weighted Degree	30.7
Network Diameter	6
Graph Density	.046
Modularity	.617
Ave. Path Length	2.59

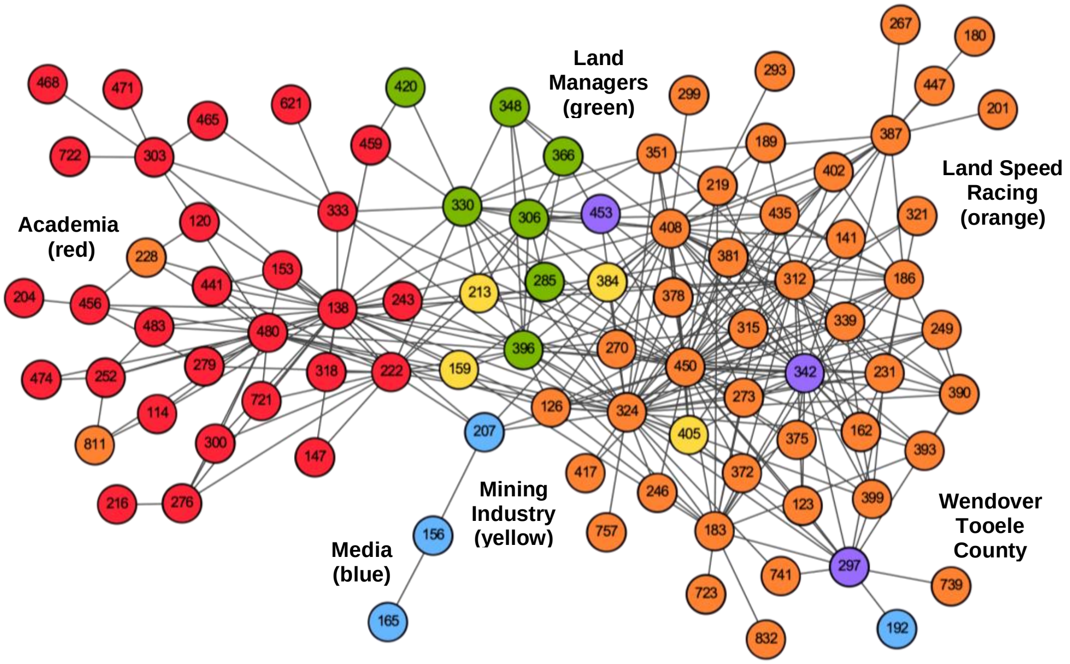

Figure 2.2. Preliminary undirected and unweighted sociogram showing all pairwise social interactions Bonneville Salt Flats stakeholder groups reported during data collection year.

Identification of Star Actors in BSF Stakeholder Communities (RQ2)

The individual-level sociogram visibly revealed influential hubs of important activity and associated key actors. As per Scott (2017), certain individuals in the social network are recognizable as ‘stars’ primarily because they are participants involved in significant interactions that were numerous, frequent, lengthy, and/or were subjectively assessed as being of relatively high importance. *Star actors* in this study are individuals who are both (a) recipients of numerous and frequent selection and (b) themselves report numerous and frequent interactions with others, resulting in their relatively high centrality and degree scores.

From each stakeholder group, I designated the two individuals with the highest total degree and centrality scores as 'star actors.’ Their degree and centrality scores—presented in Table 2.3—indicate these twelve star actors’ importance in the overall connectivity within their own stakeholder groups as well as with members of other stakeholder groups. Figures 5-10 highlight the six highest-scoring star actors’ placement and connections in the unweighted sociogram using the Force-Atlas format for rendering nodes, edges, and the effects of modularity more clearly. These graphs can thus be used to better visualize all twelve of the star actors’ potential influence in the BSF social network as well as their ability—and perhaps authority— to help assess social interaction trends in the SNA data. The network cohesion that these star actors provide can be seen clearly in consideration of what happens when they are removed from unweighted sociogram (Figure 11), which results in disconnected and isolated nodes with far fewer connections to one another.

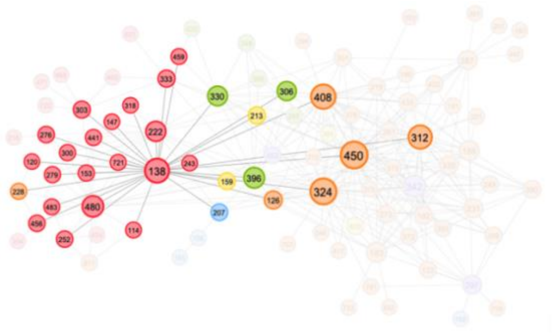

Figure 2.4. Star Actor #138 (Academia)

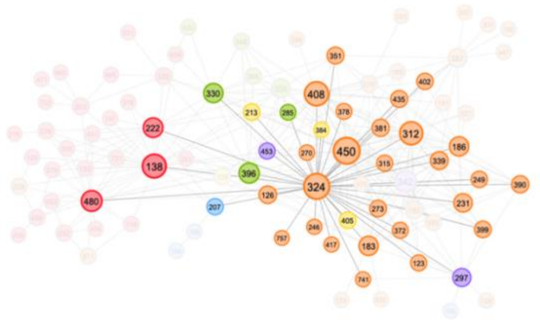

Figure 2.5. Star Actor #324 (Land Speed)

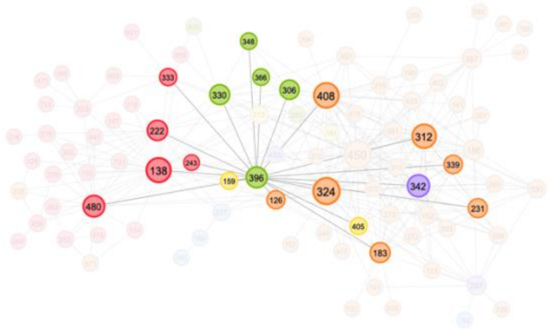

Figure 2.6. Star Actor #396 (Land Mgmt)

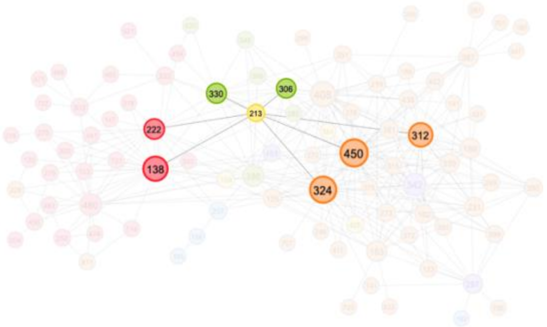

Figure 2.7. Star Actor #213 (Industry)

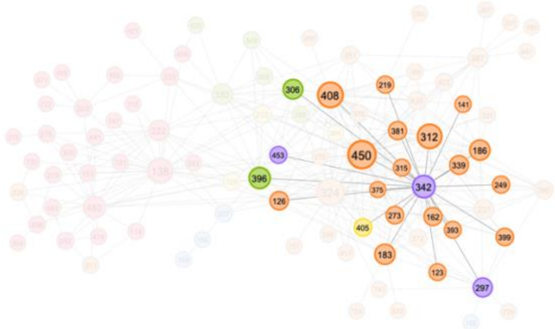

Figure 2.8. Star Actor #342 (Wendover)

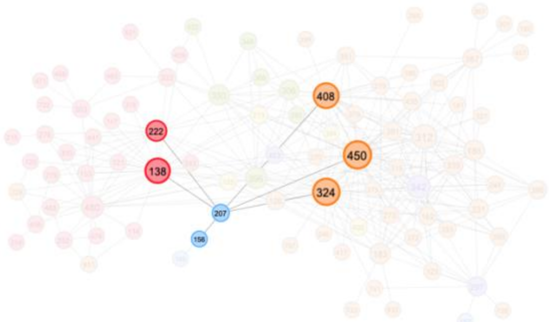

Figure 2.9. Star Actor #207 (Media)

Table 2.3. *Centrality and degree scores for star actors in the BSF social network.*

		Centrality		**Degree**	
Stakeholder Group	**Actor ID**	**Closeness**	**Betweenness**	**Weighted***	**Total**
Academia	138	.59	1289	987	46
	222	.48	131	480	24
Land Speed Racing	450	.71	157	10	44
	324	.68	803	331	43
Land Management	396	.51	350	292	25
	330	.47	109	167	22
Wendover / Tooele County	342	.54	190	336	28
	297	.48	72	171	14
Media	207	.37	86	11	6
	156	.28	0.00	.19	2
Mining / Industry	213	0.00	0.00	36	7
	159	0.00	0.00	32	6

**Note*: Mining/Industry stakeholders did not participate in SNA but were identified by other stakeholders.

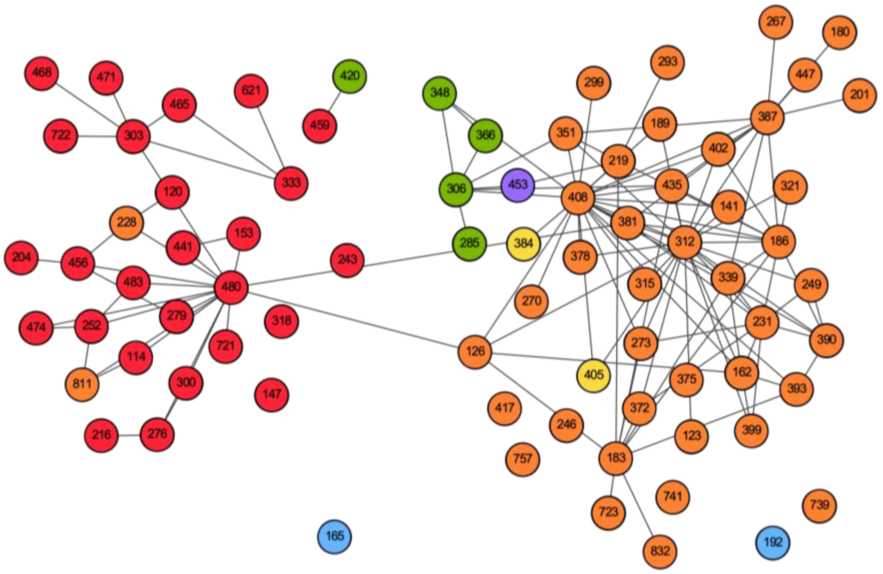

Figure 2.10. Unweighted, undirected sociogram with star actors removed.

Aggregated Group-Level Sociogram

Figure 2.3 presents a weighted and directed sociogram of social network interaction trends at the BSF stakeholder group level. The numbers in this graph represent edge weights for both internal (inside nodes) and external (at arrowheads) communication. As per figure 2.1, these weights are the mean product of frequency, duration, and importance of the BSF-related social interactions and are intended to represent the subjective overall value or significance of interactions. Table 2.2 breaks down the in-, out-, and weighted degree values related to the group-level sociogram.

Despite Industry/Mining group not participating the SNA and thus reporting no interactions with other groups, most other groups reported interacting with Industry/Mining. Academia reported interacting with all other group except Wendover/Tooele and Media, though Media reported interactions with Academia. Land Speed interacted with all groups, although Media did not report interactions with Land Speed. Land Managers reported interacting with all groups except for Media. Land Speed and Wendover/Tooele reported interacting with the Media community, though Media itself only reported interactions with Academia. All stakeholder groups except Industry/Mining (which not participate in the SNA survey) reported internal interactions, as noted by in-group edge weight values inside each node in Figure 2.3 (e.g. .55 for Media represents the average product of frequency, duration, and importance of BSF-related social interactions within the Media group). Edge weights for external communication are represented by the values adjacent to arrowheads for group-to-group interactions (e.g. 1.63 represents the edge weight of interactions that Media reported with Academia).

As per Table 2.2, Land Speed boasts the most BSF-related connectivity (D_{total} = 10) while Academia boasts the highest weighted degree (D_{wtd} = 55.8). The majority of the unweighted degree values are similar across groups, but once weighted by the product of frequency, duration, and importance, those degree values increase substantially.

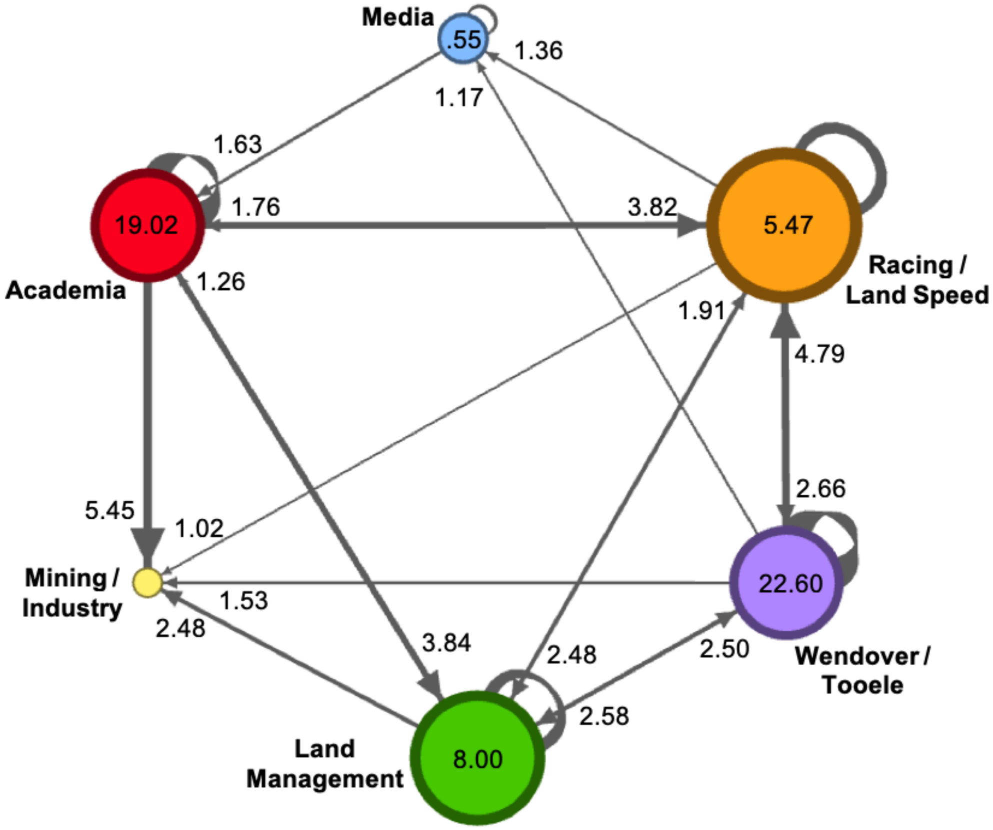

Figure 2.3. Group-level sociogram showing weighted and directed social network interactions among BSF stakeholders during the data collection year. 'Loops' on each node represent groups' internal interactions which are quantified by the in-node values.

Table 2.2. *Aggregated, directed, and weighted structural characteristics for group-level BSF social network (Data Collection Periods 1-4).*

	Degree			**Weighted Degree**		
Stakeholder Group	**In-Degree**	**Out-Degree**	**Total**	**In-Degree**	**Out-Degree**	**Total**
Academia	4	4	8	23.67	32.13	55.8
Land Speed Racing	4	6	10	15.99	14.75	30.74
Land Management	4	5	9	16.9	16.15	33.05
Industry/Mining	4	0	4	10.48	0	10.48
Wendover/Tooele	3	5	8	27.76	32.67	60.43
Media	3	2	5	3.08	2.18	5.26

Perceptions of Social Network Influence on BSF's Social Dynamics (RQ3)

During semi-structured qualitative interviews, star actors generally verified the sociogram in Figure 2.2 and the underlying social interaction trends that it depicts. Although there were minor—and sometimes conflicting—suggestions to possibly make it more accurate, they did not dispute the sociogram's depiction of the social network as a whole in terms of relative group size, relation to one another, or connectivity. As such, interviews proceeded to addressing Research Question 3: *How do star actors perceive the influence of their social network on BSF social dynamics?* Star actors' responses revealed four primary topics in this regard: (1) the influence of authority, (2) social network evolution, (3) the influence of research on the social network, (4) self-reflection.

Both formal and informal authority at the BSF have an influence on the social system.

Several actors began their response to my question with commentary on the position of the stakeholder groups relative to one another in the sociogram:

> *It makes sense that to me that hovering in the middle are the land managers and the members of [the mining] industry because ultimately these are the individuals that have the authority under which activities occur at the BSF.*
>
> *-and-*
>
> *Racing and research have become connected through a number of key nodes as we see in the [social network] model. . . . ultimately, those interactions pass between and through and around the Land Mangers and the mining industry.*

These quotes and others illustrate the intermediary role that some community members serve at the BSF in between other communities, some of which wield considerable legal authority—such as federal Land Mangers—to allow or disallow certain activities at on the salt flats at specific times. As such, these quotes demonstrate star actors' recognition of social power dynamics in regard to the use and management of a natural resource and the significance of the positioning of those powers in the social network.

One of Land Management's star actors comments addressed the influence of non-managerial stakeholder communities on the system. Specifically, this person suggested that the Academic and Land Speed communities provide a large bulk of the knowledge that ultimately informs the management of the BSF:

> *"Looking at the [social network] model . . . I think that the interactions that have the most potential to influence a change in the management of BSF [are the ones in] the research [i.e. Academic] community. We also change management based on what we hear from the [Land Speed] racers. In terms of how we communicate with the public—it depends it pretty heavily on what we hear from the scientists [and racers] and both of those have helped us change over time with how we communicate about the salt flats."*

This quote thus acknowledges that certain groups—as parts of the social network nested within the overall SES—have an impact on the SES as a whole, despite not being legally anointed to control various aspects of social and/or ecological actions directly. Furthermore, this individual suggests that the quantitative information derived from interactions with the Academic and Land Speed communities parlays into how land managers communicate with the public—which in turn may affect the way that the public interacts with the resource. The cumulative impact of tens of thousands of visitors upon a resource thus represent a large-scale physical effect of seemingly distant social interactions among stakeholder groups.

This sentiment seems echoed by the following statement, wherein a star actor from the Media community suggests that the power of the media is likely to be impactful on the SES that the BSF represents:

> *"To a degree, the media will affect public perception, and if public perception to some degree affects function and management [of the BSF] . . . then I guess there would be influence there."*

This quotation suggests that the media—in doing its due diligence to report on salient storylines about the BSF—hypothetically has an effect on public perception, and therefore possibly the way that the public interacts with the BSF as a natural resource. Just as the knowledge constructed by the Academic and Land Speed communities to informs management, the media, too, has the power to broadcast influential information to the general public, who—while they could be considered stakeholder—are not directly or heavily involved most of the social and ecological phenomena at the BSF. Nonetheless, the power of that information may influence both the public's regard for—and interactivity with—the BSF.

The sentiment of previous quotation is expressed more dramatically by another star actor. This person suggested that it was the media—though underrepresented in the sociogram—nonetheless drew from the lived experiences of the Land Speed community in telling stories that "lit the match" that culminated in the blaze of research of which this study is a part:

> *"The blue interactions are severely deficient in this model. There's no doubt in my mind that the media community is underrepresented, and it is not shown to be as powerful [as it really is]… To be honest, frankly, you and I would not be talking [about the BSF social network] if it had not been for the media . . . [who] blanketed the country [with news of the salt decline] and [shined] an absolutely glaring spotlight on this [salt crust decline] problem. . . You can't care about something you don't know about!*

The last part of that quote further suggests the power of the media to inspire both awareness and concern for the BSF, which may result in support for certain conservation initiatives. More to the point, this actor is suggesting that the Land Speed community's rallying cry—broadcast by the media—spurred the most recent endeavors to study and invest in the restoration of the BSF's salt crust.

The BSF social network has evolved over time and will continue to evolve in the future.

One of the star actors acknowledged that over time, groups and interests related to the BSF change and ultimately interact differently than they had previously:

> *"The communication structure has changed a little bit over the years . . . with the emergence of [specific individuals] from the racing community that become the point of contact between mining and racing…. the [communication with the] BLM stays consistent… Academic [communication] is going to be declining [as the Salt Crust Thickness Study wraps up] . . . we'll see how Salt Laydown goes . . . you'll probably see frequency of all discussions go up… and you'll have other players—the state [of Utah] USGS and DNR—managing that project . . ."*

The nature of any complex adaptive system is to not just generally change over time but also for its various parts to adapt, changing in relationship to one another. So, too, given the dynamic nature of social networks—wherein individuals and communities continuously change in size, purpose, etc., there is perhaps an undeniable flux of influence upon the place or phenomenon that draw them together.

Studying the BSF social network has an effect . . . on the BSF social network.

Incidentally, a star actor from Academia offered another perception of the influence of the Academic Community. This person suggests that there is potential for internal bias and of influence of this study, itself, on the BSF social-ecological system, as well as the larger-scale research of which this study is a part:

> *"Before the NSF grant [to study the salt crust], Academia would not be in the model… and if you include the [principal investigators] of a study, they're going to be highly represented [in the network model]… we*

> *included a social scientist and his graduate students on the grant… then it occurred to me that we engaged the [Academic] community [in SNA and interviews] and documented it…There's something kind of funny and profound and laughable and truly fascinating about all that…"*

This person thus suggested two things: (1) that, by including academia in the network model we are measuring the influence of our own research, and (2) that the very nature of research into the BSF social network has an impact on the BSF as a system. Both of these points speak to the reciprocity of social and ecological interactions in a complex SES. This very study, as suggested by this Academic star actor, yielded network data that may reflexively impact the network—perhaps directly or through the Land Management community who, as suggested previously, draws from the knowledge of Academia to construct and conduct its management policies. This is a noteworthy point, because one of the ultimate applications of academic research is indeed to inform policy-making in whatever field that research is performed. So, too, might the qualitative interviews hold an impact because of the things that I, personally, asked star actors to consider in regard to their social network and its influence on the BSF.

Reflecting on the social network has an effect on perceptions of its influence.

The following statement goes a deeper into the idea that this study's interviews and their content might have an effect of the social—and social-ecological—network:

> *"Looking at all those nodes in (my own community) and my place within it, there's clearly a lot of people that I should talk to, because I'm not as connected to many of those nodes as I would like to be."*

This person is thus suggesting that despite knowing that there are many individuals in their own BSF stakeholder community, seeing them illustrated makes it clear that there are many other people with whom they should probably engage more regularly.

More philosophically, one actor pointed out seemingly paradoxical representations of stakeholder communities and their relative power to influence the BSF's social-ecological system:

> *"Well… thinking about the density of lines [representing interactions, i.e. edges in the sociogram] between different communities relative their actual impact or power within the landscape. Extractive industries are not well represented [in the model] and yet financially and resource wise and ecologically—they are doing a lot [of influence]. The racers show the strongest presence, with the most lines [i.e. edges in the sociogram], but does it mean that they get to have—that they should have?—the power, you know, to determine what happens in the system?"*

This quote speaks directly to the sociogram's potential to represent not just social interaction data, but also its ability to illustrate the relative power of certain stakeholder groups to influence the social and ecological processes at the BSF.

Perhaps despite the thoughtfulness that star actors demonstrated during these qualitative interviews, one of them suggested that it is pretty easy to get wrapped up in one's own group and its particular perspective and interests:

> *"I think all of the departments probably have to step out of their comfort zones more to get a valid picture [of the whole BSF system]."*

While this is succinctly stated in this case, numerous other less explicit statements suggested similar sentiments – that as part of a specific community, stakeholders are nonetheless bound into relationships with other communities as well, which makes them all a part of the BSF community at large.

Overall, star actors offered valuable perceptions of the influence that the social network may wield upon both the function and management of the BSF as a complex

SES. So, too, did they occasionally point out potential inaccuracies regarding the how the sociogram might inspire and illustrate certain intangible ideas worthy of consideration.

Discussion

This social network study endeavored to illustrate and understand the social network connections among stakeholder groups that have a vested interest in the future, sustainable human use of a complex social-ecological system. Social network structure can have a significant impact on how actors behave and has further implications for managing environmental challenges (Bodin & Crona, 2009). With this in mind, I conducted a social network analysis with four data collection periods and engaged ‘star’ BSF actors in conversation about their social network structure. These interviews focused on discussing (a) a basic sociogram of the BSF social network, (b) the network’s general structure, and (c) qualitative interviews probing how star actors perceive the influence of social network structure on the BSF ‘s overall social dynamics. In doing so, this study revealed the potential of illustrating a social network of stakeholders related to a natural resource. In many cases, star actors were not surprised by what they saw in the sociogram; they were, however, rather fascinated by the network model and what it might mean for the relative relationships among the BSF’s many stakeholders.

Specifically, several actors were intrigued by the positioning of the BLM as mediator and moderator in between that larger communities of Academia and Land Speed Racing, both of which are comprised of a great many actors. Though small in relative stature, the Mining Industry its necessarily connected to the BLM and also finds itself between to Academia and Racing, despite having a very different relationships with each group.

Taken together, the sociogram presents not only positioning of these groups, but also the potential push-and-pull of information and perhaps other resources that these groups partially control. As some star actors pointed out, this illustration of power dynamics has the potential to inspire insight into SES functioning. These individuals' genuine interest in discussing the implications of social network structure suggested the power of making an intangible concept into a tangible one. This raises the possibility that if the whole network could see the sociograms, they might gain a better understanding and/or appreciation of their role in social-ecological complexity.

The act of engaging stakeholders in reflexive mental tasks may hold great promise in regard to the sustainable and collaborative management and governance of natural resources. Especially in relation to the way in which knowledge—perhaps regarding social-ecological complexity itself—might be transferred among actors in a social network, even knowing a little bit can provide the fuel for deeper, broader, and more powerful inquiry. Stimulating such realizations—and perhaps the discussion of which that might follow—could be tremendous potential assets for adaptive resource governance pursed through social-ecological thinking.

Despite this study's achievements, it also experienced certain limitations and liabilities. Primarily, the relatively low participation on the SNA surveys and the resulting missingness of data was undeniably a shortcoming of this study. Non-response thus had an impact on the potential for the sociograms to accurately represent the BSF stakeholder population, at least in terms of the potential size of the actual BSF stakeholder network. In addition to a huge Land Speed community that was only partially represented, the Industry/Mining, Media, and Wendover/Tooele communities were quite minimally represented. Also, as pointed out by one star actor during interviews, the inclusion of the Academic community in the SNA surveys could be construed as inviting bias into the study. Although the academic community was undoubtedly a legitimate stakeholder groups with a vested interest in the BSF, it is true that in the past, Academia would not have shown up as strongly as it did during the data collection year.

Lastly, the potential bias attributable to relying on star actors' opinions of their own star status could have be construed as a product of their regular and therefore influential participation in the SNA. It is potentially suspicion-invoking to ask the people who participated—and thus emerged as influential in the network—if they are influential in the network. Conversely, in conjunction with the aforementioned promise of stimulating contemplation of the influence of social networks, perhaps reveling star actors to themselves—replete with the personal power that they positionally may wield—could be a valuable act of social transparency with stabilizing effects on an SES. Too, the perceptions of additional potential star actors were not explored; these individuals' possible contributions may have led to very different results and implications.

The aforementioned limitations must be considered in light of the fact that this study only speaks to a limited, cross-sectional snapshot of responses to the SNA survey. While it is useful for identifying trends and eliciting impressions of the BSF social network's influence, more detailed study with a higher response rate would likely provide more reliable data for guiding decisions made about BSF policy and management.

There are numerous possibilities that this work has revealed for future research. The first of these might be to identify the format of each BSF-related social interaction—such as whether it occurred face-to-face, either between individuals or in a group, via telephone, or email. These measurement items were initially considered, but not pursued for the sake of preventing participants' survey fatigue. In failing to capture this level of detail, however, this SNA perhaps missed an opportunity to identify the most frequent or important medium for social interactions among BSF stakeholder communities.

A possible methodological consideration for future research might be to simply focus on group-level SNA instead of individual-level interactions with specific actors. This approach would entail simply surveying participants' interactions with other stakeholder groups—completely avoiding the individual identification of group members. Not only would this be a more succinct—and perhaps completely anonymous—approach, it could also potentially reduce suspicion and uneasiness about sharing what some people perceive to be personal or sensitive information. As a much-abbreviated approach, a group-level survey could be quickly and easily completed without having to recall specific details about social interactions. As such, it could even be administered at a higher frequency than quarterly, as this study's SNA did. Focusing on the group-level social structure would represent a larger-scale portion of the SES mosaic, but it could still serve as a source of inspiration for considering social-ecological complexity answer the influence of a specific social network on a specific SES.

Although using network analysis to reveal social structure and graphically representing social relationships are not new pursuits, contemporary network visualization software has made analyzing and visualizing complex social structures much easier (Makagon, McCowan, & Mench, 2012). Statistical analysis of social networks is also helpful for defining specific problems as well as to explore the roles—or influence—of particular individuals in the network. The study herein delves into one such line of inquiry and endeavored to reveal how a social network's influential individuals perceive the influence of their social interactions on the natural resources that bind them together. These perceptions included thoughtful considerations in regard to which groups have certain types of power in an SES (and whether they are entitled to it); the need to look beyond the interests of the particulars of what binds one person to another in regard to a natural resource; the dynamic nature of human social factions that change in scope, size, and emphasis over time; and the roles particular groups play in all of these regards.

As pointed out by one of the star actors, this study may not be representative of stakeholder communities related to large, iconic, and highly-visited natural resources such as Zion, Arches, or Grand Canyon National Parks—but it might be representative of other public lands that see seasonal, periodic spikes in visitation possibly attributable to specific events that draw people to an otherwise remote and perhaps infrequently-visited location. Too, the findings herein may be applicable to natural resources that are visited primarily as wayside stops *en route* to other places. For many public lands that are largely wide open and unconstrained, however, it may be difficult to identify and consistently engage related stakeholders to perform research such as SNA. Thus, SNA is not put forth here as a single, one-size-fits-all approach to SES-based land and visitor management.

Using SNA as a part of natural resource management has become more common, and as suggested by Groce, Farelly, and Jorgensen (2019) it is time for the conservation community to rally together to build a rigorous base of evidence demonstrating the extent to which social networks can contribute to achieving desired social and environmental outcomes. Applied as a tool to help navigate resource-related disputes and stakeholder conflict, SNA has the power to help strategically identify and harness the influence of star actors who may be able to rally one or more stakeholder groups of which they are integral members. These individuals may additionally be indispensable for disseminating consistent information and/or soliciting participation in regard to management-related activities across a social network. SNA’s utility to inform understanding of social influences on decision making (Groce, Farelly, & Jorgensen, 2019) builds on Prell’s (2006) declaration that stakeholders should, indeed, influence that decision making. In this manner, SNA and associated stakeholder analysis can be used to fairly represent diverse interests, avoid exacerbating conflicts, and ensure that certain groups are not marginalized (Prell, 2006).

This study’s contributions to SNA and natural resource management scholarship are twofold. Primarily, although numerous studies engage in SNA in order to identify star actors, none or few have sought to engage those star actors in member-checking the network structure. Second, while SNA has often been studied in the context of resource governance (e.g. Bodin & Prell, 2011; Crona & Hubacek, 2010; Bodin & Crona, 2009), no studies have sought to understand how stakeholders perceive the influence of their social network on social dynamics or the overall social-ecological system of which it is a fundamental part. Adding these two lines of inquiry to SNA scholarship advances exploration of the role of stakeholder perceptions of complexity at both the social network scale and at the overall social-ecological system scale.

Ultimately, this study used SNA to illuminate one small facet of stakeholders' perceptions of social-ecological complexity. That facet, in turn, represents one small tile in an overall mosaic whose creation might one day portray the complexity of the BSF's social and ecological realities clearly and accurately. That will admittedly be a difficult task—just as it would be for any natural resources fraught with SES-related uncertainties, reciprocities, and non-linear interactions. Though sometimes difficult, managers and researchers must nonetheless target specific inquiries and design methods for revealing some of complexity's infinite components for the sake of solving specific problems.

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CHAPTER III

Human Perceptions of Change in a Complex Social-Ecological System

Abstract

Whether biophysically driven or human-influenced, change is inherent in both human society as well as in natural ecosystems, and sustainability of these linked systems of humans and nature depends at least partially on the ability to cope with change. Consequently, effective natural resource management requires both objectively understanding biophysical change in resources as well as identifying subjective human perceptions of change (POCs) because those perceptions may affect the ways in which people interact with a natural resource. This study explored the driving forces for differences in people's perceptions of change related to a specific natural resource—Utah's Bonneville Salt Flats (BSF), herein posited as a complex social-ecological system (SES). The study had two primary purposes: (1) to identify what social and biophysical phenomena people may perceive to have changed over the past three decades and (2) how those perceptions might be influenced by (a) group membership—herein comprised of spectators and racers at land speed racing events, and (b) past use histories (PUH) of less than or greater than tens years' experience visiting the BSF. Findings included effects of both Group and PUH as well as an interaction effect of both of these predictors on POC.

Keywords: Bonneville Salt Flats, stakeholders, land speed racing, spectators, complexity, natural resource management, perceptions of change.

Introduction

No landscape or natural resource is immune from the changes that time may bring. Many of these changes are entirely natural, such as those owing to acute weather events or geologic processes; others may result from human processes such as recreational and extractive activities. Be they human-social or biophysical, many diverse forces contribute to myriad changes in a resource. Some of these changes may occur in relation to an ecosystem's function, structure, or aesthetics. Other changes may occur in social interaction patterns related to—or interactions with—a resource itself.

Whether biophysically driven or human-influenced, change is inherent in both human society as well as in natural ecosystems, and sustainability of these linked systems of humans and nature depends at least partially on the ability to cope with change (Davidson-Hunt & Berkes, 2003). Consequently, effective natural resource management requires both objectively understanding biophysical change in resources (Chapin, Kolfinas, & Folke, 2009) as well as identifying subjective human perceptions of change (POCs) because those perceptions may affect the ways in which people interact with a specific natural resource (Brownlee, Hallo, Wright, Moore, & Powell, 2013; Knudson & Curry, 1991). Therefore, this study explored whether participants sampled at a large racing event perceived social and biophysical at the Bonneville Salt Flats (BSF) and whether the past use history (PUH) of the resource or their affiliation as a land speed racer influenced their POC.

Although previous literature indicates that recreationists and stakeholders closely affiliated with a changing resource may be aware of change (Brownlee et al., 2013;

2014), there is insufficient understanding about (a) how, why, and when people believe that resources are changing, (b) how POCs differ between groups, and (c) the objective accuracy of people's POC.

Research Purpose, Questions, and Scholarly Contributions

Developing knowledge about perceptions of change in various landscapes may be valuable for park and protected area (PPA) managers. Often juggling both social and ecological phenomena, PPA managers are faced with difficult social-ecological reciprocities that are hard to predict. As such, they may need to better understand people's awareness and perception of change as mediating variables when examining the effects of managerial decisions on resource quality (Rogan, O'connor, & Horwitz, 2005). Furthermore, policymaking and adjustment requires a good understanding of how people behave and make decisions within different contexts (Gsottbauer & van den Berg, 2011). However, some people may perceive change whether or not it has occurred (Nichols, Berkes, Joly, & Snow, 2004) and others may perceive change even when it has objectively not occurred (Lauer & Aswani, 2010). For this reason, understanding POCs is an important endeavor for PPA researchers and managers who engage in social-ecological thinking.

