THE INFLUENCES OF WEATHER ON OUTDOOR RECREATION: A RESEARCH SYNTHESIS, A WEATHER DEPENDENCY FRAMEWORK (WDF), AND OUTDOOR RECREATIONISTS' PERCEPTIONS

by

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STATEMENT OF DISSERTATION APPROVAL

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ABSTRACT

This three-article dissertation investigated the influences of weather on outdoor recreation through three individual progressive studies addressing the following problems. First, the weather inherently influences outdoor recreation activities, yet we have very little empirical evidence about the multidimensional influences of weather on outdoor recreation. Related, there is no central article that synthesizes weather studies in outdoor recreation. Second, within the study of weather, we lack a mechanism to think about the *weather dependency* of outdoor recreation activities or the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions. Third, frameworks developed using experts rarely assess stakeholder perceptions to evaluate the credibility of a developed framework. Therefore, the first study in this dissertation employed a systematic research synthesis and gap analysis to summarize and evaluate weather studies in outdoor recreation and nature-based tourism. The second study was used to develop a Weather Dependency Framework (WDF) for outdoor recreation activities using the Delphi method and weather-related factors and variables uncovered from the first study. The third study of this dissertation sought to determine the qualitative credibility analysis of the previously developed WDF by investigating backcountry skiers' and hunters' perceptions of weather dependency through semistructured interviews. Each study reported unique findings. Specifically, the research synthesis (Study 1) identified three recurring themes from weather studies in

outdoor recreation and nature-based tourism: weather-related factors and variables that influence outdoor recreation and nature-based tourism, the importance of geographic research context, and prevailing activity types. The gap analysis indicated an abundance of under-investigated topics in weather-related studies on outdoor recreation. Study 2 resulted in the development of the WDF and considered possible applications for the WDF. Study 3 highlighted seven emergent themes about backcountry skiers' and hunters' perceptions of weather dependency including access, strategy, terrain, culture, opportunity, high engagement, and deterrent for participation. The results of Study 3 offer insights into the overall credibility of the WDF based on backcountry skiers' and hunters' perceptions of weather dependency. Each study is described in a separate article (dissertation chapters) and each provides implications for future research and management of outdoor recreation. In addition, a summary and synthesis chapter is provided at the conclusion of the dissertation.

This work is dedicated, first and foremost, to my husband, Mike, for providing everlasting motivation, inspiration, support, love, laughter, and spontaneous adventures. To my hiking and writing companion, Jake, for showing me unending love and compassion. To my parents Dr. Deborah and Richard Gochenaur, who wrote in 2005 that their hope "for all the young people who have passed through the circle of our family, and for those we have yet to meet, would be willing to dream of bigger things, believing in themselves, and understanding that education is a gift that we give to ourselves." This work is dedicated and inspired by their continued encouragement for Mike and myself to dream big and believe in ourselves.

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CHAPTER I

INTRODUCTION

Problem Statement

As a natural resource, the weather is an inherent part of and plays a critical role in outdoor recreation activities (Coghlan & Prideaux, 2009; Tucker & Gilland, 2007). The problem, presently, is that we know very little about the influences of weather on outdoor recreation participants and activities. This is important to understand because outdoor recreation activities are potentially quite weather dependent. Consequently, a strategic use of weather-dependent outdoor recreation knowledge might increase effectiveness and efficiency of management decisions (Becken, 2012) for natural resource managers. This research may not only aid outdoor recreation managers but many methods and findings may be transferable to broader research agendas.

Three primary problems led to this dissertation. First, there is no central article that has synthesized and evaluated weather studies in outdoor recreation. Creating a state-of-knowledge article is important because of the diversity and variability of weather research, in addition to the increasing attention to the multidimensional influences of weather on outdoor recreation (e.g., de Freitas, Matzarakis, & Scott, 2007; Lise & Tol, 2002; Lohmann & Kaim, 1999; Scott & Lemieux, 2010). An objective research synthesis literature review coupled with a gap analysis might result in significant recommendations for future research. Therefore, there was need for a trustworthy research synthesis and gap analysis to evaluate the multidimensional influences of weather on outdoor recreation.

Second, while a growing number of studies address the influences of weather on outdoor recreation, previous research has not directly addressed weather dependency. I define weather dependency as *the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions.* Most outdoor recreation activities are dependent on weather and resulting conditions. Despite the evident reliance on weather, we know little about the weather dependency of outdoor recreation activities. This includes the lack of a mechanism or framework to think about and display factors and variables that influence the weather dependency of outdoor recreation activities. Therefore, it was necessary to combine factors and variables into one framework (i.e., a Weather Dependency Framework) to aid researchers and mangers in interpreting the weather dependency of outdoor recreation activities.

Finally, we know little about how outdoor recreationists' perceptions of weather dependency and these perceptions can help assess the qualitative credibility of a new Weather Dependency Framework. Evidence suggests that individuals draw inferences about changes taking place in the climate from perceived changes in local weather patterns (Goebbert, Jenkins-Smith, Klockow, Nowlin, & Silva, 2012). These inferences potentially influence outdoor recreation activity's weather dependency and could be investigated further to understand the credibility of a Weather Dependency Framework.

This dissertation extends previous research and presents a state-of-knowledge chapter about weather-related variables in outdoor recreation and nature-based tourism. As well, this dissertation investigates the weather dependency of outdoor recreation activities through the development of a Weather Dependency Framework. Additionally, this work explores outdoor recreationists' perceptions of weather dependency by comparing two activity types to understand the credibility of this Weather Dependency Framework. The information gathered in this dissertation is available to natural resource managers charged with the planning and management of outdoor recreation and outdoor recreation areas. Researchers could use these studies as platforms for future investigations. As outdoor recreation behaviors becomes increasingly influenced by changing climatic conditions, this dissertation provides a valuable foundations for conducting future research about the influences of weather on outdoor recreation and the weather dependency of outdoor recreation activities.

Purpose Statement

This dissertation is intended to begin to address the lack of empirical studies regarding the influence of weather on outdoor recreation and the weather dependency of outdoor recreation activities. Three overarching goals guided this research:

1) To understand the current state of knowledge of weather studies in outdoor recreation and nature-based tourism.
2) To develop a Weather Dependency Framework (WDF) combining factors and variables influencing the weather dependency of outdoor recreation activities.
3) To assess the qualitative credibility of the WDF by investigating backcountry skiers' and ungulate hunters' perceptions of weather dependency.

Research Studies

Three distinct research studies exploring weather in outdoor recreation were carefully selected for this dissertation. Specifically, Study 1 is a research synthesis and gap analysis of weather studies in outdoor recreation and nature-based tourism. Study 2 explored the weather dependency of outdoor recreation activities using the Delphi Method to develop and introduce the WDF. The aim of the WDF is to assist in understanding factors and variables that contribute to the weather dependency of outdoor recreation activities. Study 3 investigated the credibility of the WDF by conducting an exploratory comparison of backcountry skiers' and ungulate hunters' perceptions of the weather dependency.

Each study focused specifically on the influences of weather on outdoor recreation. However, the assessment of weather-related variables was progressive, building to an in-depth analysis of outdoor recreationists' perceptions of the weather dependency and ultimately assessed the qualitative credibility of the WDF. The research synthesis and gap analysis, from Study 1, provided a broad state-of-knowledge paper on weather studies in outdoor recreation and nature-based tourism. This study was expanded to include nature-based tourism due to lack of weather studies in outdoor recreation. Study 1 discusses the most commonly examined factors and variables, activities, and geographic research contexts, and topical and methodological weather studies in outdoor recreation and nature-based tourism.

Results from Study 1 provided a firm rationale for Study 2. Study 2 explored the weather dependency of outdoor recreation activities by developing the WDF. The WDF combines factors and variables deemed essential by a panel of experts, and based on

Study 1 findings, to assess the weather dependency of outdoor recreation activities. Strategies to implement the framework as well as avenues for future research are presented.

Study 3 determined the credibility of the WDF by exploring backcountry skiers' and ungulate hunters' perceptions of weather dependency. Since a panel of experts initially developed the WDF, it was deemed important to explore the depth and complexity of backcountry skiers' and hunters' perceptions of the weather dependency of their primary outdoor recreation activity. Study 3 compared backcountry skiing and ungulate hunting to begin to understand and interpret levels of weather dependency through the lens of the WDF. Study 3 concludes by confirming, disconfirming, and presenting inconclusive findings as well as providing suggestions for future researchers employing credibility analyses.

The diversity of these studies and relevant weather influences on outdoor recreation were purposefully selected. Selection of these three studies allowed for exploratory research into weather studies in outdoor recreation as well as in-depth development of the WDF and further exploration of outdoor recreationists' perceptions of the WDF. This allowed the researcher to establish a solid foundation that can inform numerous subsequent studies can be completed.

Structure of the Document

The remainder of this dissertation is comprised of four chapters, one chapter for each of the three articles (one chapter for each study previously discussed and formatted as journal manuscripts), a summary chapter, followed by appendices and references. Each chapter (except for Chapters II and V) includes an introduction, literature review, description of methods and analysis, results, and a discussion. Chapter II represents the research synthesis (a systematic literature review) of weather studies and addresses the following research question.

1) What are the themes, trends, and gaps in weather research in outdoor recreation and nature-based tourism?

Chapter III describes the development of the WDF and addresses the following research questions.

1) What are important considerations (e.g., anchors, continuums, and utility) for developing a visual display that adequately represents the salient factors and variables influencing the weather dependency of outdoor recreation activities?
2) Where might different outdoor recreation activities fall on a continuum of weather dependency, given a place specific setting?
3) What are the potential applications of the WDF including its utility for resource managers and researchers?
4) What are the opportunities for future development of the WDF?

Chapter IV represents the investigation of outdoor recreationists' perceptions of weather dependency and addresses the following research questions.

1) In what ways do backcountry skiers' and ungulate hunters' perceptions of weather dependency confirm and disconfirm the credibility of the WDF?
2) How do the similarities and differences between backcountry skiers and ungulate hunters' perceptions of weather dependency corroborate and contradict the credibility of the WDF?
3) What is the credibility of the WDF?

Chapter V is a summary of the results from these three studies. This chapter expands the discussion to identify common results across each of the three studies and provides implications for future research. Part 2 of Chapter V is a personal reflection of my learning that has occurred throughout the dissertation process.

CHAPTER II

WEATHER STUDIES IN OUTDOOR RECREATION AND NATURE-BASED TOURISM: A RESEARCH SYNTHESIS AND GAP ANALYSIS

Abstract

The impact of weather on outdoor recreation and nature-based tourism has received increasing attention in the literature during the past 10 years. This article synthesizes the results of those inquiries, categorizing their predominant themes and identifying knowledge gaps. One hundred eighty-four (184) weather-related articles drawn from a cross-section of international journals served as the foundation for this work. The research synthesis identified three recurring themes: weather-related factors and variables that influence outdoor recreation and nature-based tourism, the importance of geographic research context, and prevailing activity types. The gap analysis indicated an abundance of under-investigated topics in weather-related studies in outdoor recreation. Based on a discussion of the predominant themes uncovered in the research synthesis and the research needs uncovered in the gap analysis, recommendations for future weather-related studies in outdoor recreation and nature-based tourism conclude the article.

Introduction

"Climate is what you expect; weather is what you get."

Mark Twain

In 1966, Clawson posited that, "even a modest acquaintance with outdoor recreation suggests that it is weather-sensitive—anyone who has had a picnic spoiled by a sudden downpour can testify to that" (Clawson, 1966, p. 184). Clawson's observation is one of the earliest acknowledgements of weather's influence on outdoor recreation. While experts acknowledge that weather exists as a backdrop to outdoor recreation and nature-based tourism, it is only in the last decade that researchers have begun to investigate weather's multidimensional influences (e.g., de Freitas, Matzarakis, & Scott, 2007; Lise & Tol, 2002; Lohmann & Kaim, 1999; Scott & Lemieux, 2010).

The influence of weather and climate on tourism has been investigated for more than 30 years, resulting in diverse studies (Scott et al., 2008). For example, from research in Kafue National Park Zambia (Thapa, 2012), Croatia's Adriatic Coast (Brosy, Zaninovic, & Matzarakis, 2013), Artic Bay Canada (Ford, Smit, & Wandel, 2006), to Eureka Springs Arkansas in the United States (Chi & Qu, 2008), there is breadth and diversity of geographic context in weather and climate research. This research focuses on a wide assortment of factors ranging from studies that focus on weather and climate's impacts on touristic demands at zoos (Aylen, Albertson, & Cavan, 2014) to space tourism (Reddy, Nica, & Wilkes, 2012). Methodologically, a great deal of variability exists in regards to investigative approaches and research designs. For example, some studies are based on secondary data (e.g., Becken, 2012; Dawson, Scott, & Havitz, 2013; Dawson & Scott, 2007; Finger & Lehmann, 2012; Jones & Scott, 2006; Martinez Ibarra, 2011; Sabir, Van Ommeren, & Rietveld, 2013; Scott & Jones, 2006; Scott, Jones, & Konopek, 2007; Wilson & Becken, 2011), while others use case- or expert-based designs (e.g., Espiner & Becken, 2014; Geissler, 2008; Hamilton, Brown, & Keim, 2007; Hartz, Brazel, & Heisler, 2006; Kajan, 2014; Karamustafa, Fuchs, & Reichel, 2012; Liu, 2014; Nicholls & Holecek, 2008; Rauken & Kelman, 2012; Reddy, Nica, & Wilkes, 2012; Scott et al., 2007; Tervo, 2008). Given this diversity and variability of research topics, geographic context, salient factors, and research approaches, we deemed it timely to synthesize empirical studies into one state of knowledge article about weather research in outdoor recreation and nature-based tourism.

The present study uses a systematic approach for synthesizing and integrating the research to answer: "What are the themes, trends, and gaps in weather research related to outdoor recreation and nature-based tourism?" The results are categorized into three predominant areas: 1) weather-related salient factors and variables, 2) the research context, 3) and activity types. Following the systematic synthesis and grouping of studies into these areas, we used an objective gap analysis that resulted in several recommendations for future research.

Research Synthesis Methodology

A research synthesis is a systematic literature review focused on empirical studies and is used to summarize previous research about interconnected or identical topics, and then to draw overall conclusions (Cooper, 2010). A research synthesis is distinctly different from a meta-analysis because the goal is not necessarily a quantitative synthesis of evidence or to specify the strength of relationships between variables (Shelby & Vaske, 2008). Rather, the purpose of a research synthesis is to provide a state of knowledge about the topic and/or variables of interest, and to highlight important unresolved issues (e.g., a gap analysis; Cooper, 2010).

The research synthesis method evolved from an increase in social science research, new information technologies, and the necessity for trustworthy research reviews (Cooper, 2010). The research synthesis process has enjoyed widespread application in social and developmental psychology, clinical/community psychology, educational psychology, and health psychology. In health sciences, thousands of papers synthesizing cumulative evidence cover topics from public health resources to clinical procedures (Cochrane Collaboration, 2015). While this method is relatively new to leisure sciences, it has demonstrated utility in providing a retroactive review of social science research on winter use in Yellowstone National Park (Gatti, Brownlee, & Bricker, 2016) and can be similarly used in other park and recreation contexts (Brownlee & Bricker, 2015).

The research synthesis process offers several advantages beyond a simple narrative review. First, the process allows for the integration of separate research projects into a coherent whole by presenting a state of knowledge and highlighting important unresolved issues (Cooper, 2010). Second, the process requires validity checks on inferences to meet the same rigorous standards applied by the initial study researchers. For example, a meta-analysis, while highly useful, cannot be applied to new areas of research that employ different methodologies, sampling designs, and/or measurements (Shelby & Vaske, 2008). Consequently, based on the need for trustworthy syntheses and rigorous methodologies, the research synthesis process is well-suited to integrate empirical weather research in outdoor recreation and nature-based tourism for summarizing themes, trends, and gaps. Additionally, a research synthesis can be replicated due to its systematic method and therefore lends itself to longitudinal comparisons that are not possible with more traditional literature reviews.

Research Synthesis Process

There are seven steps in the research synthesis process: 1) define the research questions; 2) collect research data (i.e., systematic literature search); 3) gather information from studies; 4) evaluate the quality of studies; 5) analyze and integrate the outcomes of data; 6) interpret the evidence; and 7) present the results (Cooper, 2010). The research synthesis process is described below with emphasis on searching strategies, inclusion and exclusion criteria, and coding procedures used in this current study.