Without understanding whether and how people perceive change in complex systems such as PPAs, managers cannot know the relationships among objective change, subjective perception of change, various influences on perceptions, and the resultant behaviors related to those perceptions. Managing PPAs as the complex social-ecological systems that they are is difficult without such an understanding. With this problem in mind, this study addresses two primary research questions through a survey administered at the Bonneville Salt Flats during its two largest land speed racing events to participants categorized as ‘Racers’ and ‘Spectators’. The first and most basic of these asks, *“What social and ecological phenomena do people perceive to be changing at the BSF and to what degree?”* Secondly, this study asks, “*How do Racers’ and Spectators past use history with the BSF influence their perceptions of change?”*

Background

Social-ecological Systems

Comprised of both human-social and natural or biophysical elements inextricably linked in complex cross-scale reciprocities, natural resources, parks, and other protected areas are often recognized as *social-ecological systems* (SESs; Cumming, et al., 2015). According to Glaser, Krause, Ratter, and Welp (2008), SESs consists of ‘bio-geo-physical units’ and their associated social actors and institutions. These authors explain that in addition to being both complex and adaptive, SESs are also as delimited by spatial or functional boundaries that surround particular ecosystems and their contextual problems. Furthermore, the reciprocities among biophysical and human social factors in SESs stretch across numerous spatial, temporal, organizational scales in a complex dance of perpetually changing adaptations (Redman, Kuby, & Welp, 2008) that are typically fraught with uncertainties and non-linear behaviors (Werner &McNamara, 2007; Allen & Garmestani, 2015).

This complexity thus requires any research regarding SESs to target smaller, nested systems with *a priori* boundaries intended to help to focus inquiry and analysis

(Ostrom, 2009; Hinkel, Cox, Schluter, Binder, & Falk, 2015). Similar to an act of creating a mosaic with smaller fragments, ever-larger bodies of social-ecological knowledge can therefore be constructed from even the smallest social and ecological pieces. With enough of these smaller pieces of the mosaic assembled into coherent relationships, the greater picture gains clarity and meaning. Thus, as various components of a complex system are illuminated, the overall behavior of that system may become increasingly apparent.

It is nonetheless necessary in this mosaic approach to justify and logically frame the scale of inquiry into any sub-system component of SES complexity (Berkes, Colding, & Folk, 2003). Thus, the endeavor of the study described herein addresses one facet of social-ecological complexity isolated by the aforementioned *a priori* boundaries—that of the role of human perceptions of biophysical and social change in SESs. Despite a great body of literature has sought to address the ways that entities within SESs can change, adapt, and learn (e.g. Holling & Gunderson, 2002), few studies have focused on the role of perceptions of changing biophysical or social conditions. To fill this gap in scholarship, the study herein addressed human perceptions of change at an iconic natural resource and unique protected area—Utah's Bonneville Salt Flats (BSF).

The Bonneville Salt Flats

The BSF is perceived to be many things—a land of human triumph, a land of destruction and desolation, a playground, and a surreal world of the strange and bizarre (Bushman & Davis, 1997). Part of the Utah's enormous West Desert, the BSF is approximately 125 miles west of Salt Lake City on Interstate 80. Nestled southwest of the

Great Salt Lake, the BSF is a represents the mineral remnants of the Pleistocene Epoch's Lake Bonneville. At its largest historic expanse, this ancient freshwater lake was approximately the size of modern Lake Michigan, covered an area of roughly 20,000 square miles in northwestern Utah with a maximum depth of 1,000 feet (Hunt, Varnes, & Thomas, 1953). Topographically isolated between 13,000 and 15,000 years ago (Baxter, 2018), Lake Bonneville became part of a terminal basin system from which water could only leave through evaporation. It is the mineral content of that historically immense volume of water—now long since evaporated from this terminal system—that is responsible for the accumulation of salt both on the salt pan floor (i.e. playa) as well as in associated subsurface brine aquifers.

For over a century, the BSF has been shaped by human interests that have resulted in numerous impacts (Kipnis & Bowen, 2018). Early in the 20th Century, railroads were constructed on berms crossing the playa. In the 1960s and 70s these railroads were joined by then-new Interstate 80. In the 1970s, the BSF was designated as a national historic site and, and later in the 1980s as an area of critical environmental concern. Now a mixture of both state (of Utah) and federal public lands that are overseen by the United States Bureau of Land Management (BLM), the BSF is managed as a Special Recreation Management Area for dispersed and unconstrained recreation including automotive land speed racing, rocketry, foot races, cycling, and diverse forms of artwork. The BSF and surrounding landscape, however, is also open to corporate resource extraction in the form of (a) potash, which is used for manufacturing synthetic fertilizer, and (b) both culinary and industrial salt production. These recreational and extractive human relationships with the BSF are nowhere new, either—in fact, land speed racing and mineral extraction have both been practiced at the BSF for over 100 years (Mason & Kipp, 1997).

Although recreation and mineral extraction both leave their mark on the BSF, it is further impacted by other human activities. The earthwork berms that support roads and rails across the BSF required not only compaction for stability, but also need to be of sufficient height to stay above flooded winter conditions. The combination of compaction and the height of those berms means that the BSF—once a much larger system of brine deposition that experienced seasonal flooding, evaporation, and desiccation—has been cut in two. The winter brines—pushed by winds that distributed the eventually-desiccated salt—are no longer free to move across the historic extent of the playa. North of Interstate 80, the BSF can no longer receive minerals that were once surface-transported from the south end of the system. The result is essentially two BSF systems now in place, connected only by geography, weather and climate, a deeper brine aquifer, and—of course—human activity.

The salt pan that most people associate with the BSF, however, represents only one phase in its seasonally changing character that cycles annually through flooding, evaporation, and desiccation (Kipnis & Bowen, 2018; Bowen et al., 2017). These cycles can result in at least five weather-dependent seasonal morphologies that have been identified at the BSF (Lines, 1979). Although all of these phases of the BSF's dynamic character offer what are widely accepted to be aesthetically pleasing conditions for viewing, it is only dry, desiccated crust conditions (i.e. a well-formed salt pan) that permit safe pedestrian and vehicular access to the playa (i.e. dry lake bed). Even the slightest bit of summer precipitation can soften the salt crust—causing it to be anywhere from tacky to sludgy to nearly dissolved—making foot or wheeled transit at least uncomfortable, if not impossible, in addition to being entirely prohibited by the federal land managers despite little-to-no mechanism for enforcement.

During the last 30 years the volume, thickness, and overall area of the BSF north of Interstate 80 has objectively decreased (Kipnis & Bowen, 2018; Bowen, et al., 2017) making it an ideal setting for investigating POC related to a specific resource. The decrease in the seasonal, solid expanse of the BSF's characteristic salt crust makes nearly all human recreational use of the BSF possible. Thus, decreases in salt crust volume and area have fueled tension among stakeholder groups, namely between the BLM, which issues permits for use of the playa as well leases for mineral extraction, and the land speed racing community, for whom the lack of sufficient miles of thick, hard salt crust to safely accelerate to—and decelerate from—speeds in excess of 600 miles per hour (Bowen, et al., 2017) is both a safety liability and a deal breaker for record-breaking.

Other stakeholders recognized herein are academic researchers, media professionals, artists, local community members, mining employees, and other government officials— all of whom have a vested interest in the future sustainable use of the BSF. Many members of these stakeholder communities, especially local resident and long-time land speed racers, have extensive past use histories with the BSF—some of which exceed 70 years. For the aforementioned reasons, the BSF is an excellent living laboratory for exploring human perceptions of social and ecological change. Effective management at the BSF as a natural resource for recreation requires objective monitoring of biophysical change, identifying stakeholders' subjective perceptions of changing conditions (POC), and possible resultant behaviors related to those perceptions.

By illuminating such perceptions in the BSF's living laboratory, this study endeavors to reveal generalizable implications for studying and managing other parks and protected areas (PPAs) and to contribute to a greater understanding of the complexity in social-ecological systems. Seeking to understand how people perceive social and biophysical change in a complex system in which they have a vested interest, this study reveals (a) people's perceptions of social and biophysical change at the BSF, and (b) how past use history and identity, affiliation, or other demographic attributes may influence people's perceptions of change. This study endeavors to contribute to PPA scholarship by filling a gap in regard to human perceptions of change in a salt flat landscape.

The complexity of the BSF's human-influenced biophysical history coupled with the timescales on which those processes operate makes this iconic western American landscape an ideal place to study POC. Though seemingly simple, this stark-white-in-summer and woefully-wet-in-winter ecosystem is nonetheless a product of powerful forces that are at once geological, temporal, climatological, biological, and social.

Perceptions of Change (POC)

It is often easy for people visiting a place to see the evidence and impact of human behaviors, as numerous studies have revealed in the last several decades. On small, site-specific scales, these impacts might include things such as erosion in campsites attributed to over-visitation (e.g. Price, Blacketer, & Brownlee, 2018), landscape damage from off road vehicles (e.g. Randall, Macbeth, & Newsome, 2011), or diminishing freshwater resources in a community (e.g. Williams & Barton, 2008). Thus, visual cues of biophysical or landscape change (e.g. trash on the ground or damaged/dead vegetation) may lead people to notice change. Generally speaking, the larger the cues are spatially—and the higher degree of the change—the more noticeable it might be (Davenport & Anderson, 2005; Noe, Hammitt, & Bixler, 1997; Priskin, 2003). Additionally, the rate of visible change may influence someone's ability to perceive it; thus, faster rates of change may be more likely noticed (Wagner & Gobster, 2007). While that rate is a factor of time, other factors such as the location of impact within a resource setting (Noe, Hammitt, & Bixler, 1997) or its intensity or severity (Hillery, Nancarrow, Griffin, & Syme, 2001) are also relevant characteristics of perceptible change.

Many characteristics of people's interactions with a resource can play a role in their ability or propensity to perceive changing resource conditions. The character of an individual's interaction (e.g., passive or active recreation) with a resource, for example, or the season in which an individual interacts with a resource may influence their abilities to detect changes (Priskin, 2003). An individual's resource-related activity goals—and perhaps the inability to pursue them—may also influence the way in which they perceive change in that resource. (Knudson & Curry, 1991; White, Hall, & Farrell, 2001).

Place Identity

On a deeper level, an individual's place identity attached to a resource can also be influential in perceiving changes (Kyle, Graefe, Manning, & Bacon, 2003; Rogan, O'Connor, & Horwitz, 2005). The role of place meaning in observation and interpreting anthropogenic impacts in natural areas perceiving can be additionally compounded when shared by an individual's social group (Davenport & Anderson, 2005; Noe, Hammitt, & Bixler, 1997).

Past Use History

Accurately perceiving change, however, becomes uncertain when an individual's experiences are tantamount to mere snapshots of experience with a resource that lack temporal and experiential context. Thus, the frequency of interaction with a particular resource may influence peoples' perceptions of change (McFarlane, Boxall, & Watson, 1998; White, Virden, Van Riper, 2008). For example, Zube and Friedman (1989) found that people who were more frequent users of a riparian landscape tended to be more aware of how it was changing. That experience—or *past use history* (PUH)— can provide a subjective record wherein memory records and compares past and current conditions.

Without past use history, however, our understanding of landscape change often necessarily relies on written or other sorts of records. Cultural or social memory (Lauer & Aswani, 2010) of a resource—in addition to helping forge collective identity in a group—can also transmit knowledge from one person to another over time. This can result in a different kind of perceived change—one that might use landmarks as reference points, for example, against which to compare current conditions to those communally remembered from the past (Markowitsch, 2017). In this way, cultural or social memory resulting in bodies of knowledge can provide the means to detect change on larger timescales (Aswani & Lauer, 2014) that are still nonetheless perceptible by humans groups, if not by individual themselves. For example, a natural resource perhaps once perceived as pristine or having great scenic beauty in the eyes of past generations may no longer be seen that way by subsequent generations (Anderson & Brown, 1984; Becker, 1978). Furthermore, changing resource conditions across even larger geologic timescales may remain essentially imperceptible (Resnick, Newcombe, & Shipley, 2017) without a certain level and type of knowledge about the resource (Alessa, Bennett, & Kliskey, 2003), such as a deeper understanding of geologic forces and the evidence that such forces leave on the landscape (e.g. glacial erratics, metamorphic rock, karst topography, etc.).

Other studies tell us that POCs are not limited to physical environments, and that patterns and phenomena related to social change are both perceptible and noteworthy as well (e.g. Kim, 2008; Tate, et al., 2001). Additional studies suggest social and environmental change can be interconnected, wherein the reciprocity of social and ecological change takes on even greater meaning, such as the perceived availability of ecosystem services in a post-earthquake landscape (Rojas, et al, 2017) or the perceptions of large-scale landscape changes influenced by political and economic factors (Nazer, et al. 2010).

It is clear that past studies suggest that people are able and inclined to notice changes in natural environments (e.g. parks and protected areas) and in regard to social phenomena. Indeed, such perceptions have been the focus of scientific inquiry for decades. Few or none of these studies, however, have focused on perceptions of change related to playa landscapes or salt flats specifically. The aesthetics of such places—in comparison to highly vegetation and topographically diverse landscapes—seem so stark and static that many individuals may assume their features to remain unchanging. Change in such places, therefore, may or may not be perceptible on human timescales without objective measurements over time.

Methods

I collected data for this study both remotely and onsite at the BSF in 2017 and 2018 using an exploratory sequential mixed-methods strategy with three sampling and instrument development phases (Creswell & Plano-Clark, 2017).

Phase 1: Qualitative Interviews

I used a modified[8] Seidman approach (Seidman, 2013, p. 20) to conduct semi-structured interviews (n = 22; M_{minutes} = 35) with members of five of the seven identified BSF stakeholder groups: (1) the land speed racing community; (2) the academic research community; (3) citizens of the city of Wendover and greater Tooele county, Utah; (4) federal land managers from the Bureau of Land Management; and (5) news/journalism professionals. Previous studies have shown that this approach for conducting qualitative inquiry is useful when soliciting information from nature-based tourists (Verbos, Zajchowski, Brownlee, & Skibbins, 2018) and protected-area professionals (Zajchowski, et al., 2019). Initial telephone interviews reveal biophysical and social phenomena that stakeholders[9] perceived to be changing at the BSF. I used those results and previously validated scale anchors to construct a pilot quantitative questionnaire (see Appendix 4).

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[8] This modified approach consolidates Seidman's (2013) traditional 3-step interview process—which normally reveals participants' perceptions, insights, and experiences with phenomenon or resource issue—into a single, ~30 to 60-minute conversation. This abbreviated process was deemed adequate to reveal salient information for this study.

[9] Stakeholders referred to in this study are members of one of several *a priori* groups associated with the Bonneville Salt Flats. Formal stakeholder definition, identification, or selection were not part of this study.

Phase II: Pilot Instrument Development and Administration

In the second phase, the pilot questionnaire was administered (*n* = 97) using a stratified, random-probability approach (Creswell, 2015) during two racing events—*Speed Week* in August and *World of Speed* in September—at the BSF in August and September 2017. The questionnaire consisted of three sections for (1) past visitation or past use history to the BSF; (2) perceptions of change directionally measured by 16 items in the categories of Salt, Weather, Management, and People on a 7-point Likert-type scale; and (3) standard demographic categories. Simultaneously with the administration of the pilot instrument at these racing events, research assistants conducted additional *in situ* semi-structured interviews (*n* = 38; $M_{minutes}$ = 35) that were audio recorded and parsed for additional phenomena that respondents perceived to be changing at the BSF.

Phase III: Final Instrument Development and Administration

In the third phase, I used the pilot questionnaire and onsite qualitative interview data to redevelop and administer the instrument (instrument development variation; Creswell and Plano-Clark, 2017; see Appendix 4). Using similar sampling procedures to the pilot questionnaire, three research assistants and I administered the final instrument to participants (*n* = 553) at the same two BSF racing events in 2018. The refined instrument (see Appendix 5) included the same sections as the preliminary survey but was expanded to include 37 total POC measurement items (see Table 3.1 and Appendix 5), which were grouped into (1) two biophysical POC categories relating to (a) Salt and (b) Weather, as well as (2) two social POC categories relating to (a) BSF Management and (b) Racing Events and Community.

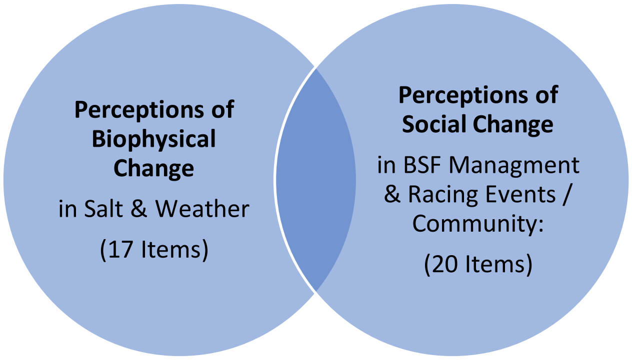

Figure 3.1. POC survey measurement items categorized as (a) social and (b) biophysical

Analysis

I calculated descriptive statistics and frequencies for standard demographic parameters including age, ethnicity, community group affiliation, education, income, and zip code. Participants fell equally into the categories of (1) individuals who were members of land speed racing teams, and (2) individuals in attendance to observe or racing activities. These people are herein referred to as ‘Racers’ and ‘Spectators.’

RQ 1: What do people perceive to be changing at the BSF?

I used SPSS to descriptively explore POC for the 37 measurement items. I then reduced those items into 10 POC dimensions through confirmatory factors analysis (CFA) through which I evaluated fit indices, factor loadings, measurement variance, and item independence. The resultant dimensions pertained to perceived change in: (1) Salt Crust Character**,** (2) Salt Crust Flooding, (3) Salt Crust Drying, (4) BSF Management Efficacy, (5) Racing Communication, (6) Spending Attributed to Racing Events, (7) Driving on the Salt Crust, (8) Racers’ Sense of Identity, (9) Popularity of Land Speed Events, and (10) Support for the BSF.

POC dimension scores were computed as ((x*POC_Item_1 + y*POC_Item_2, etc.) / # of POC Items), where x and y represent weights derived from CFA factor loadings. I then used an independent samples t-test to detect significant, item-level and dimension-level differences attributable to Group affiliation.

There were 45 bivariate correlations between the ten POC dimensions ranging from -.43 to .46. Nine (20%) of those correlations were significantly different than zero at $p < .05$. Three POC Dimensions—Salt Crust Flooding, Spending at Racing Events, and Driving on the Salt Crust—did not correlate with other POC dimensions. I thus conducted three separate ANOVAs for these dimensions as well as a MANOVA for the remaining seven POC dimensions to account for correlated dependent variables.

RQ 2: What BSF phenomena do people perceive to be changing?

I measured participants' experience at the BSF in terms of *past use history* (PUH), which I calculated as a dichotomous score of 'Low' or 'High,' corresponding the first that participants visited visit the BSF. Although PUH can logically be construed as a continuous variable, I recoded it to be dichotomous for four reasons (1) the sample was highly skewed toward participants with few years' experience at the BSF, (2) the sample was fairly even split between participants with more or less than ten years of BSF familiarity, and (3) the likelihood that the BSF's stark and seemingly static environment requires numerous years of experience to detect changing phenomena. Thus, a 'Low' score indicates fewer than ten years' experience and a 'High' score indicates greater than ten years' experience at the BSF. To determine whether interactions existed between PUH and Group in predicting POC, I used a single MANOVA for correlated POC dimensions in addition to separate ANOVAs to determine the effect of Group (Racers vs. Spectators) and PUH (Low vs. High) on POC, as well as the interaction between Group and PUH as simultaneous predictors.

Results

Research assistants and I approached 734 racers and spectators with 553 electing to complete the POC questionnaire, yielding a 75% response rate with a 4.13 confidence interval at the 95% confidence level. The stratified random sampling approach, high response rate, and the low confidence interval strongly suggests that the sample is representative people at BSF racing events in August and September of 2018.

Participants had a mean age of 56 years old and were overwhelmingly White (80%) male (78%) residents of the United States (90%). Their average highest level of education (*m* = 5.82) was at or near the baccalaureate level and their mean income was between $50,000 and $74,999 before taxes.

The sample was nearly evenly split between racers and spectators, with 252 participants identifying with the land speed community—186 of whom were active members of land speed racing teams. The second half of participants identified with communities related to mining/industry, academia government, art, media, or the local town of Wendover or Tooele County, Utah (*n* = 68); and 114 participants identified with none of the aforementioned groups.

Half of POC survey participants first visited the BSF between 2010 and 2018, 27% between 2000 and 2009, and 10% in the 1990s. The remaining 14% of survey participants first experienced the BSF in the 1980s or earlier.

Item-Level POC for Entire Sample

At the item level, survey participants perceived many biophysical and social phenomena to have changed more than slightly (i.e. greater than -1 or 1 on the Likert scale; see Table 3.1). Biophysical POC inlcuded Salt Crust Thickness (*m* = -1.52, *SD* = 1.8), Salt Extracted (*m* = 1.55, *SD* = 1.4), and Salt Crust Area without Soil/ Sediment$_a$ (*m* = -.87, *SD* = 1.5). Social POC included Communication Frequency in LS Community (*m* = 1.25, *SD* = 1.1), Communication Quality in LS Community (*m* = 1.40, *SD* = 1.1), Racers Event Spending (*m* = 1.8, *SD* = 1.1), Spectator Event Spending (*m* = 1.36, *SD* = 1.2), Spectators Driving on Dry Salt (*m* = 1.23, *SD* = 1.2), Spectators Driving on Wet Salt (*m* = 1.04, *SD* = 1.3), Racers' Sense of Community (*m* = 1.28, *SD* = 1.2), Non-Profit Support for BSF (*m* = 1.08, *SD* = 1.3), and Volunteer Support for BSF (*m* = 1.59, *SD* =1.1).

Item-Level Differences in POC between Racers and Spectators

An independent samples t-test to compare item-level POC between Racers and Spectators revealed significant differences for 14 of the 37 measurement items. For biophysical phenomena related to Salt Crust Character, Racers and Spectators reported significant differences in Salt Crust Area (m_{dif} = .42*; t* (287) = 2.24*; p* < .03*)*, Salt Crust Hardness (m_{dif} = .51*; t* (327) = 2.27*; p* < .024), Salt Crust Thickness (m_{dif} = .45*; t* (293) = 2.24*; p* < .026), Sediment on Salt Crust (m_{dif} = -.38*; t* (204) = -2.19.*; p* < .028), and Amount of Vegetation (m_{dif} = -.39*; t* (204) = -2.45*; p* < .015). Despite the significance of these differences, both Racers and Spectators agreed on the direction of change in these four POC items, as can be seen in Table 3.1; the exception is Vegetation—for which

Racers perceived a slight increase and Spectators perceived a slight decrease. In regard to biophysical phenomena related to Weather, Racers and Spectators reported significant differences in Annual Average Temperature (m_{dif} =.42; t (285) = 4.12; $p < .001$), August and September Temperature (m_{dif} =.37; t (311) = 3.76; $p < .001$), and Evaporation (m_{dif} = .30; t (153) =2.32; $p < .022$). Both groups agree on the direction of these changing POC items, but to different degrees.

For social phenomena related to BSF Management, Racers and Spectators reported significant differences in Overall Management Success (m_{dif} = .93; t (291) = 4.42; $p < .005$), the Quality of Science used (m_{dif} = .76; t (210) = 3.40; $p < .005$), the Use of Science (m_{dif} = .93; t (204) = 3.89; $p < .005$), and the Communication of Science (m_{dif} = .74; t (242) = 3.32; $p < .005$). Racers perceive that the communication of science related to the BSF is essentially not changing, but Spectators believe it is increasing. A similar difference exists for the Quality of Science Used (m_{dif} = .76; t (210) = 3.41; $p < .005$). The greatest of these management-related differences pertains to the Effective Use of Science, for which racers perceive a slight decrease, while Spectators perceive it to be increasing (m_{dif} = .93; t (204) = 3.89; $p < .005$). Similarly, Racers believe that Overall Management Success has slightly decreased, while Spectators perceive it to have slightly increased (m_{dif} = .99; t (291) = 4.44; $p < .005$).

Data Reduction and Reverse Coding

Data reduction via CFA of POC items validated ten dimensions related to perceived change at the BSF. These dimensions were Salt Character/Amount, Salt Crust Flooding, Salt Crust Drying/Desiccation, BSF Management, Land Speed

Communication, Land Speed Event Spending, Driving on Salt Crust, Land Speed Racing Identity, Land Speed Event Popularity, and Support for BSF. Dimension means and factors loadings for individual POC items combined within these dimensions are visible in Table 3.1.

Byrne (2006) and Kline (2011) advise that researchers interpret fit indices holistically with theoretical and contextual insight. For these reasons, three POC items warranted reverse coding—Salt Extracted, Sediment on Salt Surface, and Annual Precipitation—for conceptual consistency with other in-dimension items. Two items—Vegetation on Salt Crust and Salt Crust Hardness—failed to load onto any dimensions due to the conceptual incompatibility of their perceived change with other POC items. Some factor loadings were lower than desired, but overall the within-dimensions items exhibited appropriate levels of internal consistency (Cronbach's alpha > .68).

Byrne (2006) and Kline (2011) also suggest the following acceptable levels of fit: SB$\chi2$ non-significant, CFI > 0.9, NNFI > 0.90, SRMR < 0.1, and RMSEA < 0.08. Following these guidelines, CFA fit indices for the POC dimensions were deemed appropriate (see Table 3.1) suggesting that survey items appropriately reflected respective POC dimensions (CFI =.917; NNFI =.903; RMSEA =.053; SB$\chi2$ (df) = 1108.84 (514), $p < 0.05$; SRMR = .120).

Table 3.1. *POC items, dimensions, fit indices, factor loadings, means, and standard deviations*

	Entire Sample			**Racers**		**Spectators**		
BIOPHYSICAL POC	**Mean**	**SD**	**λ**	**Mean**	**SD**	**Mean**	**SD**	***t***
Salt Crust Character (*a* = .79)	-.51	.70	-	-.62	.69	-.40	.69	2.5[b]
Salt Crust Ground Coverage (area)	-.97	1.6	.43	-1.16	1.57	-.21	1.99	2.24[b]
Salt Crust Hardness[c]	-.46	2.1	-[c]	-.72	2.05	-.21	1.99	2.27
Salt Crust Thickness	-1.52	1.8	.47	-1.72	1.70	-1.27	1.76	2.24[b]
Salt Not Extracted[a]	-1.55	1.4	.63	-1.64	1.44	-1.54	1.24	.516
Salt in Groundwater (i.e. salinity)	-.35	1.5	.45	-.60	1.60	-22	1.47	1.19
Salt Crust Area without Soil/ Sediment[a]	-.87	1.5	.58	-1.05	1.56	-.67	1.28	2.21[b]
Salt Crust Area with Vegetation[c]	-.02	1.2	-[c]	.22	1.30	-.18	1.01	-2.45
Salt Crust Flooding (*a* = .92)	-.13	1.29	-	.09	1.31	-.22	1.27	-1.6
Standing Water: Amount in Wet Season	-,12	1.6	.82	-1.05	1.55	-.67	1.28	-1.02
Standing Water: Duration	-.19	1.6	.87	.03	1.64	-.26	1.55	-1.07
Salt Crust Drying (*a* = .74)	.20	.42	-	.12	.38	.31	.42	4.20[b]
Evaporation	.29	1.1	.82	.12	1.12	.51	1.02	2.32[b]
Lack of Precipitation[a]	.23	1.2	.72	.07	1.12	.40	1.24	1.80
Temperature: Annual Average	.53	.92	.42	.34	.77	.75	.95	4.12[b]
Temperature: August/September	.53	.92	.34	.36	.80	.73	.96	3.76[b]
SOCIAL POC	**Mean**	**SD**	**λ**	**Mean**	**SD**	**Mean**	**SD**	***t***
BSF Management Efficacy (*a* = .94)	.24	1.25	-	-.03	1.31	.51	1.09	3.9[b]
Communication of Salt Flat Science	.42	1.8	.74	.08	1.89	.81	1.59	3.32[b]
Effective Use of Science	.34	1.8	.86	-.13	1.90	.80	1.60	3.89[b]
Quality of Science Used	.65	1.8	.89	.29	1.94	1.05	1.41	3.41[b]
Overall Success	-.01	1.9	.60	-.47	1.94	.46	1.67	4.44[b]
Land Speed Communication (*a* = .86)	.84	.70	-	.90	.72	.80	.70	-1.2
Frequency between LS & Public	.83	1.2	.70	.90	1.17	.75	1.15	-.99
Frequency within LS Community	1.25	1.1	.81	1.33	1.12	1.19	1.00	-1.04
Quality between LS & Public	.86	1.2	.68	.95	1.18	.76	1.15	-1.34
Quality within LS Community	1.40	1.1	.79	1.45	1.08	1.37	1.03	-.599
Land Speed Event Spending (*a* = .85)	-	.97	.68	1.1	.69	.82	.63	-3.30[b]
Money: Amount Spent by Racers	1.8	1.1	.76	1.86	1.12	1.71	1.15	-1.07
Money: Amount Spent by Spectators	1.36	1.2	.34	1.35	1.25	1.34	1.16	-.03
Driving on Salt Crust (*a* = .77)	.93	.95	-	1.0	.93	.95	.94	-.36
Spectators Driving on Dry Salt	1.23	1.2	.82	1.36	1.16	1.36	1.22	.82
Spectators Driving on Wet Salt	1.04	1.3	.84	.97	1.34	1.15	1.23	-.74
Land Speed Sense of Identity (*a* = .75)	.66	.72	-	.69	.73	.65	.74	-.45
Racers’ Average Familiarity with Salt	.92	1.2	.81	.98	1.22	.88	1.13	-.62
Racers’ Experience Level	.70	1.2	.79	.69	1.20	.72	1.26	.20
Racers’ Sense of Community	1.28	1.2	.60	1.32	1.31	1.26	1.16	-.47
Land Speed Event Popularity (*a* = .83)	.31	.67	-	.31	.66	.31	.69	.06
Attendance at Racing Events	.71	1.6	.46	.75	1.57	.65	1.61	-.58
Media: Coverage of Racing Events	.29	1.5	.56	.35	1.51	.30	1.36	-.28
Number of Teams Racing	.64	1.6	.52	.63	1.59	.64	1.52	.05
Size of Land Speed Racing Teams	.64	1.3	.69	.57	1.26	.69	1.28	.78
Support for BSF (*a* = .68)	.60	.72	-	.61	.78	.61	.68	.09
Federal Government Support	-.31	1.6	.75	-.38	1.72	-.19	1.45	.82
Non-Profit Support	1.08	1.3	.65	1.07	1.42	1.12	1.27	.24
State of Utah Support	.73	1.5	.70	.76	1.67	.69	1.41	-.33
Volunteer Support	1.59	1.1	.67	1.66	1.10	1.53	1.44	-.93
Wendover/Toole Support	.95	1.5	.67	.96	1.40	1.00	1.11	.24
CFA Fit Indices: CFI =.917; NNFI =.903; RMSEA =.053; SBχ_2 (*df*) = 1108.84 (514), $p < 0.05$; SRMR = .120								

Note: [a] Items reverse-coded for conceptual consistency. [b] Significant difference between Racers and Spectators. [c] Item did not load onto dimension. Likert-type scale for means: (-3 = decreased a lot), (0 = no change), and (3 = increased a lot); λ = standard factor loading; CFI = Comparative Fit Index; *df* = degrees of freedom; NNFI = Non-Normed Fit Index; Reliability coefficient RMSEA = Root Mean Sq. Error of Approximation; SBχ_2 = Satorra-Bentler Scaled Chi-Sq.; *SD* = Standard Deviation; SRMR = Standardized Root Mean Sq. Residual.

POC Dimension Differences between Racers and Spectators

An independent samples t-test comparing POC dimensions for Racers and Spectators revealed their significantly different perceptions of change in Salt Crust Character, Salt Crust Drying, BSF Management Efficacy, and Racing Event Spending (See Figure 3.2). Compared to Spectators (m = -40, SD = .69), Racers (m = -.62, SD = .69) reported a significantly greater decrease in Salt Character/Amount (t (353) = 2.5, p < .005). This between-group difference (.22) nonetheless finds both groups' suggesting that their POC for Salt Character lies between "not changed" and "decreased slightly." Both Racers (m = .12, SD = .38) and Spectators (m = .31, SD = .42) reported a very slight increase in the POC regarding Salt Crust Drying. Although in general agreement, this difference (.19) was significant (t (327) = 4.2, p < .005). Spectators (m = .51, SD = 1.09) reported a slight increase in BSF Management Efficacy, while Racers (m = -.03, SD = 1.31) reported a significant but incrementally slight decrease in this dimension (t (306) = 3.9, p < .005), with a difference of .54. Both Racers (m = 1.1, SD = .69) and Spectators (m = .82, SD = .63) also agreed that Spending at Racing Events has increased slightly. The difference in their POC for this dimension (.19) is nonetheless significant (t (294) = -3.3, p < .005).

Effect of Group and PUH on POC Dimensions

I performed a Group X PUH MANOVA with the seven POC dimensions as outcomes and as factors. Group included 'Racer' or 'Spectator' and PUH consisted of 'Low' or 'High.' The analysis revealed multivariate effects for Group (Wilks' λ = .884, η_{2p} = .116, p = .001), PUH (Wilks' λ = .884, η_{2p} = .116, p = .001), and the Group X PUH interaction (Wilks' λ = .924, η_{2p} = .076, *p* = .023). This suggests that there were differences in POC attributable to affiliation as Racers or Spectator as well as low or high past use history.

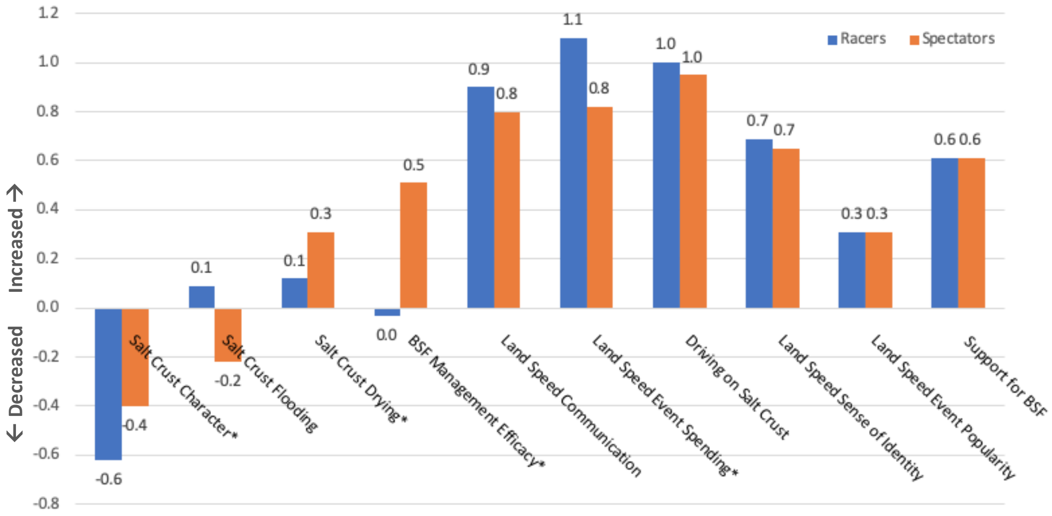

Figure 3.2. Ten POC dimension means for Racers and Spectators; * Significant difference. Likert-type scale: -3 = "Decreased a lot" to 3 = "Increased a lot"

Racer vs. Spectator Group Affiliation

Follow-up ANOVAs revealed effects of Group on POC dimensions for Management Efficacy (*F* (1, 210) = 16.09, *p* < .001, η_{2p} = .071) and Salt Crust Drying (*F* (1, 210) = 5.08, *p* = .025, η_{2p} = .024). Racers perceived a slight decrease in Management Efficacy (*M* = -.13, SD = 1.31) while Spectators perceived an increase in this dimension (*M* =.54, SD = 1.09). Racers perceived a smaller increase in Salt Crust Drying (*M* = .13, SD = .38) than Spectators (*M* = .26, SD = .41). There were no significant effects of Group on POC dimensions of Salt Crust Character, Land Speed Communication, Support for the BSF, Popularity of Land Speed Events, or Land Speed Identity. These results suggest that despite disagreement regarding change in the social dimension of Management Efficacy, both groups agree on change in the biophysical dimension of Salt Crust Character, but to different extents.