In this study, the researchers first identified the research question, "What are the themes, trends, and gaps in weather research in outdoor recreation and nature-based tourism?" With this guiding research question, a comprehensive set of weather studies was compiled during the second step (i.e., collection of research data). At this point, it is important to make clear the distinctions between outdoor recreation and nature-based tourism as well as weather and climate. *Outdoor recreation* is physically active leisure time spent in nature or the out-of-doors (Manning, 2011, p.4), and *nature-based tourism* is tourism occurring in natural areas and uses natural resources in an undeveloped area to enjoy nature (Hall et al., 2009). The distinction between weather and climate is important because the two terms are often inaccurately interchanged (Scott & Jones, 2006). *Weather* is the daily variations in the atmosphere (e.g., temperature, sun, cloud, rain), while *climate* is the long-term average behavior of weather in a specific location (Scott & Jones, 2006). This study focused on weather studies (not climate) in outdoor recreation and nature-based tourism.

Searching Strategies

Numerous search terms were used to compile these studies. The terms were developed using the table of contents from seminal works in outdoor recreation and nature-based tourism such as Manning's *Studies in Outdoor Recreation, 3rd edition: Search for Research and Satisfaction* (2011) and Scott, Hall, and Gössling's *Tourism and Climate Change: Impacts, Adaptation, and Mitigation* (2012). These texts offered insights into developing search terms that resulted in Boolean search strings that aligned with the Library of Congress Subject Headings (LCSH). The LCSH is considered to be the standard based on its international use and maintenance since 1898 (Library of Congress, 2015). Each Boolean search string included one of the following context words, "recreat*" or "sustainable tourism" or "leisure" or "tourism." This context word had to appear in combination with two sets of topic words. The first was "weather" or "meteorolog*" and the second was a list of 49 related topics. Some examples of related topics include "aesthetic*," or "skiing," and "parks." This resulted in numerous search term combinations (e.g., (recreat* OR sustainable tourism OR leisure OR tourism) AND (weather OR meteorolog*) AND (aesthetic*)).[1] Although this study focuses on weather, outdoor recreation, and nature-based tourism, some climate terms were used to identify articles that included weather-related factors and variables.

A number of search engines and databases, including Academic Search Premier (e.g., EBSCOhost, PsychInfo, and PubMed), Encyclopedia of Atmospheric Sciences, Leisure Tourism, Scopus, Meteorological and Geoastrophysical Abstracts, and WorldCat,

[1] Please contact the first author to receive a full list of the Boolean Search terms, which may be useful for conducting longitudinal comparisons in 5-10 years by replicating this study.

were selected based on consultation with subject area librarians. Searching strategies were accessed to source English language studies that contained the search terms. As a part of the systematic research synthesis process, primary author searches were also conducted, assembled, and included in the data. The researchers conducted the searches during April and May of 2015, which yielded 446 studies.

An annotated bibliography was created during step three of the research synthesis process as a tool to extract key information from each study. An a priori objective coding frame with 11 categories was implemented to extract information from each article (Cooper, 2010), including the following: database location, document citation, journal title, article purpose, context (i.e., setting of the study including geographic location, institution, or organization/destination particularly for tourism studies), sample, methods and analysis, findings and results, implications, salient constructs (i.e., all variables under investigation with specific attention to weather variables), and gaps as cited by the source. Reliability checks, conducted by one additional researcher, helped assess the accuracy of extracted information and reduced researcher subjectivity.

Inclusion and Exclusion Criteria

Step four involved the evaluation of data and application of inclusion/exclusion criteria. Studies were included if they were empirically based and peer-reviewed during the past 10 years (2005-2015). This research synthesis was time bound beginning at 2005 for two reasons. First, journals such as *Weather, Climate, and Society* did not exist prior to 2009, and second, many prolific authors began publishing weather studies around 2005 (e.g., Becken, Gossling, Hall, Scott; Scopus, 2015). The data include international studies in addition to studies conducted in the United States. Conference proceedings and papers, government documents, dissertations, and theses were excluded due to their lack of consistent peer-review processes. Papers were also excluded if they did not discuss "weather", which resulted in the exclusion of 59% of the studies.

Coding Procedures

The final steps of the research synthesis process included analyzing and integrating the studies, interpreting the data, and presenting the results. In step five of the research process, analyzing and integrating the studies, standard semi-inductive qualitative coding techniques were used to develop themes and trends from the research. To ensure the credibility and trustworthiness of the data, peer debriefing and intercoder reliability were implemented. Peer debriefing relied on expert responses to coding themes that were developing, and intercoder reliability consisted of developing definitions for each code and applying the definition to check for consistency in meaning and application between coders (Marshall & Rossman, 2011). The interpretation of data, step six of the research synthesis process, is presented in the results section of this paper.

Research Synthesis Process Validity

The research synthesis process employed several standards of qualitative validity, which aimed to ensure that throughout the research process, the results were an accurate representation of the data, trustworthy, and credible (Lincoln & Guba, 1985). In the design stage of the research synthesis process, we determined appropriate qualitative validity strategies to implement throughout the study and relied on triangulation by employing multiple sources of data to build codes and themes. The use of disconfirming evidence was another technique that enabled us to confirm the accuracy of the results through evaluating of divergent themes. For this study, the disconfirming evidence is presented in the gap analysis portion of the results. In addition, Cooper (2010) proposes that a checklist of questions be employed to ensure validity in each step of the research synthesis process including a) proper and exhaustive search terms derived in consultation with an expert subject area librarian; b) procedures to ensure the unbiased and reliable application and retrieval of relevant studies; and c) standard qualitative methods to code, combine, and compare results across the studies. This study benefited from such a checklist as well.

Gap Analysis Process

Following the research synthesis, a gap analysis was conducted to highlight important unresolved issues in the literature. Secondary sources such as books and book chapters were used during the gap analysis process to judge the research synthesis results against objective markers, such as topics contained in a book's table of contents. These types of sources are recommended for use in the objective gap analysis because they help identify themes, gaps, and trends in the research (Cooper, 2010).

For this study, the research gap analysis was conducted by consulting Scott, Hall, and Gossling's (2012) *Tourism and Climate Change: Impacts, Adaptation, and Mitigation*, Sewell's (1966) *Human Dimensions of Weather Modification*, and the following published research reviews: Gomez-Martin's (2005) *Weather, Climate, and Tourism*, Scott and Lemieux's (2010) *Weather and Climate Information for Tourism*. Thematic and methodological gaps were identified using the previously stated texts as objective markers. As a result, the gap analysis results provide relevant information for managers and researchers by exposing deficits in knowledge and illustrating opportunities for further inquiry.

Results

The results of this data collection yielded 184 weather studies, published in 84 unique journals from 2005-2015. Figure 1 provides a visual representation of the distribution of citations by publication year (n=184). As the figure depicts, there has been a steady increase in publications about weather, outdoor recreation, and nature-based tourism. Specifically, for each additional year after 2005, there have been approximately 2.84 (β = 2.84) new outdoor recreation and nature-based articles focused on weather.

A visual display of the 84 unique journals represented by this data is summarized in Figure 2 by the distribution of publications by journal title. *Tourism Management* published a high concentration of research on the topic of weather. Conversely, 61 journals published one article represented by this data.

The diverse range of journals publishing weather-related research could be indicative of two factors: first, weather is often studied alongside climate and because weather has yet to emerge as a stand-alone topic of research, articles are consequently being published in climate-oriented journals. Second, weather research is multi-disciplinary as demonstrated by collaborative research designs, and as a result is published in a wide variety of journals.[2]

Next, two sets of results are presented and discussed. The first set of results report the themes and trends in weather research in outdoor recreation and nature-based tourism. Three themes emerged from the research synthesis: 1) weather-related salient

[2] The full reference to each study is available upon request from the first author.

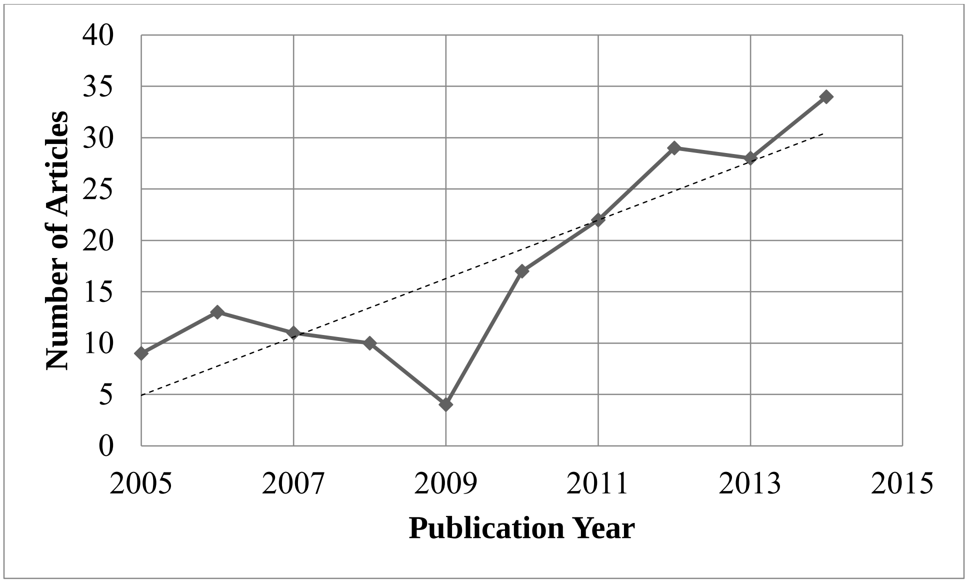


Figure 1. Distribution of Articles by Publication Year (*n*=184)

Note: It is possible that the variability in publications in 2009 was a result of the 2008 economic crisis in the United States, resulting in outdoor recreation and tourism industries focusing attention and research on the economic impacts rather than on weather-related research. Several primary journals (e.g., *Tourism Management*, *Global Environmental Change*, *Climate Research*, *Annals of Tourism Research*, and *International Journal of Biometeorology*) received significantly less publication submissions during 2009, which also could account for the variability (Scopus, 2015). While data were collected in 2015, only articles published from January to May were captured (*n*=5) contributing to an incomplete representation of weather-related articles from 2015 and therefore is not displayed in this distribution. The dashed line above represents the trendline for increases in article publications since 2005. The beta value (β=2.84) indicates that for every additional year, 2.84 weather-related articles were published.

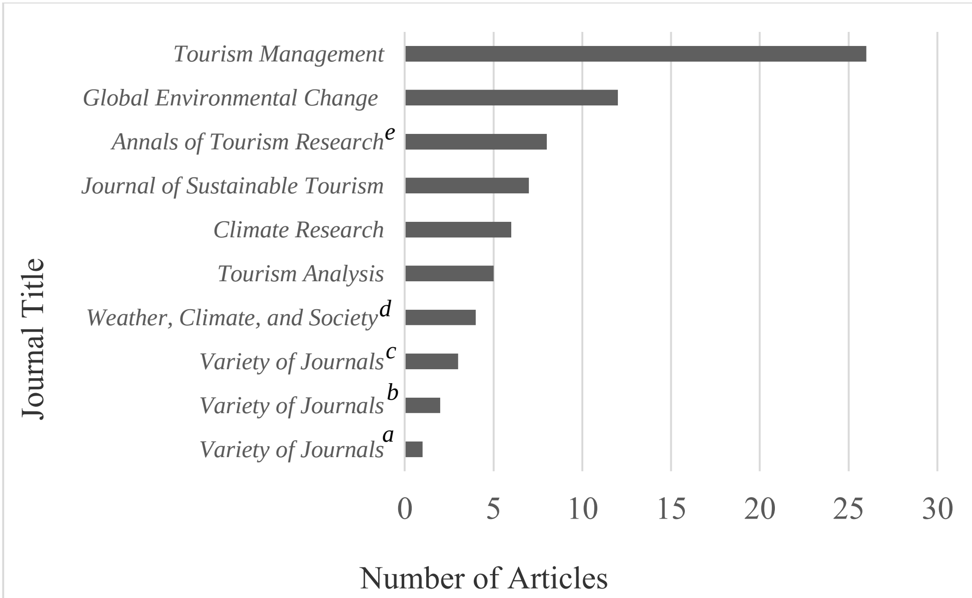


Figure 2. Distribution of Publications by Journal Title

Note:[a]Sixty-one journals are represented by one article in this data; [b]Seven journals are represented by two articles, including *Environmental Science & Policy, International Journal of Climatology*, *Journal of Environmental Psychology*, *Journal of Parks and Recreation Administration, Tourism and Hospitality Planning & Development,* and *Tourism Review International*; [c]Six journals are represented by three articles, including *Current Issues in Tourism, Journal of Leisure Research, Journal of Travel Research, Scandinavian Journal of Hospitality and Tourism, Tourism Geographies,* and *Tourism in Marine Environments;* [d]*Weather, Climate, and Society* as well as *Ocean & Coastal Management,* which are both represented by four articles; [e]*Global Environmental Change*, *Climatic Change*, and the *International Journal of Biometeorology* are each represented by twelve articles in this data.

factors and variables, 2) the importance of the geographic research context, and 3) prevailing activity types. Trends are discussed within each theme as well. The second set of results indicates research gaps based on the gap analysis. The research gap analysis indicated deficit areas within each emergent theme, followed by methodological gaps, and other under-researched areas where future research can focus attention.

Discussion

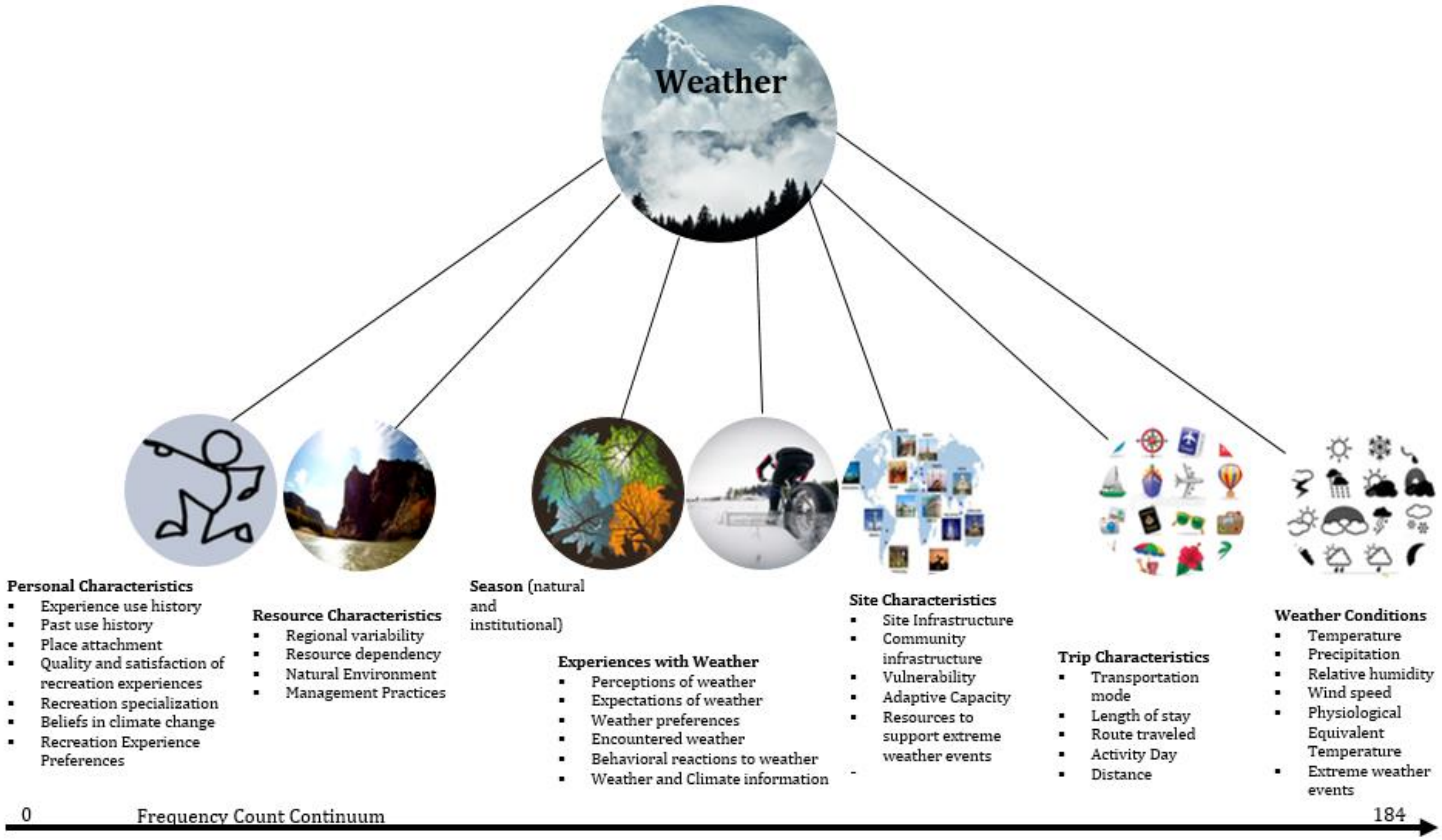
Research Synthesis Discussion: Emergent Theme One: Weather-Related Salient Factors and Variables

The first theme emerged from predominate and reoccurring weather-related salient factors and variables throughout the literature. These variables were categorized into larger factor groups. The salient factors include 1) weather conditions (most prevalent factor), 2) trip characteristics, 3) site characteristics, 4) experiences with weather, 5) season, 6) resource characteristics, and 7) personal characteristics (least prevalent factor; see Figure 3).

Weather Conditions

Numerous weather conditions were studied in a variety of contexts, research designs, and activity types, making *weather conditions* the most prevalent factor uncovered in the research synthesis. Temperature and precipitation were the two most common variables used in tourism climate impact studies (Matzarakis, Hämmerle, Koch, & Rudel, 2012), while relative humidity, wind speed, and Physiological Equivalent Temperature (PET) were typically measured alongside temperature. The overwhelming majority of the studies used secondary meteorological data as sources to distill weather

Figure 3. Frequency Occurrence Continuum of Salient Factors and Variables of Weather Research in Outdoor Recreation and Nature-based Tourism
Note: Factor and variable categories are not mutually exclusive. Frequency counts were based on the number of times the variable appeared within the 184 articles for this data set. If variables appeared more than once in a given article, the article was counted once.


Weather
Personal Characteristics
Experience use history
Past use history
Place attachment
Quality and satisfaction of recreation experiences
Recreation specialization
Beliefs in climate change
Recreation Experience Preferences
Resource Characteristics
Regional variability
Resource dependency
Natural Environment
Management Practices
Season (natural and institutional)
Experiences with Weather
Perceptions of weather
Expectations of weather
Weather preferences
Encountered weather
Behavioral reactions to weather
Weather and Climate information
Site Characteristics
Site Infrastructure
Community infrastructure
Vulnerability
Adaptive Capacity
Resources to support extreme weather events
Trip Characteristics
Transportation mode
Length of stay
Route traveled
Activity Day
Distance
Weather Conditions
Temperature
Precipitation
Relative humidity
Wind speed
Physiological Equivalent Temperature
Extreme weather events
0
Frequency Count Continuum
184

condition data (e.g., Becken, 2012; Brosy, Zaninovic, & Matzarakis, 2013; Dawson & Scott, 2007; Gómez-Martín & Martínez-Ibarra, 2012; Jones & Scott, 2006; Matzaraki et al., 2012; Sabir, van Ommeren, & Rietveld, 2013; Scott & Jones, 2006; Zhang & Wang, 2013) with temperature being the most common weather variable examined. Occasionally, field measurements were taken to observe key weather conditions relevant to researcher work (Andrade et al., 2011; Pantavou & Lykoudis, 2014).

Researchers have widely examined the effects of key weather conditions on outdoor recreation and nature-based tourism participation. Studies examined the influence of weather on the number of rounds played at golf courses (Scott & Jones, 2006), tourists' participation in scenic flights (Becken, 2012), and the variation of effects on outdoor recreation activities as compared to commuting (Helbich, Böcker, & Dijst, 2014). Participation in daily outdoor activity has been linked to key weather conditions (Wolff & Fitzhugh, 2011), including beach recreation as an indicator of preference for key weather parameters (de Freitas, 2015), and to predict beach traffic and travel modals (Sabir et al., 2013). Tourism visitation trends at Khaoyai National Park were evaluated based on temperature and precipitation (Pongkijvorasin & Chotiyaputta, 2013). Weather was used to investigate visitors' willingness to pay for trips to key national parks in the United States (Richardson & Loomis, 2005), ultimately predicting future recreation participation.

Human-biometeorological relationships (i.e., human-atmosphere interactions) were used to understand and predict future outdoor recreation and nature-based tourists' participation decisions (Gómez-Martín & Martínez-Ibarra, 2012; Lindner-Cendrowska, 2013). Human-biometeorological relationships were also pursued to inform future outdoor recreation plans and to develop adaptation strategies (Matzarakis et al., 2012b). Biometeorological data have been interpreted through relationships to personal characteristics (Andrade et al., 2011b) and used to predict thermal sensation by creating thermo-physiological models (Pantavou & Lykoudis, 2014; Rutty & Scott, 2014a, 2014b).

One common thermal measurement index, PET (i.e., human bio-meteorological index) was used to assess comfort and discomfort based on five key weather conditions (e.g., air temperature, relative humidity, wind speed, and cloud cover; Höppe, 1999). PET has been used to assess tourism's dependency on weather conditions (Brandenburg et al., 2007; Zhang & Wang, 2013), examine beach users' preferences for weather and ocean conditions (Zhang & Wang, 2013), and assess temporal frequency of daily recreational and commuting cyclists (Brandenburg et al., 2007). Models input PET and weather conditions to estimate thresholds of acceptability for tourism based on secondary data (Endler & Matzarakis, 2011; Matzarakis, 2014).

Other important weather conditions examined in the literature include extreme weather events and climate variability. Investigations include the effects of extreme weather events on the ski industry (Dawson & Scott, 2007; Dawson & Scott, 2013; Haanpää, Juhola, & Landauer, 2014; Hamilton, Rohall, Brown, Hayward, & Keim, 2003; Scott, Dawson, & Jones, 2008; Scott, McBoyle, Minogue, & Mills, 2006), tourists' perceptions (Hübner & Gössling, 2012), holiday destination selection (Windle & Rolfe, 2013), and resource users' vulnerability (Marshall, Tobin, Marshall, Gooch, & Hobday, 2013). The results suggest that climate variability[3] was typically examined through climate modeling and scenarios incorporating weather conditions into prediction and planning for outdoor recreation and nature-based tourism. Key studies have quantified the climate tourism potential of specific regions to predict future participation (Brosy et al., 2013; Matzarakis et al., 2012). Studies using climate scenario impact assessments have evaluated the influence of weather conditions on golfing: season length, operations, adaptation costs (e.g., snowmaking), and water requirements (Scott et al., 2006). Planning research utilized weather conditions and climate scenario projections to provide relevant data for tourism destinations (Matzarakis et al., 2012; Topay, 2013). Vulnerability-based planning approaches paired with weather data was used to provide insights for resource use, risk management, and adaptation strategies for the Artic Bay Inuit population (Ford et al., 2006).

Trip Characteristics

The second salient factor was trip characteristics and included the variables of transportation mode, length of stay, route traveled (i.e., distance at site and covered topography), activity day, and distance. Throughout the data, transportation mode signified the mode of transport employed to access and then engage in recreation at a destination (Becken et al., 2003; Reddy, Nica, & Wilkes, 2012), often categorized as motorized (i.e., vehicle traffic) or nonmotorized (i.e., on foot or by bike; Manning & Anderson, 2012). Length of stay was measured by the amount of time spent on-site or at the destination during the current visit and paired with weather data (Barbieri &

[3] Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

Sotomayor, 2013; Becken & Wilson, 2013; Coghlan, 2012; Dawson, Havitz, & Scott, 2015; Pongkijvorasin & Chotiyaputta, 2013; Woodside, Caldwell, & Spurr, 2005).

Route traveled was operationalized as a path or series of elements traveled at a destination, and typically joined resources and attractions, varied in length, and influenced visitor numbers (Becken & Wilson, 2013; Lackstrom, Kettle, Haywood, & Dow, 2014). Route traveled included distance during activity and topography, while weather was treated as a situational factor influencing route decision-making (Becken & Wilson, 2013). Activity day indicated the day of the week, including work days, weekends, and holidays recreationists and nature-based tourists engage in outdoor recreation and the relationship between weather conditions (Brandenburg, Matzarakis, & Arnberger, 2007; Shih, Nicholls, & Holecek, 2008). Assessing activity days allowed for an understanding of the day-to-day variations in recreation use paired with weather data. Distance, a proxy for travel costs and travel time, calculated in kilometers and/or miles from residential city to holiday destination location, was used assess the effect of weather in tourists residential city on holiday destination selection (Bigano, Hamilton, & Tol, 2006).

Site Characteristics

The third most prevalent factor, site characteristics, encompass the variables of site infrastructure, community infrastructure, vulnerability, adaptive capacity, and resources to support extreme weather events. In the literature, site infrastructure was often conceptualized as the operations and development at specific recreation or tourism areas (Barbieri & Sotomayor, 2013; Lemieux, Beechey, Scott, & Gray, 2011). Site infrastructure included transportation infrastructure (e.g., parking lots and roadways) and facility infrastructure (e.g., restrooms, visitor centers, campgrounds, and trailheads). Community infrastructure referred to the ability of surrounding communities to support tourism or recreation development (e.g., support services, water, and energy supply; Bennett, Lemelin, Koster, & Budke, 2012).

Espiner and Becken (2014) treated vulnerability in a geographic context, including conditions contributing to a sector's vulnerability such as distance from mass markets, increasing fuel costs, global financial forecasts, and a diverse range of physical environmental factors. Meanwhile, Dawson and Scott (2010) relied on a supply and demand approach to assess vulnerability by proposing models to project future climate change impacts (i.e., supply) and behavioral responses to historic and expected conditions (i.e., demand). Related to vulnerability, adaptive capacity was examined throughout the literature specifically in relationship to climate change impacts. Scott, Simpson, and Sim (2012) found that the following key factors determined the adaptive capacity of coastal destinations to cope with weather variations (e.g., climate change):

> policy and planning frameworks that enable or actively assist coordinated structural protection and cost-sharing of beach nourishment; resort property ownership and local taxation structures; insurability and insurance costs; the ability to afford the major costs associated with structural protection and recurrent beach nourishment, which typically must be redone every decade or sometimes after major storm events, and the availability of affordable and environmentally sustainable sources of sand. (p. 894)

Another common variable of interest in this data was resources to support extreme weather events. This included the physical built infrastructure and data processing infrastructure designed to support or withstand extensive damage resulting from extreme weather events (Perch-Nielsen, 2010; Scott & Lemieux, 2010).

Experiences With weather

The factor *experiences with weather* characterizes the research about recreationists' and tourists' connections with weather. Significant variables investigated throughout the research related to *experiences with weather* include weather perceptions, expectations and preferences, encountered weather, behavioral reactions to weather, and weather and climate information as significant variables investigated throughout the research data.

Tourists' perceptions, expectations, and preferences of weather were intertwined concepts throughout many studies. Perceptions of weather were investigated by assessing tourists' responses to meteorological conditions (i.e., weather conditions) such as temperature, precipitation, and humidity (Andrade, Alcoforado, & Oliveira, 2011; Denstadli, Jacobsen, & Lohmann, 2011). Researchers investigated tourists' expectations of weather through predetermined understandings of local weather conditions at a destination (Becken & Wilson, 2013; Coghlan, 2012; Hübner & Gössling, 2012). Weather preference assessments were based on subjective and self-reported partialities for specific weather conditions (Førland et al., 2013). While these three concepts are distinctly different, often these variables were investigated in some combination within one questionnaire or interview, in situ, presenting challenges in differentiating measurement uniqueness. For example, weather perceptions, most often measured as a single item (e.g., Denstadli et al., 2011, Hübner & Gössling, 2012) have been conflated with measurements of tourists' experienced weather and expectation congruence (Hübner & Gössling, 2012). Similarly, weather expectations, typically a single item measurement, was paired with encountered weather measurements to predict tourists' behavioral changes (Becken & Wilson, 2013). Weather preference measurements often required tourists to predict changes in plans due to unexpected weather (Denstadli et al., 2011) or to assess the relationship between bioclimatic comfort through weather preferences (Andrade, Alcoforado, & Oliveira, 2011). Only very unique studies combined self-reported weather preferences with present and future climate conditions at select destinations (Førland et al., 2013), indicating a need for consistent and distinct measurement items for weather perceptions, expectations, and preferences.

Encountered weather, and weather and climate information, were inextricably linked to investigations of behavioral reactions to weather. The aggregate data suggest in situ encountered weather (Denstadli, Jacobsen, & Lohmann, 2011), coupled with prior and concurrent engagement with weather information, often resulted in behavioral reactions to weather (i.e., travel adaptation; Becken & Wilson, 2013). Research also suggested destination selection is based on encountered or expected weather conditions and perceptions of weather conditions at a destination (Gössling & Hall, 2006).

Season

The fifth most prevalent factor was *season*, which was examined in the literature through the lens of natural seasonality and institutional seasonality. Natural seasonality, defined as the length and quality of tourism and recreation seasons (Butler, 2001), was based on unstable weather patterns resultant from climate influences on the physical resources that provide foundations for nature-based tourism and outdoor recreation (Jones & Scott, 2006). Studies on natural seasonality targeted the lengthening of warm weather recreation and tourism seasons as a result of climate change (Yu, Schwartz, Walsh, Schwartz, & Salmon, 2009, 2013). Studies also examined the implications for park visitation and golfing towards projecting regional impacts of winter tourism (Dawson & Scott, 2010). Furthermore, the influx of seasonal tourism products and experiences reliant on weather as a result of a healthy natural environment (Bennett et al., 2012). Institutional seasonality was characterized by systematic fluctuations of visitation around summer school holidays (Scott, Jones, & Konopek, 2007). Increases in visitation to tourist locations typically occur around institutional seasons (De Freitas et al., 2008, Scott, Jones, & Konopek, 2007).

Resource Characteristics

Research in the area of *resource characteristics* often included regional climate variability, resource dependency, natural environment, and management practices. Regional climate variability was assessed in these data related to the impacts of weather on skiing and the ski economy (Scott, McBoyle, & Minogue, 2007), the length of outdoor skating season (Damyanov, Damon Matthews, & Mysak, 2012), increasing energy costs and extreme weather events (Espiner & Becken, 2014), and adaptation (Brugger & Crimmins, 2013). Resource dependency was used to characterize the strength of linkages between social and ecological systems, which also included an activity's dependency on certain resources. For example, the concept of resource dependency helps interprets individuals' sensitivity to changes in resource conditions (e.g., weather variations) of the Great Barrier Reef - resources on which communities, industries, and systems depend (Marshall et al., 2013).

The natural environment variable was often separated into push and pull factors, representative of natural site characteristics rather than human built infrastructure. Previous research suggested that push and pull factors influence travel in diverse ways.

Push factors motivate travel (i.e., social psychological factors that motivate travel) and are represented by weather at a trip's origin. Both climate and recreation have been reported as push factors (Pomfret, 2006). Pull factors influence destination or site selection (e.g., landscapes, physical resources, and features, the geography, and ecosystem features; Pomfret, 2006). For example, the natural mountain environment draws mountaineers to areas with suitable resources to promote recreation engagement (Pomfret, 2006).

Lastly, management practices at recreation and tourism sites were a key topic related to resource conditions. Management practices were studied in relationship to weather-related challenges such as environmental sustainability at ski resorts (Spector, Chard, Mallen, & Hyatt, 2012), seasonally based personnel management and operations (Lackstrom et al., 2014), risk management strategies (Becken & Hughey, 2013; Ford, Smit, & Wandel, 2006), and snow production strategies (Scott, McBoyle, & Minogue, 2007).

Personal Characteristics

The study of personal characteristics existed in many studies but was also the least prevalent factor. These personal characteristics are in addition to standard demographic information and include experience use history, past use history, place attachment, quality and satisfaction of recreation experiences, recreation specialization, beliefs in climate change, and recreation experience preferences. Because these are commonly examined concepts in outdoor recreation literature (see Manning, 2011 for a review), research on personal characteristics and weather are listed in Table 1.