Low vs. High Past Use History (PUH)

A follow-up ANOVA revealed a main effect of PUH on the POC dimensions for Popularity of Racing Events (F (1, 210) = 10.93, p = .001, η_{2p} = .049. Participants with high PUH perceived a larger increase (M = .47, SD = .63) in POC Popularity than participants with low PUH (M = .17, SD = .62. This suggested that the longer people have been attending land speed events, the more change they perceive in how their popularity has grown over the years. There were no significant effects of PUH on the other six inter-correlated POC dimensions.

Group x PUH Interaction

A follow-up ANOVA revealed a Group x PUH interaction for Popularity of Racing Events (F (1, 210) = 12.93, p < .001, η_{2p} = .058). Racers with high PUH perceived a greater increase in Popularity (M = .57, SD =.61) than Racers with low PUH (M = -.01, SD = .59). For Spectators, POC in Popularity was not significantly different by PUH ($M_{\text{Low PUH}}$ = .36, SD = .61; $M_{\text{High PUH}}$ = .34, SD = .64). This suggest that although there was a main effect of PUH on Popularity, the interaction revealed that this was driven by Racers. See Figure 3.2. There were no significant interactions for the other six POC Dimensions.

I performed separate ANOVAs for the three POC Dimensions that did not correlate with the seven previous dimensions. No significant effects were found for one of these—the POC Dimension for Driving on the Salt Crust. Two of these analyses revealed significance.

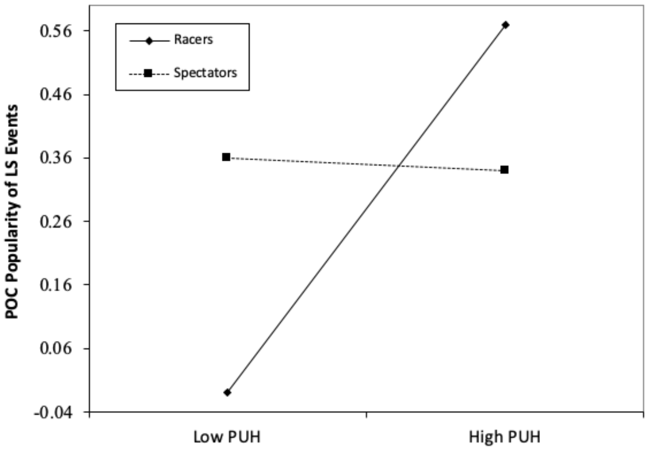

Figure 3.3. Interaction of Group and PUH for POC Popularity

Salt Crust Flooding

An ANOVA revealed significant differences in the POC for Salt Crust Flooding by PUH, *F* (1, 171) = 8.86, *p* = .003, η_{2p} = .049. Participants with high PUH perceived an increase in Flooding (*M* = .21, SD =1.21) while those with low PUH perceived a decrease in Flooding (*M* = -.38, SD = 1.32). This suggests that people with more than ten years' history at the BSF perceive that the salt flats are staying wetter for longer periods of time.

Spending at Land Speed Racing Events

An ANOVA revealed a significant difference in the POC for Spending at/related to Racing Events between the two Groups, *F* (1, 292)= 9.42, *p* = .001, η_{2p} = .031. Racers perceived a greater increase (*M* = 1.08, SD = .69) in POC Spending than Spectators (*M* = .82, SD = .63). There was also a Group X PUH interaction for this dimension, *F* (1, 292) = 4.59, *p* = .033, η_{2p} = .015. For Racers, POC in Spending did differ by PUH; Racers with high PUH perceived greater increase in Spending (*M* = .1.21, SD = .67) than Racers with low PUH (*M* = .91, SD = .69). This suggests that Racers with more than ten years' history at the BSF perceive more of a difference in their past and current event-related expenses than Racers with less than ten years' history. For Spectators, POC in Spending was not significantly different by (PUH $M_{\text{Low PUH}}$ = .84, SD = .56; $M_{\text{High PUH}}$ = .81, SD = .72). See Figure 3.3.

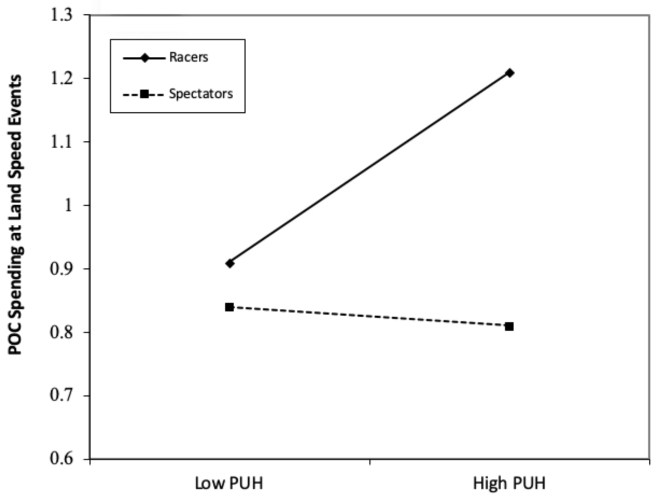

Figure 3.4. Interaction of Group and PUH for POC Spending

Discussion

This study explored the driving forces for differences in people's perceptions of change in a social-ecological system. Specifically, I was interested in (a) what social and ecological phenomena people perceived to be changing at the BSF (RQ1) and (b) how Group and PUH might influence certain perceptions of change (RQ2). This study found that, indeed, people at the BSF racing events perceived change in both biophysical and social phenomena at the BSF in recent decades. Furthermore, their past use history and identity as a land speed racer played a role in their perceptions.

At the item level, my analyses revealed that although none of the POC measurement items were perceived to have changed ‘a lot,’ survey participants perceived numerous biophysical and social changes, 12 of which somewhat more than ‘slightly.’ The five item-level phenomena perceived to have increased or decreased the most included (1) Salt Crust Thickness, (2) Salt Extraction; the Land Speed community’s (3) Communication Quality, (4) Event Spending; and (5) Volunteer Support for the BSF.

At the dimension level, group affiliation (Racer vs. Spectator) and past use history (>10 years vs. < 10 years) were significant predictors for differences related to several POC dimensions. Affiliation in this study as a ‘Racer or Spectator’ was attributed as a significant predictor for POC related to Spending at Racing Events, Efficacy of BSF Management, and Salt Crust Drying. Having low vs. high PUH was attributed as a significant predictor in regard to POC in Flooding on the Salt Flats as well as Racers’ POC in Spending at Land Speed Events.

In addition to revealing some degrees of accuracy in survey participants’ POC, the study also found some likely evidence of collective and/or social memory in the community comprised of land speed racers and other enthusiasts as discussed henceforth. Specifically, in regard to biophysical phenomena, changes related to flooding and drying of the BSF was more correctly perceived by people with longer histories of use at the salt flats. So too, has the amount of salt at the BSF been generally and correctly perceived as diminishing between 1960 and 2016 (Kipnis & Bowen, 2018; Bowen, Kipnis, & Pechmann, 2018).

In regard to social phenomena, changes in BSF management were widely perceived across several measures. Indeed, in response to past conflicts and concerns for the diminishing salt playa, the Bureau of Land Management completed an Environmental Assessment in 2012 and issued a Decision Record the following month that requires the mining company adjacent to I-80 company to continue the Salt Laydown Project for the life of its lease so as to maintain a balance in (a) sodium chloride extracted from groundwater brine with (b) brine returned to the salt flats during the wet season (White, 2013). Support for the BSF, also a social phenomenon, has also been correctly perceived—both in relation to the Salt Laydown as well as possibly to non-profits such as Save the Salt and the Utah Alliance, which have been advocating for salt flat restoration for many years.

Perceived Change in BSF Management Efficacy

Regarding BSF Management Efficacy, Racers barely perceived a decrease while Spectators perceived a slight increase. This phenomenon may be related to a unique relationship between the land speed racing community and the U.S. BLM. While Spectators see improvements in biophysical conditions, their recreation goals and objectives have perhaps not been precluded by BSF management decisions in the same ways that Racers' have been.

Although PUH is not a predictor in this regard statistically speaking, its effect cannot be ruled out due to the nature of the racing community's collective narrative regarding how and why their goals—e.g. breaking land speed records—have been directly or indirectly constrained by BLM management decisions; this phenomenon may not be captured in simply rating PUH as low or high. Spectators may thus see evidence of improved BSF Management efficacy, while Racers have yet to see enough improvement in this dimension to satisfy the higher standards that they espouse for salt crust conditions in the long term that would continue to support land speed racing for future generation of racers.

Perceived Change in the Flooding of the Salt Flats

Both Racers and Spectators perceived change in Flooding—an important biophysical process for shaping the eventual salt crust—but while people with low PUH perceived flooding to be decreasing slightly, people with high PUH perceived flooding to be increasing. This is perhaps related to a relationship between two things: (a) the interpretation of PUH may be somewhat skewed due to the fact that nearly 30% of participants actually have only 2-3 years of experience with the BSF, and (b) documented, historic, quasi-decadal cycles of precipitation that cause potentially prolonged flooded conditions (Bowen, et al., 2018), the ramifications of which people with fewer than 10 years of experience at the BSF had yet to witness. As relative newcomers to the BSF—especially in regard to their perception of phenomena that impacts land speed racing—these people have not generally experienced biophysical conditions that result in unfavorably social phenomena such as the cancellation of racing at the BSF. Indeed, racing events were cancelled several times in past decades due to excessive water remaining on the flats in late summer; this occurred quasi-decadally in 1982, 1983, 1993, 1994, 2014, and 2015 (Bowen, et al., 2018). Thus, the recent relatively improved salt crust and resultant racetrack conditions may be perceived as more typical by people with lower PUH.

Perceived Change in the Drying of the Salt Flats

The aforementioned reasons—i.e. collective narrative or goal orientation—may also explain the finding that Racers perceived less drying of the salt flats than Spectators. This difference may also be partially rooted in the nature of expectations that Racers and Spectators have regarding BSF-related recreation. That is, for Spectators, a ‘dry’ salt crust may simply be one that is stable enough to walk or drive on without undo worry about getting stuck. For Racers, however, the condition of the salt crust is a sacred and particular thing—the parameters for composition, moisture, thickness, and area are very specific due to Racers’ need to safely accelerate and decelerate to/from many hundreds of miles per hour. Thus, the definition of ‘dryness’ to these groups is perhaps quite different.

Perceived Change in the Popularity and Spending re: Land Speed Racing Events

PUH was also a significant predictor Racers’ POC in both the Popularity of Racing Events as well as Spending associated with these events. While Spectators did not perceive change in these dimensions differently based on their PUH, Racers with high PUH perceived greater increases than did Spectators. Both of these perceptions may be attributable not just to growth in the size of land speed events over the years, but may also be attributable to the aforementioned racing event cancellations that resulted in a general wariness to attend—and spend at—events in year immediately following cancellations. Thus, Racers with low PUH may not have witnessed these historic decreases in popularity and spending, and the relatively large bounce-back in response to improved salt conditions since 2016. Conversely, it may simply be that Racers' with many decades of PUH remember a time that land speed events were more casual, intimate, and exclusive to their specific community—before a time when the media broadcasted fears that the salt was disappearing and a movement was kindled to 'Save the Salt.' Fear of the salt disappearing may have even inspired greater spectator attendance in an act of 'last-chance-tourism' to see the world's fastest wheel-driven vehicles in action.

Each of the aforementioned considerations are significant in the human-social realm of social-ecological systems thinking. While perceptions of change at the BSF are relatively small, they are nonetheless occurring, and are at least partially shaped and/or driven by various social factors such as one's membership in a community or the extent to which one is familiar with the resource as well as the interplay between these two influences. Because such influences can carry momentum in a group's collective consciousness, some perceptions of change may linger for an unknown length of time following cessation of objective change due to social memory or group narrative. Certain perceptions may even be subject to cognitive dissonance in regard to a community's average conceptualization of a resource—perhaps even shaping the degree to which complexity can be comprehended; such an incompatibility may destine these perceptions for disregard. As forms of small-scale social complexity, the ramifications of the relationships between and among human dimensions are worthy of PPA managers' and researchers' consideration because the influence they may wield in shaping people's ability to perceive change could be a powerful predictor of resultant human behaviors in social-ecological systems.

Conclusion

As relatively unique natural resources, salt flats generally appear to be quite stark, simple and unchanging, but are nonetheless complex systems in their own right—seasonally ephemeral, their character and utility changes with the seasons. As such, salt flats serve many human purposes. They provide venues for diverse types of casual and serious recreation, are sources of valuable minerals, and are often cultural assets due to their aesthetics, desolation, and rarity. Utah's Bonneville Salt Flats fits all of these descriptions.

This study endeavored to contribute to scholarship related to perceptions of change, its influences, and its validity in a type of landscape that is rarely studied in social science. It revealed that even in a landscape—such as a salt playa—in which change may go unnoticed, people can nonetheless perceive change over time in both biophysical as well as social dimensions, even across decades. This is a salient point to consider in the course of natural resource or park and protected area management. While many social and biophysical processes may occur on long, seemingly intangible time scales, the potential for social structures and collective memory should not be ignored in identifying causes for ecological concern. Coupled with objective measurement of both social and biophysical phenomena, the complex, reciprocal relationships that various human activities have with natural resources—both broadly and in terms of specific attributes—can be both broadly and intimately considered in the course of management.

Future research related to perceptions of change should consider social-ecological relationships, resource user groups, and the transmission of knowledge from older to younger generations to gain a deeper understanding of complex landscapes that are so often more than meets the eye. Each of these considerations represent small pieces of the social-ecological mosaic that—once illuminated and put into place—can help describe previously elusive aspects of system complexity.

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CHAPTER IV

Natural Resource Stakeholders' Mental Models of Social-Ecological Complexity

Abstract

Mental models, while often limited in terms of extent or accuracy, nonetheless give us confidence and frameworks to navigate life's uncertainties. Unfortunately, the differing and yet similar mental models held collectively by groups can lead to misunderstanding and conflict on large scales. Such challenges are likely familiar to natural resource managers who must consider many issues that are neither simple nor exclusively ecological or social in nature in the course of their work. This study endeavored to reveal the mental models espoused by eleven individuals representing six different stakeholder communities with a vested interest in Utah's Bonneville Salt Flats (BSF). Data gathered during the mental modeling process was used to construct fuzzy cognitive maps (FCMs) representing the perception of important social and ecological concepts related to the BSF. The study revealed differences among groups' perceptions of important concepts and levels of perceived complexity, as well as areas of agreement in regard to the strength, direction, and character of social-ecological relationships.

Keywords

Fuzzy cognitive mapping, FCM, Mental Modeler, Bonneville Salt Flats, cognitive maps, stakeholders, dispute resolution, mental modeling, participatory modeling, complex systems, social-ecological systems, perceptions, social-ecological systems thinking.

Introduction

Psychologist Kenneth Craik's (1943) work suggested that the human mind constructs small-scale models of reality to anticipate and understand events. As such, these mental models represent images of the world that provide perspective for navigating our lives. Because no human mind can fully or all-at-once imagine the entirety of complex entities—e.g. the world, a government, a country, etc.—we necessarily but unconsciously select only certain concepts and the relationships between them to represent the real system (Forrester, 1971). Though often simplified and limited, mental models are therefore cognitive representations of external reality (Jones, et al. 2011) that are still valuable for understanding a complex world (Johnson-Laird, 1983).

Such reductions of reality are not necessarily a liability. Mental models, while often limited in terms of extent or accuracy, nonetheless give us confidence and frameworks to navigate life's uncertainties. Conversely, mental models can, however, come into conflict as one person's perception of reality seems incompatible with another's (Spicer, 1998), such as when espousing political leanings (e.g. Mason & Fragkias, 2018), pursuing common goals, or using common resources (e.g. Kim & Senge, 1994). This idea should be familiar to anyone who has experienced a misunderstanding based on differing perspectives. Fortunately, when such disagreements occur, discussion can often mitigate the issue to lead to a common understanding and a consensual path forward (Pérez-Teruel & Estrada-Sent, 2015).

Unfortunately, the differing and yet similar mental models held collectively by groups can lead to misunderstanding and conflict on large scales (e.g. Crandal, Monroe,

& Lorenzen, 2019). Such challenges are likely familiar to natural resource managers—and by extension, parks and protected area management (PPAM) practitioners—who must consider many issues that are neither simple nor exclusively ecological or social in nature in the course of their work (Miller, et al., 2017). For this reason, people charged with managing natural resources such as PPAs must employ a likewise diverse array of approaches to foster the complexity, resilience, and reciprocity of human and ecological variables (Berkes, Colding, & Folke, 2002). This is in part due to the fact that the integration of human social processes with ecological systems in these realms of management necessitates acknowledging natural resources (e.g. PPAs) as *social-ecological systems*[10] (SESs; Berkes, 2017).

Furthermore, due to SESs' varying degrees of complexity, uncertainty, and non-linear behaviors among system components, such an acknowledgement often entails managers must engage in *SES thinking*. This practice entails making management processes flexible, able to engage uncertainty, and building various capacities to adapt to social and ecological dynamics (Berkes, Colding, & Folke, 2003).

More directly, however, resource management issues can be complicated by the various mental-model-influenced perspectives that are either involved in—or stand to be affected by—resource-related decision-making (Biggs, et al., 2011). Although mental models are never fully accurate or complete (Meadows, 2008), identifying and illustrating them graphically may help illuminate how people conceive—and thus

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[10] Social-ecological systems (SESs) represent integrated, 'bio-geo-physical units' and their concomitant human social actors and institutions (Glaser, Krause, Ratter, & Welp, 2008).

behave—in the complex world around them. This is an appealing prospect for natural resource management practitioners (Jones, et al., 2011), because systems-thinking literature suggests that mental models form the basis of shared social agreements about the nature of reality; as such, mental models can be seen as sources of behavior in social systems (Meadows, 2008).

Whether consciously or not, key actors[11] such as stakeholders[12] in social-ecological systems (SESs) have mental models regarding how that system functions, and these cognitions may influence formal and informal behaviors as well as adaptation to SES perturbations (Gray, Chan, Clark, & Jordan, 2012). On a larger scale, however, it is unclear how distinct groups' perceptions of SES components and functions influence both formal and informal adaptation behaviors in response to change. Understanding the concepts, strength, and nature of the variables within an SES—from various groups' perspectives—may uncover implicit system conflict, generate new governance solutions, and identify key cognitions that are antecedents to informal and formal adaptation behaviors. To this end, this study herein explores perceptions of complexity and systems thinking of stakeholder groups associated with a PPA via mental modeling to produce *fuzzy cognitive maps* of a complex, SES. In doing so, the study reveals stakeholder groups' perceptions of important and powerful social and ecological components in a

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[11] In social network analysis, actors are network members that are distinct *individuals* such as residents of a neighborhood, members of clubs, or clients of particular entity. Actors may also be *collective units* such as groups or organizations within an overall community (Hawe, Webster, & Shiell, 2004).

[12] Stakeholders referred to in this study are members of one of several *a priori* groups associated with the Bonneville Salt Flats. Deeper, more theory-based stakeholder definition, identification, or selection was not part of this study. More about stakeholders is included in Part 3 of Appendix 1: Definitions

complex SES and thus reveals potential implications for natural resource and PPA management.

Background

Mental Models

While mental models are organized knowledge structures that individuals hold in their minds, *cognitive maps* are visual representations of those models in graphical format (Shen, Tan, & Siau, 2017). These representations are useful tools for linking seemingly disparate concepts related to a key issue (Eden, Jones, & Sims,1983; Eden & Ackermann, 2001). As such, they are highly useful for visualizing complex situations, especially applied to group thinking and problem solving. By integrating such modeling—which might reveal either robust or limited understandings of complexity—into natural resource and PPA management, it may be possible to increase managerial flexibility and responsivity to identify unrealized synergies between system components, particularly across key stakeholder groups (Berkes, Colding, & Folke, 2008).

Fuzzy cognitive maps (FCMs) help quantify relationships embedded in cognitive maps with fuzzy values (from -1 to 1) or linguistic values to suggest the strength of causal relations, usually elicited from experts (Gray, Zanre, & Gray, 2014). FCMs are therefore directed graphs that apply matrix algebra to the cognitive mapping process to semi-quantitatively explore the relationships of related phenomena in mental models. Grounded largely in network analysis, FCMs can be analyzed for any number of dimensions to detect differences in how individuals may view system dynamics and components in a particular domain (Gray, Zanre, & Gray, 2014). FCMs have been used in numerous fields of scholarship to illuminate relationships among variables, to further understand system dynamics, and to promote learning (Wei, Lu, & Yanchun, 2008). Recently, a growing interest in the use of FCMs has focused on their utility as a participatory method for understanding social-ecological systems and PPA management (Gray, et al., 2015).

Similar to network analysis models—such as sociograms used for *social network analysis*—FCMs are semi-quantitative, graphical representations of systems that are useful for illustrating the relationships—or *edges*—between key concepts—or *nodes*—of a system, including feedback relationships (Gray, et al, 2015). As such, these maps represent the relational connectivity of components—that might represent social or biophysical elements—as well as the suspected strength and direction of those relationships indicated by values assigned to the edges between nodes (see Figure 4.1). Useful for mapping individual or group knowledge systems, FCMs are often utilized in participatory mapping activities to help stakeholders communicate their understandings of a resource or co-create knowledge together. FCMs have also been used in a number of disciplines to reveal system dynamics (Gray, et al., 2015) and facilitate shared decision making (e.g. Özesmi & Özesmi, 2004).

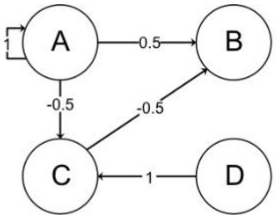

Figure 4.1. An example of a fuzzy cognitive map showing weighted edge relationships between system components A, B, C, and D; adapted directly from Gray, et al., (2015).

Mental models are measured via specific structural attributes similar to those in network analysis. In creating a mental model, a person identifies a number of *concepts* (i.e. variables), among which direct and indirect relationships may exist; the greater number the concepts identified though mental modeling, the more *components* there are in a fuzzy cognitive map (Özesmi & Özesmi 2004). Connections between pairs of components represent direct interactions and therefore direct relationships wherein directional change in one component drives change—i.e. increase or decrease—in the other component, either in the same direction (i.e. a positive relationships) or in the opposite direction (i.e. a negative relationship). The number of between-component connections in a mental model can vary, however a higher number of connections definitively indicates a higher degree of component interactions in a mental model (Özesmi & Özesmi 2004). According to Eden, et al. (1992) components in a mental model therefore can serve one or both of two functions: (1) as independent variables or *drivers*—sometimes referred to as a *transmitters*—that have only “forcing” functions (); (2) as dependent variables or *receivers* that have only receiving functions; or (3) as *ordinary* components that perform both driving and receiving functions. The *centrality* of components is a function of their overall influence in the model or the conceptual weight/importance of individual concepts (Kosko, 1986). The density of a mental model represents the total number of identified component connections compared to number of all possible connections among components. For this reason, the higher the density, the more potential interactions among components there are to consider, and the more potential management implications there may be (Özesmi & Özesmi, 2004; Hage &

Harary, 1983). Lastly, the *complexity score* for a mental model represents the ratio of receiver variables to driver variables and thus measures of the degree to which potential outcomes of driving forces are considered. For this reason, higher complexity scores indicate more complex *systems thinking* represented in a model (Eden et al.1992; Özesmi & Özesmi, 2004.

According to Özesmi and Özesmi (2004), fuzzy cognitive mapping offers numerous benefits for ecological modeling. Such benefits include (a) the ability to incorporate abstract as well as aggregate variables in models, (b) the ability to graphically represent relationships lacking known certainty, (c) the capacity to model complex relationships with various feedback loops, and (d) the straightforward facility for collecting and combining divergent sets of knowledge with which to parse potential scenarios that might result from management actions. It is for these reasons, as well as simply document groups differences that this study applies fuzzy cognitive mapping to stakeholders' perceptions of complexity at Utah's Bonneville Salt Flats.

The Bonneville Salt Flats

The Bonneville Salt Flats (BSF) is perceived to be many things—a land of human triumph, a land of destruction and desolation, a playground, and a surreal world of the strange and bizarre (Bushman & David, 1997). Part of the Utah's enormous West Desert, the BSF is approximately 90 minutes west of Salt Lake City on Interstate 80. Nestled southwest of the Great Salt Lake, the BSF is a represents the mineral remnants of the Pleistocene Epoch's Lake Bonneville. At its largest historic expanse, this ancient freshwater lake was approximately the size of modern Lake Michigan, covered an area of roughly 20,000 square miles in northwestern Utah with a maximum depth of 1,000 feet (Hunt, Varnes, &Thomas, 1953). Topographically isolated between 13,000 and 15,000 years ago (Baxter, 2018), Lake Bonneville became part of a terminal basin system from which water could only leave through evaporation. It is the mineral content of that historically immense volume of water—now long since evaporated from this terminal system—that is responsible for the accumulation of salt both on the salt pan floor (i.e. playa) as well as in associated subsurface brine aquifers.

The salt pan that most people associate with the BSF, however, represents only one phase in the its seasonally changing character that cycles annually through flooding, evaporation, and desiccation (Kipnis & Bowen, 2018, citing Lowenstein and Hardie, 1985; Bowen et al., 2017). These cycles can result in at least five weather-dependent seasonal morphologies that have been identified at the BSF (Lines, 1979). Although all of these phases of the BSF's dynamic character offer what are widely accepted to be aesthetically pleasing conditions for viewing, it is only dry, desiccated crust conditions (i.e. a well-formed salt pan) that permit safe pedestrian and vehicular access to the playa. Even the slightest bit of summer precipitation can soften the salt crust—causing it to be anywhere from tacky to sludgy to nearly dissolved—making foot or wheeled transit at least uncomfortable, if not impossible.

The seasonal, solid expanse of the BSF's characteristic salt crust makes nearly all human recreational use of the BSF possible. However, during the last 30 years the volume, thickness, and overall area of the BSF north of Interstate 80 has objectively decreased (Kipnis &Bowen, 2018; Bowen, Kipnis, & Raming, 2017) making it an ideal setting for investigating POC related to a specific resource. Thus, decreases in salt crust volume and area have fueled tension among stakeholder groups, namely between the U.S. Bureau of Land Management—which manages permits and leases for all activities—and the land speed racing community, for whom it is absolutely necessary to have sufficient miles of thick, hard salt crust to safely achieve speeds in excess of 600 miles per hour (Bowen, Kipnis, &Raming, 2017). In the past two decades, efforts to dissolve and return stockpiled waste salt from mineral extraction activities have endeavored to replenish the decreasing salt crust (Kipnis & Bowen, 2018; White, 2004). Other stakeholders recognized herein are academic researchers, media professionals, artists, local community members, mining employees, and other government officials—all of whom have a vested interest in the future sustainable use of the BSF. For the aforementioned reasons, the BSF is an excellent living laboratory for applying mental modeling of social and ecological complexity.

Research Purpose, Questions, and Scholarly Contributions

All people hold mental models that help them make sense of, navigate, and function in various environments and in the world at large. Without understanding the role of these mental models in driving behaviors in places like parks and protected areas, the results of behavior rooted in mental models cannot be easily anticipated, predicted, proactively addressed. Unfortunately, understanding the role of mental models in shaping behavior is impossible without first constructing and analyzing them to identify the structure, commonalities, and disparities that may vary based on the character of individuals' relationships with a particular resource. Thus, this study's purpose is to explore the utility of illuminating influential stakeholders' perceptions of important concepts related to the Bonneville Salt Flats' social-ecological complexity. It pursues this understanding by constructing FCMs that represent these individuals' mental models, the analysis of which reveals implications for better managing parks and protected areas as the complex social-ecological systems that they are.

This study addresses four primary research questions related to understanding the stakeholder's perceptions of the complexity in the social-ecological system represented by a unique, iconic natural resource—the Bonneville Salt Flats. The first of these questions asked, "What important concepts do stakeholders' mental models consider when thinking about the BSF as an SES?" The answer for that question was revealed by conducting quantitative interviews with representatives from each stakeholder group.

Using the data collected in those interviews, I created FCMs with the software program *Mental Modeler* to graphically represent these individuals' mental models of the BSF. Analysis of those models addressed this study's second and third research questions, which asked, "How does the structure of stakeholders' mental models—and therefore fuzzy cognitive maps—of the BSF differ?" and "To what extent do stakeholder groups similarly perceive correlations between important BSF concepts?" Lastly, to address whether BSF stakeholder groups—represented by their star actors[13]—might hold similar mental models, this study's fourth research question asked, "How confident are

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[13] '**Sociometric stars'** are recipients of numerous and frequent selection by others (Moreno, 1934 in Scott, 2017), thus indicating their popularity through social network analysis. This study extends the concept and defines **star actors** as individuals who are both (a) recipients of numerous and frequent selection and (b) themselves report numerous and frequent interactions, resulting in high centrality and degree scores.

star actors that their FCMs represent the perception of BSF concept relationships held by the average member of their stakeholder community?" Taken together, these four questions sought to address how stakeholders perceive the complexity and influence attributed to what they profess to be important concepts in a social-ecological system.

This study endeavored to contribute to scholarship and to fill several possible gaps in academic literature. First of these deficiencies is in regard to how people perceive social-ecological systems. This study also has implications for fostering stakeholder collaboration and therefore adaptive governance of natural resources. Additionally, no studies to date have applied mental modeling to a salt flat environment such as the BSF—a landscape unlike almost any other in both its aesthetics as well as in its human uses and user groups. Furthermore, no studies in natural resource management have applied representative or surrogate mental modeling, wherein knowledgeable community members—i.e. star actors—have been selected via social network analysis to represent their stakeholder group in creating FCMs. This study endeavored to fulfill all of these academic deficiencies and to reveal the utility for mental modeling to reveal areas of stakeholder group agreement in regard to natural resource related social-ecological complexity.

Methods

In this study, I applied a sequential, exploratory approach (Creswell & Plano-Clark, 2010) in three phases to reveal BSF stakeholders' mental models through fuzzy cognitive mapping. This entailed interviewing representatives from key stakeholder communities and using data gathered during those interviews to create FCMs that identify, display, and compare their mental models (Axelrod, 1976; Kosko, 1986). These FCMs—created in *Mental Modeler* (Gray, Gray, Cox, & Henly-Shepard, 2013)—provided parameterized concept models that were translated into semi-quantitative maps for examining pair-wise structural relationships between components in stakeholder groups' models.

Phase 1— Initial Sampling

I conducted semi-structured interviews (n = 22; M_{minutes} = 35) via telephone with members of six *a priori* BSF stakeholder groups: (1) the academic research community; 2) the land speed racing community; (3) federal land managers; (4) citizens of the city of Wendover and greater Tooele county, Utah; 5) news/journalism professionals, and (6) an employee of the mineral extraction company near the BSF. During these telephone conversations, I adapted Seidman's (2013) 3-interview process following recommendations by Verbos, et. al and Zajchowski (2019) and collected data pertaining to perceptions, insights, and experiences in a single interview. Previous studies have shown that this approach for conducting qualitative inquiry is useful when soliciting information from nature-based tourists (Verbos, Zajchowski, Brownlee, & Skibbins, 2018) and protected-area professionals (Zajchowski, et al., 2019). These initial telephone interviews were conducted to gain an understanding of the social and biophysical concepts that stakeholders perceived to be important at the BSF (as per Gray, Gray, Cox, & Henly-Shepard, 2013).

Following a brief introduction regarding the goals of the study, participants were asked to list the top ten social or biophysical concepts—e.g. elements, activities, or processes—that they thought were influential in shaping the BSF. I recorded and complied these concepts into a list of the 45 most commonly reported; I later shared this list with key, influential BSF stakeholders who were selected for the final phase of data collection.

Phase II—Identifying and Engaging Star Actors

As part of a different but related BSF study (Blacketer, 2020; Chapter II), I performed a social network analysis (SNA) of BSF stakeholders over the course of one year to identify influential members of each BSF stakeholder community group. As *star actors*[14], these individuals appeared in network sociograms as points (i.e. *nodes*) with numerous rays (i.e. *edges*) connecting them to other points, thus resembling a star (Scott, 2017). Due to their positions in the social network, star actors hold networks together; their removal results in fragmented cliques and isolated individuals.

Serving as hubs through whom a great amount of BSF-related social interactions occurred during the data collection year, these star actors were potentially and uniquely qualified to speak to the mindset of the average member of each of their stakeholder community groups—specifically in regard to their communities' perceptions of the BSF's social-ecological complexity. Because they were objectively identified by the SNA study, these star actors' mental models were solicited as representative of their larger groups' thinking about the BSF; thus, their FCMs—although created individually—serve as

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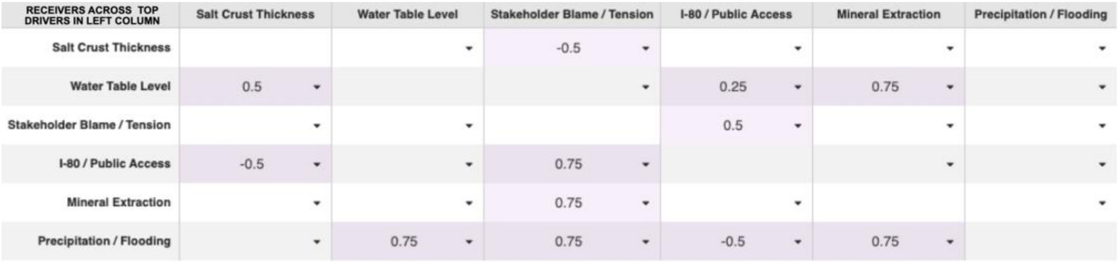
[14] '**Sociometric stars'** are recipients of numerous and frequent selection by others (Moreno, 1934 in Scott, 2017), thus indicating their popularity through social network analysis. This study extends the concept and defines **star actors** as individuals who are both (a) recipients of numerous and frequent selection and (b) themselves report numerous and frequent interactions, resulting in high centrality and degree scores.

proxies for their stakeholder communities. I solicited these individuals via email for participation in one last round of qualitative data collection via telephone. In that email, I included brief project description and a request that they consider the concepts in Table 4.1—which was also included in the email—before our phone call.

During each telephone interview (n = 11, $M_{minutes}$ = 45), I asked star actors, “What are the 5-15 concepts that you perceived as ‘important to consider’ when thinking about the BSF as a social-ecological system.” If interviewees did not understand the ‘social-ecological system’ part of the question, I rephrased as, “ . . . when thinking about the BSF’s use, management, or ecology.”

These conversations were highly qualitative and narrative in nature, but nonetheless yielded semi-quantitative mental model data for FCM analysis. As we spoke, I built a correlation matrix with their reported concepts—the list of which was entered in both the leftmost column and also across the topmost row (see example in Figure 4.2). Moving across the matrix, I then asked participants to communicate five pieces of data for each pair of correlations: (1) if they perceived a direct relationship to exist, (2) if so, which concept was a driving variable and which was a receiving variable, (3) whether an increase or decrease in the driver would produce likewise or opposite increase or decrease in the receiver, (4) whether the relationship was low, medium, or high in strength; and lastly (5) how confident they were that other members of their community group would agree with each characterization of component correlations (on a Likert-type scale of 1= ‘not at all confident’ to 7 = ‘very confident,’ as per Mental Modeler’s built-in parameters). Participants were given as much time as they needed to cogitate and/or provide as much explanation as they felt necessary for every correlation. Their list of concepts and perceived correlations between individual concepts provided all FCM data, which was the basis for answering Research Question 1.