Table 1 *Weather-Related Factor: Personal Characteristics*

Variable	Operationalized variable	Study Citation
Experience use history or travel behavior	Surfing behavior – number of times a year an individual has been surfing, number of days a week, weeks in the last year	(Barbieri & Sotomayor, 2013)
	Traveler behavior – likelihood to return based on weather conditions	(Denstadli, Jacobsen, & Lohmann, 2011)
Past use history	Surfing behavior – number of trips in the last five years, trip length, and variety	(Barbieri & Sotomayor, 2013)
	Traveler behavior – likelihood to return based on weather conditions	(Denstadli et al., 2011)
Place attachment	Examined to determine recreational tourism potential	(Yang, Madden, Kim, & Jordan, 2012)
	Social component of a natural resource system	(Marshall, Tobin, Marshall, Gooch, & Hobday, 2013)
Quality and satisfaction of recreation experiences	Weather quality Trip satisfaction Environmental quality Human-built destination specific infrastructure Quality of overall experiences Recreation season Overall satisfaction with wildlife encounters, recreation experiences, and destination specific attributes	(Hipp & Ogunseitan, 2011; Richardson & Loomis, 2005; Scott & Jones, 2006; Sutton, 2005; Thapa, 2012; Yu, Schwartz, Walsh, Schwartz, & Salmon, 2013)
Recreation specialization	Touristic skill construction	(Tsaur, Yen, & Chen, 2010)
	Effects of extreme weather on climbers	(Bassi & Fave, 2010)
Beliefs in climate change	Anthropogenic causation Occurrence	(Brownlee & Verbos, 2015; Brownlee, Hallo, Wright, Moore, & Powell, 2013)
Recreation experience preferences	Traveler motivations Weather influences on likelihood of return visitation	(Denstadli, Jacobsen, & Lohmann, 2011)
	Participation in frontier tourism Desert trekking	(Laing & Crouch, 2011)
	Motivations for sun, sand, and sea travel	(Hübner & Gössling, 2012)

Research Trends for Weather-Related Salient Factors

The research trends for *weather-related salient factors and variables* are discussed below. Temperature has been the most studied variable throughout weather-related research. Despite urging from researchers to pair temperature data with other weather variables, studies continue to assess and correlate temperature with outdoor recreation and nature-based tourism observation data. Additionally, an overwhelming majority of the weather studies use secondary meteorological data that are infrequently paired with recreation or tourism use data. In the face of the trends in these data, it is important to not only use secondary meteorological data about temperature, but to assess tourists' and recreationists' perceptions of important weather variables including but not limited to temperature, precipitation, wind speed, and extreme weather events. Assessments of recreationists' perceptions can lead to heightened understandings of recreation participation and recreation prediction patterns based on several indicators. Outside of these two trends, the remainder of the research is diverse in regards to salient factors and variables.

Emergent Theme Two: The Importance of Geographic Research Context

Research theme two emerged from results that revealed the *importance of geographic research context*. The data fit into three larger categories that are not necessarily mutually exclusive due to the nature of comparative study designs and overlapping research contexts: 1) North American land-based context, 2) European winter and land-based context, and 3) islands marine-based context.

Well over 50 articles (approximately 30%) were situated in the North American land-based context and these studies mostly examined aspects of winter tourism. The majority of these studies come from a Canadian and United States ski-based context. This is evidenced by the sheer volume of studies conducted on the effects of a warming climate to the ski industry (Scott et al., 2008; Scott, McBoyle, & Minogue, 2007). Logically, this finding makes sense if we think about the location of the most prolific authors in this research synthesis. Second, about half of the articles originated in a European winter- and land-based context. Studies in this category were conducted in places like Finnish Lapland's Artic tourism context (Dawson, Johnston, & Stewart, 2014; Huntington et al., 2007; Jacobsen, Denstadli, Lohmann, & Førland, 2011; Kajan, 2014) and the French Mediterranean coast (Balouin, Rey-Valette, & Picand, 2014). Lastly, about a quarter of the articles originated in an islands marine-based context. This includes studies conducted in Australia's Great Barrier Reef Marine Park (Coghlan, 2012; Marshall et al., 2013; Sutton, 2005), New Zealand's coastal tourism (Becken, 2012; Becken, 2013; Becken & Hughey, 2013; Espiner & Becken, 2014; Hughey & Becken, 2014; Jeuring & Becken, 2013; Perch-Nielsen, 2010; Wilson & Becken, 2011), and in iconic places such as Hawaii (Nelson, Dickey, & Smith, 2011) and the Caribbean Islands (Becken, 2014; Hübner & Gössling, 2012; Nelson et al., 2011; Rutty, 2013; Rutty & Scott, 2014b; Weaver, 2005).

The *importance of geographic research context* is clear from the studies in which weather is a major factor in nature-based tourism destination selection. The increasing trend for theme two unequivocally points to the growing body of research originating from the European ski tourism context. Climate prediction models suggest that under certain climatic conditions, the availability of snow will be concentrated to key areas and these impacts suggest a greater concentration of tourists in higher altitude areas

(Gilaberte-Burdalo, Lopez-Martin, Pino-Otin, & Lopez-Moreno, 2014). The implications of model research has resulted in a focus on high-altitude ski tourism and the growing body of research is focused on the ski tourism industry in Europe.

Emergent Theme Three: Prevailing Activity Types

There were four primary activity types investigated throughout the research. Skiing was the number one activity type. The ski industry, under certain climate scenarios and subsequent weather changes, will be the most evidently influenced, bringing the study of weather to the forefront. These studies collectively examined the ski industry holistically from stakeholder interviews (Scott et al., 2006), ski operator focus groups (Bank & Wiesner, 2011), and ski and snowboard participant surveys (Buller et al., 2012). Nature-based tourism was the second prevailing activity type and included undertakings such as ‘sun and beach tourism’ (Martinez-Ibarra, 2011), surf tourism (Ponting & McDonald, 2013), and winter tourism activities (Tervo, 2008). Third was the residential and/or community oriented category. About 15 studies examined one aspect of residential or community recreation activity. For example, one study asked 950 residents over the age of 18 years to complete travel diaries on randomly assigned days based on their recreation and commuting activity (Helbich et al., 2014). This category also included studies of Inuit communities (Ford, Pearce, Duerden, Furgal, & Smit, 2010; Ford et al., 2006). The final category was defined by the *visitor* and regards park and protected area visitation around the world. The *visitor* experience in relation to weather has been examined in Canada’s National Parks (Jones & Scott, 2006), Rocky Mountain National Park (Loomis & Richardson, 2006) and Kenai Fjords National Parks (Brownlee, Hallo, Wright, Moore, & Powell, 2013) in the United States, and Kafue National Park in

Zambia (Thapa, 2012). Despite the importance of each activity type, the trend for theme three is overwhelmingly skiing, which is the largest studied activity.

Research Gap Analysis Discussion

Results from the gap analysis indicated deficiencies in knowledge about weather within outdoor recreation and nature-based tourism. The research gap analysis results are discussed relative to each emergent theme, followed by methodological gaps, and other under-researched areas. Under-researched areas are highlighted and suggestions for future research attention are presented.

It is apparent that previous research has focused investigations on the influence of weather information on tourist behavior. However, there still exists limited knowledge about how outdoor recreationists' process and integrate weather information. The effects on tourists' decision-making, in addition to weather-related travelling motivations and activity participation (Scott, Hall, & Gössling, 2012), resultant from weather and climate information is relatively unknown. Therefore, future research can investigate the process of how nature-based tourists and outdoor recreationists not only engage with weather but also integrate weather information, such as forecasts.

The results from emergent theme two, *the importance of research context*, indicated few studies occur in developing nations, which has limited the number of studies about indigenous populations' outdoor recreation and weather. Specifically, limited studies investigate weather and outdoor recreation and nature-based tourism in Central and South America, Asia, and Africa. The current data contain only one study from each of these aforementioned areas and no studies from the Middle East and Russia about weathers' influence on outdoor recreation and nature-based tourism. Scott and

Lemieux (2010) acknowledge this gap and recommend weather and nature-based tourism be conducted in developing nations (p. 146). Therefore, future inquiries about the weather in outdoor recreation and nature-based tourism can focus in under-researched geographies such as the Middle East, Russia, Asia, and developing nations.

Gaps in research also exist in prevailing activity types investigated. The results indicated golf and skiing as the predominantly investigated activities, leaving a large portion of outdoor recreation activities under-researched. Intuitively, golf and skiing, are weather dependent but so are other outdoor recreation activities such as hunting, hiking, mountain biking, sailing, surfing, and kayaking. The 'weather dependency' of specific outdoor recreation activities is an interesting area where future inquiries can focus attention. For example, research could investigate the weather dependency of three activities that represent a likely range of weather sensitivity such as backcountry skiing, ungulate hunting, and hiking in a particularly weather sensitive research context. Additionally, very little is known about the weather dependency of urban-oriented outdoor recreation, and is another area future research can explore.

The gap analysis revealed a lack of diversity in research methods. Most commonly, the qualitative methods were case-based, expert-based, and descriptive, while the quantitative methods traditionally used secondary weather data to predict future participation in activities or visitation to destinations. Less commonly, researchers paired secondary weather data with in situ questionnaires to compare recreationists and tourists' perceptions of different weather scenarios. In future investigations, recreationists' perceptions of weather could be measured and coupled with climate prediction modeling data or used to holistically understand the weather dependency of key outdoor recreation and nature-based tourism activities.

Other identified gaps in knowledge fell outside the emergent themes indicated by this study, but nevertheless are notable. Gómez-Martin (2005) suggested research gaps between the links of tourism fashion and weather, the use of perceived inclement weather for providing new types of tourism ventures (p. 574), and weather conditions that deter tourism outside of temperature (p.149). Absent from the literature are studies examining the effects of technology on outdoor recreation and nature-based tourism, specifically in relation to adaptation strategies. Long ago, Clawson (1966) speculated that the influence of weather on outdoor recreation can be offset through technological advances to outerwear (i.e., wearing a Gortex rain jacket may make hiking in the rain tolerable) by extending the human capacity for previously intolerable conditions. Research has yet to investigate the impacts of technological advances to outdoor gear, under a range of weather scenarios. These deficiencies in knowledge about weather-related influences on outdoor recreation and nature-based tourism indicate areas of future research.

Conclusion

Employing a research synthesis and gap analysis, this study uncovered what the literature suggests are common themes in weather-related outdoor recreation and nature-based tourism research as well as gaps in knowledge. The 184 empirical studies from which the research synthesis and gap analysis findings are drawn were summarized into emergent themes including the most salient factors and variables, the importance of research context, prevailing activities, and resultant gaps in knowledge. This research synthesis illustrates that despite limited literature about weather in outdoor recreation and nature-based tourism, the number of weather studies is steadily increasing. As the impact of weather on outdoor recreation and nature-based tourism continues to receive increasing attention, it will be necessary to fill several of the knowledge gaps revealed by this study.

CHAPTER III

A WEATHER DEPENDENCY FRAMEWORK FOR OUTDOOR RECREATION ACTIVITIES

Abstract

This paper describes the creation of a Weather Dependency Framework (WDF) and its potential usefulness for managers and researchers. The WDF is a mechanism for understanding the multidimensional variables that influence the weather dependency of outdoor recreation activities. The need for this work was evident because of the growing number of studies probing the general influence of weather on outdoor recreation without an organizing framework for making sense of those influences. A modified Internet-based Delphi process employing a panel of 27 experts in the areas of weather, climate, outdoor recreation, and natural resource management was facilitated in the summer of 2015 to develop the WDF. Additionally, the panel of experts tested the WDF's potential usefulness by applying it to three outdoor recreation activities that represent a likely spectrum of weather dependency. The paper concludes by considering other possible applications as well as recommendations for the WDF's future development.

Introduction

The multidimensional influences of weather have been receiving increasing attention in the outdoor recreation literature (Chapter II). In a recent study, for example, weather was identified as a primary topic in 184 published research articles (Chapter II). This weather research appeared in 84 different journals and is important to outdoor recreation to facilitate effective and efficient weather-related decision-making (Becken, 2012), planning and management of weather-dependent activities (Scott & Lemieux, 2010), and future research (Gómez Martín, 2005; Gössling & Hall, 2006; Scott & Lemieux, 2010).

Despite the importance of weather to outdoor recreation, previous research has not addressed ‘weather dependency,’ a concept arising from the resource dependency literature. *Resource dependency* is human dependency on the natural environment and is characterized as the strength of linkages between social and ecological systems (Tidball, 2012). Similarly, we define weather dependency as *the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions*. Most outdoor recreation activities are highly affected by weather and resulting conditions.

Despite outdoor recreationists’ evident reliance on weather, we know little about the weather dependency of outdoor recreation activities. Studies investigating weather have typically only indirectly assessed weather dependency, such as the impact of decreased snowfall on downhill skiing (Hamilton, Rohall, Brown, Hayward, & Keim, 2003) and extended shoulder seasons’ impacts on golf participation (Scott & Jones, 2006). Moreover, research has yet to address the comprehensive nature of variables influencing the weather dependency of outdoor recreation activities.

Given the increasing attention paid to weather research and limited studies on the weather dependency of outdoor recreation (Chapter II), it was deemed necessary to combine factors and variables into one framework that could aid researchers and managers in assessing the weather dependency of outdoor recreation activities. Consequently, this paper presents a Weather Dependency Framework (WDF) for outdoor recreation activities, and extends previous research by incorporating variables formerly scattered through various research into one framework. The purpose of developing the WDF was to create a useful tool for researchers and managers interested in interpreting and understanding weather dependency in a multitude of settings. We suggest the WDF as an orientation to the most salient factors and variables influencing weather dependency.

Review of Relevant Literature

Weather-related research is diverse and scattered, often intertwining with climate research. Therefore, we first focus on the distinction between weather and climate, making clear that while researchers have interchanged them, the concepts are distinct. We then examine weather dependency and offer a justification for the importance of understanding the weather dependency of outdoor recreation activities. Finally, we synthesize the prevalent weather-related factors and variables identified throughout outdoor recreation research to provide a background and rationale for including key concepts in the WDF. Throughout, we consider *outdoor recreation* to be active leisure time spent in the outdoors (Manning, 2011, p. 4).

Weather versus Climate

Although inextricably linked, weather and climate are distinct: c*limate* is the long-term average behavior of weather in a specific location, while *weather* is the daily variations in meteorological conditions (e.g., temperature, sun, cloud, rain; Scott & Jones, 2006). The review of relevant literature and the WDF focus on weather specifically.

Outdoor recreation studies involving weather and climate exist in disparate journals, siloed by disciplines that often interchange weather and climate. This makes sense because weather and climate are linked concepts and both significantly influence outdoor recreation. For example, research has linked the weather and climate variability to golf participation (Scott & Jones, 2006), destination selection (Becken, 2012; Windle & Rolfe, 2013), and ski demand (Dawson, Scott, & Havitz, 2013). However, it is important to distinguish weather and climate as unique concepts despite this linkage. While key climate parameters have been investigated in the context of tourism for over 30 years (Scott et al., 2008), weather studies have only just begun to receive increasing attention over the last 10 years (Chapter II).

Weather Dependency

We define weather dependency as *the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions,* and many outdoor recreation activities are highly weather dependent. For example, downhill skiing and golf are both reliant on precipitation and temperature (Dawson & Scott, 2013; Hamilton et al., 2003; Nicholls, Holecek, & Noh, 2008). Other research has connected the impacts of seasonal weather to national park visitation (Jones & Scott, 2006), and surfing behavior is linked to wind and related wave conditions (Barbieri & Sotomayor, 2013).

Despite these studies, we know little about outdoor recreationists' direct dependency on weather forecasts, motivations to engage in weather-sensitive activities, and cultural interpretations of weather (Scott, Lemieux, & Malone, 2011). For instance, Rutty and Andrey (2014) found skiers, snowboarders, and snowmobilers to be reliant on weather forecasts when planning winter recreation activities. These authors also found that the use of weather forecasts varied by recreation type (e.g., the difference between skier site selection and snowmobilers' use of radar imagery). Previous research also indicates a need to combine recreationists' motivations for participation in weather-sensitive activities with other variables such as season (Qu, Kim, & Im, 2011). As well, it is important to further understand how motivations influence travel behavior under weather conditions (Spencer & Holecek, 2007). Additionally, destination choice and choice models have begun to investigate the interactions between push and pull factors and the weather to understand travel destination selection (Matzarakis, Hammerle, Koch, & Rudel, 2012; Nostrand, Sivaraman, & Pinjair, 2013; Smith, Li, Pan, Witte, & Doherty, 2015). While the studies conducted to date hint at links between weather-related variables and weather dependency, research has yet to explore specifically the weather dependency of outdoor recreation activities. The WDF is one way to combine influential factors and variables into one framework, thereby specifically addressing weather dependency.

The limited existing research on the weather dependency of outdoor recreation points to gaps in the research, especially in the manner that researchers, managers, and recreationists conceptualize weather dependency. For example, in one study, ski-tourism industry authorities did not perceive the ski industry to be particularly weather dependent while local ski-tourism operators considered the industry to be highly weather dependent (Rauken & Kelman, 2012). Investigations of travel adaptations have relied on only two variables to understand weather dependency: ‘engagement with weather and climate information’ linked to ‘behavioral reactions to weather’ (Becken & Wilson, 2013). The reliance on two variables does not account for the variety of external factors influencing weather dependency, such as the process of integration, and engagement with weather information or the effects of travel adaptations related to motivations of participation in weather dependent activities (Scott, Hall, & Gössling, 2012). Additionally, the large majority of research that points to weather dependency has used secondary data to predict outdoor recreation participation. For example, secondary data have been used to investigate the role of weather in beach travel (Sabir, van Ommeren, & Rietveld, 2013), regional tourism potential (Matzarakis, Hämmerle, Koch, & Rudel, 2012), the golf industry (Scott & Jones, 2007), and the vulnerability of the ski industry (Scott, McBoyle, Minogue, & Mills, 2006). Assessments concerning the weather dependency of outdoor recreation activities could benefit from multidimensional investigations incorporating a variety of variables.

There is a need to know more about recreationists’ culturally bound interpretations of weather dependency. In work with arctic communities, Kajan (2014) found that adaptation strategies employed local and traditional knowledge to combat weather exposure. Karamustafa and colleagues (2012) also found that culturally defined risk perceptions influence weather dependency. A weather dependency framework could help elucidate important factors and variables that relate to culturally bound interpretations of weather.

Weather Factors and Variables

Outdoor recreation weather-related studies include a multitude of factors and variables. For example, in a previous study, the authors' uncovered seven weather-related factors and 32 variables investigated in the literature (Chapter II). First, the factor *site characteristics* includes the variables' of site infrastructure (Barbieri & Sotomayor, 2013), community infrastructure (Bennett, Lemelin, Koster, & Budke, 2012), vulnerability (Espiner & Becken, 2014), adaptive capacity (Scott, Simpson, & Sim, 2012), and resources to support extreme weather events (Scott & Lemieux, 2010). Second, the *trip characteristics* factor includes the variables transportation mode (Reddy, Nica, & Wilkes, 2012), length of stay (Barbieri & Sotomayor, 2013), and route traveled (i.e., distance, topography, and activity day; Lackstrom, Kettle, Haywood, & Dow, 2014). Third, research in the area of *resource characteristics* considers regional weather variability (Scott, McBoyle, & Minogue, 2007), resource dependency (Marshall, Tobin, Marshall, Gooch, & Hobday, 2013), natural environment (Pomfret, 2006), and management practices (Spector, Chard, Mallen, & Hyatt, 2012). Fourth, the factor *personal characteristics* includes experience-use history (Barbieri & Sotomayor, 2013), past-use history (Barbieri & Sotomayor, 2013), place attachment (Yang, Madden, Kim, & Jordan, 2012), quality and satisfaction of recreation experiences (Richardson & Loomis, 2005; Thapa, 2012), recreation specialization (Tsaur, Yen, & Chen, 2010), beliefs in climate change (Brownlee & Verbos, 2015), and recreation experience preferences (Denstadli, Jacobsen, & Lohmann, 2011). Fifth, natural seasonality (Jones & Scott, 2006) and institutional seasonality (Scott, Jones, & Konopek, 2007) are included in the factor *season*. Sixth, the factor *experiences with weather* includes weather perceptions

(Andrade, Alcoforado, & Oliveira, 2011), expectations (Becken & Wilson, 2013), and preferences (Førland et al., 2013), encountered weather (Denstadli et al., 2011), behavioral reactions to weather, and weather and climate information (Becken & Wilson, 2013). The seventh and final factor is *weather conditions*, which includes variables such as temperature and precipitation (Matzarakis, Hämmerle, Koch, & Rudel, 2012), relative humidity (Becken, 2012), wind speed (Matzarakis et al., 2012), and Physiological Equivalent Temperature (PET; Höppe, 1999).

The above factors and variables provide a foundation for the creation of the WDF. Notwithstanding the variety of salient factors and variables, research has yet to combine these factors and variables into one framework to understand weather dependency. Consequently, we know very little about the weather dependency of outdoor recreation activities, which led to pivotal research questions.

Research Questions

Based on the absence of a framework to understand weather dependency, we developed the following research questions:

1. What are important considerations (e.g., anchors, continuums, and utility) for developing a visual display that adequately represents the salient factors and variables influencing the weather dependency of outdoor recreation activities?
2. Where might different outdoor recreation activities fall on a continuum of weather dependency, given a place specific setting?
3. What are the potential applications of the WDF including its utility for managers and researchers?
4. What are the opportunities for future development of the WDF?

Research Design and Methods

Given the dispersed knowledge about weather within individual disciplines and the need to analyze differences and similarities from an interdisciplinary perspective, the Delphi method (Dalkey & Helmer, 1963; Strauss & Zeigler, 1975) was considered the best option to address these research questions. Delphi studies have found widespread use in the fields of business, climate change adaptation, education, land-use conflicts, natural resources, nature conservation, and tourism (e.g., Landeta, 2005; McKenna, 1994). The Delphi method can also be used in a variety of ways in the social sciences (Strauss & Zeigler, 1975), such as identifying the differences and similarities in park and protected area managers' values and management practices and priorities (Ruschkowski, Burns, Arnberger, Smaldone, & Meybin, 2013). Delphi studies have also defined financial funding mechanisms and identified necessary knowledge to implement funding tools for conservation professionals responsible for financing international protected areas (e.g., Ecuador, Peru, and Columbia; Mancheno et al., 2013). The Delphi method is typically used to address complex research problems that require the involvement of discipline-specific experts (Ruschkowski et al., 2013).

The Delphi method relies on a panel of experts to explore a subject matter, identify dissent, arrive at consensus, and provide final evaluations of a product (e.g., the WDF) through a systematic process of iterative and controlled feedback (Landeta, 2005; Ruschkowski et al., 2013; Strauss & Zeigler, 1975). The premise behind the Delphi method is the notion that two heads are better than one, and, therefore, obtaining information from a panel of experts is ideal (Landeta, 2005; Ruschkowski et al., 2013; Strauss & Zeigler, 1975). For the purposes of this study, the researchers used a modified, Internet-based Delphi method as a committee evaluation tool, soliciting input and output from the panel of experts. The method required the researchers to first identify the area of interest (e.g., weather dependency) and then select the panel of experts.

Expert Selection

Panel selection was a critical component of the study design. Previous research has suggested panel size is less important than the qualifications of the experts (Wilhelm, 2001). Furthermore, Delphi method limitations can arise if the panel of experts is too homogenous or like-minded (Landeta, 2005; Ruschkowski et al., 2013; Strauss & Zeigler, 1975). Accordingly, panel selection included heterogeneous individuals with research expertise or field-based knowledge in weather, climate, outdoor recreation, and/or natural resource management. Inclusion criteria ensured the panel was composed of diverse and experienced professionals. The following criteria were used to select panel members: a) evidence of peer recognition as an expert in weather, climate, outdoor recreation, and natural resource management (e.g., peer-reviewed publications, books, book chapters), b) recent and multiple years of professional experience, c) educational training related to the relevant subject matter, and d) experience working with outdoor recreation providers and stakeholders (modified from Mancheno et al., 2013). The pool of experts was validated using member checking to ensure all potential experts fit the selection criteria. Twenty-seven experts participated in this four-round, modified, Internet-based Delphi process.

Data Collection and Analysis

Study data were collected and managed using Research Electronic Data Capture (REDCap) a software program hosted at the University of Utah[4]. We collected data by conducting a four-round Delphi process, and the data generated in each round were analyzed and served as the basis for developing the questions for the next round. We employed standard qualitative analysis-coding techniques to characterize and analyze the responses for each round (Cresswell, 2015). During the analysis process, we used peer debriefing to enhance the trustworthiness of the findings (Cresswell, 2015).

We conducted the Delphi process with one initial questionnaire based on a previous research synthesis (Chapter II) and three additional feedback cycles thereafter. During the first round, the panel of experts provided feedback on the definition of weather dependency, potential salient factors, and variables related to weather dependency; subsequent inclusions and exclusions; and operationalized definitions of the factors and variables. After we analyzed the first round of major findings, a synopsis of the results was returned to the Delphi panel for comments, accompanied by round-two questions. The third round allowed the panelists to test the developed framework by placing three outdoor recreation activities (hiking, backcountry skiing, and ungulate hunting) along the framework continuum. The fourth round of the Delphi process was conducted to gain further consensus among the experts.

The researchers embedded a forum for agreement and dissent into each round. Experts were encouraged to clarify contradictory statements and seek further consensus

[4] REDCap is a secure, Web-based application designed to support data capture for research studies, providing: a) an intuitive interface for validated data entry, b) audit trails for tracking data manipulation and export procedures, c) automated export procedures for seamless data downloads to common statistical packages, and d) procedures for importing data from external sources (CCTS, 2015; Harris et al., 2009).

or to correct data that the researchers may have misinterpreted. Delphi participants were encouraged to comment on their peers' statements as well. Study participation varied between the rounds. This was an intentional choice on behalf of the researchers to ensure flexibility, thereby permitting participants to complete rounds, as they were able. Due to the cumulative nature of the Delphi method and the flexible research design, there were no foreseeable negative effects on the study results.

Results

The four-round Delphi process resulted in the development of the Weather Dependency Framework (see Figure 4). The results section discusses the response rate, results from each round, the definitions of factors and variables included in the framework, and elements of the WDF. Experts selected rounds to participate in based on their availability, and subsequently, out of 27 experts, 21 (84%) participated in the first round of the Delphi study, 22 (84%) returned the second questionnaire, 24 (89%) participated in the third round, and in the last round 16 (61%) completed the questionnaire. The overall response rate of 80% was similar to other Delphi studies (e.g., Kaynak et al., 1994), and allowed for valid analysis.

Round #1 Results

The results from round one included factors and variables contributing to the weather dependency of outdoor recreation activities, addition, and deletions of variables, and grouping and/or renaming of some variables or factors. Overall, round one results contributed significantly to the scope of the framework and were used to develop a visual representation of the WDF.

Weather Dependency Framework for Outdoor Recreation Activities			
Factors and Variables of Weather Dependency	***Low Weather Dependency***	**0 1 2 3 4 5 6 7 8 9 10** ↔	***High Weather Dependency***
Site Characteristics			
Site Infastructure	More Infastructure	↔	Less Infastructure
Resiliency to weather (adaptive capacity, vulnerability, resources to support extreme weather events)	High Resiliency	↔	Low Resiliency
Management Practices	Limited	↔	Specific
Trip Characteristics			
Transportation mode	Multi-modal (including motorized)	↔	Uni-modal (human-powered, non-motorized)
Length of stay	Shorter/Day trips	↔	Extended
Route traveled (distance at stie and topography)	Simple route, limited topography	↔	Extensive route, expansive topography
Planning (distance to site, group size, group type)	Limited planning	↔	Extensive planning
Resource characteristics			
Regional variability	High predictability	↔	Limited predictability
Resource dependency	Low	↔	High
Natural Environment (push factors)	Low motivation	↔	High motivation
Natural Environment (pull factors)	Low attraction	↔	High attraction
Personal Characteristics			
Experience Use History (EUH)	High EUH	↔	Low EUH
Recreation specialization	Highly Specialization	↔	Low Specialized
Past Use History	Extensive	↔	Limited
Place Attachment	High Place Attachment	↔	Low Place Attachment
Satisfaction (of recreation experiences)	Low	↔	High
Recreation Experience Preferences	Limited motivations	↔	Multi-dimensional and diverse motivations
Season			
Natural Seasonality	High predictability	↔	Limited predictability
Institutional Seasonality	High predictability	↔	Limited predictability
Experiences with Weather			
Perceptions of weather	Insignificant	↔	Highly Influential
Expectations of weather	Low or unknown expecrations	↔	Rigid expectations
Engagement with weather and climate information	Low engagement	↔	High engagement
Weather preferences	Adaptable preferences	↔	Stringent preferences
Encountered Weather	Insignificant events	↔	Significant events
Behavioral reactions to weather	Limited changes	↔	Frequent changes
Weather Conditions			
Temperature	Insignificant	↔	Highly Significant
Relative humidity	Insignificant	↔	Highly Significant
Wind speed	Insignificant	↔	Highly Significant
Precipitation	Insignificant	↔	Highly Significant
Physiological Equivalent Temperature	Insignificant	↔	Highly Significant
Extreme Weather Events	Insignificant	↔	Highly Significant
Climate variability	Insignificant	↔	Highly Significant

Figure 4. The Weather Dependency Framework for Outdoor Recreation Activities

Round #2 Results

During round two, we provided panelists with a visual representation of the WDF. Round two results included comments regarding scale, anchors, reverse coding, and conceptual correlations of higher scores to higher levels of weather dependency and vice versa for lower levels of weather dependency. Visual aspects of the framework were adapted to enhance category separation and overall visual appeal. Lastly, we adapted the low end of weather dependency to zero. The panelists determined zero was easier to understand and interpret as no weather dependency. At the high end of weather dependency, an activity could receive 10 points for each of the 33 variables within the WDF to achieve an overall maximum possible score of 330. As a result, outdoor recreation activities can receive a score as low as a zero (i.e., no weather dependency) and as high as 330 (i.e., high weather dependency).

Round #3 Results

The results from round three included the panelists' comments related to testing the WDF. Topics discussed included reverse-coded items, re-evaluation of anchors, weather dependency contributions, and aggregate activity-based scores resulting from interactive placement of three activities on the WDF. The majority of panel feedback deemed the anchors adequate and appropriate, with limited comments for additional clarification. With re-aligned anchors, the panel agreed that higher scores indicated higher weather dependency and vice versa for low levels of weather dependency. Round three concluded with interactive placement of three activities—hiking, ungulate hunting, and backcountry skiing—by variable and factor according to levels of weather dependency. These three activities were selected to represent a likely spectrum of weather dependency. A place-based description accompanied each activity and illuminated key factors within the framework, thereby providing a context for each activity[5].

Round #4 Results

The fourth and final round results included suggestions for reverse coding, WDF applications, utility for natural resource managers and as a research framework, scale of management, and potential limitations. We synthesize and discuss these topics in the discussion section.

Salient Factor and Variable Definitions

The definitions of the salient factors and variables included in the WDF were informed by the literature and adapted through the Delphi process. Panelists commented on the relevancy of each definition to weather dependency. Table 2 provides a definition of each variable as well as interpretations of the anchors contained within the WDF.

Scoring and Using the WDF

The framework contains a comprehensive set of salient factors and variables, listed in the left column of the framework (see Figure 4 and 5). Panelists assessed each activity and variable on a continuum from zero to 10, where zero indicates no weather dependency and 10 suggests the highest levels of weather dependency. The panelists gave each activity a variable level score, which added first to a factor level score, and

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[5] We provided lengthy descriptions but in summary described the hiking activity as a "weekend warrior" on the Appalachian Trail in Shenandoah National Park and the Blue Ridge Parkway area. We described the ungulate hunting and backcountry skiing setting as the southern Rocky Mountains in Utah, including the Uinta-Wasatch-Cache National Forest, which is characterized as a backcountry and middle country setting.