RECEIVERS ACROSS TOP DRIVERS IN LEFT COLUMN	Salt Crust Thickness	Water Table Level	Stakeholder Blame / Tension	I-80 / Public Access	Mineral Extraction	Precipitation / Flooding
Salt Crust Thickness			-0.5			
Water Table Level	0.5			0.25	0.75	
Stakeholder Blame / Tension				0.5		
I-80 / Public Access	-0.5		0.75			
Mineral Extraction			0.75			
Precipitation / Flooding		0.75	0.75	-0.5	0.75	

Figure 4.2. Example of FCM matrix produced by Mental Modeler showing positive/negative correlations, with driving (IV) components at left and receiving (DV) components at top.

Phase III—Fuzzy Cognitive Map Construction and Analysis

Using the free, online Mental Modeler interface at *www.mentalmodeler.org* (Gray, Gray, Cox, & Henly-Shepard, 2013), I created one FCM for each star actor. This entailed drawing pairwise relationships between reportedly related concepts using weighted, directional arrows (i.e. *edge relationships*) to indicate positive or negative relationships with high (.75), medium (0.5), or low (.25) strength.

Mental Modeler calculated network structural characteristics for each participant's FCM. At the model level, these measures included the number of (a) component connections, (b) driving variables, (c) receiving variables, and (d) ordinary variables, as well as (e) density, (f) diameter, and (g) complexity measures of each model. Mental Modeler also provided component-level metrics, including (a) centrality, (b) indegree, (c) outdegree, and (d) type for each component. Ultimately, data analysis following stakeholder interviews endeavored to address Research Questions 2, 3, and 4.

Results

Of the 12 potential participants identified as star actors during a separate social network analysis of BSF stakeholders, 11 individuals participated in the mental modeling exercises used to construct FCMs for this study. Following these qualitative conversations, FCM construction and analysis yielded the following results.

Table 4.1. *'Important' BSF concepts identified in Phase II qualitative interviews*

Salt Crust Thickness
Wind
Annual Precipitation
Salt Crust Area
Salt Crust Composition
Erosion
Water Table Level
Mgmt. Activity Level
Dike/Berm Structures
Surface Brine Movement
Soil/Sediment
Ground Water Percolation
Summer Temperature
I-80 / Public Access
Salt Brine Return
Mineral Extraction
Salt Brine Removal
Mining Leases
Driving on Salt
Stakeholder Blame/Tension
Misinformation
General Racing Activities
Media Attention
Precipitation/Flooding
Subsurface Brine Movement
Stockpiled Waste Salt
Drainage/Canal Structures
Evaporation
Drying/Desiccation/Crystallization
Track Prep/Grooming
Quality of Management
Microbe Action/Population

RQ1: Important SES concepts in Stakeholders' Mental Models

Participants selected a total of 32 of 45 original concepts (see Table 4.1).The total frequency with any one of these concepts was reported as 'important' by one or both star actors in a stakeholder group ranged from one to eight times. This list provided the basis for answering Research Question 1:"*What important concepts do stakeholders' mental models consider when thinking about the BSF as an SES?* The top ten of these BSF concepts reported as 'important to consider' by four to eight participants from two or more stakeholder groups were Salt Crust Thickness (*n* = 8), Evaporation (*n* = 7), Salt Brine Return (*n* = 6), Precipitation/Flooding (*n* = 5), Subjective Quality of Management (*n* = 5), General Racing Activities (*n* = 5), Salt Brine Removal (*n* = 4), Mineral Extraction (*n* = 4), Salt Brine Removal (*n* = 4), and Track Preparation/Grooming (*n* = 4).

RQ2: Structure of Participants' Fuzzy Cognitive Maps

Mental model-based FCM structure varied somewhat widely (see Table 4.2). The total number of components in FCMs ranged from 6 to 13, for which the number of connections per component correspondingly ranged between 1.2 and 6.4. Across all stakeholder FCMs, the number of components that functioned exclusively as drivers or receivers ranged from 1 to 3, and ordinary components—i.e. those that function as both driver and receiver depending on the relationship—ranged from 2 to 13. In regard to FCM model complexity, the total number of connections ranged from as few as 8 to as many as 90 connections among components, with FCM network densities ranging from .25 to .49. Resultant complexity scores— for which higher scores indicate more complex systems thinking based on the extent to which outcomes of driving forces are considered (as per Eden et al.,1992; Özesmi & Özesmi 2004)—ranged from 0 to 1.5.

The centrality of the top ten most frequently reported mental model concepts—and thus FCM components—appear in Table 4.3. These are important for understanding the importance of these concepts in holding participants' mental models together. As the most influential of important FCM components, these variables helped additionally provide a partial basis for answering Research Question 3: *To what extent do stakeholder groups similarly perceive correlations between important BSF concepts?* The lowest individual component centrality was 1.25 for Quality of Management, reported by the Media Community. The highest individual component centrality—9.9 for Salt Crust Thickness—reported by the Land Speed community. The mean centrality for each component ranged from 3.3 to 6.5.

Table 4.2. *FCM network structure by stakeholder group and participant*

Stakeholder Group	*Actor	Total Components	Connections per Component	# Drivers	# Receivers	# Ordinary	Total FCM Connections	FCM Density	FCM** Complexity Score
Academia	138	8	2.63	2	1	5	21	.38	.5
	222	14	6.43	2	1	11	90	.49	.5
Land Speed Racing	450	13	4.46	2	0	11	58	.37	0
	324	14	5.79	1	1	13	81	.45	1
Land Management	396	8	3.25	2	1	5	26	.46	.5
	330	8	3.5	1	1	6	28	.5	1
Wendover/ Tooele County	342	8	1.75	2	3	3	14	.25	1.5
	297	7	2.43	2	1	4	17	.40	.5
Media	207	6	2	0	0	6	12	.40	0
	156	8	2.75	3	2	3	22	.39	.67
Mining / Industry	213	6	1.33	2	3	2	8	.267	1
	159	NR	NR	NR	NR	NR	NR	NR	NR

Note: *Indicates the anonymous number for star actors identified in the separate social network analysis study (Blacketer, et al., 2020)

Table 4.3. *Matrix of top ten FCM components' centralities by stakeholder group*

	Component Centrality by Stakeholder Community						
FCM Component	Academia	Land Speed	Land Mgmt	Mining/ Industry	Media	Wendover/ Tooele	Mean
Evaporation	5.12*	-	5.12	2.75	-	3.75	4.19
General Racing Activities	4.25*	9.0	4.51*	-	-	-	5.92
Mineral Extraction	-	8.0	4.0	0.5	2.25	-	3.69
Precipitation / Flooding	3.93*	4.75	-	2.75	2.76	2.7	3.38
Quality of Management	2.5	6.88*	-	-	1.25	3.25	3.47
Salt Brine Removal	2.8*	6.5*	-	-	-	-	4.65
Salt Brine Return	3.25	6.5*	2.5	-	1.5	2.95	3.34
Salt Crust Area	7.0	9.75*	-	-	2.75	-	6.50
Salt Crust Thickness	5.75	9.88*	3.25	-	2.13	3.64	4.93
Track Preparation & Grooming	-	-	4.24	2.0	-	3.75	3.33

Note: *Denotes mean for both star actors in group, as opposed to only one actor in group.

Figures 4.3 and 4.4 below display FCMS created in Mental Modeler that represent the two relative extremes of mental models in this study in terms of (a) the number of SES components that participants deemed important to consider when thinking about the BSF as an SES, and (b) the extent of components interconnections in each model. Figure 4.3 presents a relatively simple model comprised of only six components that the actor determined to be important to consider. Conversely, the FCM in Figure 4.4 includes thirteen components and therefore many more pairwise relationships. Blue arrows represent positive correlations, whereas orange arrows represent negative correlations. Line thickness indicates differs based on the strength of correlation strength. Nine additional FCMs for the remaining star actor interviewees are provided as Figures 4.5 through 4.13 in Appendix 11.

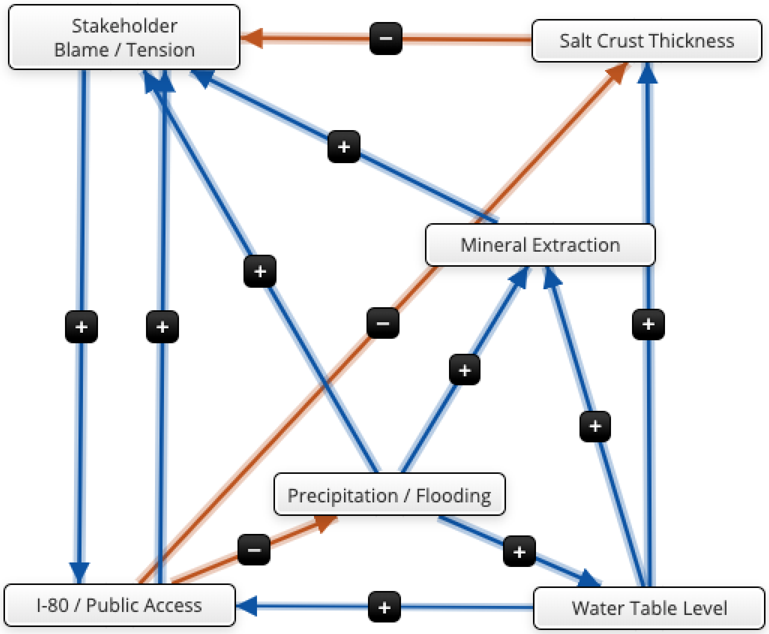


Figure 4.3. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Media community reported as ‘important to consider’ in regard to the BSF’s social-ecological complexity

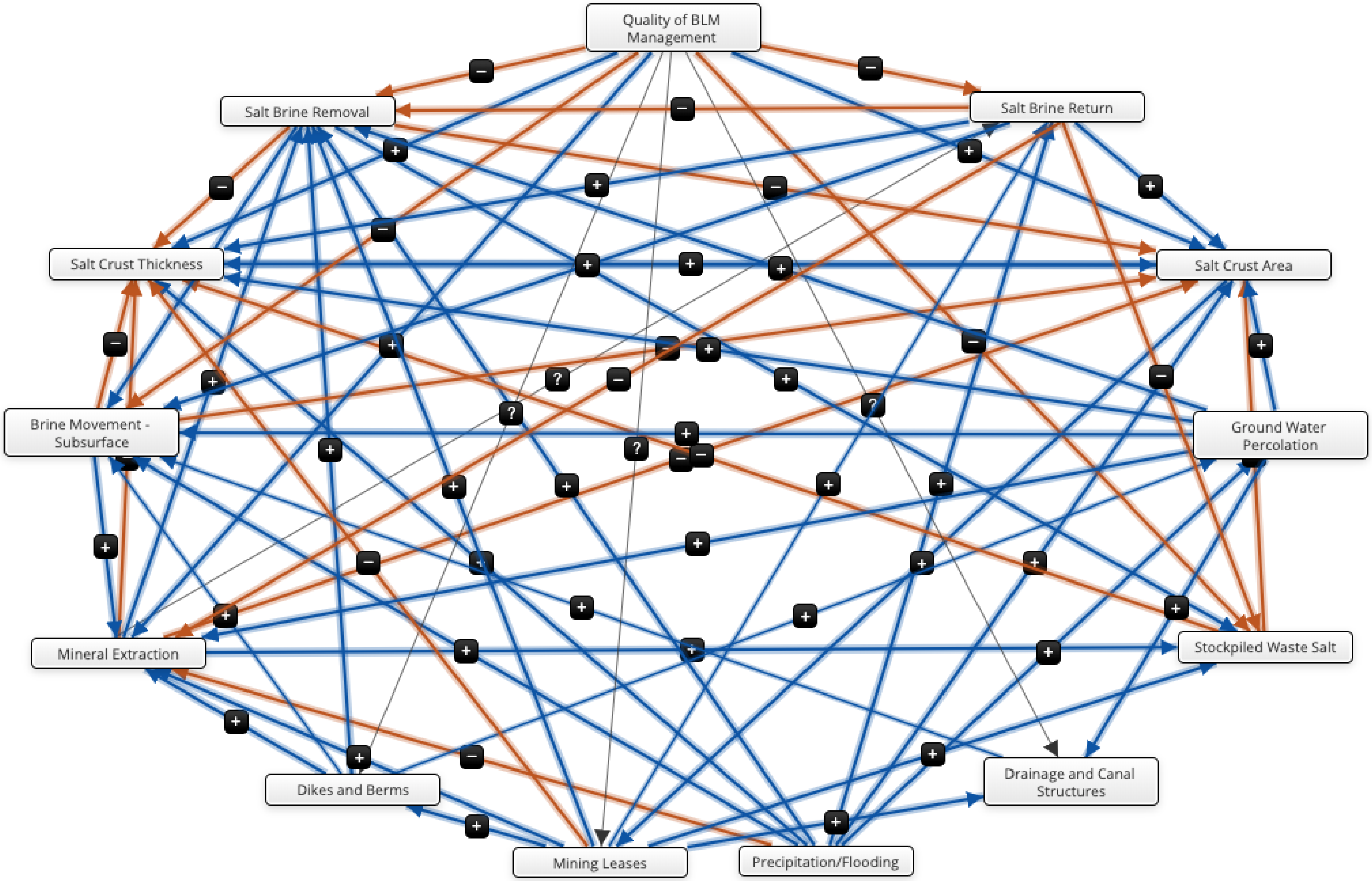


Figure 4.4. FCM representing the relationships among 13 important SES components at the BSF as reported that a member of the Land Speed Racing community reported as 'important to consider' in regard to the BSF's social-ecological complexity

Table 4.4. *Matrix showing star actors reporting correlations between the top ten reported driving and receiving components*

Independent / Driver Variables ↓	Dependent / Receiver Components Evaporation	Mineral Extraction	Precip/ Flooding	Quality of Mgmt (subj.)	Racing Activities (general)	Salt Brine Removal	Salt Brine Return	Salt Crust Area	Salt Crust Thickness	Track Preparation / Grooming
Evaporation	—				Academia (H+/-) Land Mgmt (2H+)	Academia (H+)	Wendover (H+)	Academia (H+)	Academia (H+) Land Mgmt (H+) Wendover (2H+)	Industry (H+) Land Mgmt (2+) Wendover (H+)
Mineral Extraction		—			Land Mgmt (L-)	Land Sp. (H+)	Land Sp. (?)	Land Sp. (H-)	Land Mgmt (H-)	Land Mgmt (L-)
Precipitation / Flooding	Academia (H+/-) Industry (H-) Wendover (H-)	Land Sp. (H-) Media (H+) Industry (M+)	—		Academia (2H-)	Academia (?) Land Speed (H+)	Land Sp. (H+)	Academia (H-) Land Sp. (M+)	Academia (M+) Wendover (H-)	Industry (H-)
Quality of Management (subjective)		Land Speed (H-)		—	Academia (M-) Land Sp. (H+)	Academia (?) Land Sp. (H-)	Land Sp. (2H+) Media (?)	Land Sp. (2H+) Media (?)	Land Sp. (H+) Media (?) Wendover (H+)	
Racing Activities (general)					—			Academia (L-)	Academia (L-) Land Mgmt (M-)	
Salt Brine Removal					Academia (M-)	—	Academia (?)	Academia (H-) Land Sp. (2H)	Academia (H-)	
Salt Brine Return	Land Mgmt (H+)	Land Sp. (M-)			Academia (?) Land Sp. (H+) Land Mgmt (L+)	Academia (?) Land Sp. (2M-)	—	Academia (M+) Land Sp. (2H+) Media (H+)	Academia (H+) Land Sp. (H+) Land Mgmt (?) Media (H+) Wendover (H+)	Land Mgmt (L+) Wendover (H+)
Salt Crust Area	Academia (H+)				Land Sp. (H+)			—	Academia (?) Land Sp. (H+)	
Salt Crust Thickness					Land Sp. (H+)			Academia (?) Land Sp. (2H+) Media (M+)	—	Wendover (H+)
Track Prep/ Grooming					Land Mgmt (2H+)				Land Mgmt (M-)	—

Note: Notation in parentheses indicates strength (L = Low, M = Medium, H = High), and direction of perceived correlation (positive or negative). If both members of a group reported identical correlations, notation is preceded by a ‘2.’ Question marks (?) denote professed but unspecified correlations.

RQ3: Perceptions of Important Concepts and Relationships

Numerous pairwise relationships existed between stakeholders' top ten reported concepts that were translated into FCM components. However, varying levels of agreement emerged regarding correlations among these components. The matrix in Table 4.4 addresses this study's research question: *To what extent do stakeholder groups similarly perceive correlations between important BSF concepts?* Many correlations between components were reported by only one or two groups. However, several noteworthy correlations were perceived to exist by three or more groups. The component correlation with the highest agreement among stakeholder groups was that between Salt Brine Return (as a driver) and Salt Crust thickness (as a receiver). Four groups—Academia, Land Speed, Media, and Wendover—reported a high positive correlation between these components, with a fifth group, Land Management, reporting a certain but an unspecified relationship. Three groups—Academia, Land Speed, and Media—reported a positive correlation between Salt Brine Return and Salt Crust Area, but whereas Academia rated the strength of this correlation as 'medium,' the others rated it as 'high.' Similarly, these three groups reported a relationship between Salt Crust Thickness and Salt Crust Area, and while Academia was uncertain of the character of the correlation, Land Speed and Media reported it to be a positive correlation; they differently perceived the strength as 'high' and 'medium,' respectively. Three groups reported a high-strength correlation between Precipitation/Flooding and Evaporation, although the Academic actors were split on the direction, while Industry and Wendover reported this correlation as negative. Three groups reported a relationship between Precipitation/Flooding and

Mineral Extraction, but Land Speed and Media disagreed about the direction while reporting a high-strength correlation, with Media reporting a medium-strength positive correlation. Academia, Land Management, and Wendover reported a high-strength positive correlation between Evaporation and Salt Crust Thickness. Industry, Land Management, and Wendover reported a high-strength positive correlation between Evaporation and Track Preparation. Land Speed and Wendover reported a high-strength positive correlation between their individual perceptions of Management Quality and Salt Crust Thickness, and while Media agreed that a relationship existed, the actor reporting was unsure of that correlation's character. Similarly, Land Management and Land Speed agreed that a positive correlation exists between Salt Brine Return and General Racing Activities, but disagreed on the strength, while Academia recognized an unclear relationship between those two components.

RQ 4: Stakeholder Confidence in FCMs

Stakeholders' confidence (RQ 4) refers to the level of certainty they hold regarding whether their perception of the pairwise relationships between components are shared by their stakeholder community. Including only the values for identified relationships between components (i.e. $m_{confidence}$ = total confidence/# relationships for which confidence was reported), these confidence scores ranged from 4.5 ('slightly confident) to 6.6 (nearly 'fully confident') for each overall FCM. The mean of 5.7 equated to 'moderately to very high' confidence on the Likert scale, as reported previously in Table 4.5. While confidence was assessed for each pairwise BSF component relationship, on very few occasions did star actors report low levels of confidence for their characterizations. In such cases, the actors suggested that despite the importance of the two concepts separately, their low confidence for a specific correlation between those concepts was attributed their own uncertainty, based on the fact that they had not considered that particular correlation previously. Some of these unspecified correlations—denoted with a question mark—are visible in the matrix in Table 4.4.

Table 4.5. *Confidence for participants' mental models/FCMs*

Stakeholder Group	Actor*	Mean Confidence
Academia	138	5.8
	222	4.5
Land Speed Racing	450	6.5
	324	6.1
Land Management	396	6.6
	330	5.1
Wendover / Tooele County	342	5
	297	5.9
Media	207	5.6
	156	5.1
Mining / Industry	213	6.4

Note: *Indicates the anonymous ID number for star actors identified in the separate social network analysis study (Blacketer, et al., 2020). Mean confidence was calculated by diving the sum of reported pairwise confidence values by the number of those confidence values, and does not consider unspecified correlations between certain components

Discussion

This study sought to contribute to several realms of scholarship related to social ecological systems, mental modeling, fuzzy cognitive mapping, and natural resource management research. Conceptually speaking, by focusing on important concepts in social-ecological systems through mental models—for which perceptions are implicit—the study links to several realms of research dealing with human perceptions related to natural resources. Some of these areas include perceptions of change in a resource (e.g. Brownlee et al., 2013; 2014), our ability to perceive change on geologic timescales (e.g. Rezney, Davatzes, Newcombe, & Shipley, 2017), the role of perceptions in place meaning related to anthropogenic impacts (e.g. Davenport & Anderson, 2005), and our propensity to perceive resources as less pristine or beautiful than member of previous generations (e.g. Anderson & Brown, 1984).

More specifically, this study engaged in mental modeling related to a salt flat environment. As landscapes unlike almost any others in terms of aesthetics and human uses, places such as the BSF remain perhaps just as academically isolated—in terms of social science, at least—as they are geographically isolated. Additionally, this study utilized the relatively untested method of representative or surrogate mental modeling in which knowledgeable community members were objectively selected to represent the members of their own community. In doing so, these individuals characterized the relationships among social-ecological concepts in their mental models of a complex natural resource. The study endeavored to fulfill all of these academic deficiencies and to reveal the utility for mental modeling to reveal areas of stakeholder group agreement in regard to natural resource related social-ecological complexity.

Despite its contributions, the study itself expresses and embodies certain limitations and liabilities—some theoretical or conceptual, and others more tangible or process-oriented. For example, in regard to the first research question—which sought to reveal which concepts related to the BSF were considered to socially and ecologically important—there were certain challenges with which participants wrestled regarding characterizing certain relationships. The most salient of these was perhaps in regard to the specificity, ambiguity, or subjectivity of some of the concepts listed for selection in the mental modeling exercise. Though derived from numerous Phase I interviews, participants regarded some of the items as too specific, not specific enough, or as a body of concepts that were too were divergent in their relevance, scale (e.g. socially, ecologically, geologically, economically), or subjective definitions. Future efforts similar to this study might seek better bounding or expert opinion regarding the generation of a list of concepts to compare across groups and reduce concerns about scale, subjectivity, and relevance. Conversely, perhaps soliciting numerous mental models at different scales—and then linking them—might be a laudable approach to truly mapping cognitive complexity regarding SES complexity.

Research Question 2 addressed the comparison of FCM network structure across BSF stakeholder groups. Despite the similarities regarding the top five or ten most included concepts, many FCMs were demonstrably and structurally different even within-group (see Appendix 11). Truly aggregating these models—i.e. combining FCMs for each stakeholder group—was not deemed to be appropriate because of the low number of overlapping concepts between same-group participants. This is simply a shortcoming of the low—albeit intentionally representative—sample size of participants. Properly aggregating numerous models is still suspected to be more valuable for arriving at a clear picture of groups' mental models of an SES, especially in the form of aggregating individual-level models into representative group models for comparing perceptions of complexity and associated complexity scores.

Complexity scores themselves were also problematic. Because they represent the ratio of receiver variables to driver variables, two FCMs—one from Land Speed Actor and one from Media—contain no components functioning solely as a receiver, and thus these models have complexity scores of zero. Characterizing models with numerous components and correlations as having zero complexity seems unrepresentative of the actors' mental models, which are demonstrable laden with complex considerations. This phenomenon suggests that a different scoring method may be in order; Wiesner's and Ladyman's (2019) comprehensive assessment and consequent recommendations for assessing complexity may be useful in this regard.

Related to complexity, another noteworthy potential limitation of this study is in regard to its SES research angle. This study partially endeavored to reveal differences in the potential FCM complexity among stakeholder groups, it did not, however, purport to hold that more complex FCMs are preferable. As mentioned in the Introduction, mental models are typically bounded by a person's experience and understanding, and although sometimes are perhaps inaccurate or incomplete, those models are nonetheless useful for navigating life. Speaking in regard to larger SESs, Holling (2001) suggested that one way to address deliberately bounding a system for research purposes (e.g. modeling) is to consider the *Rule of Hand* (Holling & Sundstrom in Allen & Garmestani, 2015)—an approach that suggests that five variables at different scales can capture a broad range of system complexity. Walker et al. (2006) explain further that more complex models can be unnecessary for explaining primary cause-and-effect patterns, going as far to say that additional model complexity may even be likely to mask these primary patterns. Walker, et al. suggest that this is due to (a) our human ability to understand only low-dimensional systems and (b) because it appears that only a few variables are ever dominant in observed system dynamics. With this in mind, BSF stakeholder may not need complex mental models to cooperate or use the BSF for their chosen purposes, but agreement in regard to tangible, objectively measurable, or evidentiary correlations among social and biophysical concepts is certainly in order.

In regard to Research Question 3—agreement among groups' reportedly important SES concepts—the same concerns arose as discussed above. Without full confidence in the concept list, the pairwise relationships between concepts are likewise called into question. Nonetheless, concept relationships that are consistent from group-to-group are valuable places to begin discussion and collaboration among stakeholders. Due to various reasons, stakeholder groups may engage one another with suspicion and distrust, and so pointing out concepts and related relationships with which they agree may be a wise place to begin collaborative activities.

Lastly, star actors' confidence in their FCMs—the topic of Research Question 4—was reported as a mean for each model. Reporting confidence for every concept relationship proved awkward with so much diversity in 'important' concepts and the relationships between them; it was thus determined to be a less-than-helpful way to present the data. Furthermore, the validity and overall accuracy of confidence at the group level is called into question due to the low sample size; again, this would be overcome by engaging in collaborative mental modeling with numerous individuals.

This study also has implications for the role of mental models in fostering stakeholder collaboration—perhaps through dispute resolution—and therefore adaptive governance of natural resources (e.g. Susskind, 2005). Mental modeling serves as a form of communal knowledge-building through the participatory aspect of modeling in groups (e.g. Hoffman, Lubbell, & Hillis, 2014). As mentioned previously, during this study's mental modeling interviews, several actors struggled to determine the character of certain concept correlations due to having not explicitly considered them before. This suggests a valuable opportunity for increasing group-level cognition of relationships—a process that may have benefits for more consensual knowledge-building as well as for dispute resolution.

Regardless of agreement or disagreement, mental models and resultant FCMs provide a valuable starting point for group sharing, learning, and consensus-building by illustrating group knowledge or perceptions of real-world conditions (e.g. Hoffman, Lubbell, & Hillis, 2014). Even more noteworthy, perhaps, is the value of participatory mental modeling in negotiation and dispute resolution. Meant to engage the implicit and explicit knowledge of stakeholders in creating create formalized and shared representation(s) of reality, this process thus helps co-formulate problems to help describe problems and guide group decision-making toward solving problems collectively (Jones, et al., 2009). As such, the act of constructing a group mental model through consensus can be a powerful way to not only clarify various understandings between vital components of a model, but to build community trust based on clarified, shared knowledge (Gray & Gray, 2015).

Promisingly, Voinov & Bousquet (2010) suggest there is general agreement that better decisions can be implemented—with less conflict and more success—when resource-related stakeholders drive the decision-making through participatory modeling. These authors also suggest that this makes PM a form of citizen science because its process engages stakeholders in developing new knowledge, even as it solicits and carefully examines public needs, opinions, preferences, and constraints. Participatory modeling can thus heighten stakeholders' understanding of systems and the dynamic relationships therein as well as elucidate the effects of potential solutions to systems-based problems, potentially streamlining decision- or policy-making and management (Voinov & Bousquet, 2010).

The partial illumination of each stakeholder community's perceptions of important SES concepts at the BSF is likely a good place to begin larger discussions about the overall social-ecological complexity of the BSF. Insomuch as groups agree or disagree on important concepts—the simple identification of mental model intersections is a logical starting point for more extensive communal knowledge-building (Langfield-Smith, 1992). In the hand of this study's influential star actors, the findings herein and their resultant implications might be usefully disseminated into the larger BSF community to perhaps lessen tension among stakeholder groups that may be based on conceptual misunderstandings of the BSF's social-ecological complexity.

While the BSF is arguably socially and ecologically complex, it may be that many people who are intimately tied to this resource do not see it as such owing to its stark aesthetics and reputation for barrenness. This study thus sought to reveal how certain stakeholder groups who perhaps understand and use the BSF the most conceive of its complexity. Therefore, this study suggests that the illumination of people's cognitive maps for a given natural resource can contribute to a greater understanding and better management of that resource as a complex social-ecological system.

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CHAPTER V

A Proposed Conceptual Model for Illuminating Resource-Specific Values and the Stakeholders that Seek Them

Introduction

The Bonneville Salt Flats (BSF) is perceived to be many things—a land of human triumph, a parcel of destruction and desolation, a playground, and a surreal world of the strange and bizarre (Bushman & Davis, 1997). For so many reasons, people value the BSF for the amazing natural resource that it is. The minerals (e.g., potash) extracted from the BSF's brine are valuable to more than just the mining industry's bottom line. For the world at large, potash is used for manufacturing synthetic fertilizers that have helped double global food production in the last several decades. Whether or not most people are aware of it, they have probably consumed minerals from the BSF. The value of the BSF's minerals is evidenced by an expanded global human population as well as increases in global human health.

The BSF is internationally recognized for not just racing, but also for its beauty and dynamism. Its character as wintertime-mirrored-lake is dramatically juxtaposed by its transformation into a summertime-solar-oven. Finding yourself on the flats in July is an experience of having the sun shining from seemingly every direction—down, up, sideways, and almost straight through you. The aesthetic and *uniqueness* value of BSF is espoused by anyone who is familiar with this place. So, while many places are valuable to people for numerous reasons, it is—at least to me—very interesting that a landscape so boiled-down in its elements can be of such diverse, complicated value. Whether economic, aesthetic, recreational, spiritual, social, or all of the above, the value of the BSF is just as complex as the social-ecological system that the BSF comprises. Indeed, value—in its many shapes, sizes, colors, and conceptions—is itself an underlying, nested web of complexity in a larger complex system. There is nothing simple about this place, its people, or the many values that are held in people's heads, hearts, and livelihoods.

At once both objective and subjective, the value of a person, place, or thing is a subject for ongoing debate. What may be immensely valuable to one person may be worthless to another. We overcome this dichotomy in capitalist culture by defining things in terms of monetary value, even when certain things are less-than-amenable to doing so. This is true in many places. Indeed, it is true of many scenic and natural resources—and the BSF is no exception. Beloved for its iconic landscape features, the BSF—the nearly 100 square miles of hard mineral remnants of Pleistocene lake Bonneville—is legendary in the media. Whether as the venue for breaking the limits of wheel-driven automotive speed, or used in movies as a breathtaking, otherworldly backdrop, this unique resource inspires dreams of both roaring engines as well as silent solitude. BSF's value, it seems, is very dynamic—and this dynamic value is nested within the hearts, minds, and actions of the people who interact with its stark attributes.

The human community interested in this unusual expanse of hard, white salt in Utah's West Desert includes mineral extraction companies; diverse recreationists;

local, state, and federal government; academics, and other people embedded in the media, art, and local communities. Each of these groups has a stake in the BSF that can simultaneously be measured in some ways, and yet remains nearly immeasurable in others. What often shapes the value that these people place on the BSF is their wants, needs, and desires for the way that they interact with this landscape as a whole, or just certain parts of it.

Many questions come to mind in this regard. How do we put value[15] on the viability of the BSF as a venue for recreation or a source of much-needed minerals? How do we put value on people's ability to communicate effectively about BSF, or do their BSF-related jobs? How do we put a value on the scientific exploration of this resource, or the transparency of scientific findings? How do we place value on artists' ability to inspire or the media's ability to keep the public informed?

These are questions that I have been grappling with over the last year that have come full-circle in the course of writing my dissertation. As such, I have arrived back at the idea of 'value' as central to the social-ecological system known as the Bonneville Salt Flats. It is this unique natural resource that lies at the heart of a social network composed of numerous stakeholders, each group of which attaches value to certain attributes and characteristics of the salt flats. These values are of many sorts, too—aesthetic, economic, recreational, spiritual, cultural, and many more. Some of

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[15] I use the term 'value' rather loosely here to include its traditional definition as the relative worth, utility or importance of something, including 'value' as something intrinsically valuable or desirable. When applied to natural resources, it also makes sense to think of 'value' in terms of ecosystem services, which are "the benefits of nature to households, communities, and economies," as suggested by Boyd and Banzhaf (2007).

these values are associated with tangible products such as minerals extracted for commercial sale, or a thick salt pan that's suitable for land speed record-setting. Others are intangible, such as the cultural values attached to certain activities that take place on the playa, or the sensation of solitude that overwhelms the senses when surrounded by the salt flats' vast 'nothingness.' Whether tangible things or intangible ideas or feelings, numerous attributes of the Bonneville Salt Flats are the source of such values.

Rationale for the Socio-Ecogram and its Composition

My first study focused on the structure of the Bonneville Salt Flats' social network and asked star actors how they perceived the influence of their social network on the greater BSF social-ecological system. Their perceptions of this influence were diverse, but insightful, and taken together served to illuminate one portion of the BSF's SES mosaic.

My second study investigated how people at the Bonneville Salt Flats—either for their first time or their four-hundredth time—perceived social and ecological change related to that iconic, immersive natural resource. Their perceptions, too, were diverse, and ultimately were affected by their goal-oriented identities and past use histories.

My third study engaged the same star actors in Study I to ask them—in an act of mental modeling—to represent the perceptions of their particular stakeholder groups in terms of how important social and ecological concepts at the BSF were related to one another. There, too, were diverse conceptual cognitions in addition to genuine acts of introspection into social-ecological complexity of the resource.

Each of these versions of perception—of social influence, of social and ecological change, and of social-ecological reciprocity—were revealed by using different tools presented in Chapters II, III, and IV. The nuance and potential implications derived from each of those studies is synthesized to reveal greater meaning.

Over the course of this dissertation's three studies, I have continuously had questions about value in mind. In addition to the ideas just discussed regarding the nature of value, I also asked myself repeatedly, "What's the value of these studies—or specifically, the value of their findings?" In broad terms—as mentioned several times previously—value lies in the ability of each study to 'illuminate social-ecological complexity' through a 'mosaic approach' of sorts. But what does that really mean, and how can we use social network analysis, perceptions surveys, and mental modeling as viable tools for illuminating complex social-ecological reciprocities? There has to be a way to choose and apply these tools—and assuredly many others—to truly wrap our minds around the complex, tangled web human-social pursuits attached to biophysical phenomena and their many individual attributes or requisite parts.

What I propose here is the conceptual model for a 'socio-ecogram', or SEG. This concept is at once both very simple and potentially quite useful for framing, evaluating, and communicating social-ecological complexity related to a specific natural resource. Although I had some preliminary ideas for how to structure such a model, the format I share here was inspired by periodically referring back to the Human Ecosystem Model (HEM, Machlis, Burch, and Force, 2017) as an organizing framework for my three dissertation studies while also considering the nature of 'value,' the many perceptions of which draw people to particular resources.

My thinking has additionally been shaped by my consideration of the ultimate purpose of those studies—to help inform a more holistic and SES-oriented form of parks and protected area management. Before I present the model, however, I think I need to back up a bit first. If I may use a metaphor here—my dissertation studies and all they entailed provided fertile ground for the germination of a line of thinking that has helped me to synthesize my understanding of Studies 1, 2, and 3. The seed that germinated in that soil was (inadvertently?) sown by Dr. Bowen, who—during the second phase of comprehensive exam questioning—asked me three things:

1. *What is the value of the Bonneville Salt Flats?*
2. *What shapes that value?*
3. *How does the perception of the value of BSF vary for different stakeholder populations?*

These questions returned to my original body of interests related to parks and protected areas, that—despite running in 'standby mode' in the back of my mind for the last several years—had yet to really guide the inquiry and objectives for my research. Being asked to consider the nature of value resulted in a rather satisfying act of philosophizing. As a social construct that humans place on both tangible objects and attributes as well as intangible emotions, feelings, and idea, ‘value’ is at the root of the human connection to, well, *everything*.

The SEG is partially a response to the reality that the HEM, while extremely useful for tracing resource flows in systems, is really intended as a tool to be engaged one flow at a time. Although it can—and perhaps should—be utilized alongside the SEG, it is not useful for simultaneously illustrating social-ecological relationships based on the valuable products and concepts stemming from a resource. Thus, what I put forth hereafter is a proposed conceptual model that has emerged from my consideration of the methods, analysis, and results of my three dissertation studies.

This conceptual SEG is intended as a supplement to the Human Ecosystem Model. Whereas the HEM is useful for tracing cascades across social and ecological relationships (and thus deeply exploring the reciprocity of components from those realms), the SEG is focused on human attraction to a resource through both convergent and divergent values placed on—or derived from—various resource elements and attributes.

The Conceptual Socio-Ecogram Model

Although admittedly in an early developmental phase, the socio-ecogram (SEG) I present here is predicated on a combination of ideas rooted in social network analysis, mental modeling, and stakeholder assessment[16]. Its intended purpose is to

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[16] Although I did not engage in true stakeholder assessment in the course of these three dissertation studies, I believe it to be an integral component of systems thinking applied to managing parks and protected areas as the social-ecological systems that they are.

help make sense of the relationships that communities that have with each other in respect to a common relationship with a resource such as a park or protected area. Its utility is fourfold: (1) it arranges the resource, its attributes, the range of those attributes' values, and the human social groups that seek, posit, or conceive of create those values in a format that is relatively easy to interpret; (2) it helps reveal overlaps in human groups' interest—perceived or real—in particular values; (3) it helps reveal whether those overlaps are real or perceived based on different dimensions of values assigned/perceived to specific attributes; and (4) by revealing potential for conflict and collaboration, the model can serve as an aid in communal knowledge-building as well as dispute resolution.

The SEG is a hybrid network model that uses concentric rings to simultaneously displays resource elements, the values attached to them, and the people seeking to satisfy needs and desires based on those values. If performed at different scales in response to specific tiers or values that people may seek, the SEG can provide many 'tiles' for assembling an SES mosaic. First, the outermost ring of stakeholders must be populated through analysis, assessment, and investigation. With stakeholders identified—and whether relationships to one another are quantified—their relationship with the resource must be described, including how they use it, relate to it, and conceive of it. This includes recreational, educational, cultural, or economic activities, as well as various aspects of identity. Based on those findings, the value that stakeholders derive from specific aspects or qualities of the resource can be determined. Next, the relationships among of these items, and attach stakeholder groups to each quality or attribute as appropriate. Lastly, the relationships among these attributes can be quantified, perhaps through mental modeling.

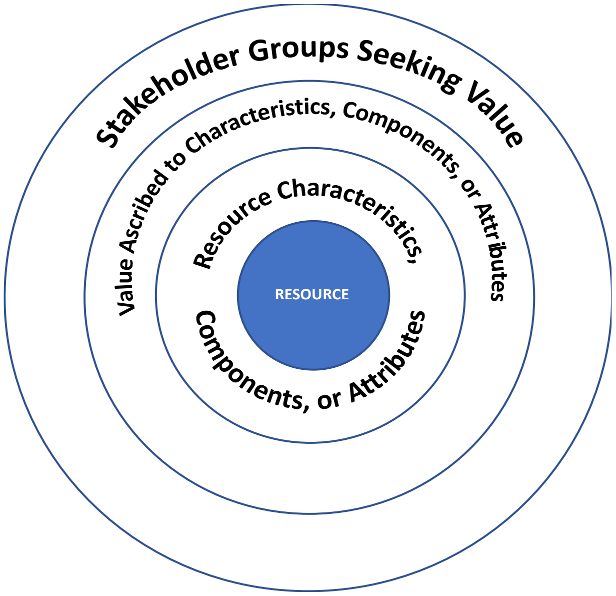

Figure 5.1. Conceptual socio-ecogram (SEG) or social-ecological map (SEM) showing (a) the natural resource at the center, (b) primary resource components and qualities, (c) values ascribed to the resource attributes, and (d) stakeholder groups who seek certain values.

The key idea of the model is that it focuses thinking on the resource at its center and connects people with resource attributes necessary for their pursuit of certain valuable experiences or products. Each ring is intended to be populated with resource-specific labels, at the very least. For the sake of clarity, network-style relationships have not been drawn in above. They may or not be necessary. Alternatively, the model may be useful for conducting mental modeling activities with stakeholder groups to build broad understanding of social-ecological connectivity. The results of such mental modeling could be performed in a matrix and used to construct and fuzzy cognitive map.

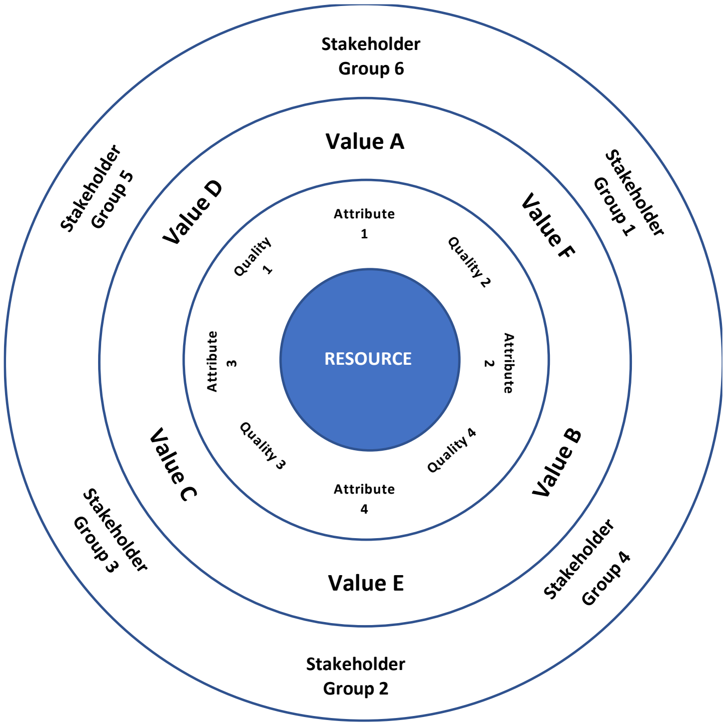

Figure 5.2. Conceptual socio-ecogram (SEG) populated with generic

The 'Hungry, Hungry Hippos®' Analogy

Another way of visualizing the form of an SEG is akin to a game of 'Hungry, Hungry Hippos,' wherein the hippos are stakeholders that seek to acquire or experience marbles that represent value concepts stemming from a resource. While people seem very adept at furiously competing in zero-sum or winner-take-all, real-world versions of this childhood game, I propose the analogy here in format only—not in regard to an competition-based objective. Rather, by recognizing a resource—composed of certain cross-scale elements and processes with perceived, desirable value—as an attractor at the center of a social network, we can begin to see how we might explore the relationships among human actors, biophysical phenomena, and abstract concepts(e.g. perceptions of value) all in one sitting. The model is thus useful for considering where values placed on common elements might overlap.

Figure 5.3. Hungry, Hungry Hippos® game as a metaphor for the conceptual socio-ecogram showing stakeholders seeking values related to a common resource, perhaps in an arena of competition

What is hard to convey in such a simple diagram is that the human stakeholders are not truly outside the resource looking in. Rather, they are woven together with one another as well as with the values that connect them to specific resource attributes in a cohesive tapestry of social-ecological complexity. The groups espousing or assigning values to the same phenomena, therefore, have to be recognized as possibly cooperative or competitive—or perhaps both under certain conditions. This addresses the potential influence that each group has over certain components/processes, and therefore over eventual phenomena, such as change in natural resource attributes or overall character. Other groups enmeshed in the network may serve as bystanders or mediaries in such a relationship related to a commonly valued phenomenon.

Applying the Conceptual SEG to the BSF

The ‘boiled down’ aspect of the BSFs social-ecological complexity—in comparison to other natural resources with numerous human user groups, extensive biophysical realms, overlapping management regimes, and high levels of visitation is what perhaps makes it easier to experiment the following tool. To demonstrate, below is a BSF-specific version of the SEG, to show some of findings from Studies 1, 2, and 3. At the center is, of course, the Bonneville Salt Flats. Surrounding it are resource-specific elements that that shape or characterize the resource; these are limited for clarity, but there could be many more. In the next ring are the types of values that are attached to each of these elements; again, these are not precisely defined, but they could and should be in a full application of a SEG. Lastly, the stakeholders who seek specific value are in the outer ring. All that’s left to do is draw in the connections.

Ultimately, the SEG at least identifies social-ecological connections in resource-related social networks. Furthermore, biophysical entities may be akin to the star actors in an SEG– they will have high centrality and degree but will not serve as hubs of communication. Groups attached to the same biophysical network node must negotiate their common relationship with that element, perhaps moderated by another stakeholder group that is connected to the first two. The relationships among these connections can subsequently be traced through cascades in the HEM for the purpose of scenario-building. The SEG could also be used to trace scenarios, thus identifying the groups that will have the most to gain or lose, or which would be likely to take the lead in particular ways.

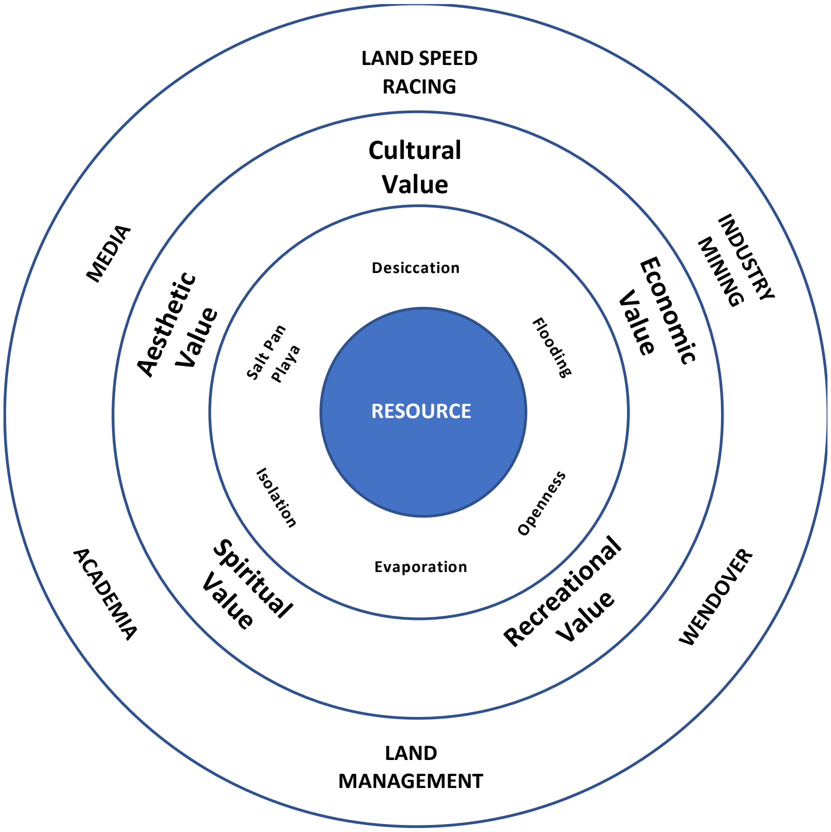

Figure 5.4 . Resource-specific socio-ecogram (SEG) showing (a) the BSF at the center, (b) primary resource attributes and qualities, (c) values attributed to the resource attributes, and (d) stakeholder groups who seek certain values.

As mentioned previously, the Human Ecosystems Model is less of an organizing framework than it is inspiration for resource-specific SEGs. As such, the HEM provides an oversized/generalized model that can be tailored to a specific place by ‘whittling it down’ into the proposed SEG. That is, the HEM provides guidance for identifying key relationships that may be necessary to consider for ties in a SEG. The goal is to map human objectives to values that the resource has to offer. Conversely, if a resource is found lacking—in species, nutrients, stability, etc.—the surrounding human population can identify elements to supply for its recovery. This transactional relationship between human and natural resources is not a new idea, but perhaps envisioning it graphically in this way is, indeed, novel. I find that it helps make sense of what can be head-spinning, confounding complexity in its simple approach to positioning a resource as central to a core of human communities.

Additional Thoughts on the SEG

Several findings from Studies 1, 2, and 3 led me to the idea for the SEG. In Study 1, revealing the structure of the BSF social network proved very informative, and despite its shortcomings was nonetheless useful for eliciting valuable perceptions of the network's influence on the BSF. The act of considering that influence itself seemed particularly valuable for the star actors I spoke with. In Study 2, it occurred to me that a great deal of the missing data for POC items was likely attributable to people not having any particular perceptions of change in regard to specific BSF elements/phenomena, perhaps because they were unaware of those things to begin with. This suggested to me that people may not be aware of any aspect of social-ecological systems in which they do not perceive value—racers value hard, flat, thick salt of extensive surface area, industry values precipitation and flooding for the dissolution of salt for the sake of mineral extraction, spectators value an experience at racing events that makes them feel part of something special, and the media values having compelling stories to report to the public.

The list could go on, but at the heart of every social-ecological transaction, there is value perceived, pursued, extracted, and exchanged. In Study 3, the same phenomenon seemed to occur. Star actors' mental models ranged from concise to complex—probably based on the value that each individual perceived in those items. If a social or biophysical concept was not valuable to them personally or to their community group, it seemed less likely to appear in their model. I could be wrong—after all, I did ask them to talk about things that were important in regard to the BSF's ecology and management—but I couldn't help but notice certain trends in the elements and concepts to which each person paid particular (and sometimes quite passionate) attention.

For each of these reasons and many more, it made sense to include 'value' in the socio-ecogram because of its role in linking people to a resource. Too, certain values are jointly pursued by many people, or many groups, and that needs to be recognized; I think it's important to do so visually, in the same way that we do for social networks, mental models, and fuzzy cognitive maps. Each of these things can help reveal values and concepts, and in doing so, identify key groups connected to a resource and the key actors within those groups. Furthermore, perceptions—and the social-realm phenomena that influence them—can help define and specify values as well as provide means through which to ascertain change in the phenomena upon which those values are predicated.

Limitations (and Surmounting Them)

Several shortcomings became apparent in my three studies, pertaining mostly to missing data. In the SNA study, non-response or incomplete response to the surveys left me little data to perform analysis at the individual level. In the POC study, the number of viable surveys was shaved down substantially due to incomplete responses. In the FCM study, missingness was a reality in a different way; the original intent for the study was to perform mental modeling exercises with each stakeholder group in an act of collecting knowledge-building. Short of being able to engage in those activities, I chose to solicit the star actors from Study 1 for mental models that could be construed as representative of their overall groups' model.

In every case, I chose the pragmatic path forward—altering my analyses and reimagining research questions as appropriate to still aim each article toward illuminating various perception-related facets social-ecological complexity. As such, my 'mosaic approach' to revealing portions of SES clarity was conducted in good faith and was true to the spirit of this dissertation's purpose. To say I would do nothing differently would, of course, be a stretch; I would clearly make different decisions, drive certain points harder, or plan further ahead in regard to many things if I had to do it all over again. Applying the pragmatic lens to seek meaning from limited data was still a worthwhile endeavor—especially in light of the fact that this study attempted new or modified methodologies in the face of several obstructions that somewhat hindered inquiry. Pragmatism provided a path through the limitations.

This pragmatic approach to my research problems thus enabled the studies to contribute to academic scholarship despite ideal conditions. In doing so, I took to heart the words of Richard Ormerod (2006), who suggested that, philosophically speaking, pragmatism is a means to "disallow the best to be the enemy of the good" in order to make progress toward action. Action is, after all—when guided by objective truth-seeking—the goal of natural resource and park and protected area management, even in the face of uncertainties related to social-ecological complexity. That action, in turn, a response to—and in preservation of—the value we place on natural resources.

Conclusion

In Chapter I, I suggested that my dissertation's three studies contributed to an act of mosaic artwork in which numerous small tiles coalesced to a create a greater, cohesive image of SES complexity. To that end, the tiles that I have assembled here have endeavored to help build an image of human perceptions as a component of that complexity, and in doing so, contribute to the holistic management of parks and protected areas.

Whether the BSF can be managed into the future in sustainable ways depends not just on good science revealing effective, sustainable objectives, but also on functional social structures that exist or will be built among BSF stakeholders. Scientific inquiry will provide what it can to inform the policies that manage the BSF, but acceptance of that science and the faith and patience necessary for its application will rely on trust, collaboration, social learning, and innovation. The values that stakeholders attach to the BSF must be identified and acknowledged, even if it means dissecting specific positions people hold that may conceal the true nature of those values. Ultimately, more and better communication, mutual gains negotiation, and transdisciplinary effort will be needed to ensure the sustainable use of the BSF in the coming generations.

APPENDICES

Appendix 1: Definition of Terms

Terms Related to Research Philosophy

Pragmatism is treated in academic literature as a research paradigm, as a methodological approach, and as a philosophical positioning (Silva, Dornelas, & Aruajo, 2018). Pragmatism is a rich philosophical tradition and is famous for its distinct approach to truth, method, and meaning (Pratt, 2016) and can be traced back to the academic sceptics of classical antiquity. Their teachings posited that authentic knowledge of a complete, ultimate 'real' truth was not possible. Instead, we must make do with plausible information adequate to the needs of practice (Ormerod, 2006). That is, any truth we might seek is only as useful as its ability to fulfill what we endeavor to do. This is the foundation for pragmatism's emphasis on adaptation, action, and problem solving.

Terms Related to Resource Management

Adaptive Co-Management is an emergent social–ecological system governance approach that links the learning function of adaptive management with co-management (via various actors/stakeholder) through shared learning-by-doing on medium-to-large timescales (Plummer, et al., 2012)

Adaptive Management is regarded as an approach to natural resource management that emphasizes learning through management where knowledge is incomplete, and when, despite inherent uncertainty, managers and policymakers must act (Walters, 1986).

Ecosystem management is a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political, and cultural needs of current and future generations. EM's principal objective is the efficient maintenance and ethical use of natural resources in a multi-faceted, holistic approach. (Szaro, Sexton, & Malone, 1998)

Human Ecosystem Model is a coherent system of biophysical and social factors capable of adaptation and sustainability over time (Machlis & Burch, 1997) via resource *cascades.*

Integrated Coastal Management is a science-based and holistic approach to managing the interrelated social and ecological marine and terrestrial resources through integrated intersectoral, intergovernmental, and spatial management to promote resilient, sustainable ecosystems and economies (Grumbine, 1994; Cicin-Sain & Knecht, 1998).

Management by Objective (MBO) is a process by which ecological and/or social objectives are determined and management actions are structured to attain those objectives. Subsequently, progress towards those objectives is evaluated, and actions modified as needed to meet objectives. One key distinction between this approach and adaptive management is that adaptive management assumes policy failures will occur and that they provide a valuable contribution for learning, while MBO approaches seek to avoid policy failure (Gunderson & Light, 2006).

Managers is a term used as a catch-all herein to describe members of the United States Bureau of Land Management (BLM) in addition to other persons who manager natural resources, parks, and protected areas (PPAs).

Park and Protected Area Management (PPAM) refers to the management strategies, processes, and tools used by natural resource managers who are charged with planning, maintaining, and otherwise caring for parks and other protected areas. PPAM may include management of physical resources, invasive species control, restorative activities, visitor management, interpretation, and public outreach, among other activities.

Protected areas (PAs) are geographically prescribed locations—including marine areas—that are granted protection in recognition of their natural, ecological or cultural values.

Stakeholder Analysis, as addressed by Renard (2004) stressed the importance of clearly defining stakeholders, and suggested that a) stakeholders are not only local people, but also governments and agencies; b) stakeholders can be individuals, organizations, formal groups, informal networks, or whole communities; c) stakeholders are not just the users of natural resources, but also the people and institutions that both directly and indirectly affect those resources without even using them; d) stakeholders may be people who do not even realize that they have a stake in a resource or its management; and d) stakeholders can change over time as new individuals enter or exit a system or gain or lose specific roles. Renard (2004) considered the relationship between people and natural resources to be both changing and complex and therefore warned against classifying stakeholders in ways that might marginalize certain groups who may be not have an obvious stake or who may be powerless or even voiceless.

Stakeholder Groups as discussed int this dissertation is in reference to seven *a priori* categories of people with a historic, recognized stake in the Bonneville Salt Flats.

These included members of the land speed racing community, scientist/academic researchers, land managers (primarily the BLM), individuals working in media and journalism, employees of the mineral extraction industry, artists of many disciplines, and residents of Tooele County, UT as well as the towns of Wendover (Utah) and West Wendover (Nevada). The groups were officially identified for study in the early stages of the Salt Crust Thickness Study that was part of the CHN grant from the National Science Federation to study the Bonneville Salt Flats as a social ecological system. Other stakeholder groups not included in these three studies (which were recommended in the course of data collection) included the Wendover Air Force Base, State of Utah land managers (including the Departments or Natural Resources and Fish and Wildlife).

Stakeholders, according to Chevalier (2001) the term "stakeholder" was first used in 1708 to mean a bet or a deposit; thus, a deposit held a stake in a wager whose outcome would affect the future of the person making the bet. The word "stakeholder" now refers to anyone who significantly affects or is affected by someone else's decision-making activity; this may be due to purely altruistic reasons or having voluntarily accepted benefits and thus accepting an obligation of fairness (Chevalier, 2001).

Terms Related to Social-Ecological Systems

Complex Adaptive Systems (CAS) are systems in which a perfect understanding of any individual parts cannot automatically convey perfect understanding of the whole system's behavior (Miller, 2009). Complex systems thus consist of populations of interacting entities where overall system behavior—rather than being predefined—

emerges through the entities' interactions (Kim & Kaplan, 2001). Holland's (2006) description of CASs additionally explains that CASs are "systems that have a large number of components, often called agents, that interact and adapt or learn." Thus, the study of complex adaptive systems focuses the complex, emergent and macroscopic properties of systems (Diment, Yu, & Garrety, 2009; MacLennan, 2007).

Emergence is the appearance of behavior or phenomena in a complex system that could not be anticipated from knowledge of the parts of the system alone

Non-Linearity is an aspect of systems dynamics is the root of uncertainty, resulting in path dependency—local rules of interaction that change as systems evolve. Path dependency can result in multiple steady states in ecosystem development as well as threshold-surmounting behavior that lead to qualitative shifts in system character. (Levin, 1998).

Panarchy, according to Gunderson and Holling (2002), panarchy is the structure in which systems, including those of nature and of humans, as well as combined human-natural systems, are interlinked in continual adaptive cycles of growth, accumulation, restructuring, and renewal. Panarchy explicitly takes fast/slow dynamics and cross scale interactions and interdependencies into account.

Resilience is demonstrated by the ability of a system's elements and processes to reorganize in the face of sudden change, such as that caused by stresses and shocks (Holling 1973). *Social-ecological system resilience* is related to three key considerations of a particular system: a) the magnitude of shock that the system can absorb and remain within a given state; b) the degree to which the system is capable of self-organization;

and c) the degree to which the system can build capacity for learning and adaptation (Folke, 2002). The more resilient a system is, the less likely that unexpected events—i.e. shocks or stresses— may cause that system to shift away from a certain characteristic state.

Rule of Hand is an approach that suggests that five variables at different scales can capture a broad range of system complexity (Holling & Sundstrom in Allen & Garmestani, 2015). Walker et al. (2006) explain that more complex models can be unnecessary for explaining primary cause-and-effect patterns, going as far to say that additional model complexity may even be likely to mask these primary patterns. Walker, et al. suggest that this is due to a) our human ability to understand only low-dimensional systems and b) because it appears that only a few variables are ever dominant in observed system dynamics.

Scale is important when dealing with complex systems. In a complex system many subsystems can be distinguished; and since many complex systems are hierarchic, each subsystem is nested in a larger subsystem etc. (Allen & Star, 1982). For example, a small watershed may be considered an ecosystem, but it is a part of a larger watershed that can also be considered an ecosystem and a larger one that encompasses all the smaller watersheds. Phenomena at each level of the scale tend to have their own emergent properties, and different levels may be coupled through feedback relationships (Gunderson & Holling, 2002). Therefore, complex systems should always be analyzed or managed simultaneously at different scales.

Self-Organization (SO) is one of the defining properties of complex systems. The basic idea is that open systems will reorganize at critical points of instability. Holling's adaptive renewal cycle is an illustration of reorganization that takes place within the cycles of growth and renewal Gunderson & Holling, 2002).

Social-ecological systems (SESs) are a type of complex adaptive system (CAS) in which many human and natural elements and processes change or learn as they interact through reciprocal linkages. A social-ecological system, therefore, consists of ' a 'bio-geo-physical unit' and its associated social actors and institutions. Social-ecological systems are complex and adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their context problems (Glaser, Krause, Ratter, & Welp, 2008).

The SO principle, operationalized through feedback mechanisms, applies to many biological systems, social systems and even to mixture of simple chemicals. High speed computers and nonlinear mathematical techniques help simulate SO by yielding complex results and yet strangely ordered effects. The direction of SO will depend on such things as the system's history; it is path dependent and difficult to predict.

Uncertainty is a human experience and is both a relative and subjective entity, as well as social construct ,which is affected by the individual and collective processes that lead us to anticipate the future. It has further been described as a function of how individuals and groups perceive their place in the world and the things that threaten it. Beyond the experiential, uncertainty can also refer to a situation where possible events per se are known, but where it is impossible to determine the likelihood or timing of these events (Ratter, 2013).

Vulnerability is the functional opposite of resilience. It represents the extent to which a system is unable to cope with the undesirable impacts of a change such as with the poverty-generating impact of resource degradation or climate change (Glaser, et al. 2008, citing IPCC, 2007)

Terms Related to Social Network Analysis

Actors are network members that are distinct *individuals* such as residents of a neighborhood, members of clubs, or clients of particular entity. Actors may also be *collective units* such as groups or organizations within an overall community (Hawe, Webster, & Shiell, 2004).

Betweenness Centrality was devised as a general measure of centrality (Freeman, 1977) in a network graph. For every pair of vertices in a connected graph, there exists at least one shortest path between the vertices such that either the number of edges that the path passes through (for unweighted graphs) or the sum of the weights of the edges (for weighted graphs) is minimized. The betweenness centrality for each vertex is the number of these shortest paths that pass through the vertex.

Centrality in network analysis is a measure of positionality in a network and characterizes the extent to which a point (node) has a high degree, quantified by the number of lines (edges) that connect that point (node) to others. Ignoring the directed of those lines (edges), this degree can be regarded as a measure of *local centrality*.

Corresponding to the in- or out- directions of network connections, centrality can be differentiated as *in*-centrality or *out*-centrality, to denote the origin of connections.

Cliques are subgroups of actors who are all directly connected to one another and no additional network member exists who is also connected to all members of the subgroup (Hawe, Webster, & Shiell, 2004).

Closeness Centrality scores each node based on their 'closeness' to all other nodes in the network. What it tells us: This measure calculates the shortest paths between all nodes, then assigns each node a score based on its sum of shortest paths.

Cohesion describes the interconnectedness of actors in a network via three common measures (Hawe, Webster, & Shiell, 2004):

Components are portions of the network in which all actors are connected, directly or indirectly, by at least one tie. By definition, each isolate is a separate component (Hawe, Webster, & Shiell, 2004). In the case of this study, each of the five stakeholder groups represents a component, as all members within each group are connected either directly or indirectly.

Degree in network analysis, is the number of nodes—which represent stakeholders or stakeholder groups in this dissertation—that are connected via directional lines (edges) that either emanate *from* or terminate *at* a point (node) in question. Degree is the measure of the number of lines (edges) that are connected to a point (node) in question without specification of those line's direction/origin.

Density is an elementary measure in network analysis; it represents the overall number of relational ties (lines or edges) divided by the total *possible* number of relational ties. As such, it represents the ratio of actual relationships to possibility relationships. Low-density networks have few links; high-density networks have many links.

Diameter of a network is calculated as the greatest number of possible steps between any pair of nodes. Diameter can also be thought of as the maximum number of degrees.

Distance between two actors in a network (or nodes in a graph) is calculated by summing the number of distinct ties (lines) that exist along the shortest route between them. This is the notion of ‘degrees of separation,’ an idea that gave rise to the ‘six degrees of Kevin Bacon’ that implies that by relation, Kevin Bacon—a very prolific actor—has essentially worked with everyone in Hollywood. By extension, the distance between any two people on earth is implied to be a maximum of six degrees.

Force-directed graphs represent a class of algorithms that render graphs in an aesthetically-pleasing, more interpretable way. The goal of this is to position the nodes of a graph two- or three-dimensional space so that all the edges are of more or less equal length with as few crossed edges as possible. The algorithm achieves this by assigning forces among the edges and node sets based on their relative positions, and then using these forces either to simulate the motion of the edges and nodes or to minimize their energy (Kobourov, 2012).

Graphs are visual representations of networks that depict actors as points (nodes) and the relational ties connecting those actors as lines (edges).

Homophily describes the extent to which actors form ties with similar versus dissimilar others. *Similarity* of actors can be defined by gender, race, age, occupation, educational achievement, status, values or any other salient characteristic (McPherson, Smith-Lovin, & Cook, 2001).

Indegree represents the number of total number of points (nodes) that direct lines (edges) toward the point (node) in question (Scott, 2017).

Outdegree represents total number of other points (nodes) to which the point (node) in question directs lines (edges) (Scott, 2017).

Reachability measures whether actors in a network are directly or indirectly related to all other actors in the network. An actor that is connected to no other actors is called an *isolate* as per Doreian (1974).

Relational ties link actors within a network. These ties can be informal (e.g. whether people in one organization know people in another organization) or formal (for example, whether one organization funds another). Actors can have multiple ties with other actors, a feature known as multiplexity (Hawe, Webster, & Shiell, 2004).

Sociograms are graphs that specifically depict social networks.

Sociometric stars are persons most highly chosen in social network analysis (Moreno, 1934) indicating their popularity; a term formalized by Bavelas, 1950.

Star Actors are those individuals in this study who are exhibit the highest centrality and degree scores and are thus poised to be influential in regard to zzzz

Subgroup measures show how a network can be partitioned.

Terms Related to the Bonneville Salt Flats

BSF is the abbreviation for 'Bonneville Salt Flats,' the living laboratory for this dissertation's research. Spread out across over 30,000 acres near the Utah-Nevada border, the BSF represents the accumulated mineral remnants Pleistocene Lake Bonneville that occupied much of present-day Utah and small parts of Idaho, and Nevada. The basin that held this vast inland sea was made possible by the spreading of the earth's crust in this region.

FED Cycle is an abbreviation for 'Flooding-Evaporation-Desiccation.' The FED cycle is the annual process of change at the Bonneville Salt Flats in response to the presence of—and later lack of—meteoric precipitation. Precipitation floods and dissolves the salt surface of the BSF, which becomes an inches-deep hyper-saline lake typically from October through May of each year. Following the cessation of regular seasonal precipitation (the 'F' for flooding), warming summer temperatures help drive moisture off the salt (the 'E' for evaporation); by late summer, the salt typically forms a thick crust that is baked hard by increasing summer temperatures (the 'D' for desiccation). It is during the and after the desiccation phase that land speed racing can safely be practiced. As autumn progresses, the BSF once again floods anew.

Land speed racing is a form of motorsport best known for its efforts to break the not only the absolute land speed record, but also speed records set in specific classes of motor vehicle type. Land speed racing began when the Southern California Timing Association first held meets for a variety of hot rodded (modified for speed) vehicles in the 1930s.

Racer(s) or Land Speed Racer(s) are terms used in this dissertation to refer to any individual member of the land speed racing community. The plural, 'racers' is herein used to refer to the collective group individual that comprise the land speed racing community. As one of the seven primary stakeholder groups, racers are numerous, well-connected, and share a decades-long presence at the Bonneville Salt Flats, where they "turn dollars into decibels" in pursuit of wheel-driven speed records on the salt.

Salt Crust is the terms for the halite crust at the Bonneville Salt Flats—as well as other such landscapes around the world—whose hardened surface is the stage for just about every recreational pursuit on this iconic landscape. The perennial halite surface at BSF has led to a unique history of land use with the extensive use of the landscape for automobile racing (Noeth, 2002). The crust is defined as the uppermost halite layer whose late-season thickness, hardness, and area accommodate pedestrian and vehicular travel. The total salt crust thickness is defined as the distance from the ground surface to the bottom of the saline minerals (gypsum and halite) and/or the top of the underlying fine-grained unit (the salt-clay boundary) (Bowen, Kipnis, & Pechmann, 2018).

(The) Salt Laydown Project was originally planned as a five-year cooperative experiment conducted by Bureau of Land Management's Salt Lake Field Office and the resident, lease-holding potash mining company from 1997 through 2002 (White 2002, 2004). Its objective was an attempt to return sequestered, potassium-depleted salt to the BSF salt crust through dissolution and pumping during winter wet seasons. The project was continued voluntarily by the mining company from 2003 through 2012 (White 2012). As of July 2019, a five-million-dollar appropriation became available through the

Utah State Legislature to fund this pumping endeavor with the purpose of restoring the historic thickness and extent of the BSF's halite crust. With an additional 45 million dollars from the federal government, the Salt Laydown Project will now extend through 2029.

Terms Related to Mental Models and Fuzzy Cognitive Maps

Adjacency Matrix is a square *matrix* used to represent a finite graph. The elements of the matrix indicate whether pairs of vertices are adjacent or not in the graph.

C is for "Cookie;" that's good enough for me (Monster, C. 1971).

Centrality Scores for an overall FCM indicate the overall perceived degree of dynamic influence within a system. Centrality score of individual variables represents the degree of relative importance of a system component to system operation.

Cognitive Maps are visual representations of mental models in graphic format (Shen, Tan, & Siau, 2017) that are useful tools for linking seemingly disparate concepts related to a key issue (Eden, Jones, & Sims,1983; Eden & Ackermann, 2001).

Complexity Scores are a measure of "expert views" of systems (Means 1985; Rouse and Morris 1985; Gray et al., 2012) and therefore it is assumed that the FCMs generated by individuals with deeper understanding of a domain will have higher complexity scores relative to others with less understanding.

Components represent concepts derived from mental modeling activities that are structural, semi-quantitative parts of fuzzy cognitive maps.

Concepts are the interconnected items identified in mental models that consist of both intangible ideas and physical/tangible objects or processes that can be both human-social or ecological/biophysical. When used in fuzzy cognitive mapping (FCM), concepts become **components** in a model.

Density is an elementary measure in network analysis; it represents the overall number of relational ties (lines or edges) divided by the total *possible* number of relational ties. As such, it represents the ratio of actual relationships to possibility relationships. Low-density networks have few links; high-density networks have many links.

Density scores are associated with the perceived number of options that are possible to influence change within a system as the relative number of connections per node indicate the potential to alter how a given system functions.

Hierarchy Scores indicate the degree of democratic thinking (McDonald 1983) and may indicate whether individuals view the structure of a system as top-down or whether influence is distributed evenly across the components in a more democratic nature.

Matrix Algebra is generalized algebra that deals with the operations and relations among *matrices*, which are collections of numbers ordered by rows and columns.

Mental Models are cognitive representations of external reality (Jones, et al. 2011) that are valuable for understanding a complex world (Johnson-Laird, 1983).

Number of Connections in a mental model indicates increased or decreased structural relationships between system components or the degree of connectedness between components that influence system function and emergent properties (Gray, Zanre, & Gray, 2014).