Table 2 *Factor and Variable Definitions Integrated With Weather Dependency*

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations Low Levels of Weather Dependency[b] ↔ High Levels of Weather Dependency[a]
<u>Factor: Site characteristics</u>		
Site Infrastructure	Fundamental operations and development specific to an area (i.e., roadways, restrooms, and visitors centers; Lemieux, Beechey, Scott, & Gray, 2011)	More ↔ Less Less infrastructure indicates a higher dependency due to higher exposure to weather conditions
Resiliency to weather (adaptive capacity, vulnerability, resources to support extreme weather events)	*Adaptive Capacity* - The ability of a system to adjust, the 'system' referred to is the outdoor recreation and nature-based sector. *Vulnerability* - The degree to which a system is susceptible to adverse change (IPCC, 2015). *Resources to support extreme weather events* - Include the physical and built as well as data processing infrastructure (Scott & Lemieux, 2010)	High ↔ Low Low indicates a higher dependence due to limited capacity, high vulnerability, and limited resources to support extreme weather events
Management Practices	Specific management practices in place at a specific recreation site (Manning, 2011)	Limited ↔ Specific Specific indicates high weather dependency
<u>Factor: Trip characteristics</u>		
Transportation mode	The mode of travel/transport used before and during recreation at a destination (Becken et al., 2003)	Multi-modal ↔ Uni-modal Uni-modal or human-powered, has high dependency on the weather to travel to, from, and within a recreation destination
Length of stay	Defined by amount of time spent on-site or at the destination, during the current visit (Woodside, Caldwell, & Spurr, 2005)	Shorter/Day trips ↔ Extended Trips Extended trips suggests multiday overnights, highly dependent on the weather and resulting conditions

Table 2. continued

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations	
		Low Levels of Weather Dependency[b]	High Levels of Weather Dependency[a]
Length of stay	Defined by amount of time spent on-site or at the destination, during the current visit (Woodside, Caldwell, & Spurr, 2005)	Shorter/Day trips ←→ Extended Trips Extended trips suggests multi-day overnights, highly dependent on the weather and resulting conditions	
Route traveled (distance at site and topography)	Route traveled on-site or at a destination (Rogerson, 2009)	Simple route ←→ Extensive route Extensive routes indicates higher weather dependency	
Planning (distance to site, group characteristics such as group type and size)	A proxy for travel costs and travel time from residential city to destination location (Bigano, Hamilton, & Tol, 2006)	Limited ←→ Extensive Extensive planning contributes to higher weather dependency	
<u>Factor : Resource characteristics</u>			
Regional climate variability	Variations in the mean state and other statistics of the climate on all temporal and spatial scales (WMO, 2015)	High ←→ Limited Limited contributes to higher weather dependency	
Resource dependency	The strength of linkages between social and ecological systems (Tidball, 2012)	Low ←→ High High resource dependency is reflective of high weather dependency	

Table 2. continued

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations: Low Levels of Weather Dependency[b] ↔ High Levels of Weather Dependency[a]
Natural environment (push factors)	Push factors motivate travel (Pomfret, 2006)	Low ↔ High High indicates weather is an important push factor
Natural environment (pull factors)	Pull factors influence destination selection (Pomfret, 2006)	Low ↔ High High indicates weather is an important pull factor
<u>Factor : Personal Characteristics</u>		
Experience use history	Engagement in an activity and years of participation (Manning, 2011)	High ↔ Low Less contributes to higher weather dependency
Recreation specialization	"A continuum of behavior from the general to the particular, reflected by equipment and skills used in the sport and activity setting preferences" (Bryan, 1977, p. 175)	High ↔ Low Low specialization indicates higher levels of weather dependency
Past use history	Past experience at a particular site, including frequency of visitation and amount of time spent (Hammitt, Kyle, & Oh, 2009)	Extensive ↔ Limited Limited indicates higher weather dependency
Place attachment	The emotional and symbolic, and functional attachment to a place (Manning, 2011)	High ↔ Low Low indicates higher weather dependency
Satisfaction (of recreation experiences)	"The congruence between expectations and outcomes" (Manning, 2011, p. 20)	Low ↔ High High indicates previous satisfaction and thus higher dependency on weather to simulate similar experiences

Table 2. continued

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations Low Levels of Weather Dependency[b] ↔ High Levels of Weather Dependency[a]
Recreation experience preferences	Assess individual's motivations for recreation (Manning, 2011)	Limited ↔ Multi-dimensional Multi-dimensional, diverse motivations indicates a variety of motivations for participation and anyone could contribute to higher levels of weather dependency
<u>Factor : Season</u>		
Natural Seasonality	Length and quality of recreation seasons (Jones & Scott, 2006)	High ↔ Limited Limited indicates higher dependence on weather
Institutional Seasonality	Characterized by systematic fluctuations of visitation around summer school holidays (Daniel Scott, Jones, & Konopek, 2007)	
<u>Factor : Experiences with Weather</u>		
Perceptions of weather	Interpretations and responses to meteorological conditions (Gossling, Bredberg, Randow, Sandstrom, & Svensson, 2006)	Insignificant ↔ Highly Influential Highly Influential indicates higher levels of weather dependency
Expectations of weather	Pre-determined understanding of conditions at a destination or recreation site (Hübner & Gössling, 2012)	Low ↔ Rigid Rigid expectations suggest higher weather dependency
Weather preferences	Preferences for specific weather conditions. (Steen Jacobsen, J., Denstadli, J., Lohmann, M., Forland, 2011)	Adaptable ↔ Stringent Stringent preferences indicates high levels of dependency on weather
Engagement with weather and climate information	Engagement with weather information (e.g., forecasts) prior to a trip, during-trip, and resultant plan (Becken & Wilson, 2013)	Low ↔ High High engagement indicates high levels of weather dependency

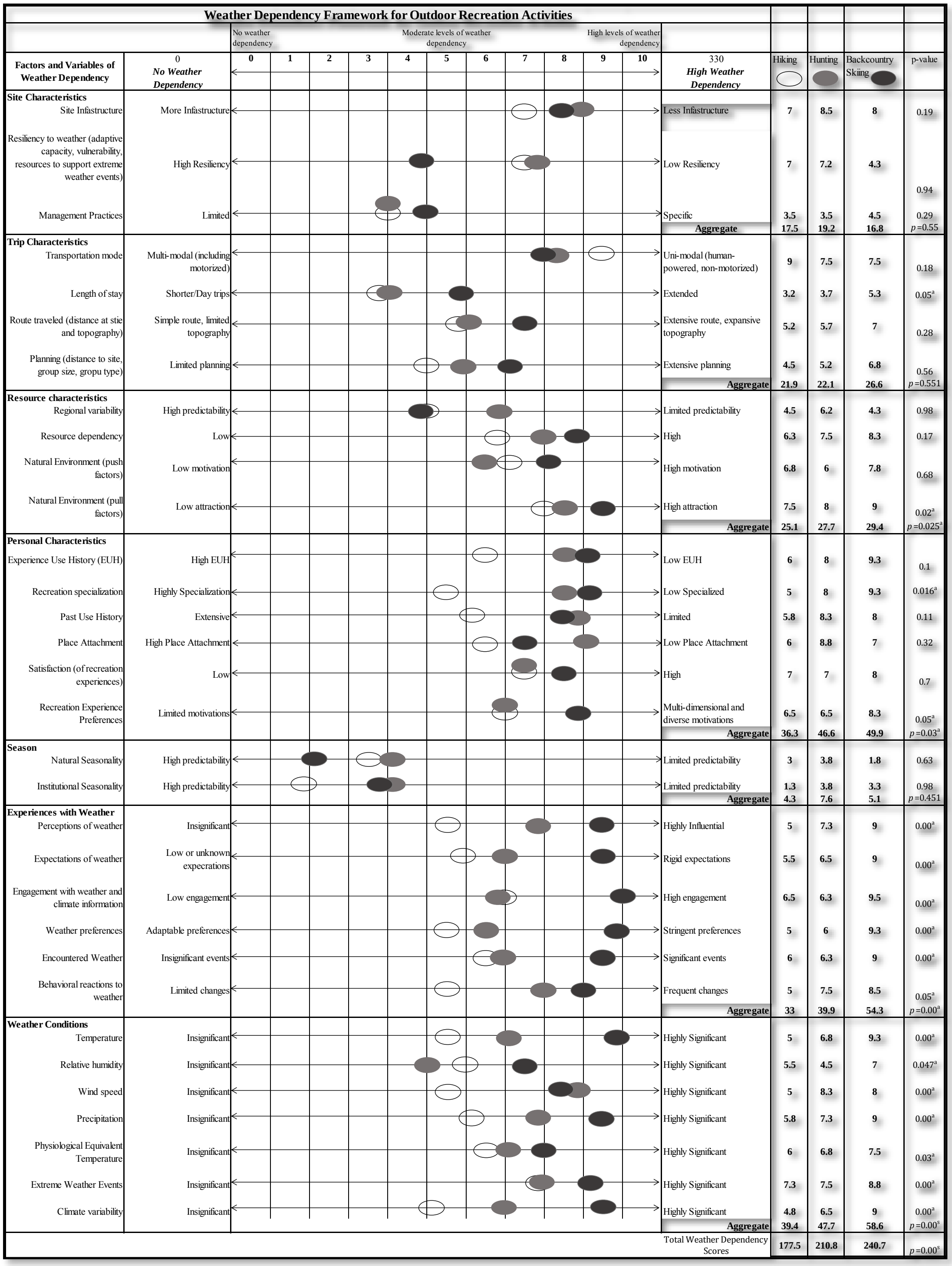
Table 2. continued

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations: Low Levels of Weather Dependency[b] ↔ High Levels of Weather Dependency[a]
Encountered weather	Experienced weather at recreation site (Denstadli, Jacobsen, & Lohmann, 2011)	Insignificant ↔ Significant Significant indicates high dependency on weather
Behavioral reactions to weather	Changes in travel or destination selection based on actual or expected weather conditions (Becken & Wilson, 2013)	Limited ↔ Frequent Frequent reactions indicates higher weather dependency
Factor: Weather Conditions		
Temperature	Internal energy that a substance contains (NOAA, 2015)	Insignificant ↔ Highly Significant Highly Significant indicates high weather dependency
Relative humidity	Amount of atmospheric moisture relative to the amount that would be present if air were saturated (NOAA, 2015)	Insignificant ↔ Highly Significant Highly Significant indicates high weather dependency
Wind speed	The rate air is moving horizontally (NOAA, 2015)	Insignificant ↔ Highly Significant Highly Significant indicates high weather dependency
Precipitation	Rain, sleet, snow, hail, etc (NOAA, 2015)	Insignificant ↔ Highly Significant Highly Significant indicates high weather dependency

Table 2. continued

Factors and Variables[a]	Variable Definitions and Citations	Anchor Explanations: Low Levels of Weather Dependency[b] ←→ High Levels of Weather Dependency[a]
Physiological Equivalent Temperature (PET)	Thermal comfort index using air temperature, relative humidity, wind speed, and cloud cover (Höppe, 1999)	Insignificant ←→ Highly Significant Highly Significant indicates high weather dependency
Extreme weather events	Statistical reference to distribution at a place (IPCC, 2015)	Insignificant ←→ Highly Significant Highly Significant indicates high weather dependency
Climate variability	Variations in the climate temporal and spatial scales (IPCC, 2015)	Insignificant ←→ Highly Significant Highly Significant indicates high weather dependency

Note: [a] Please contact the first author for an expanded list of definitions and related research. [b]The definition of weather dependency is the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions.



Weather Dependency Framework for Outdoor Recreation Activities

No weather dependency (0) — Moderate levels of weather dependency — High levels of weather dependency (10)

Factors and Variables of Weather Dependency	0 *No Weather Dependency*	330 *High Weather Dependency*	Hiking	Hunting	Backcountry Skiing	p-value
Site Characteristics						
Site Infastructure	More Infastructure	Less Infastructure	7	8.5	8	0.19
Resiliency to weather (adaptive capacity, vulnerability, resources to support extreme weather events)	High Resiliency	Low Resiliency	7	7.2	4.3	0.94
Management Practices	Limited	Specific	3.5	3.5	4.5	0.29
		Aggregate	17.5	19.2	16.8	*p* =0.55
Trip Characteristics						
Transportation mode	Multi-modal (including motorized)	Uni-modal (human-powered, non-motorized)	9	7.5	7.5	0.18
Length of stay	Shorter/Day trips	Extended	3.2	3.7	5.3	0.05[a]
Route traveled (distance at stie and topography)	Simple route, limited topography	Extensive route, expansive topography	5.2	5.7	7	0.28
Planning (distance to site, group size, gropu type)	Limited planning	Extensive planning	4.5	5.2	6.8	0.56
		Aggregate	21.9	22.1	26.6	*p* =0.551
Resource characteristics						
Regional variability	High predictability	Limited predictability	4.5	6.2	4.3	0.98
Resource dependency	Low	High	6.3	7.5	8.3	0.17
Natural Environment (push factors)	Low motivation	High motivation	6.8	6	7.8	0.68
Natural Environment (pull factors)	Low attraction	High attraction	7.5	8	9	0.02[a]
		Aggregate	25.1	27.7	29.4	*p* =0.025[a]
Personal Characteristics						
Experience Use History (EUH)	High EUH	Low EUH	6	8	9.3	0.1
Recreation specialization	Highly Specialization	Low Specialized	5	8	9.3	0.016[a]
Past Use History	Extensive	Limited	5.8	8.3	8	0.11
Place Attachment	High Place Attachment	Low Place Attachment	6	8.8	7	0.32
Satisfaction (of recreation experiences)	Low	High	7	7	8	0.7
Recreation Experience Preferences	Limited motivations	Multi-dimensional and diverse motivations	6.5	6.5	8.3	0.05[a]
		Aggregate	36.3	46.6	49.9	*p* =0.03[a]
Season						
Natural Seasonality	High predictability	Limited predictability	3	3.8	1.8	0.63
Institutional Seasonality	High predictability	Limited predictability	1.3	3.8	3.3	0.98
		Aggregate	4.3	7.6	5.1	*p* =0.451
Experiences with Weather						
Perceptions of weather	Insignificant	Highly Influential	5	7.3	9	0.00[a]
Expectations of weather	Low or unknown expecrations	Rigid expectations	5.5	6.5	9	0.00[a]
Engagement with weather and climate information	Low engagement	High engagement	6.5	6.3	9.5	0.00[a]
Weather preferences	Adaptable preferences	Stringent preferences	5	6	9.3	0.00[a]
Encountered Weather	Insignificant events	Significant events	6	6.3	9	0.00[a]
Behavioral reactions to weather	Limited changes	Frequent changes	5	7.5	8.5	0.05[a]
		Aggregate	33	39.9	54.3	*p* =0.00[a]
Weather Conditions						
Temperature	Insignificant	Highly Significant	5	6.8	9.3	0.00[a]
Relative humidity	Insignificant	Highly Significant	5.5	4.5	7	0.047[a]
Wind speed	Insignificant	Highly Significant	5	8.3	8	0.00[a]
Precipitation	Insignificant	Highly Significant	5.8	7.3	9	0.00[a]
Physiological Equivalent Temperature	Insignificant	Highly Significant	6	6.8	7.5	0.03[a]
Extreme Weather Events	Insignificant	Highly Significant	7.3	7.5	8.8	0.00[a]
Climate variability	Insignificant	Highly Significant	4.8	6.5	9	0.00[a]
		Aggregate	39.4	47.7	58.6	*p* =0.00[s]
		Total Weather Dependency Scores	177.5	210.8	240.7	*p* =0.00[s]

Figure 5. The Aggregate Weather Dependency Framework for Outdoor Recreation Activities

Note: [a] Indicates significance at the *p*=.05 level using a Related Samples Freidmans's Two-Way ANOVA by Ranks. This test was selected based on the small sample size and violation of the general linear model assumption of normality.

second to a total overall score for the weather dependency of each activity.

Variables combine to form factors that receive a total weather dependency score for each factor. In this study, the researchers selected hiking, ungulate hunting, and backcountry skiing to represent a potential range of weather-dependent activities. Not surprisingly, hiking received the lowest score, 177.5 out of 330 from the panelists. By percentage, hiking is approximately 53.7% weather dependent, based on panelists' feedback. Next, ungulate hunting received 210.8, not that different from hiking at 63.8% weather dependent. Finally, backcountry skiing received a total score of 240.7, equating to 72.9% weather dependent (see Figure 5 for totals and the final WDF). The scores in Figure 5 are the average of the panelists' assessment of the three activities, given a detailed place-based descriptive setting. The researchers used a Related Samples Freidman's Two-Way ANOVA by Ranks to understand statistical significance between activity types for each variable and aggregate factors. The results suggest statistical differences between activity types for 17 of the 32 variables and four of the seven factors (see Figure 5).

Discussion

The WDF has potential applications for social science researchers as well as natural resource managers. In the first section of this discussion, we offer potential applications of the WDF for social scientists. Second, we suggest promising implications for natural resource and outdoor recreation managers. To conclude the discussion, we present recommendations for future development of the WDF. Both the authors' insights and panelists' suggestions guide the discussion.

Social Science Research Applications

One purpose of creating the WDF was to develop a tool for researchers to interpret and make sense of the weather dependency of outdoor recreation activities. The WDF could be viewed as a 'roadmap' to guide future research, as it contains identified variables of interest related to the weather dependency of outdoor recreation activities. For example, similar to sections of a roadmap, each variable represents a comprehensive area of research. Jones and Scott (2006, 2007) illustrate this point with their study about the relationships between specific weather conditions (e.g., temperature and precipitation) and golf participation. Temperature and precipitation are each variables representing potential areas of research within the WDF but could be paired to other variables as well. For example, researchers might use the WDF as a starting place to investigate the relationships between recreation specialization and resource dependency under specific weather conditions to make sense of the weather dependency of outdoor recreation participation for multiple activities. Many research examples exist as prospective applications of the WDF to aid in interpreting the weather dependency of outdoor recreation activities.