Variables in Fuzzy Cognitive Maps are the number of transmitting, receiving, or ordinary variables and the complexity scores indicate whether the system is viewed as largely comprised of driving components or whether the outcomes of driving forces are considered (i.e. that some components are only influenced). These include:

1. **Driving Variables** that are independent variables that drive variability of dependent (receiving) variables,
2. **Receiving Variables**, which are dependent variables upon which independent (driving) variables influence variability, and
3. **Ordinary Variables** that perform both driving and receiving roles in fuzzy cognitive maps.

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Appendix 2: Initial BSF Stakeholder Interview Script

Used for preliminary SNA list and Cognitive Mapping elements

Study 1: Social Network Analysis (Spring, 2017)

Study Risks and Confidentiality

The risks of this study are minimal. Your involvement in this research project is limited to the sharing of your contact information, discussing your involvement with the Bonneville Salt Flats, your social contacts related to the BSF, and the issues you think are part of the systems that shapes the future of the BSF

In order to protect confidentiality of records and data pertaining to participants, all data will be stored in encrypted files, on password-protected computers, in locked offices. If at any time you have concerns about risks or confidentiality, please contact the study coordinators and they will assist you however they can.

Interview Text:

Hello. My name is _____________, and I'm calling from the University of Utah Department of Parks, Recreation, and Tourism. We are currently embarking on an interdisciplinary research project to learn more about the people who see themselves as having a stake in the future of the Bonneville Salt Flats and the ways in which the salt flats are changing over time. Specifically, we are trying to understand how often and to what degree the key people involved with the BSFs interact with each other. This helps us understand where effective relationships might be occurring and where missed opportunities may exist. We also want to understand how these key people view and think about the BSF. Given your involvement in the BSF, and topical expertise, we have identified you as potential participant in this study.

Before you decide if you would like to participate in this study, it is important for you to understand how you will be involved in the research and what is expected. The rest of this first conversation will take 15 minutes or so.

Are you interested in helping out?

If "No,"

Well, I'd like to thank you for your time so far today. Can you refer me to any other people you interact with in regard to the Bonneville Salt Flats who might be interested in participating in this study?

If "Yes," proceed:

The study will hopefully improve our understanding of the social and natural systems that are intertwined at BSF. Humans and the environment are clearly tightly interconnected in a shared system at BSF, but the forces between the connections are not fully understood. As a result, it is difficult to explain the changes that take place at the Bonneville Salt Flats.

Social Network

While there are many parts to this study, there are two that we would like your help with. The first is to help us build a 'social network diagram' that identifies the people who play key roles either managing the BSF or using of the BSF for sport, recreation, art, industry, or research. We're hoping to observe relevant changes among the key players' social connections over the next few years. During this part of the study, we will ask you to identify the other BSF-oriented individuals that you interact with, how often, and what the significance of those interactions are. We will not ask you details about your interactions, such as topics discussed or outcomes of your conversations or interactions. After our discussion today, your time commitment for this part of the study would be approximately 15 minutes every quarter fulfilled by completing a brief online questionnaire that you would receive by email.

Cognitive Mapping

The second part of the study is a little more involved. For each person identified in the social network, we would like to understand what they believe are the issues, processes, and phenomena that shape the BSF, as well as how confident they are that about the accuracy or relevance of each of those things.

This portion requires a larger time commitment. We are asking for a commitment of **one hour up front** for training either online or in-person, followed by a **three-hour session in early April** to work with a focus group of approximately 10 people that shares the same primary relationship to the Bonneville Salt Flats. These focus groups can take place at the University of Utah or the stakeholder group's preferred meeting place, or you can join electronically via Skype. After that, the quarterly time commitment will be **about an**

hour to update the data you previously provided to reflect changes in your ideas about the BSF or experiences with the BSF.

So, all in all we're looking at **a total of about five hours per year for four years, with about four hours of training and group work up front**. We could really use your input as someone with a vested interest in the future of the Bonneville Salt Flats.

Is this project still something you are willing to participate in?

If "Yes,"

Can I get additional contact information so that I can reach out to you with the next steps?

If "Yes,"

Thanks so much! → *Write these down*

Feel free to contact me if you change your mind or have any questions. My phone number is ______, and you can email me at ___________.

Have a great day!

-OR-

In our initial email, we included a social network example that visually represents who interacts with who in a social network. We are interested in constructing a similar model for the BSF. Who are 5-10 people that you interact with the most in regard to the BSF? Interactions include in-person or phone conversations, emails, text messages, and social media messages.

In the project proposal attached to the initial email, we also included an example of a ‘model’ created by stakeholders detailing the specific elements that they thought were most influential in the commercial fishing industry on the east coast. As you probably noticed in that model, some of the elements are biophysical, social, meteorological, managerial, and political. We want to construct a similar model for the BSF but with its own unique elements and relationships. In your opinion what are some of the elements at the Bonneville Salt Flats are the most influential?

Can you think of any other people who might be potential participants? → *Write these down*

Thanks so much! Feel free to contact me if you change your mind or have any questions. My phone number is ______, and you can email me at ___________.

Have a great day!

Appendix 3: Racing Event Interview Script

Hi, my name is ________________ and I am a student (or researcher) from the University of Utah. I am helping a group of professors with a study to understand how people use the Salt Flats and their opinions about the Salt Flats. As part of this study, I am asking racers and others at the event today a few questions. We are not asking for any names, addresses, emails, or other personal information. We simply want to hear people's opinions. Do you have ten to fifteen minutes to speak with me today?

If yes: Thank you. As part of this process we often audio record the conversations so that we can listen to the conversation again and make notes. We do not share the audio recording with anyone and after the study the recording is destroyed. Do you mind if I record our conversation today?

If no: Thank you for your time. Have a good day.

Interview questions

1. Tell me a little about yourself, such as why you are here today and how long you have been coming to the Salt Flats.

2. When was your last visit or experience at the Salt Flats?

3. Is this a typical visit or experience for you at the Salt Flats? If not, how is this visit different?

4. One of the elements that we are trying to understand is how people view the Bonneville Salt Flats. In your opinion, during the last 30 years, has the Bonneville Salt Flats changed?
    a. If so, how?
        i. Are there any other ways it has changed?
        ii. Are those changes good, bad, or neither?
        iii. In your opinion, what has caused those changes?
        iv. So, are those changes preventable or not?

    b. If not, how have the Salt Flats been able to remain stable?
        i. Is stability good, bad, or neither?

5. How confident or certain are you regarding these perspectives?

6. You seem to have a lot of information about the Salt Flats. I know that sometimes people read a lot, or watch documentaries, or go to meetings, or learn by lived experiences. How have you gained your knowledge or information?

7. Is there anything that you are uncertain about regarding how the Salt Flats have or have not changed?

    a. Specifically, what would you like to know about that?

8. Is there anything that we have not discussed today that you want me to know?
9. Thank you for your time

Appendix 4: Pilot Study Perceptions of Change Questionnaire (Summer, 2017)

BONNEVILLE SALT FLATS
VISITOR USE SURVEY 2017 (POC)

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

To be completed by field staff:

ID ________ Date ________________

Location ___________ Field staff____________

SECTION 1: YOUR VISITS TO THE BONNEVILLE SALT FLATS

1. Including today, how many times have you visited the Bonneville Salt Flats during…
   a. The last week (7 days)? ____________ # of times
   b. The last month (30 days)? ____________ # of times
   c. The last year (12 months)? __________ # of times

2. Including today, on average, how much time do you spend during each visit to the Bonneville Salt Flats

   ____________ # of hours OR ___________ # of days

3. What are the approximate year(s) of your **PREVIOUS VISITS to** the Bonneville Salt Flats?
   (For example: 1992, 1997, 2003, etc.)

   ____

4. Including today, approximately how many total times (all years) have you visited the Bonneville Salt Flats?

   ___________ # of total visits

SECTION 2: YOUR OPINIONS ABOUT THE BONNEVILLE SALT FLATS

5. Below is a list of resources and processes that may or may not have changed during the last 30 years at the Bonneville Salt Flats. We are interested to know your opinion about change related to these resources or processes. Please select the box that indicates how much you think each resource or process has increased, decreased, or not changed during the last 30 years at the Bonneville Salt Flats. *(select one box for each row)*

During the last 30 years at the Bonneville Salt Flats…	Decreased a lot	Decreased	Slightly decreased	Neither increased or decreased	Slightly increased	Increased	Increased a lot	Don’t know
Salt								
Hardness of the surface layer of salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of vegetation	☐	☐	☐	☐	☐	☐	☐	☐
Amount of ground (surface area) covered by salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of standing water during the wet season	☐	☐	☐	☐	☐	☐	☐	☐
Length of time that standing water is present	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt in the ground water	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt extracted from the area	☐	☐	☐	☐	☐	☐	☐	☐
Amount of sediment (dirt, dust, etc.) on the salt	☐	☐	☐	☐	☐	☐	☐	☐
Thickness of the salt	☐	☐	☐	☐	☐	☐	☐	☐
Weather								
Annual average temperature	☐	☐	☐	☐	☐	☐	☐	☐
Temperature during August and September	☐	☐	☐	☐	☐	☐	☐	☐
Amount of annual precipitation	☐	☐	☐	☐	☐	☐	☐	☐
Inconsistency of precipitation across seasons	☐	☐	☐	☐	☐	☐	☐	☐
People								
The number of people racing	☐	☐	☐	☐	☐	☐	☐	☐
The number of people attending events	☐	☐	☐	☐	☐	☐	☐	☐
Amount of money spent during an event	☐	☐	☐	☐	☐	☐	☐	☐

6. In your opinion, are there any other processes or resources that are not listed in Question 5 that have changed at the Bonneville Salt Flats during the previous 30 years?

☐ No

☐ Yes, please specify the resource or process and how it has changed

____

____

7. Using the same list from the Question 5 and 6, please use Column A to select the <u>top five processes or resources</u> that have changed the most during the last 30 years at the Bonneville Salt Flats. Next, use Column B to select the <u>one resource or process</u> that has changed the most. **If you answered "no" to Question 6 and "don't know" in all the rows in Question 5, then please skip to Question #9.**

	Column A **Please select the <u>top five</u> resources or processes that have change the most** *(select five boxes)*	**Column B** **Please select <u>one</u> resource or process that has changed the most** *(select one)*
<u>Salt</u>		
Hardness of the surface layer of salt	☐	☐
Amount of vegetation	☐	☐
Amount of ground (surface area) covered by salt	☐	☐
Amount of standing water during the wet season	☐	☐
Length of time that standing water is present	☐	☐
Amount of salt in the ground water	☐	☐
Amount of salt extracted from the area	☐	☐
Amount of sediment (dirt, dust, etc.) on the salt	☐	☐
Thickness of the salt	☐	☐
<u>Weather</u>		
Annual average temperature	☐	☐
Temperature during August and September	☐	☐
Amount of annual precipitation	☐	☐
Inconsistency of precipitation across seasons	☐	☐
<u>People</u>		
The number of people racing	☐	☐
The number of people attending events	☐	☐
Amount of money spent during an event	☐	☐
<u>Other</u>		
Other (from Question #6), please specify___________________________	☐	☐

8. In your opinion, what is causing changes in the one process or resource that you identified in Column B in the previous question (#7)?

____

____

____

____

9. How much do you expect resources and processes at the Bonneville Salt Flats to change in the next 30 years? *(select one box)*

Not at all			**Moderate amount**			**A lot**	**Don't know**
☐	☐	☐	☐	☐	☐	☐	☐

10. Sometimes people are concerned about changes in processes and resources at the Bonneville Salt Flats. However, people differ in the consequences that concern them most. Please rate your agreement to the following statement using the scale from "completely disagree" to "completely agree." *(select one box for each row)*

"I am <u>extremely</u> concerned about changes at the Bonneville Salt Flats because of the consequences for …"

	Completely disagree	**Mostly disagree**	**Slightly disagree**	**Slightly agree**	**Mostly agree**	**Completely agree**
… animals	☐	☐	☐	☐	☐	☐
… birds	☐	☐	☐	☐	☐	☐
… all children	☐	☐	☐	☐	☐	☐
...future generations	☐	☐	☐	☐	☐	☐
… my community	☐	☐	☐	☐	☐	☐
… me	☐	☐	☐	☐	☐	☐
… all people	☐	☐	☐	☐	☐	☐
… my future	☐	☐	☐	☐	☐	☐
… my health	☐	☐	☐	☐	☐	☐
… my lifestyle	☐	☐	☐	☐	☐	☐
… plants	☐	☐	☐	☐	☐	☐
… marine life	☐	☐	☐	☐	☐	☐

SECTION 3: ABOUT YOU

11. Are you affiliated with a team that races at the Bonneville Salt Flats? ☐ No ☐ Yes

12. What is your country of residence? _____________________

a. If you answered United States, what is your zip code? ____________

13. What year were you born? ________________

14. What is your gender? *(select one)* ☐ Male ☐ Female ☐ Other

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

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

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

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

17. Which category best describes your total household income in U.S. dollars during 2016 before taxes? *(select one)*

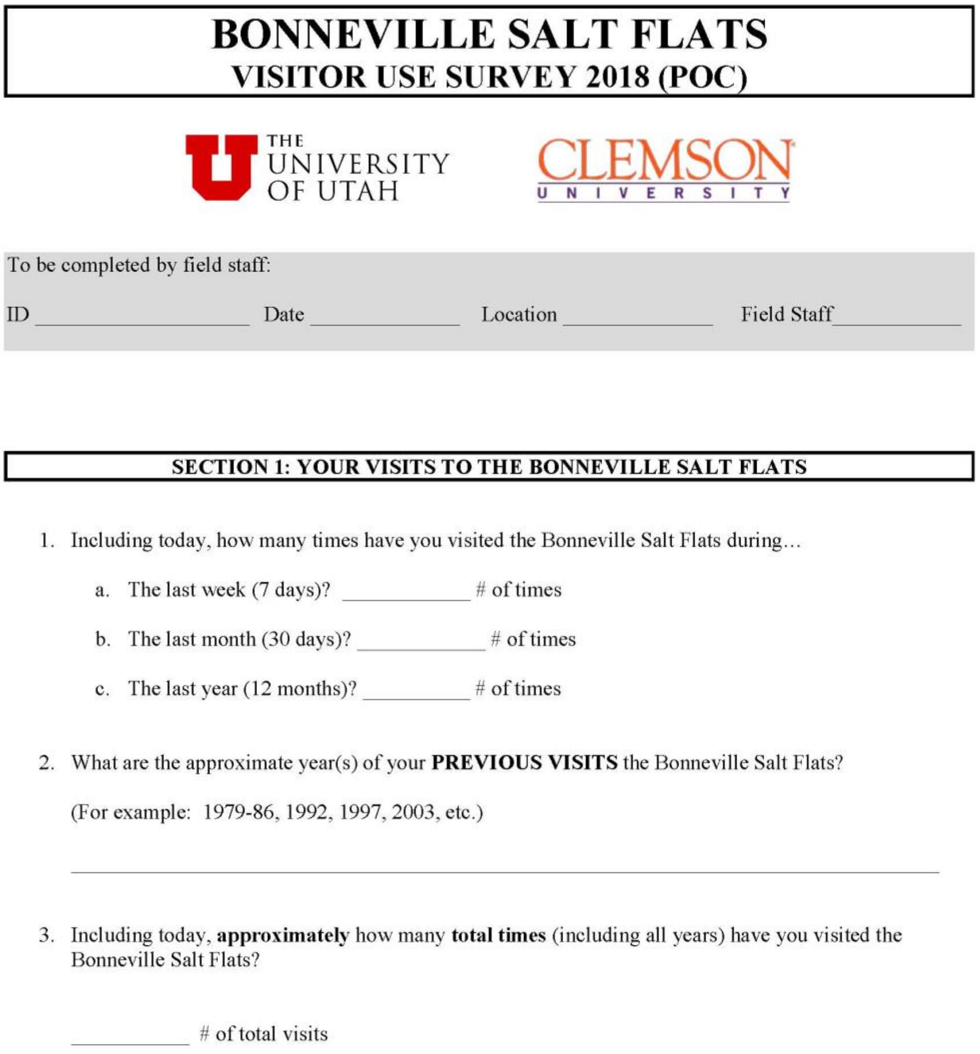
☐ Less than $24,999
☐ $25,000 to $34,999
☐ $35,000 to $49,999
☐ $50,000 to $74,999
☐ $75,000 to $99,999
☐ $100,000 to $149,999
☐ $150,000 to $199,999
☐ $200,000 or more
☐ Do not wish to answer

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

If you have any question or concern, please contact:

Matthew T.J. Brownlee, Ph.D. at matthew.brownlee@hsc.utah.edu

Appendix 5: Final Perceptions of Change Questionnaire (Summer, 2018)



BONNEVILLE SALT FLATS
VISITOR USE SURVEY 2018 (POC)

THE UNIVERSITY OF UTAH
CLEMSON UNIVERSITY

To be completed by field staff:

ID ____________________ Date ______________ Location ______________ Field Staff____________

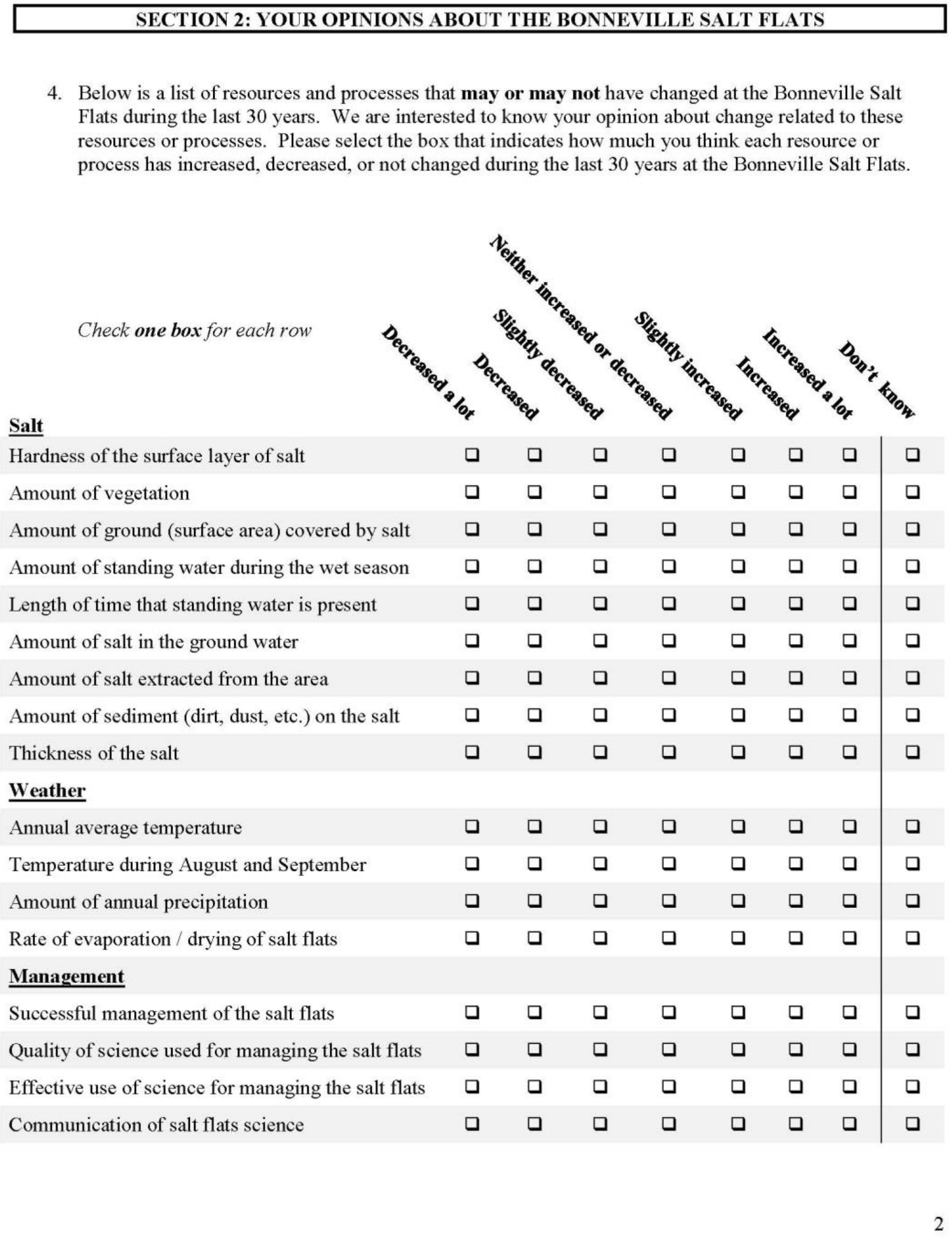
SECTION 1: YOUR VISITS TO THE BONNEVILLE SALT FLATS

1. Including today, how many times have you visited the Bonneville Salt Flats during…
    a. The last week (7 days)? ____________ # of times
    b. The last month (30 days)? ____________ # of times
    c. The last year (12 months)? __________ # of times
2. What are the approximate year(s) of your **PREVIOUS VISITS** the Bonneville Salt Flats?

    (For example: 1979-86, 1992, 1997, 2003, etc.)

    ____
3. Including today, **approximately** how many **total times** (including all years) have you visited the Bonneville Salt Flats?

    ___________ # of total visits



SECTION 2: YOUR OPINIONS ABOUT THE BONNEVILLE SALT FLATS

4. Below is a list of resources and processes that **may or may not** have changed at the Bonneville Salt Flats during the last 30 years. We are interested to know your opinion about change related to these resources or processes. Please select the box that indicates how much you think each resource or process has increased, decreased, or not changed during the last 30 years at the Bonneville Salt Flats.

Check ***one box*** *for each row*

	Decreased a lot	**Decreased**	**Slightly decreased**	**Neither increased or decreased**	**Slightly increased**	**Increased**	**Increased a lot**	**Don't know**
Salt								
Hardness of the surface layer of salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of vegetation	☐	☐	☐	☐	☐	☐	☐	☐
Amount of ground (surface area) covered by salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of standing water during the wet season	☐	☐	☐	☐	☐	☐	☐	☐
Length of time that standing water is present	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt in the ground water	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt extracted from the area	☐	☐	☐	☐	☐	☐	☐	☐
Amount of sediment (dirt, dust, etc.) on the salt	☐	☐	☐	☐	☐	☐	☐	☐
Thickness of the salt	☐	☐	☐	☐	☐	☐	☐	☐
Weather								
Annual average temperature	☐	☐	☐	☐	☐	☐	☐	☐
Temperature during August and September	☐	☐	☐	☐	☐	☐	☐	☐
Amount of annual precipitation	☐	☐	☐	☐	☐	☐	☐	☐
Rate of evaporation / drying of salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Management								
Successful management of the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Quality of science used for managing the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Effective use of science for managing the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Communication of salt flats science	☐	☐	☐	☐	☐	☐	☐	☐

SECTION 2: YOUR OPINIONS ABOUT THE BONNEVILLE SALT FLATS (continued)

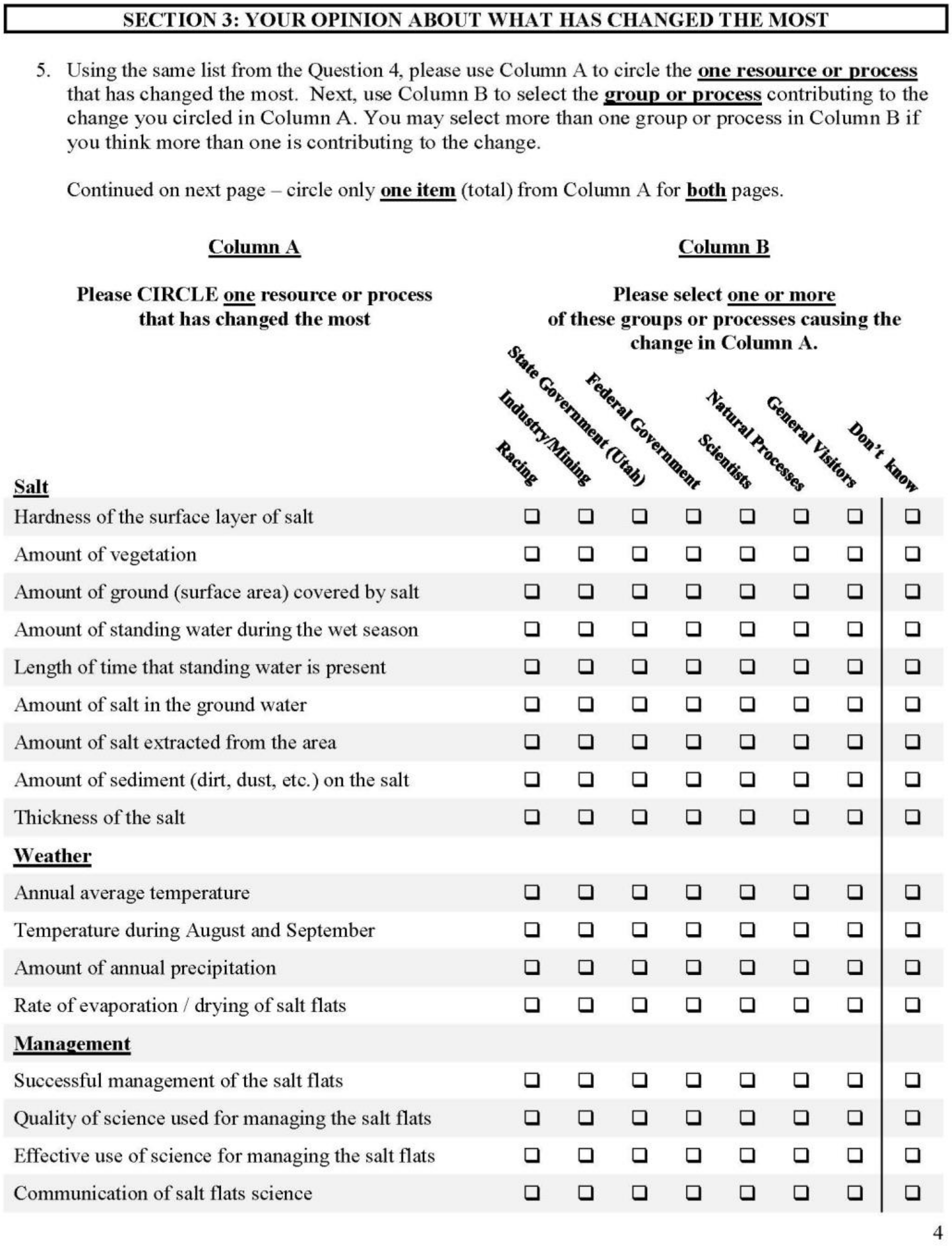
(Continued from previous page)

Please select the box that indicates how much you think each resource or process has increased, decreased, or not changed during the last 30 years at the Bonneville Salt Flats.

*Check **one box** for each row*

People	Decreased a lot	Decreased	Slightly decreased	Neither increased or decreased	Slightly increased	Increased	Increased a lot	Don't know
The number of people attending racing events	☐	☐	☐	☐	☐	☐	☐	☐
The number of teams racing at events	☐	☐	☐	☐	☐	☐	☐	☐
The size of racing teams	☐	☐	☐	☐	☐	☐	☐	☐
Average experience level of racers	☐	☐	☐	☐	☐	☐	☐	☐
Average racers' familiarity with the salt	☐	☐	☐	☐	☐	☐	☐	☐
Sense of community among racers	☐	☐	☐	☐	☐	☐	☐	☐
Media coverage of racing events	☐	☐	☐	☐	☐	☐	☐	☐
Number of non-racers driving on salt during wet conditions	☐	☐	☐	☐	☐	☐	☐	☐
Number of non-racers driving on salt during dry conditions	☐	☐	☐	☐	☐	☐	☐	☐
Amount of money spent by racers	☐	☐	☐	☐	☐	☐	☐	☐
Amount of money spent by spectators	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from Wendover community	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from the State of Utah	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from the federal government	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from non-profits	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from volunteers	☐	☐	☐	☐	☐	☐	☐	☐
Quality of communication **within** the racing community	☐	☐	☐	☐	☐	☐	☐	☐
Frequency of communication **within** racing community	☐	☐	☐	☐	☐	☐	☐	☐
Quality of communication **between** racing community & the public	☐	☐	☐	☐	☐	☐	☐	☐
Frequency of communication **between** racing community & public	☐	☐	☐	☐	☐	☐	☐	☐

3



SECTION 3: YOUR OPINION ABOUT WHAT HAS CHANGED THE MOST

5. Using the same list from the Question 4, please use Column A to circle the <u>**one resource or process**</u> that has changed the most. Next, use Column B to select the <u>**group or process**</u> contributing to the change you circled in Column A. You may select more than one group or process in Column B if you think more than one is contributing to the change.

Continued on next page – circle only <u>**one item**</u> (total) from Column A for <u>**both**</u> pages.

Column A **Please CIRCLE one resource or process that has changed the most**	**Column B** — **Please select one or more of these groups or processes causing the change in Column A.**							
	Racing	**Industry/Mining**	**State Government (Utah)**	**Federal Government**	**Scientists**	**Natural Processes**	**General Visitors**	**Don't know**
Salt								
Hardness of the surface layer of salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of vegetation	☐	☐	☐	☐	☐	☐	☐	☐
Amount of ground (surface area) covered by salt	☐	☐	☐	☐	☐	☐	☐	☐
Amount of standing water during the wet season	☐	☐	☐	☐	☐	☐	☐	☐
Length of time that standing water is present	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt in the ground water	☐	☐	☐	☐	☐	☐	☐	☐
Amount of salt extracted from the area	☐	☐	☐	☐	☐	☐	☐	☐
Amount of sediment (dirt, dust, etc.) on the salt	☐	☐	☐	☐	☐	☐	☐	☐
Thickness of the salt	☐	☐	☐	☐	☐	☐	☐	☐
Weather								
Annual average temperature	☐	☐	☐	☐	☐	☐	☐	☐
Temperature during August and September	☐	☐	☐	☐	☐	☐	☐	☐
Amount of annual precipitation	☐	☐	☐	☐	☐	☐	☐	☐
Rate of evaporation / drying of salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Management								
Successful management of the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Quality of science used for managing the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Effective use of science for managing the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Communication of salt flats science	☐	☐	☐	☐	☐	☐	☐	☐

4

Continued from previous page – circle only **one item** (total) in Column A for **both** pages.

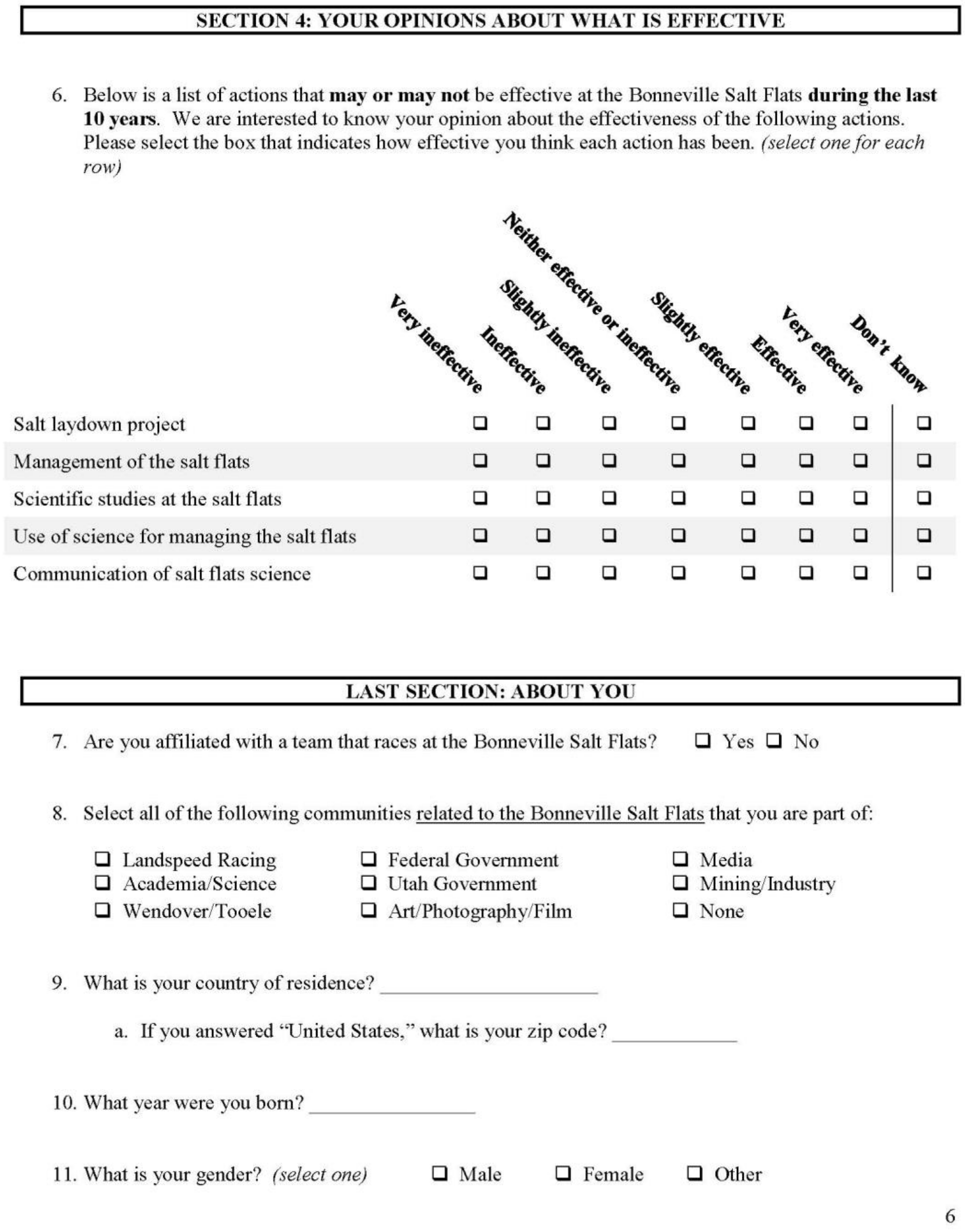
Column A

Please CIRCLE one resource or process that has changed the most

Column B

Please select one or more of these groups or processes causing the change in Column A.

People	**Racing**	**Industry/Mining**	**State Government (Utah)**	**Federal Government**	**Scientists**	**Natural Processes**	**General Visitors**	**Don't know**
The number of people attending racing events	☐	☐	☐	☐	☐	☐	☐	☐
The number of teams racing at events	☐	☐	☐	☐	☐	☐	☐	☐
The size of racing teams	☐	☐	☐	☐	☐	☐	☐	☐
Average experience level of racers	☐	☐	☐	☐	☐	☐	☐	☐
Average racers' familiarity with the salt	☐	☐	☐	☐	☐	☐	☐	☐
Sense of community among racers	☐	☐	☐	☐	☐	☐	☐	☐
Media coverage of racing events	☐	☐	☐	☐	☐	☐	☐	☐
Number of non-racers driving on salt during wet conditions	☐	☐	☐	☐	☐	☐	☐	☐
Number of non-racers driving on salt during dry conditions	☐	☐	☐	☐	☐	☐	☐	☐
Amount of money spent by racers	☐	☐	☐	☐	☐	☐	☐	☐
Amount of money spent by spectators	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from Wendover community	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from the State of Utah	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from the federal government	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from non-profits	☐	☐	☐	☐	☐	☐	☐	☐
Support for salt flats from volunteers	☐	☐	☐	☐	☐	☐	☐	☐
Quality of communication **within** the racing community	☐	☐	☐	☐	☐	☐	☐	☐
Frequency of communication **within** racing community	☐	☐	☐	☐	☐	☐	☐	☐
Quality of communication **between** racing community & the public	☐	☐	☐	☐	☐	☐	☐	☐
Frequency of communication **between** racing community & public	☐	☐	☐	☐	☐	☐	☐	☐



SECTION 4: YOUR OPINIONS ABOUT WHAT IS EFFECTIVE

6. Below is a list of actions that **may or may not** be effective at the Bonneville Salt Flats **during the last 10 years**. We are interested to know your opinion about the effectiveness of the following actions. Please select the box that indicates how effective you think each action has been. *(select one for each row)*

	Very ineffective	**Ineffective**	**Slightly ineffective**	**Neither effective or ineffective**	**Slightly effective**	**Effective**	**Very effective**	**Don't know**
Salt laydown project	☐	☐	☐	☐	☐	☐	☐	☐
Management of the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Scientific studies at the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Use of science for managing the salt flats	☐	☐	☐	☐	☐	☐	☐	☐
Communication of salt flats science	☐	☐	☐	☐	☐	☐	☐	☐

LAST SECTION: ABOUT YOU

7. Are you affiliated with a team that races at the Bonneville Salt Flats? ☐ Yes ☐ No

8. Select all of the following communities related to the Bonneville Salt Flats that you are part of:

- ☐ Landspeed Racing
- ☐ Academia/Science
- ☐ Wendover/Tooele
- ☐ Federal Government
- ☐ Utah Government
- ☐ Art/Photography/Film
- ☐ Media
- ☐ Mining/Industry
- ☐ None

9. What is your country of residence? ______________________

   a. If you answered "United States," what is your zip code? ____________

10. What year were you born? ________________

11. What is your gender? *(select one)* ☐ Male ☐ Female ☐ Other

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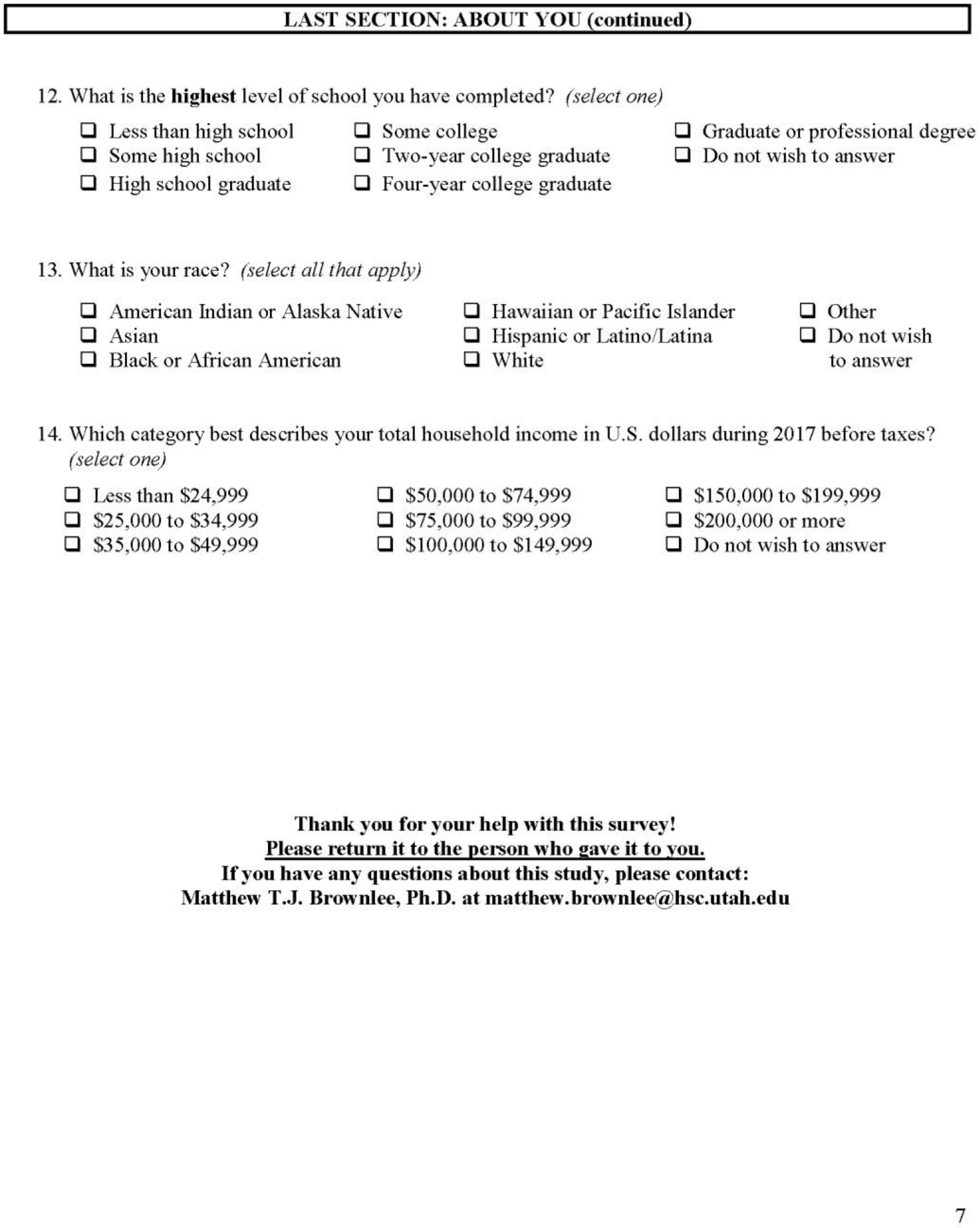


LAST SECTION: ABOUT YOU (continued)

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

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

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

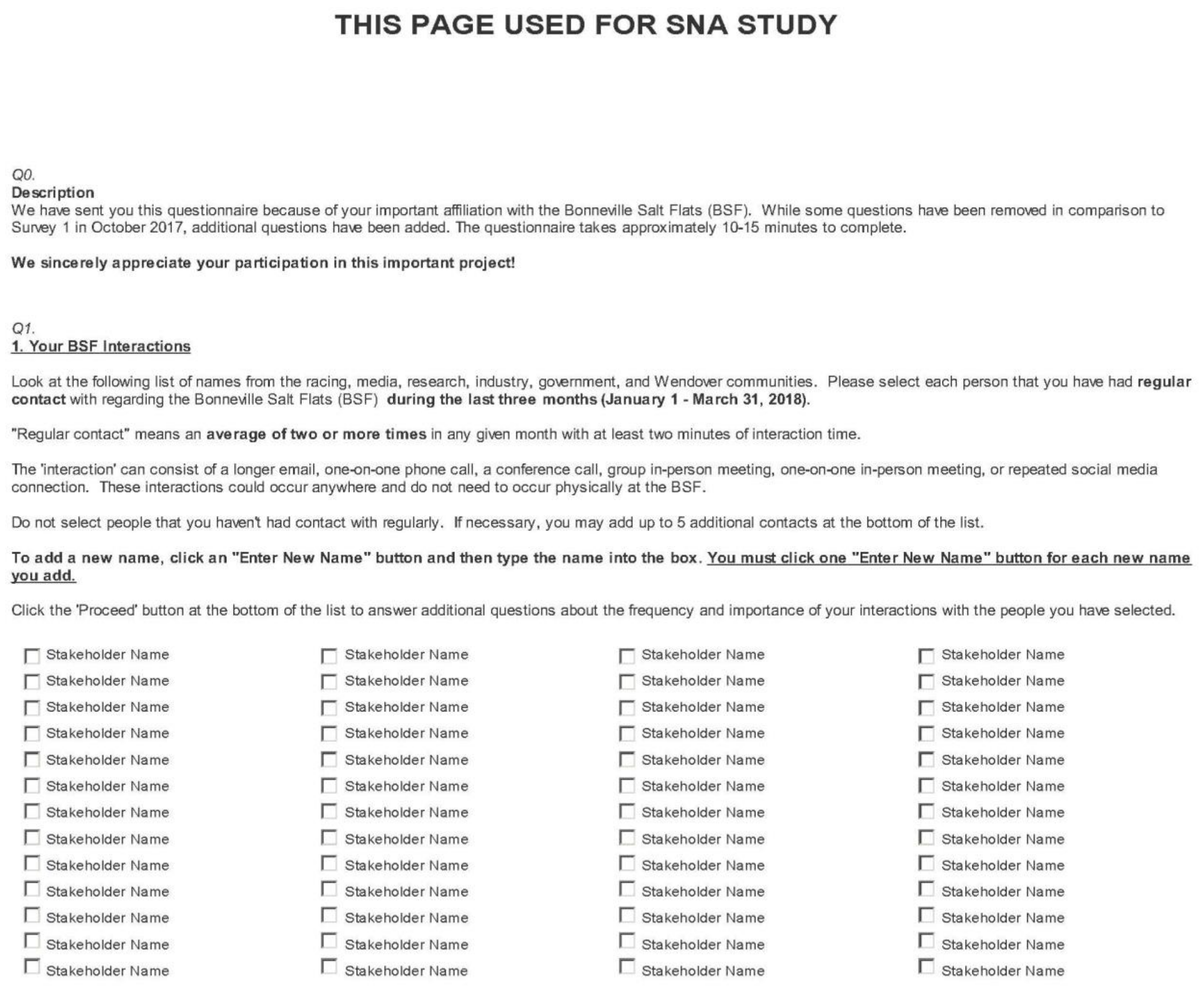
☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Hawaiian or Pacific Islander
☐ Hispanic or Latino/Latina
☐ White
☐ Other
☐ Do not wish to answer

14. Which category best describes your total household income in U.S. dollars during 2017 before taxes? *(select one)*

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

Thank you for your help with this survey!
<u>Please return it to the person who gave it to you.</u>
If you have any questions about this study, please contact:
Matthew T.J. Brownlee, Ph.D. at matthew.brownlee@hsc.utah.edu

Appendix 6: Social Network Analysis Questionnaire



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Q0.
Description
We have sent you this questionnaire because of your important affiliation with the Bonneville Salt Flats (BSF). While some questions have been removed in comparison to Survey 1 in October 2017, additional questions have been added. The questionnaire takes approximately 10-15 minutes to complete.

We sincerely appreciate your participation in this important project!

Q1.
1. Your BSF Interactions

Look at the following list of names from the racing, media, research, industry, government, and Wendover communities. Please select each person that you have had **regular contact** with regarding the Bonneville Salt Flats (BSF) **during the last three months (January 1 - March 31, 2018).**

"Regular contact" means an **average of two or more times** in any given month with at least two minutes of interaction time.

The 'interaction' can consist of a longer email, one-on-one phone call, a conference call, group in-person meeting, one-on-one in-person meeting, or repeated social media connection. These interactions could occur anywhere and do not need to occur physically at the BSF.

Do not select people that you haven't had contact with regularly. If necessary, you may add up to 5 additional contacts at the bottom of the list.

To add a new name, click an "Enter New Name" button and then type the name into the box. You must click one "Enter New Name" button for each new name you add.

Click the 'Proceed' button at the bottom of the list to answer additional questions about the frequency and importance of your interactions with the people you have selected.

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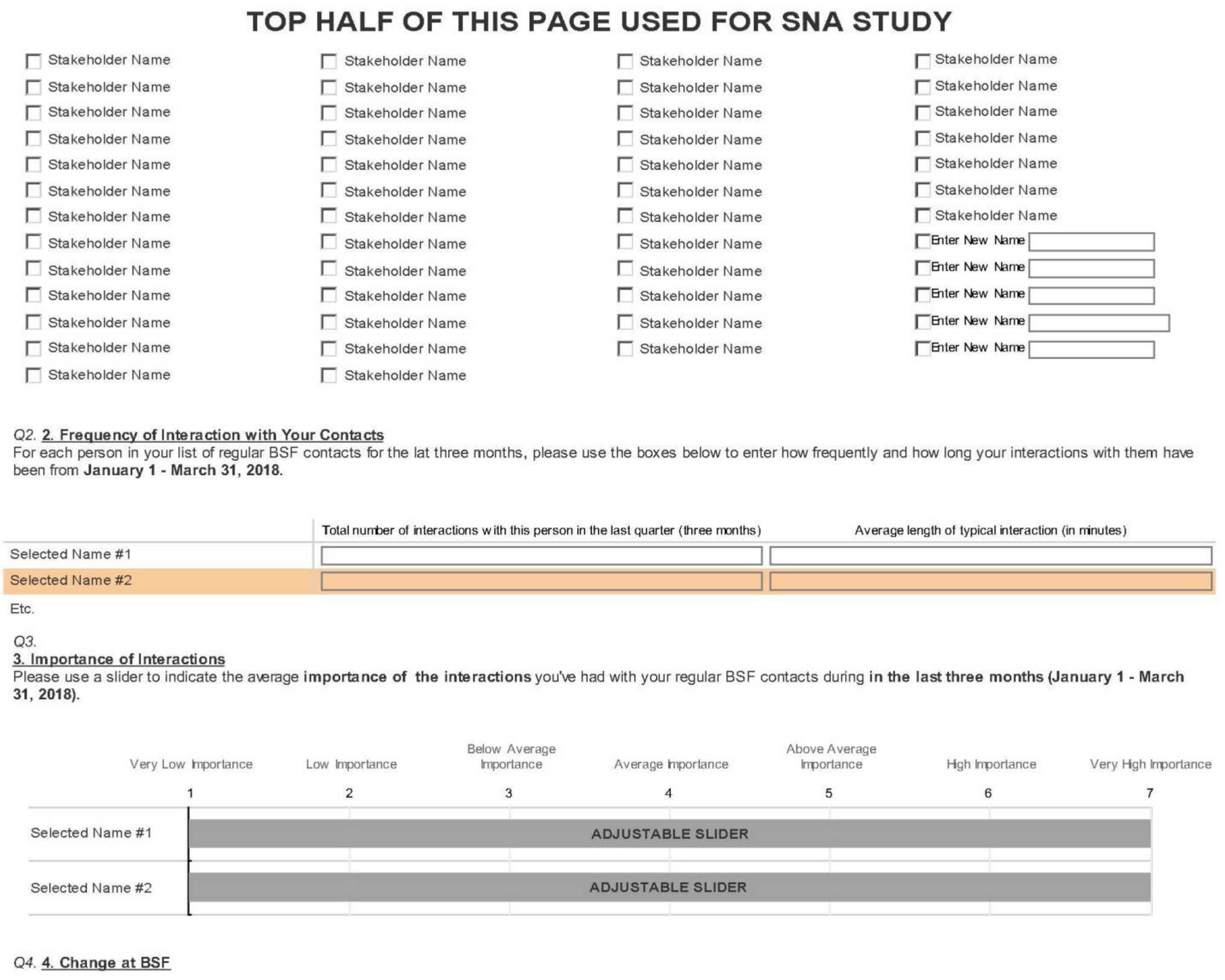

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Q2. **2. Frequency of Interaction with Your Contacts**
For each person in your list of regular BSF contacts for the lat three months, please use the boxes below to enter how frequently and how long your interactions with them have been from **January 1 - March 31, 2018**.

	Total number of interactions with this person in the last quarter (three months)	Average length of typical interaction (in minutes)
Selected Name #1		
Selected Name #2		

Etc.

Q3.
3. Importance of Interactions
Please use a slider to indicate the average **importance of the interactions** you've had with your regular BSF contacts during **in the last three months (January 1 - March 31, 2018)**.

	Very Low Importance 1	Low Importance 2	Below Average Importance 3	Average Importance 4	Above Average Importance 5	High Importance 6	Very High Importance 7
Selected Name #1	ADJUSTABLE SLIDER						
Selected Name #2	ADJUSTABLE SLIDER						

Q4. **4. Change at BSF**

Appendix 7. Results of Social Network Analysis (Email #1)

Dear __________,

My name is Michael Blacketer, and I would like to sincerely thank you for your past participation in one or more of the 2017-2018 surveys about the social network of Bonneville Salt Flats (BSF) stakeholders. I have finished analyzing the data from those surveys, and you have emerged as one of twelve individuals who are integral to the communication structure of BSF social network.

This means two things:
1) that you reported frequent important interactions with many people regarding the BSF over the course of the data collection year, and
2) numerous people also reported numerous and/or important interactions with you.

Because of these findings, I think you could provide a valuable perspective regarding my research related to BSF stakeholders. I would like to speak to you about that by phone one last time, which would take approximately one hour or less.

If you are willing to assist me in this last brief phase of my data collection, please look at my availability below and **select three** one-hour time periods that match your availability. If none of the times below work for you, please feel free make a suggestion and I will do anything I can to accommodate your availability.

Please reply with your three timeslot choices and the best number to reach you. Following your response, I will confirm the time and date, as well as provide you with some simple data to review to prepare our future phone conversation.

My current availability is as follows (as I am currently on the east coast, all times are on Eastern Standard Time): *(enter relevant times and dates)*

Thank you in advance for your help, and please let me know if you have any questions. The input you provide for this last part of the study is incredibly valuable both to me and the rest of the BSF research team. I look forward to hearing from you!

Sincerely,
Michael P. Blacketer
Graduate Research Assistant
Clemson University Park Solutions Lab
http://www.parksolutionslab.com/

Appendix 8. Results of Social Network Analysis and Initiation of Cognitive Mapping Exercise (Email #2)

Hi, ________,

Thank you so much for agreeing to speak with me about my Bonneville Salt Flats research! Your help is greatly appreciated and extremely valuable for both my individual efforts as well as the BSF team's overall research.

I will call you on at EST/ MST.

Although I will explain the research in more detail during our phone call, please spend a few minutes before that conversation looking over the information below to familiarize yourself with it. Please let me know if you have any questions about the data.

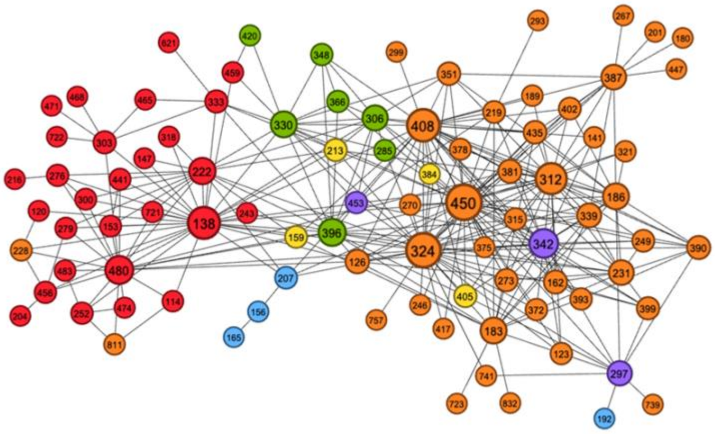
Part 1: Social Network Analysis of Bonneville Stakeholders

The quarterly BSF social interaction data collected in 2017 and 2018 is displayed in the social network diagram, or *sociogram,* below (Figure 1). You are identifiable as #213 (in yellow) near the center of the diagram. The second diagram (Figure 2) highlights you, specifically, and shows any people that reported interacting with you.

Each of the circles is colored by stakeholder group and contains a number to anonymously identify participants and/or who they reported interacting with over the course of the year. These people are connected by the lines between circles. The larger circles represent individuals that are a) connected to the most people, b) were participants in more numerous reported interactions, and therefore c) potentially influential for making and maintaining other connections in the network.

During our phone call, I will ask you about a) your general thoughts about this diagram as well as b) some changes in communication patterns that I measured from during the data collection period. I would simply like your opinion to help understand the findings.

Read the above at the beginning of phone call.
Take Notes Here:



Color Key for Sociogram
Blue = Media Community
Red = Academic Community
Orange = Racing Community
Purple = Wendover/Toole Community
Yellow = Mining/Industry Community
Green = Resource/Land Management Community

Figure 1. Example of a social network diagram (sociogram). Each number in the Social Network represents an individual person in a group.

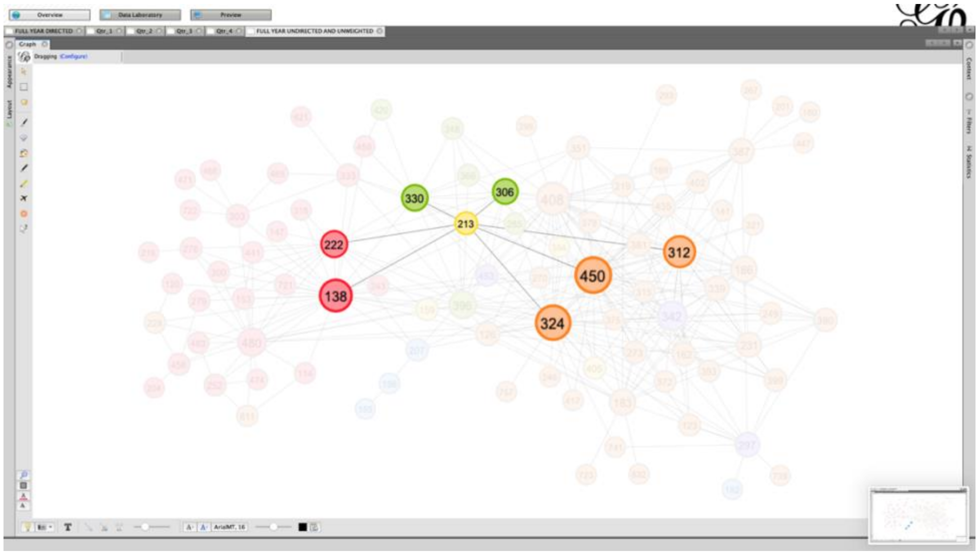


Figure 2. Your specific place in the diagram and the individuals you interacted with during the data collection period

Part 2: Cognitive Maps of the Bonneville Stakeholders

Secondly, I'm trying to understand how different BSF stakeholder groups perceive the influential processes at the BSF. Consider the elements/processes in Table 1 below that were suggested by people from various BSF groups. Please do the following before our phone call:

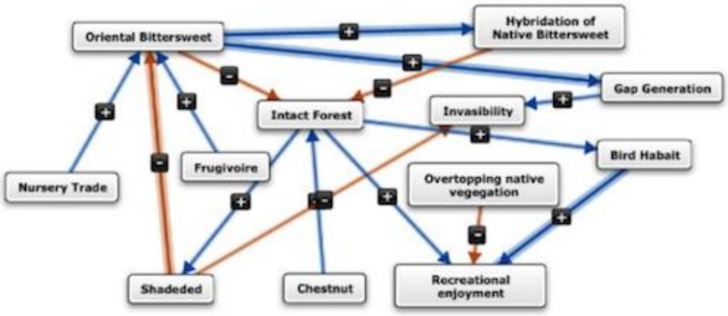
1. Select the top 5-15 most elements and/or processes that you think are the most important to consider when thinking about how the BSF functions.
2. Take a few minutes to consider the relationships among the 5-15 elements that you chose.

During our phone call, I will ask you about a) your general thoughts about these elements/processes, and b) how they relate to one another. I plan to create a diagram like the one in Figure 3 below to illustrate the way people perceive the BSF's function.

Table 1. Important elements and processes at the Bonneville Salt Flats

Salt Crust Thickness	Summer Temperature	Brine Movement - Subsurface
Wind	I-80 / Public Access	Stockpiled Waste Salt
Annual Precipitation	Salt Brine Return	Drainage/Canal Structures
Salt Crust Area	Mineral Extraction	Evaporation
Salt Crust Composition	Salt Brine Removal	Drying/Desiccation/Crystallization
Erosion	Mining Leases	Track Prep/Grooming
Water Table Level	Soil/Sand Particles	Race Equip, Trailers, Etc.
BLM Management	Driving on Salt	Salt Crust Compaction
Dike/Berm Structures	Stakeholder Blame/Tension	Quality of Management
Brine Movement - Surface	Misinformation	Racing Activities (general)
Soil/Sediment Deposition	Media Attention	Chemical/Fuel/Oil Pollution
Ground Water Percolation	Precipitation/Flooding	Microbe Action/Population

Figure 3. An example of a Cognitive Map that shows how people view and think about forest ecology.



I look forward to speaking with you on ENTER TIME AND DATE. Please let me know if you have any questions before then.

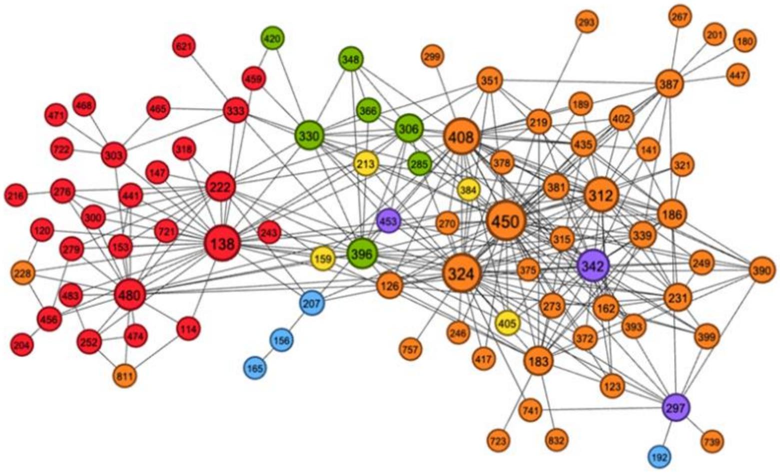
Many, many thanks,

Michael Blacketer

Appendix 9: Final Stakeholder Interview Script for SNA Results and FCM elements

Hi, ______

Thank you so much for making time to talk today! Before we get started, I'm hoping you don't mind if I record this conversation simply for maintaining the accuracy of my own notes. *Y/N*



Please recall that there are 2 parts to the data I sent you that I would like to discuss. The first is the SNA. Despite relatively low response rates to the quarterly surveys and a fair amount of missing data, I was still able to build this sociogram with the data that summarizes all interactions across one year of data collection. I was also able to identify some trends in communication among stakeholders that I'll be asking you about shortly.

The sociogram shows that the network is largely built on interactions among pairs of approximately 90 total individuals representing six stakeholder groups. There are only about half a dozen of these actors who seem to hold much of the network togethers, of which you are one.

The highest number of reported interactions are from Academia and Racing. As they are clearly the largest groups with an interest in the BSF in real life, this is not surprising. Most interactions are between members of the same group, which is also not very surprising. By proportion of total possible group members to participating group members, land managers are highest represented, and Industry, Media, and Wendover lowest.

Do you have any other questions about the sociogram? *Take notes . . .*

I'll be asking you some rather redundant questions about a) typical communication qualities for the academic community, both internally in your own group and externally with other groups. Ultimately, I'll ask you about whether communication patterns might have an impact on the BSF, so keep that in the back of your mind while we talk. I'd like to share with you what I found regarding trends in frequency, duration, and importance of BSF-related interaction over the course of a year. For each measure, I'd like to get your opinion as to the accuracy of the trends that I observed.

The table below represents the Excel charts displaying the relevant Frequency, Duration, and Importance means for Group-to-Group interactions. These are used to guide conversation and to seek validation or correction of trends in communication. Describe charts to participant and take notes regarding agreement/disagreement with results as well as possible attribution.

Frequency, Quarters 1-4	Duration, Quarters 1-4 (minutes)	Importance, Quarters 1-4
G:G (e.g. Academia:Academia)	G:G (e.g. Academia:Academia)	G:G (e.g. Academia:Academia)
G:G (e.g. Academia:Media)	G:G (e.g. Academia:Media)	G:G (e.g. Academia:Media)
G:G (e.g. Academia:Racing)	G:G (e.g. Academia:Racing)	G:G (e.g. Academia:Racing)
G:G (e.g. Academia:Industry)	G:G (e.g. Academia:Industry)	G:G (e.g. Academia:Industry)
G:G (e.g. Academia:Wendover)	G:G (e.g. Academia:Wendover)	G:G (e.g. Academia:Wendover)
G:G (e.g. Academia:Wendover)	G:G (e.g. Academia:Wendover)	G:G (e.g. Academia:Wendover)

1. First, do you have any questions about the sociogram or what went into making it?

2. Group:Group 1
a. Frequency Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
b. Duration Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
c. Importance Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
d. What is important in regard to communication this and your group each quarter?

3. Group:Group 2
a. Frequency Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
b. Duration Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
c. Importance Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
d. What is important in regard to communication this and your group each quarter?

4. Group:Group 3
a. Frequency Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
b. Duration Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
c. Importance Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
d. What is important in regard to communication this and your group each *quarter*?

5. Group:Group 4
a. Frequency Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
b. Duration Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
c. Importance Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
d. What is important in regard to communication this and your group each quarter?

6. Group:Group 5
a. Frequency Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
b. Duration Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
c. Importance Trend – Describe Qtr-Qtr change and ask if seems accurate. *Record*.
d. What is important in regard to communication this and your group each quarter?

(etc.)

8. Looking at the network model, does it seem that the structure or layout might influence the management of the BSF, or the way that the BSF functions? (e.g. BLM in the middle)

9. Is there a time that would be advantageous for improving any aspect of stakeholder group communication?

10. Is there a group we're leaving out?

11. Are you willing to continue collaboration among SH groups? *Yes/No*

12. Are you willing to forgo the anonymity of this study and have your identity revealed to the other individuals who emerged as important in the network structure? *Yes/No*

FUZZY COGNITIVE MAPPING:

For the second part, recall that I asked you to consider the relationships among social and biophysical phenomena at the BSF. Did you have a chance to look at that?

Can you select 5-15 of those items that you think are the most important to consider when thinking about the BSF’s function? *(Highlight these for the record and enter into grid)*

Table 1. Important elements and processes at the Bonneville Salt Flats

Salt Crust Thickness
Wind
Annual Precipitation
Salt Crust Area
Salt Crust Composition
Erosion
Water Table Level
BLM Management
Dike/Berm Structures
Brine Movement - Surface
Soil/Sediment Deposition
Ground Water Percolation
Summer Temperature
I-80 / Public Access
Salt Brine Return
Mineral Extraction
Salt Brine Removal
Mining Leases
Soil/Sand Particles
Driving on Salt
Stakeholder Blame/Tension
Misinformation
Media Attention
Precipitation/Flooding
Brine Movement - Subsurface
Stockpiled Waste Salt
Drainage/Canal Structures
Evaporation
Drying/Desiccation/Crystallization
Track Prep/Grooming
Race Equip, Trailers, Etc.
Salt Crust Compaction
Quality of Management
Racing Activities (general)
Chemical/Fuel/Oil Pollution
Microbe Action/Population

OK – Now I would like you to consider what you think is the average understanding of the BSF across the Academic Community. That is, I would like for you to speak on behalf of the community.

I will ask you about the relationships between pairs of those elements – and whether each pair of items is positively related (i.e. as one increases it makes the other increase), negatively related (as one increases, it makes the other decrease), or not related.

If you think they are related, I want to know how strong that relationship is on a scale of 1-3, high, medium, or low. Lastly for each pair, I would like you to rate your confidence that what you're telling me represents the typical perception of the Academic community on a scale of 1-7, from 'not at all confident' to 'very confident.'

Enter item names (from Table 1) down left column and across top row. Item correlations can be entered into upper or lower wedge, so long as the independent variable is identified via audio recording and entered into Mental Modeler accordingly, which will distribute item correlations across the gird based on IVs on left and DVs at top. In matrix below, enter Relationship Direction (0/+/-) for 1; Strength: Low, Medium, High for 2; & Confidence: 1-7 (not-very) for 3.

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
		2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	1		1	1	1	1	1	1	1	1	1	1	1	1	1
	2		2	2	2	2	2	2	2	2	2	2	2	2	2
	3		3	3	3	3	3	3	3	3	3	3	3	3	3
3	1	1		1	1	1	1	1	1	1	1	1	1	1	1
	2	2		2	2	2	2	2	2	2	2	2	2	2	2
	3	3		3	3	3	3	3	3	3	3	3	3	3	3

(etc.)