The WDF has the potential to predict recreation participation under weather conditions and for specific activities. For example, weather-dependent activity-based assessments could determine which outdoor recreation activities will suffer the most from changes in climate or cyclical meteorological events, such as El Niño. This could contribute to results about the most weather-dependent activities, as well as activity sectors that are less sensitive to weather. Predicting recreation participation under weather conditions might also provide the opportunity for researchers to understand how the WDF might be implemented as a decision-making tool for recreationists. Specifically, researchers might want to understand how weather and climate information is used to mitigate risk under certain weather conditions and for specific activities.

The WDF might also result in site assessments. Researchers conducting site assessments, using the WDF, could select specific elements from the framework. For example, site characteristics and personal characteristics could be used to determine the weather dependency of beach tourism, and recommend site infrastructure improvements for destination tourism operators based on the assessment results. More specifically, a site assessment could aid in festival or event planning site selection, based on areas where there is higher predictability in the weather for outdoor events. For instance, the winter Olympics site assessment could include specific elements of the WDF to plan for optimal venue conditions.

Besides site assessments, the WDF could potentially be used by social scientists interested in programmatic evaluations. Researchers might examine destinations as a part of strategic planning for programming under key weather conditions. Additionally, outdoor education research on adventure-based programs could use the WDF to determine student populations with the potential to disengage from course experiences based on certain weather. Adventure-based programs involving at-risk or adjudicated youth might conduct program evaluations to determine beneficial seasons to facilitate extended outdoor activity-based expeditions. These evaluations might be based on personal characteristics and optimal weather conditions to obtain desired program outcomes.

It is also important to note the dynamic nature of weather dependency and, consequently, the WDF. The researchers designed the WDF as a way to think about weather dependency and as a mechanism to compile and visually represent dynamic factors and variables influencing the weather dependency of outdoor recreation activities. This is important because all of the variables within the WDF may be highly contextual. Consequently, the weather dependency of skiing in the Rocky Mountains may not be equal to the weather dependency of skiing in the Adirondacks as a result of contextual site characteristics and weather conditions. Additionally, personal characteristics contribute to the weather dependency of outdoor recreation activities, including the variables experience use history, place attachment, and recreation specialization, each of which are circumstantial and vary according to place and population. Personal characteristics might also reflect a recreationists' individual resiliency or adaptive capacity, and might be further investigated to reflect the dynamic nature of weather dependency. The dynamic nature of weather dependency and consequently, the WDF, are reliant on these contextual elements.

Management Applications

Natural resource managers of parks and protected areas might use the WDF as a planning tool. Parks and protected area planning requires diverse information about user groups, and the WDF might provide a greater sense of how each type of outdoor recreation activity is related to weather dependency factors and variables. Therefore, the WDF could become a method for managers to assess the weather-related needs and behaviors of recreationists by activity type with results contributing to planning efforts. Managers might plan for site characteristic adaptations or manage according to personal characteristics of certain recreation groups. For example, if a manager identifies that mountain bikers could be highly weather dependent, the manager could then examine site and resource conditions for susceptibility to weather-related changes asking the question *does site infrastructure, such as trails, require improvement to prevent resource degradation during recreation participation under certain weather conditions?* Answering this question through the lens of the WDF might allow managers to plan for mountain bikers' desired site characteristics and resource dependency under certain weather conditions. In general, the WDF could be used as a planning tool to assess a number of outdoor recreation activities for the purposes of supporting effective planning and management of parks and protected areas.

Natural resource managers may have the ability to increase or decrease weather dependency by manipulating certain variables within the WDF. For example, to increase weather dependency, natural resource managers could create more specific management practices, require extensive planning paperwork for permitted areas (e.g., distance, travel plans, group type, group size), or decrease site infrastructure to a specific area. Alternatively, to decrease weather dependency managers might increase site infrastructure (e.g., facilities such as warming huts or shelters), decrease trip length requirements for areas requiring permits, or allow multimodal transportation access where possible. As another example, managers might require recreationists to show evidence of certifications that would link individuals to higher levels of experience use history and recreation specialization and thereby lower levels of weather dependency. The WDF has possible utility for outdoor recreation resort operators and managers. The WDF may allow for targeting populations and making management decisions about types and levels of infrastructure that could potentially be introduced into a specific area based on weather-dependent factors. Resort owners and managers may use the WDF to develop goals relative to sustainable development and policies, and projects for key destinations. For example, resorts might begin to develop weather resiliency by incorporating elements of the WDF into programming and management of activities.

At the activity level, the WDF could aid in understanding changes in demand for outdoor recreation. These changes in demand might allow managers to mitigate the impacts of recreation flow based on weather-related variables. For example, an impact of climate change for some regions will be decreasing snowfall; a mitigation strategy for resorts is to produce more snow. However, managers' first need to understand the increase in demand that results from the weather dependency of resort skiing. It may be the case that decreased snowfall in the backcountry is linked to an increase in demand for resort skiing or shift destination selection, which could be elucidated by the WDF.

Outdoor recreation managers could gather and provide weather-related information to visitors. Gathering information on the variable personal characteristics in the WDF could benefit the development of effective programs in areas where the weather is a programmatic factor. For example, managers might assess the personal characteristics of visitors likely to attend a night sky program under certain weather conditions (e.g., percent cloud cover). Next, managers might gather information related to engagement with weather and climate information. Gathering information could aid in the development of communication strategies about weather-related considerations for outdoor recreation participation specific to park and protected area resources. For instance, parks and protected areas ideal for human-powered boating (i.e., sea kayaking and canoeing), might create tailored forecasts, based on gathered information, specific to resource characteristics or weather information applications that recreationists' can access during their trip.

Additionally, resource managers may benefit from gathering weather-related information from visitors in order to provide more effective programming for weather dependent outdoor recreation activities. For example, many visitors to parks and protected areas may select their visitation place and time-of-year based on weather conditions. Winter recreation in Yellowstone National Park is one example. Gathering weather-considered programming information could benefit Yellowstone National Park winter recreationists. Programs might be tailored to key characteristics within the WDF such as trip and personal characteristics based on winter outdoor recreation activities such as snowmobiling, cross-country skiing, and snowshoeing. More broadly, this information from visitors could give parks and protected area managers the opportunity to predict visitation patterns based on levels of weather dependency at a specific park or resource unit. Managers' resulting use of the WDF may lead to reconsidering programs and policies, recreation impact mitigation, inspire weather-based planning initiatives, and predict land access trends.

Future Development of the WDF

A variety of next steps might be considered to develop the WDF. Researchers might consider developing place-based activity assessments for multiple activities as well as quantifying and developing standard measurement techniques for specific variables of the WDF. We provide suggestions for interpreting dimensionality within the WDF and make recommendations for research to explore outdoor recreationists' perceptions of the WDF.

Primarily, there is a need to develop place-based activity assessments for multiple activities. As an example, researchers could assess the weather dependency of water sports comparing the differences between lake and whitewater recreationists' in eastern Kentucky. Developing place-based specific activity assessments might allow researchers to account for similarities in regional weather conditions and compare differences in the weather dependency of outdoor recreation activities, such as trip, personal, and resource characteristics.

Researchers could quantify the WDF by investigating the interrelationships between variables such as correlations, weights, and predictor variables of outdoor recreation behavior. Explorations of variable correlations might help to decrease the number of variables within the WDF, allowing the WDF to become more parsimonious. For example, if the variable 'encountered weather' is highly correlated to 'behavioral reactions to weather', researchers might suggest adapting the WDF to merge these variables with one another. Next, the framework currently does not weight variables by level of importance (e.g., if one variable is more significant for determining weather dependency for specific activities). By first determining which variables are most significant, based on activity type, weighting variables may aid researchers' interpretations of weather dependency. For example, recreation experience preferences (REP; i.e., motivations) might be more significant than specific weather conditions for certain activities. Therefore, weighting REP and weather conditions based on their respective level of significance could provide a more accurate representation of the weather dependency of outdoor recreation activities. Additionally, predicting outdoor recreation behavior based on weather-related factors is another beneficial outcome of quantifying the framework.

Researchers might employ multiple regression analysis to predict outdoor recreation behavior based on specific predictor variables or factors. For instance, based on the Related Samples Freidman's' Two-Way ANOVA by Ranks, the factor *experiences with weather* indicated overall significant differences between activity types for each variable within the factor. This might indicate that *experiences with weather* is potentially more predictive of outdoor recreationists' behavior than the factor *season*, which indicated there was not statistically significant differences between activity types. Future research might further investigate interrelationships and predictive power of factors and variables within the WDF.

Forthcoming research might seek to develop standard measurement techniques for specific variables within the WDF. Due to the varied and diverse nature of weather-related studies, many of the variables lack consistent measurement techniques. This includes most of the variables within the *experiences with weather* factor. Resource dependency and resiliency to weather are also variables lacking consistent measurement. Other variables require standard measurement techniques because previous research has relied on secondary data. For example, research on U.S. National Park attendance was based on monthly recreation visitation patterns and air temperature data to predict attendance shifts relevant to increases in average springtime temperatures (Buckley & Foushee, 2012). Findings such as these can be enhanced by incorporating other WDF factors and variables such as resource and site characteristics and their standard measurement techniques.

Since a panel of experts developed the WDF, recreationists' perceptions of weather dependency could contribute to a more in-depth understanding of the weather dependency of outdoor recreation activities. Researchers could investigate recreationists' perceptions of weather dependency through a variety of methods, including qualitative interviews or quantitative survey methods. Researchers could explore winter recreationists' perceptions of weather dependency in a highly weather sensitive place. Investigations might include weather sensitive activities such as downhill skiing, snowmobiling, snowshoeing, or backcountry skiing.

Lastly, researchers should be aware that presently the WDF could appear to be oversimplifying multidimensional items into unidimensional measurements, which is not the authors' intent. The aim is for the WDF to be implemented as a research tool to describe the salient factors and variables that contribute to the weather dependency of outdoor recreation activities. For example, researchers interested in the contributions of place attachment to the weather dependency of backcountry skiing, would employ the standard multidimensional measurements of place attachment (see Manning 2011 for review). The premise is that if the framework included the dimensionality of each variable, it would become a cumbersome tool and therefore would be difficult to interpret and use effectively.

Implications for Future Research

Based on the previous discussion, there appear to be areas where future research with the WDF might focus. What we have done initially is to create the WDF and demonstrate its use with three outdoor recreation activities. Implications for future research presented here include testing the WDF with a multitude of other weather dependent activities, exploring variables unintentionally excluded, and validating of the

WDF by assessing recreationists' perceptions of weather dependency.

Potential next steps of research could test the WDF with a multitude of other weather dependent activities. For example, whitewater sports such as canoeing and kayaking are dependent not necessarily on direct weather conditions but the resulting conditions of weather that significantly influence water flow. There also exist thresholds of use when water flow exceeds or diminishes optimal conditions, shifting recreation participation based on the resulting conditions of weather. Previous research has also noted that relationships exist between subdimensions of recreation specialization and place attachment for whitewater boaters (Bricker & Kerstetter, 2000); likely, weather dependency is another element influencing whitewater recreation. Therefore, future research might continue to test and add a variety of weather dependent activities to the WDF.

There are also possible variables and factors unintentionally excluded from the WDF. Future research could continue to develop and add these variables and factors to the WDF. Likewise, there are potentially variables included that are not as important as they initially seemed to be. For example, relative humidity is a weather condition that could be irrelevant in dry and arid climates. Future research might add variables and remove non-essential items through discovering if this framework makes sense to outdoor recreationists. One way to accomplish this is to explore the framework under a multitude of activity types in diverse settings. One suggestion we offer is to compare the weather dependency of recreationists by region. For example assessing recreationists' perceptions of weather dependency in the southeast as compared to their western counterparts.

Lastly, experts developed this framework, and the next logical sequence is to validate this by assessing outdoor recreationists' perceptions of weather dependency. For instance, researchers might assess winter recreationists' perceptions of weather dependency in highly weather sensitive activities and places, such as examining skiing or snowmobiling in the Rocky Mountains. Researchers might also consider comparing place-based assessments of the weather dependency of one activity across multiple regions, such as comparing big game hunters' perceptions of weather dependency in various regions of the United States including the Pacific Northwest, West, Northeast, and Southeast. Alternatively, place-based investigations might assess and compare recreationists' perceptions of the weather dependency of several outdoor recreation activities in one region.

Conclusion

The purpose of this study was to develop an interpretive framework to understand the weather dependency of outdoor recreation activities. The Weather Dependency Framework (WDF) contains the most salient factors and variables and three activity examples of how researchers and natural resource managers might use the framework. This WDF illustrates the diverse opportunities that exist for future research and as applications for outdoor recreation and natural resource managers. As the impact of weather on outdoor recreation continues to receive increasing attention, the WDF is a roadmap to understanding outdoor recreationists' reliance on weather and resulting conditions. If researchers and managers want to understand and investigate weather dependency, the Weather Dependency Framework is one place to begin.

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CHAPTER IV

ASSESSING THE CREDIBILITY OF THE WEATHER DEPENDENCY FRAMEWORK: COMPARING BACKCOUNTRY SKIERS AND HUNTERS' PERCEPTIONS

Abstract

This article describes the results of a credibility analysis of the Weather Dependency Framework (WDF; Chapter III), a tool that combines multidimensional weather-related variables to aid in the interpretation of the weather dependency of outdoor recreation activities. The need for this work was evident because the WDF was created using prior literature and an expert panel, and therefore required an inquiry into its credibility. The credibility of the WDF was assessed by exploring backcountry skiers' and hunters' perceptions of their own weather dependency using semistructured interviews (n=40). Researchers highlight seven emergent themes including access, strategy, terrain, culture, opportunity, high engagement, and deterrent for participation. We discuss insights into the credibility of the WDF based on backcountry skiers' and hunters' perceptions of weather dependency and provide recommendations for future research, including further development of the WDF.

Introduction

This article describes the results from a qualitative credibility analysis of the newly developed Weather Dependency Framework (WDF; see Figure 4; Chapter III). The WDF is a mechanism for understanding the multidimensional factors and variables that influence the weather dependency of outdoor recreation activities[6]. We define weather dependency as *the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions*. In the WDF, seven factors and thirty-two variables have been hypothesized to contribute to a recreation activity's weather dependency. As a tool, managers might use the WDF to assess and plan for weather dependent outdoor activities. Managers might also increase or decrease an activity's weather dependency by manipulating variables within the WDF, such as increasing site infrastructure to decrease weather dependency (Chapter III). Meanwhile, researchers might use the WDF to investigate the weather dependency of outdoor recreation activities or conduct assessments with key variables and factors found within the WDF (Chapter III).

Assessing the credibility of the newly developed WDF is particularly important because the WDF was created using previous literature and an expert panel, and therefore requires an evaluation of its qualitative credibility. Credibility, in qualitative research, is an alternative term to quantitative validation (Whittemore, Chase, & Mandle, 2001), and is used to assess if existing results (e.g., a framework) are true representations of participants' meanings and experiences (Creswell, 2015). A credibility analysis requires researchers to employ predetermined standards to assess results, including peer

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[6] For a thorough explanation of the Weather Dependency Framework including the development process, and potential applications, see Chapter III.

debriefing, prolonged engagement with the data, and actively seeking confirming and disconfirming evidence (Cresswell, 2015; Cresswell & Miller, 2000; Marshall & Rossman, 2011).

In addition to the need to verify the credibility of the WDF, other important factors led to this study. First, while weather studies in outdoor recreation and nature-based tourism have been receiving increasing attention over the last 10 years (Chapter II), outdoor recreationists' perceptions of weather[7] remain under-researched. The majority of weather perception research originates in the tourism field and focuses on destination centric perceptions (e.g., Buzinde, Manuel-Navarrete, Yoo, & Morais, 2010; Denstadli et al., 2011, Tervo-Kankare, Hall, & Saarinen, 2012), such as tourists' perceptions of coastal destinations (Buzinde et al., 2010), weather at their destination (Denstadli et al., 2011), and perceptions of winter weather and the influence on destination selection (Tervo-Kankare, Hall, & Saarinen, 2012). Additionally, the majority of weather studies in outdoor recreation focus on one activity group, such as golf (Scott & Jones, 2006, 2007), and skiing (Dawson, Scott, & Havitz, 2013), while limited studies compare relationships across activity groups.