Appendix 10: Mental Modeling Matrix Data for Star Actors

DEPENDENT VARIABLES

FCM Components below either INCREASE (+) or DECREASE (-) based on change in the FCM components on right.
Values represent relative strength of relationship: (+/-.25 = weak), (+/-.5 = medium), (+/-.75 = strong), ('0' = asserted but unknown)
Positive numbers represent a positive relationship between items, wherein as one goes increase/decreases, it drives the other in the SAME direction
Negative numbers represent a negative relationship between items, wherein as one goes increase/decreases, it drives the other in the OPPOSITE direction

Data ID	Stakeholder Group	INDEPENDENT VARIABLES: Components below either INCREASE (+) or DECREASE (-) items on right.	Annual Precipitation (IV Only)	BLM Management	Dikes Berms	Drainage Canal Structures	Driving on Salt	Drying Desiccation Crystallization	Erosion	Evaporation	General Racing Activities	Ground Water Percolation	Interstate 80 Public Access	Media Attention	Microbe Action Population	Mineral Extraction	Mining Leases	Misinformation	Precipitation Flooding (IV Only)	Quality of Management	Salt Brine Removal	Salt Brine Return	Salt Crust Area	Salt Crust Composition	Salt Crust Thickness	Soil Sediment	Stakeholder Blame Tension	Stockpiled Waste Salt	Subsurface Brine Movement	Summer Temperature	Surface Brine Movement	Track Prep Grooming	Water Table Level	Wind (IV Only)
636	Academia	**BLM Management**			0.5			0		0	0.5										0.5	0.5	0	0	0.25								-0.5	
435	Academia	**Dikes Berms**						0		0	-0.25										0.75		-0.5	0	0				0		-0.5		0	
134	Academia	**Driving on Salt**																																
568	Academia	**Drying Desiccation**									0.75												0.75		0.75				0.1		-0.75		0	
422	Academia	**Evaporation**					0.49				-0.75		0.5								0.75												-0.5	
520	Academia	**Evaporation**						0.75			0.75												0.75		0.75				0.25		-0.75		-0.5	
973	Academia	**General Racing Activities**					0.75						0.75																					
693	Academia	**General Racing Activities**																					-0.25	0	-0.25									
757	Academia	**Interstate 80 Public Access**					0.75																											
531	Academia	**Precipitation Flooding**					-0.75			-0.75	-0.75										0												0.75	
734	Academia	**Precipitation Flooding**						-0.75		0.75	-0.75												-0.75	0	0.5				0.1		0.75		0.5	
827	Academia	**Quality of Management**					0.5				-0.5		0.75						0		0												0.75	
321	Academia	**Salt Brine Removal**																															-0.75	
644	Academia	**Salt Brine Removal**						0.1			-0.5											0	-0.75	0	-0.75				0				-0.75	
801	Academia	**Salt Brine Return**						-0.75			0										0		0.5	0	0.75				0				0.25	
664	Academia	**Salt Crust Area**		0				0.75		0.75														0	0				0					
739	Academia	**Salt Crust Composition**		0				0		0													0		0.75								0	
407	Academia	**Salt Crust Thickness**		0.25																			0											
496	Academia	**Subsurface Brine Movement**																					0	0	0						0		0	
875	Academia	**Surface Brine Movement**									0.75											0.5	0.75	0	-0.25				0					
211	Academia	**Water Table Level**									0.25																							
634	Academia	**Water Table Level**								0.5													0.5	0	0.5									
698	Industry	**Evaporation**																														0.75		
503	Industry	**Mineral Extraction**																																
515	Industry	**Precipitation Flooding**								-0.75						0.5														-0.75		-0.75		
675	Industry	**Summer Temperature**								0.75																						0.5		
593	Industry	**Track Prep Grooming**																																
866	Industry	**Wind**								0.5																								
831	LandMgmt	**Annual Precipitation**								-0.75	-0.75					-0.5						-0.5			-0.75				0			-0.5		
432	LandMgmt	**Annual Precipitation**					-0.75	-0.75		-0.75	-0.75																				0.75	-0.75		
717	LandMgmt	**Driving on Salt**																																
529	LandMgmt	**Drying Desiccation**					0.75				0.75																					0.75		

DEPENDENT VARIABLES

FCM Components below either INCREASE (+) or DECREASE (-) based on change in the FCM components on right.
Values represent relative strength of relationship: (+/-.25 = weak), (+/-.5 = medium), (+/-.75 = strong), ('0' = asserted but unknown)
Positive numbers represent a positive relationship between items, wherein as one goes increase/decreases, it drives the other in the SAME direction
Negative numbers represent a negative relationship between items, wherein as one goes increase/decreases, it drives the other in the OPPOSITE direction

Data ID	**Stakeholder Group**	**INDEPENDENT VARIABLES: Components below either INCREASE (+) or DECREASE (-) items on right.**	**Annual Precipitation (IV Only)**	**BLM Management**	**Dikes Berms**	**Drainage Canal Structures**	**Driving on Salt**	**Drying Desiccation Crystallization**	**Erosion**	**Evaporation**	**General Racing Activities**	**Ground Water Percolation**	**Interstate 80 Public Access**	**Media Attention**	**Microbe Action Population**	**Mineral Extraction**	**Mining Leases**	**Misinformation**	**Precipitation Flooding (IV Only)**	**Quality of Management**	**Salt Brine Removal**	**Salt Brine Return**	**Salt Crust Area**	**Salt Crust Composition**	**Salt Crust Thickness**	**Soil Sediment**	**Stakeholder Blame Tension**	**Stockpiled Waste Salt**	**Subsurface Brine Movement**	**Summer Temperature**	**Surface Brine Movement**	**Track Prep Grooming**	**Water Table Level**	**Wind (IV Only)**
862	LandMgmt	**Evaporation**									0.75					0.75									0.75				0.5			0.75		
720	LandMgmt	**Evaporation**					0.75	0.75			0.75																					0.75		
684	LandMgmt	**General Racing Activities**																							-0.5				-0.5					
839	LandMgmt	**General Racing Activities**					0.75																											
518	LandMgmt	**Mineral Extraction**									-0.25											0.75			-0.75							-0.25		
838	LandMgmt	**Salt Brine Return**								0.75	0.25														0				0			0.25		
566	LandMgmt	**Salt Crust Thickness**																																
501	LandMgmt	**Subsurface Brine Movement**														0.75									0									
868	LandMgmt	**Summer Temperature**					0.75	0.75		0.75	0.75																					0.75		
760	LandMgmt	**Surface Brine Movement**					-0.75	-0.75		-0.75	0.75																					0.5		
669	LandMgmt	**Track Prep Grooming**									0.75														-0.5				-0.5					
576	LandMgmt	**Track Prep Grooming**					0.75				0.75																							
495	Media	**BLM Management**					-0.75								0.5					0		0	0		0									
850	Media	**Driving on Salt**																0							-0.75									
477	Media	**Interstate 80 Public Access**																							-0.5		0.75							
635	Media	**Microbe Action Population**																																
640	Media	**Mineral Extraction**																									0.75							
546	Media	**Misinformation**					0																											
567	Media	**Precipitation Flooding**											-0.5			0.75											0.75						0.75	
446	Media	**Quality of Management**		0			-0.75								0.5							0	0		0									
508	Media	**Salt Brine Return**													0								0.75		0.75									
499	Media	**Salt Crust Area**					0.75											-0.75																
479	Media	**Salt Crust Thickness**																0.75					0.5											
813	Media	**Salt Crust Thickness**																									-0.5							
409	Media	**Stakeholder BlameTension**											0.5																					
858	Media	**Water Table Level**											0.25			0.75									0.5									
489	Racing	**Dikes Berms**				0.75					0.75										0.75		-0.75		-0.75		0.5							
727	Racing	**Dikes Berms**										0.25				0.75					0.75								0.25					
856	Racing	**Drainage Canal Structures**			0.75			-0.5	0.75					0								0.5	-0.75		-0.75		0.5							
765	Racing	**Drainage Canal Structures**																											0.25					
607	Racing	**Drying Desiccation**							-0.5		0.75			0.75									0.75		0.75									
443	Racing	**Erosion**									-0.75			0.75									-0.75		-0.75		0.75							

DEPENDENT VARIABLES

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Data ID	Stakeholder Group	INDEPENDENT VARIABLES: Components below either INCREASE (+) or DECREASE (-) items on right.	Annual Precipitation (IV Only)	BLM Management	Dikes Berms	Drainage Canal Structures	Driving on Salt	Drying Desiccation Crystallization	Erosion	Evaporation	General Racing Activities	Ground Water Percolation	Interstate 80 Public Access	Media Attention	Microbe Action Population	Mineral Extraction	Mining Leases	Misinformation	Precipitation Flooding (IV Only)	Quality of Management	Salt Brine Removal	Salt Brine Return	Salt Crust Area	Salt Crust Composition	Salt Crust Thickness	Soil Sediment	Stakeholder Blame Tension	Stockpiled Waste Salt	Subsurface Brine Movement	Summer Temperature	Surface Brine Movement	Track Prep Grooming	Water Table Level	Wind (IV Only)
702	Racing	**General Racing Activities**			-0.75									0.75													0.75							
502	Racing	**Ground Water Percolation**		0.75		0.75										0.75					0.74		0.50						0.75					
380	Racing	**Media Attention**																																
713	Racing	**Mineral Extraction**		-0.75																	0.75	0.00	-0.75					0.75						
628	Racing	**Mining Leases**			0	0.75			0.5		-0.75			0.5							0.75		-0.75		-0.75		0.75	0.75						
504	Racing	**Mining Leases**		-0.75	0.75	0.75										0.75					0.75	0.25						0.75						
598	Racing	**Precipitation Flooding**		0.50								0.75				-0.75					0.75	0.75	0.50						0.75					
434	Racing	**Quality of Management**			-0.75	-0.5					0.75			0.75			-0.75				-0.75	0.75	0.75		0.75		-0.75	-0.75						
444	Racing	**Quality of Management**		0.75	0.00	0.00										0.75	0.00				-0.75	-0.75	0.75					-0.75	-0.50					
627	Racing	**Salt Brine Removal**																					-0.75		-0.75			0.75						
716	Racing	**Salt Brine Removal**		-0.75																			-0.75					0.75	0.75					
448	Racing	**Salt Brine Return**						0.75	-0.5		0.75			0.75							-0.5		0.75		0.75		-0.75	-0.75						
396	Racing	**Salt Brine Return**		0.75												-0.50					-0.50		0.75					-0.75	0.50					
841	Racing	**Salt Crust Area**			-0.75	-0.75					0.75			0.75											0.75		-0.75							
469	Racing	**Salt Crust Area**		0.75													0.75																	
476	Racing	**Salt Crust Thickness**			-0.75	-0.75					0.75			0.75									0.75				-0.75							
403	Racing	**Salt Crust Thickness**																					0.75											
463	Racing	**Stakeholder Blame Tension**							0.75					0.75						0.75														
600	Racing	**Stockpiled Waste Salt**				1					0.75			0.75									-0.75		-0.75		0.75							
426	Racing	**Stockpiled Waste Salt**		-0.75																			-0.75											
483	Racing	**Subsurface Brine Movement**		-0.50												0.75							-0.50											
837	Wendover	**BLM Management**												0.75												-0.5		-0.5						
631	Wendover	**Evaporation**																				0.75			0.77	-0.75						0.75		
411	Wendover	**Evaporation**																							0.75			-0.5						
578	Wendover	**Interstate 80 Public Access**								-0.75															-0.75	0.75								
401	Wendover	**Media Attention**																																
431	Wendover	**Misinformation**																																
722	Wendover	**Precipitation**								-0.75												0.7			-0.75	0.5						0		
615	Wendover	**Quality of Management**		0.75										0.75											0.75	-0.5		-0.5						
780	Wendover	**Salt Brine Return**																							0.75							0.75		
812	Wendover	**Salt Crust Thickness**																														0.75		
383	Wendover	**Salt Crust Thickness**																								0.5								

DEPENDENT VARIABLES
FCM Components below either INCREASE (+) or DECREASE (-) based on change in the FCM components on right.
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573	Wendover	**Soil Sediment**																							-0.75							-0.75		
456	Wendover	**Soil Sediment**																																
832	Wendover	**Stockpiled Waste Salt**																																
735	Wendover	**Summer Temperature**								0.75															0.75							0.75		
794	Wendover	**Track Prep Grooming**																																

Appendix 11: Additional Fuzzy Cognitive Maps for Study III

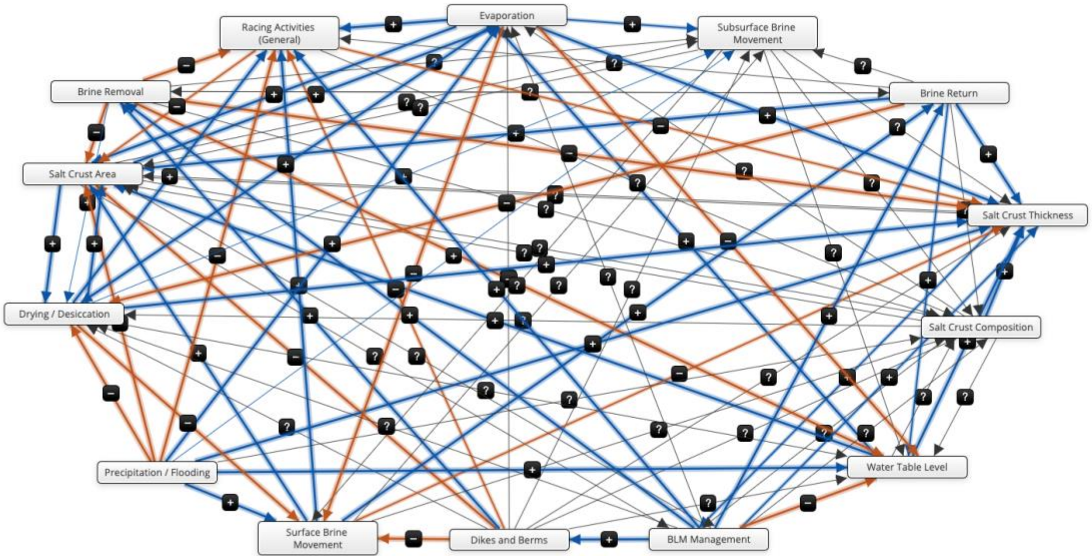

Figure 4.5. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Academic community reported as ‘important to consider’ in regard to the BSF’s social-ecological system. Question marks (?) denote uncertain relationships.

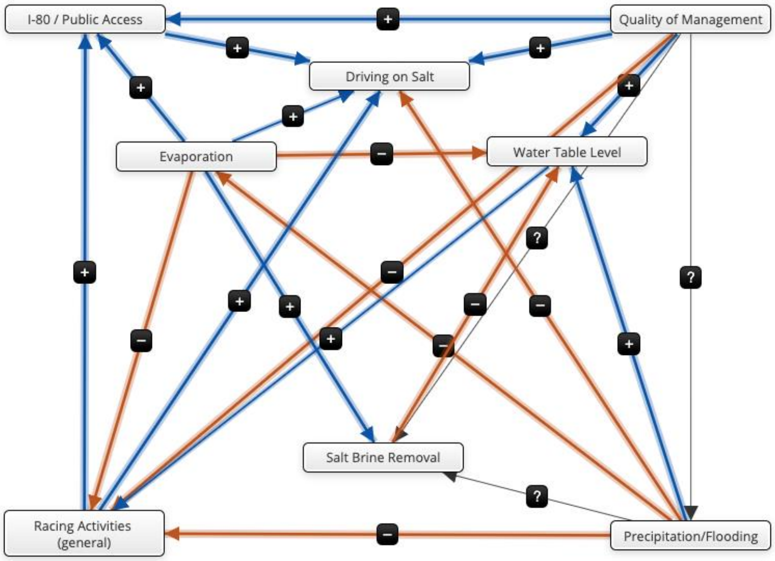

Figure 4.6. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Academic community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

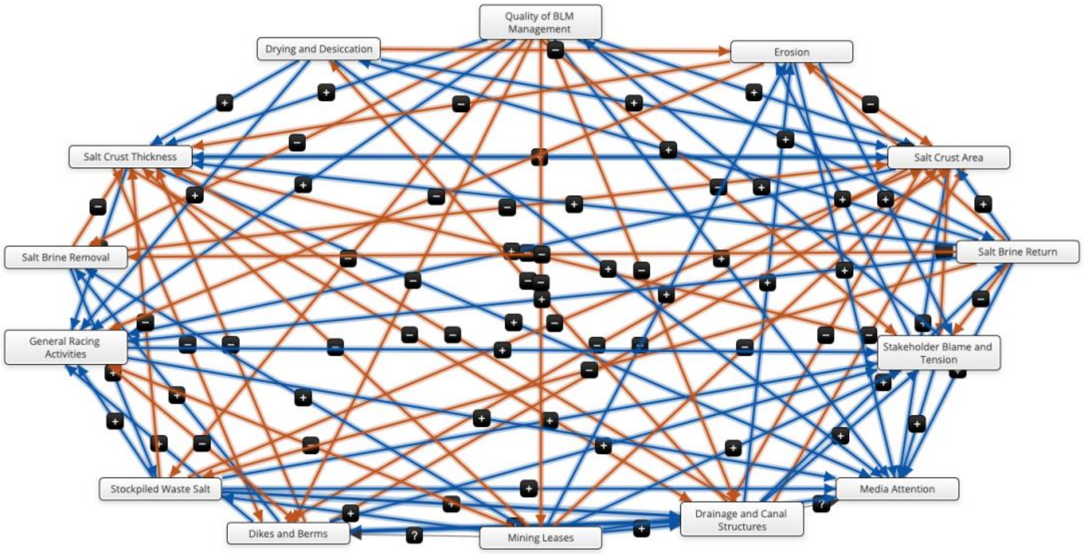

Figure 4.7. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Land Speed racing community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

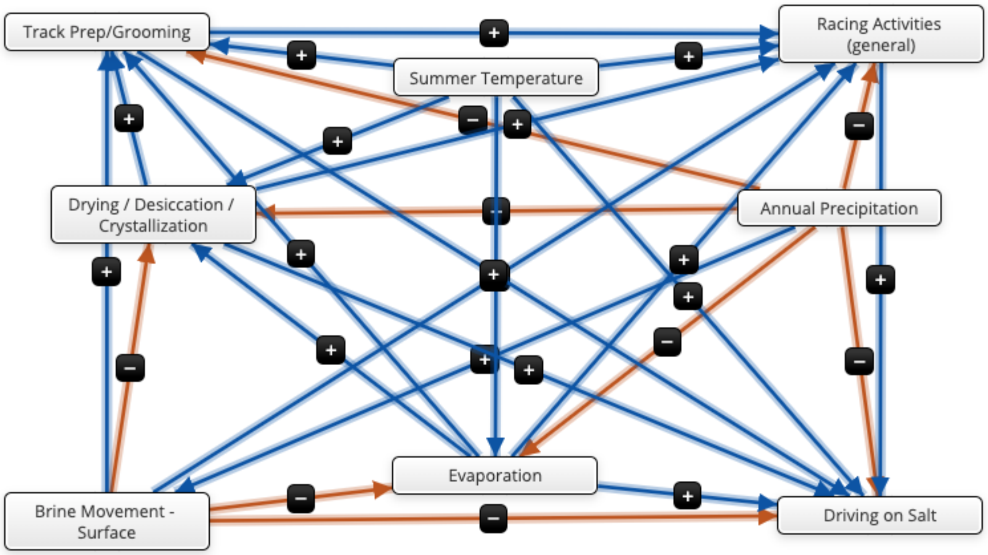

Figure 4.8. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Land Management community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

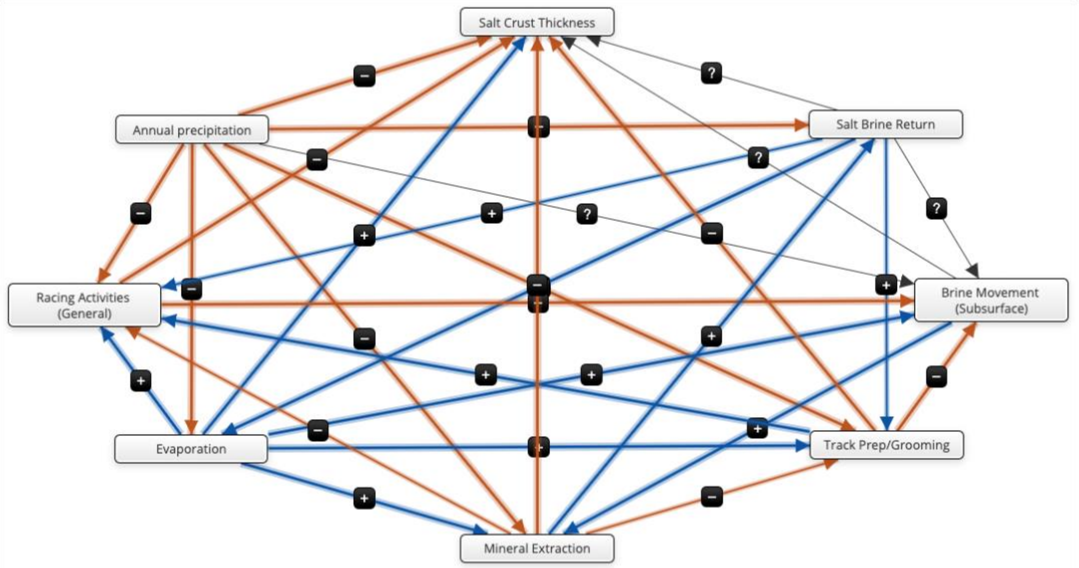

Figure 4.9. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Land Management community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

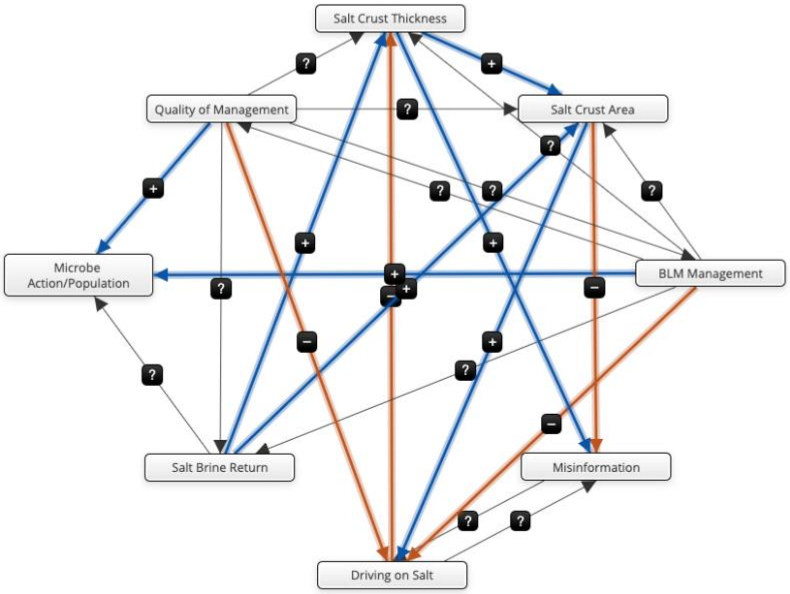

Figure 4.10. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Media community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

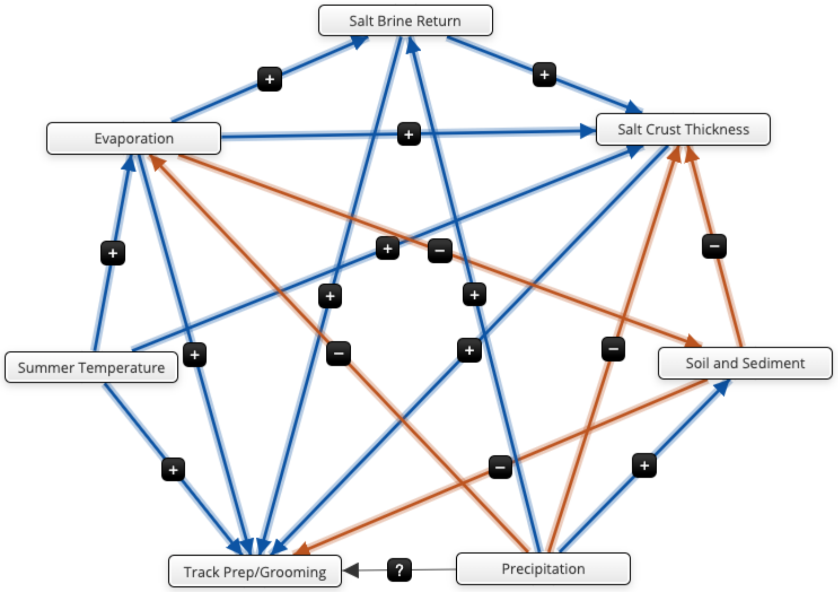

Figure 4.11. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Wendover/Tooele community reported as 'important to consider' in regard to the BSF's social-ecological system.

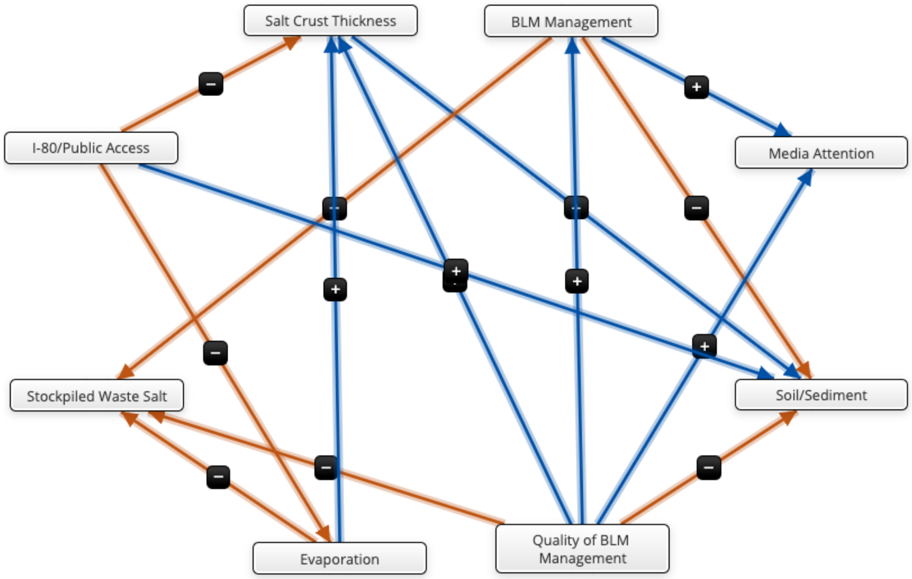

Figure 4.12. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Wendover/Tooele community reported as 'important to consider' in regard to the BSF's social-ecological system.

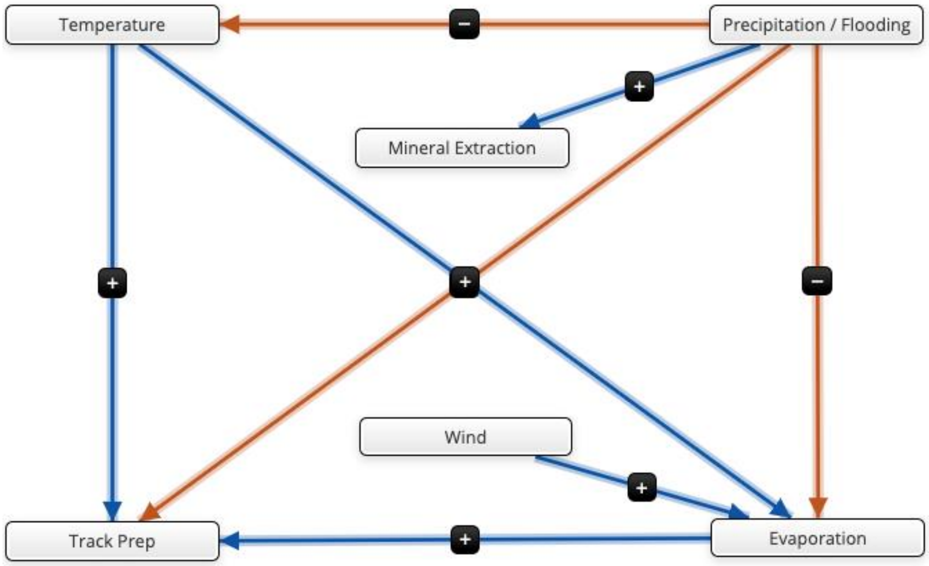

Figure 4.13. Fuzzy cognitive map of the relationships among 6 SES components at the BSF that a member of the Industry/Mining community reported as ‘important to consider’ in regard to the BSF’s social-ecological system.

Appendix 12: Research Philosophy

The Author and the Pragmatic Paradigm

I have probably been a ‘systems thinker’ all my life. While this realization wasn’t clear to me until I began my doctoral studies, I have long held that just about everything we can conceive is somehow connected, from natural entities or phenomena to mental attitudes and everyday behaviors. It is surprising to me that my systems-rooted thinking remained unidentified to me for many years—after all, my education and work have almost always dabbled in complex connectivity. My undergraduate studies connected community with environmental planning and architecture, and my master’s program taught me to think systemically and ecologically when analyzing and planning for human use of landscapes across many scales. For all of my adult life, I have been thinking about the human relationship with natural systems and the potential for that relationship to be harmonious if only the many connections among elements in our vast social-ecological world could be recognized and managed wisely. I was thinking in terms of systems comprised of *human-social* and *natural-ecological* elements for years without realizing that there was such a thing as *social-ecological systems.* Upon learning this, I was pretty well hooked.

To develop this line of systems thinking, my doctoral studies are oriented toward parks and protected areas (PPAs). Specifically, I have been researching PPAs as social-ecological systems (SES) comprised of many elements both human-social and natural-ecological. To that end, I have been a member of an interdisciplinary team research funded by a National Science Foundation CNH grant seeking to understand Utah’s

Bonneville Salt Flats (BSF) as a complex, dynamic SES. While most often regarded as one of the world's foremost venues for setting land speed records, the BSF is a highly complex system with numerous stakeholders, many of whom have differing opinions about how the natural and human elements at the BSF affect one another. As a 'boiled down' natural system—with limited human use and minimal plant/animal biology—the BSF offers great potential as a living laboratory for exploring the relationships that play out among social and ecological actors.

As I embarked on several aspects of my research, it became necessary for me to clarify my research philosophy, both for my own thinking as well as the elucidation of anyone interested in my work. To the point, I consider myself to be a Deweyan pragmatist. That is, my beliefs and tendencies as a researcher are very much in line with the writings and tenets of pragmatism's "Big Three"—Charles Sanders Peirce, William James, and ultimately John Dewey.

Just like the aforementioned realization of myself as a 'systems thinker,' however, I didn't appreciate that I was a pragmatist until I began the reflexive task of identifying the paradigmatic 'home' of my research. And while it is somewhat bizarre to identify with something so well established—almost like discovering the name for a long-afflicting malady—it is also a comfort to be reassured that I needn't chart unknown realms of thought without philosophical guidance. Deweyan pragmatism offers such guidance.

I embrace pragmatism as a research paradigm for many reasons. Though often perceived as an approach that utilizes "whatever works," pragmatism is in reality much more. Pragmatism does not merely reach out in all directions to all forms of thought, but rather is all-at-once self-conscious, self-reflective, and self-critical (Ormerod, 2006). As a person, and as a researcher, that description fits me very well. It also resonates with the holistic nature of studying social-ecological systems. Pragmatists find truth in whatever can be used for desirable action, but still are wont to examine our own ideas as tentative. We recognize that we may one day need to revise—through reflexive inquiry—aspects of what we hold to be truths about the world. Pragmatism also accepts that there are (philosophically) singular as well as multiple realities that are open to empirical inquiry (Morgan, 2014; Feilzer, 2010; Creswell & Plano Clark, 2007; Ormerod, 2006). Through this ‘ontological sidestep’ past a forced-choice dichotomy, pragmatism orients itself toward solving practical problems in the real world.

Peirce believed we should adopt the ‘method of science’, which holds that real things have characters are entirely independent of our opinions about them and nonetheless affect our senses according to regular laws. Though our individual sensations are as different as our relations to the objects, we nevertheless take advantage of the laws of perception and thus ascertain by reasoning how things really are (Ormerod, 2006). However, pragmatism suggests to us that no part of our thinking can be immune to the weight of evidence that we might discover through future experience (Ormerod, 2006). This Darwinian argument, I find, is true of science as a whole. While science is often regarded as a question of resolving uncertainties of fixed categories and laws, those very categories and laws are part of a dynamic process of change—along with experience and understanding—over time. We hold beliefs that drive our actions until new beliefs displace the old, thus changing our actions until the next go-round.

Peirce held that in a universe where events are uncertain and perception is fallible, knowing cannot be a matter of individual mind 'mirroring' reality (Menand, 2001, as cited by Ormerod, 2006). The mechanics of truth, in this regard, are very complex! In addition to each individual's mind 'reflecting' reality differently, any single mind reflects differently at different moments, and multiple minds might communicate in an infinite, mirror-reflecting-mirror web of echoed and distorted realities. If that's not enough, reality isn't likely to remain stationary long enough to truly, accurately be mirrored at all! Peirce's conclusion was that knowledge must therefore be social (Menand, 2001, as cited by Ormerod, 2006). This suggests that pragmatism is particularly flexible form of social ontology (Pratt, 2016). The implications of this idea in regard to social-ecological systems—where knowledge is a social commodity and driver of social, ecological, and biophysical change—are both vast and beguiling.

Our construct of reality, then, is something that can at least partially be renegotiated, debated, and interpreted through new and unpredictable situations. Thus, I don't believe that there is one *singular* objective reality – after all, we all experience the world in very different spatial, environmental, social, and temporal circumstances. Indeed, while all people are literally on the same planet, we are figuratively living in different worlds shaped by massively complex systems that influence our interpersonal and environmental interactions.

People who have a stake in the Bonneville Salt Flats are no exception to these malleable realities, and as a qualitative researcher, I necessarily have a relationship with those stakeholders, both as stakeholder *groups* and also as *individual agents* in the social ecological system. My understanding and eventual description of anything that stakeholders communicate to me is also subject to my own experience and values.

I eschew being a spectator of knowledge and embrace both positivist and interpretivist positions regarding the nature of reality. That is, ontologically speaking, I believe that reality can be both observed as well as constructed. This dichotomy is not so strange once the ideas of the social and ecological are considered with respect to complex systems. Natural forces and phenomenon can clearly be observed and measured; Indeed, relationships among these things can even be described, quantified, and distilled into very useful laws regarding the nature of physical reality. However as living, conscious, and overtly curious entities, we human beings—while subject to larger natural laws—shape our own social world through varying behaviors, practices, and ideologies. While some of these social processes and products can be simply observed, described, and measured, they are also open to interpretation and distortion by any given human individual, including myself, the researcher.

It is perhaps through William James that pragmatism began to be generically viewed as embracing “whatever works.” Indeed, I myself initially approached pragmatism as a simple, rational approach to research for many reasons. My previous interpretation of pragmatism was simply about being practical and realistic—sometimes even necessarily being “brutally pragmatic” when attempting to bring positive change to fruition. Too, pragmatism seemed—in its emphasis on action—to endeavor to at least get things done, even if not done perfectly. Richard Ormerod (2006) echoes this slightly reductionist sentiment in saying that to him, pragmatism was a means to disallow the "best to be the enemy of the good, taking account of other's views, not being hung up on unattainable principles and yielding on some issues in order to make progress on others." Together, my thoughts and Ormerod's suggest that applying pragmatism as a research to SES research can help us achieve our goals—however imperfectly—through action.

Framing My Work Within Pragmatism

There are several things that I will keep in mind regarding pragmatism in my PPA research. First, I have researched this paradigm to deepen my own understanding of pragmatism. Therefore, my writing about the subject is not only informative, but also reflexive. Second, whether consciously or not, I believe it is highly likely that most PPA researchers and managers are already embracing pragmatism in their endeavors to shape and maintain the resilience of the resources under their care and contemplation. These people should be aware that there is a philosophical foundation to guide them in their efforts. Lastly, as already mentioned, while pragmatism is often regarded as a paradigm that embraces "whatever works," that particular attribute tends to be reductively misapplied through ignorance of pragmatism's deeper philosophical foundations.

Part of my research explores stakeholders' perceptions of the BSF. Specifically, I am interested in how those stakeholders perceive the BSF as an SES. And since I believe that we all have different perceptions that grow from and respond to our individual experiences, I need to develop an understanding of those differences and how they are formed. Those perceptions are constructions built from experiences large and small including from interactions with each other at the Bonneville Salt Flats. As a researcher, I will have to approach the pragmatist philosophers' views knowing that they are built from their own interpretations, and further filtered through my own personal interpretations.

The pragmatic lens is also useful for understanding people's communication of their view of the world; we must often dig deeper than the words that people use to express their perceptions. It's dizzying how once we begin to apply systems thinking to our perceptions of the world, we often have to dissolve and deconstruct many of our most fundamental assurances. While this is sometimes a terrifying prospect, I think it leads to more flexible thinking once we accept that our perceptions and actions will likely change with the acquisition of more knowledge and experience in in any given realm.

Pragmatism is concerned with action and change and the interplay between knowledge and action. This makes it appropriate as a basis for research approaches *intervening* into the world and not merely *observing* the world. To pursue my research on both human and ecological elements, I must employ both quantitative as well as qualitative inquiry, and therefore multiple- or mixed-methods design. I tend to think of my topic—parks as SESs—through a variety of lenses including post-positivism, interpretivism, and constructionism/constructivism. More broadly, however, the primary research paradigm through which I will perform multiple- or mixed-methods research (MMR) is Deweyan pragmatism. Especially considering the complexity of social-ecological systems, one cannot rely on one approach to research. The best course of action, therefore, is whatever is applicable and efficacious at the time of deployment. The design of my research will likely evolve in tandem with changing circumstances. The qualitative aspects of my research (through design) will lean on interpretivism, the purpose of my work is to inform human efforts to manage PPAs as social-ecological systems.

As these ideas pertain to perception and action, I find pragmatism applicable to MMR inquiry into a complex social-ecological system such as the BSF. Specifically, my research is partially aimed at understanding human perceptions, but I must also seek to understand *changing* perceptions that drive stakeholders' interactions with (and therefore impact upon) the social and biophysical processes of the BSF. The end-result of this understanding would theoretically be implications for management to bring into alignment actions that have sustainable relationships with biophysical realities. Morgan (2014) suggests that "our attempts to understand and act in the world are inherently contextual, emotional, and social." More specifically, he says, pragmatism "emphasizes that all aspects of research inherently involve decisions about which goals are most meaningful and which methods are most appropriate." In my thinking, this is directly relevant to applying pragmatism to complex social-ecological systems.

As a demonstrably contested resource—in that there is historic disagreement and friction between certain stakeholder groups—the BSF is in need of a research paradigm that effectively guides policy-driven management toward the best outcome for the greatest number of stakeholders but still seeks to balance the system's biophysical 'needs.' Pragmatism offers the clearest path to pursuing—through any and all particular methods—what our research reveals to be effective for achieving any given management goal. Pragmatism offers a philosophy that is inclusive of interpretivism as well as positivism, with neither being blinded by ridged adherence to the other.

Ultimately, research into social-ecological elements and processes in dynamic systems can reveal what is working well—managerially speaking—and healthily for the resilience of those system, as well as threats to destabilize them. As both an ontological and epistemological framework, Deweyan pragmatism offers the perhaps the greatest potential for effectively addressing problems and exploring uncharted domains of potential knowledge. Pragmatism seeks to apply what is revealed to be useful for accomplishing goals that change in response to new, dynamic realities—this is its strength and value as a research paradigm. In this way, most interestingly, Deweyan pragmatism behaves very much like the complex systems for which I wholeheartedly advocate its application for research. This paradigm for research is complex, adaptive, and systems-friendly.

~Michael P. Blacketer, August 2019

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