Second, while many outdoor recreation activities are highly dependent on meteorological conditions such as precipitation and temperature, we know little else about the relationships between weather dependency and weather-related variables, such as temperature and aridity of an area. Previous research has hinted at links between weather-related variables and weather dependency such as winter recreationists' reliance on weather forecasts (Rutty & Andrey, 2014). However, we know little about outdoor

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[7] Perceptions of weather are interpretations and responses to meteorological conditions (e.g., temperature and precipitation; Gossling et al., 2006)

recreationists' direct dependency on weather, and weather forecasts. Additionally, we know little about how researchers, managers, and recreationists think about, discuss, and rank the weather dependency of outdoor recreation activities (Chapter III).

Third, there is a lack of qualitative methods investigating outdoor recreationists' perceptions of weather. For example, weather-related outdoor recreation studies tend to rely on secondary data, which are rarely paired with social data such as perceptions derived from qualitative methods (e.g., Becken, 2012; Dawson & Scott, 2007; Dawson, Scott, & Havitz, 2013; Finger & Lehmann, 2012; Jones & Scott, 2006; Martinez Ibarra, 2011; Sabir, Van Ommeren, & Rietveld, 2013; Scott & Jones, 2006; Scott, Jones, & Konopek, 2007; Wilson & Becken, 2011). Expert or case-based research designs are also prevalent, examining a site or topic of interest in depth (e.g., Espiner & Becken, 2014; Geissler, 2008; Hamilton, Brown, & Keim, 2007; Hartz, Brazel, & Heisler, 2006; Kajan, 2014; Karamustafa, Fuchs, & Reichel, 2012; Liu, 2014; Nicholls & Holecek, 2008; Rauken & Kelman, 2012; Reddy, Nica, & Wilkes, 2012; Scott et al., 2007; Tervo, 2008). Few studies have employed diverse methods such as qualitative credibility analyses to explore outdoor recreationists' perceptions of weather (Chapter III).

In summary, the need for this study was based primarily on the importance of assessing the credibility of the WDF. Furthermore, limited investigations of outdoor recreationists' perceptions of weather and limited knowledge of the weather dependency of outdoor recreation activities, coupled with few comparative studies across activity groups, and lack of diverse methods, also contributed to the need for this study. Consequently, this study assessed the credibility of the WDF by exploring outdoor recreationists' perceptions of weather dependency, comparing backcountry skiers, and ungulate hunters (i.e., those who hunt hooved animals such as elk and deer). This study represents the first qualitative inquiry into the topic of weather dependency and aims to expand the literature by comparing activity groups while creating space for diverse methodological approaches.

Review of Literature

In the review of literature, we cover four relevant areas. First, we clarify the difference between weather and climate. Then we discuss the WDF, its elements, and explain the importance of studying weather dependency. In the third section of the literature review, we synthesize the limited studies that have investigated outdoor recreationists' perceptions of weather. The literature review provides a background and rationale for assessing the credibility of the WDF by exploring outdoor recreationists' perceptions of weather dependency. Ultimately, we conclude the review of literature by discussing the guiding research questions for this study. Throughout the study and review of literature, we define *outdoor recreation* as active leisure time spent outdoors (Manning, 2011, p. 4).

Weather versus Climate

Weather is the everyday variations in the atmosphere (e.g., temperature, precipitation, clouds; Scott & Jones, 2006), whereas *climate* is the long-term behavior of weather in a specific location (Scott & Jones, 2006). Although weather is the primary focus of this paper and the following literature, both weather and climate have significant influences on outdoor recreation, and research relies on the link between the two concepts. For example, research has compared tourists' weather preferences with regional level climate projections (Førland et al., 2013). Studies have also linked the impacts of weather on visitor's willingness to pay under projected climate scenarios in U.S. national parks (Richardson & Loomis, 2005).

However, by interchanging these concepts, comprehensive and multidisciplinary analyses can be problematic, making it difficult to disentangle weather and climate. It is important that future research investigate outdoor recreationists' dependency on daily weather variations as distinctly separate from climate. Given the increasing attention paid to outdoor recreation weather research (Chapter II), it is prudent to understand recreationists' reliance on weather-related variables. If researchers can understand how recreationists' respond to, or are dependent on, weather and resulting conditions, we can better understand and predict outdoor recreation under a variety of meteorological scenarios. Therefore, this paper focuses solely on weather, and specifically on outdoor recreationists' perceptions of their own weather dependency.

The Weather Dependency Framework

The WDF combines weather-related factors and variables (Chapter III), and is a tool that researchers and managers can use to assess the weather dependency of outdoor recreation activities (Chapter III). We define weather dependency as *the degree to which a specific outdoor recreation activity is reliant on particular weather and resulting conditions.* In 2015, researchers used results from a research synthesis and gap analysis (Chapter III) to identify key factors and variables that might contribute to the weather dependency of outdoor recreation activities. Following this synthesis, researchers developed the WDF using a modified Delphi approach with 27 experts. The result from this process was the WDF, which is a mechanism to a) interpret and understand the complex factors and variables contributing to the weather dependency of outdoor recreation activities, and b) ultimately assess weather dependency in a variety of settings with a multitude of activities.

The WDF contains seven factors and 32 variables that have been hypothesized to contribute to an outdoor recreation activity's weather dependency. The first factor is *site characteristics*. This factor consists of the variables site infrastructure (Barbieri & Sotomayor, 2013), resiliency to weather (Espiner & Becken, 2014; Scott & Lemieux, 2010; Scott, Simpson, & Sim, 2012), and management practices (Dawson & Scott, 2010). Second, the factor *trip characteristics* combines the variables transportation mode (Reddy et al., 2012), length of stay (Barbieri & Sotomayor, 2013), route traveled (Lackstrom, Kettle, Haywood, & Dow, 2014), and planning (Lackstrom et al., 2014). The third factor, *resource characteristics*, includes the variables regional variability (Scott, McBoyle, & Minogue, 2007), resource dependency (Marshall, Tobin, Marshall, Gooch, & Hobday, 2013), and natural environment push and pull factors (Pomfret, 2006). Fourth, the factor *personal characteristics* incorporates the variables experience use history (Geissler, 2008), recreation specialization (Tsaur, Yen, & Chen, 2010), past use history (Barbieri & Sotomayor, 2013), place attachment (Yang, Madden, Kim, & Jordan, 2012), satisfaction of recreation experiences (Denstadli, Jacobsen, & Lohmann, 2011), and recreation experience preferences (Hübner & Gössling, 2012; Laing & Crouch, 2011). The fifth factor, *season*, encompasses the variables natural and institutional seasonality (Jones & Scott, 2006; Scott, Jones, & Konopek, 2007). Sixth, the factor *experiences with weather* includes the variables perceptions of weather (Andrade, Alcoforado, & Oliveira, 2011), expectations of weather (Becken & Wilson, 2013), engagement with weather and climate information (Lackstrom et al., 2014), weather preferences (Førland et al., 2013), encountered weather (Denstadli et al., 2011), and behavioral reactions to weather (van Cranenburgh, Chorus, & van Wee, 2014). The seventh and final factor, *weather conditions* includes temperature and precipitation (Matzarakis, Hämmerle, Koch, & Rudel, 2012), relative humidity (Becken, 2012), wind speed (Helbich, Böcker, & Dijst, 2014), physiological equivalent temperature (PET; Höppe, 1999), extreme weather events (Ford, Pearce, Duerden, Furgal, & Smit, 2010), and climate variability (Berrang-Ford, Ford, & Paterson, 2011).

The WDF has a range of applications for social scientists and managers. It might be used by social scientists to interpret and make sense of the weather dependency of outdoor recreation activities, to predict outdoor recreation participation under certain weather scenarios, and for site and programmatic assessments (Chapter III). Managers might use the WDF as a planning tool to understand outdoor recreationists' relationships to weather dependency factors and variables, to increase or decrease weather dependency by manipulating variables within the WDF, or to aid in understanding weather-related outdoor recreation demand (Chapter III).

Although the WDF is a compilation of a wide range of weather-related variables studied throughout outdoor recreation and nature-based tourism, and has a variety of practical applications, the credibility of the WDF has yet to be examined. Assessing credibility is particularly important because the WDF was developed using prior literature and an expert panel (Chapter III). It is important to understand the credibility of the WDF by exploring outdoor recreationists' perceptions of weather dependency because outdoor recreationists' views about weather dependency may be different from findings in previous literature and opinions offered by experts.

Outdoor Recreationists' Perceptions of Weather

Perceptions result from "the process of receiving and interpreting information through all senses which might include feedback processes leading to short- or long-term changes in the understanding and interpretation of the environment" (Gossling, Bredberg, Randow, Sandstrom, & Svensson, 2006, p. 423). Perceptions of weather are interpretations and responses to meteorological conditions (e.g., temperature and precipitation; Gossling et al., 2006) and perceptions of weather dependency include other weather variables in addition to meteorological conditions, such as personal, site, and resource characteristics described in the WDF.

The majority of research investigating perceptions of weather is housed primarily in tourism journals and reports. Studies have assessed tourists' destination-centric perceptions of winter weather (Tervo-Kankare, Hall, & Saarinen, 2012) and vacationers' perceptions of summer weather (Denstadli et al., 2011). Researchers have examined tourists' perceptions of the devastating impacts of extreme weather to coastal destinations (Buzinde et al., 2010). Other work on the impacts of extreme weather include tourists' in situ experiences with weather and climate information (Hübner & Gössling, 2012). De Freitas, Scott, and McBoyle (2008) measured tourists' perceived level of importance of meteorological conditions and temperature thresholds. Studies have also considered stakeholders' perceptions of the impacts of weather on local business operations, destination development, and management of environmental conditions (Rauken & Kelman, 2012).

While outdoor recreationists' anecdotally recognize that many activities are subject to weather, research has only recently started to acknowledge that outdoor recreation participation is often highly 'dependent' on weather and resulting conditions. For example, snow availability at winter destinations (Scott, Dawson, & Jones, 2008), and abundance of 'good waves' for beach recreation (Barbieri & Sotomayor, 2013) dramatically influence outdoor recreation participation. As well, higher temperatures and warmer weather influences parks and protected area visitation (Coombes & Jones, 2010; Gonzalez, 2012; Daniel Scott, Jones, et al., 2007). Each of these examples illustrates the extent to which weather and resulting conditions influence outdoor recreation participation. Exploring outdoor recreationists' perceptions of weather dependency will expand the literature by specifically understanding outdoor recreationists' perceptions of weather dependency, which to date have not been investigated.

In summary, the need for this study was evident given the importance of studying weather separate from climate, the need to assess the credibility of the newly developed WDF, and the desire to further understand outdoor recreationists' perceptions of weather, and particularly weather dependency. Therefore, the following research questions were developed, which are situated in an exploratory study comparing backcountry skiers' and hunters' perceptions of weather dependency.

RQ1: In what ways do backcountry skiers' and hunters' perceptions of weather dependency confirm and disconfirm the credibility of the WDF?

RQ2: How do the similarities and differences between backcountry skiers' and hunters' perceptions of weather dependency corroborate and contradict the credibility of the WDF?

RQ3: Overall, what is the credibility of the WDF based on recreationists' perceptions?

Methods

Study Area

These research questions were investigated in the context of the Uinta-Wasatch-Cache National Forest (UWCNF) in northern Utah, which spans nearly 2.1 million acres and is in close proximity to one of the west's fastest growing metropolitan areas, Salt Lake City (UWCNF, 2015). The unique weather conditions in the Wasatch and Uinta Mountains (located within the UWCNF) partially drive demand for backcountry skiing and ungulate hunting. Located within the midlatitude storm track, perfect conditions create some of the world's best powder (Steenburgh, 2014) that draws winter recreationists to the area. Similarly, the area includes wide ranges of life zones (Whiteman, 2000) that are suitable habitat for ungulates, which consequently draw hunters to the area.

Participants

Prior to identifying interviewees, the researchers defined the recreation setting and categorized the types of participants to contact. We used the Recreation Setting Prescription Matrix Schematic (Driver, Hopkins, & Peck, 2008) to narrow the population to backcountry and middle country recreationists in the UWCNF. We further narrowed the participant sample to compare human-powered consumptive and nonconsumptive outdoor recreation activities (Vaske & Roemer, 2013)[8]. For this study, ungulate hunting represented consumptive recreation and backcountry skiing represented nonconsumptive

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[8] We acknowledge the position that all recreation might be considered consumptive. However, for the purpose of this research, the two categories create a platform for comparisons.

recreation (ungulate hunting is referred to as 'hunting' throughout the remainder of the manuscript). The WDF assesses weather dependency for specific outdoor recreation activities and therefore, direct activity comparisons are important when evaluating the credibility of the WDF.

Sampling

We employed purposive snowball sampling to identify interviewees, which involved initial research participants suggesting ideal candidates for future interviews (Noy, 2008; Patton, 2001). We repeated this process until we reached data saturation (Cresswell, 2015). Purposive snowball sampling ensured a range of representation within recreation specialization, past use history, demographic indicators, and allowed deliberate selection of hunters and skiers beyond participant suggestions (Teddlie & Yu, 2007).

Data Collection

Data were collected through semistructured in-depth interviews with hunters (n=20) and backcountry skiers (n=20). Semistructured in-depth interviews are preferable for exploratory research assessing the credibility of conceptual frameworks (i.e., WDF; Cresswell & Plano Clark, 2011). After obtaining consent from participants, interviews were audio recorded for transcription and analysis.

A semistructured guide (Patton, 2002) and a pre-interview survey helped to direct the interviews. We developed the interview guide with a list of questions and topics to discuss with participants based on the factors, variables, and anchors contained in the Weather Dependency Framework (WDF; Chapter III). Pre-interview surveys included standard measurements to capture participants' demographic information (U.S. Census

Bureau, 2015), recreation motivations (Manfredo & Driver, 1996), past use history (Hammitt & McDonald, 1983), experience use history (Schreyer et al., 1984), and recreation specialization (Beardmore, Haider, Hunt, & Arlinghaus, 2013). To begin the interviews, we presented interviewees with the definition of weather dependency and asked them to provide descriptive stories to illuminate or discredit the definition through their own experiences. Subsequent questions allowed participants to describe their own weather dependency (or lack thereof) in association with WDF factors and variables. All but four of the interviews took place in-person and lasted between 20 and 90 minutes.

Respondents agreed to interviews with the understanding that their responses regarding weather dependency would not be credited to them personally. Therefore, we attribute the results to the type of activity they represent, using an H for hunter or BCS for backcountry skier, as well as an interviewee number (1-20 per activity type). All interviews informed the study but not every interviewee's responses are quoted in this paper.

Data Analysis

Prior to analysis, interviews were transcribed verbatim and reviewed for clarity and correctness. We used HyperRESEARCH software to organize the codes, implement first and second cycle coding, code-and-retrieve data analysis, and conceptualize various levels of abstractions within the data (following procedures outlined by Saldaña, 2013).

We subjected the transcripts to two rounds of coding. The first cycle coding employed an a priori structural coding technique. Structural codes were content-based, conceptual phrases that represented the topic of inquiry (i.e., weather dependency), and segmented data that related to specific research questions (MacQueen et al., 2008, p.

124). We grouped similarly coded segments together for more detailed coding and analysis. For example, we compiled and further analyzed all segments coded *site infrastructure*, from the WDF structural frame. Structural coding is particularly applicable for exploratory investigations with a categorical and thematic framework guiding the investigation (e.g., the WDF; Saldaña, 2013).

In second cycle coding, we implemented axial procedures to describe the conceptual and thematic codes from cycle one. Axial coding describes each category's properties, dimensions, and the interrelationships between subcategories (Saldaña, 2013). Charmaz (2006) describes properties as characteristics or attributes, and dimensions as the location along a continuum or range (i.e., the WDF). Each attribute refers to the contexts, conditions, interactions, and consequences of defining "if, when, how, and why" something happens (p. 62).

Credibility

In qualitative investigations, researchers discuss credibility as an alternative term to quantitative validation (Whittemore, Chase, & Mandle, 2001). Credibility analyses generally ask the following question: Are the results an accurate representation and interpretation of the participants' meaning and experiences? For this study, the credibility analysis helped address the following question: Is the WDF an accurate representation and interpretation of outdoor recreationists' perceptions of weather dependency? Cresswell (2015) suggests that the goal of validation in qualitative research is a movement towards confirming the accuracy of the results, as reported through the researchers' worldview.

Following standards for determining the credibility of the WDF, we employed peer debriefing, prolonged engagement, rich data and thick description, comparisons, and sought disconfirming as well as persuasive evidence (Creswell, 2015; Cresswell & Miller, 2000; Marshall & Rossman, 2011). The peer debriefing provided external verification of the research process, ensuring methodological rigor, as well as allowed researchers to question meanings and interpretations. Additionally, it was a way to discuss the emergent findings as a research team to ensure the results were grounded in the data and an accurate representation of outdoor recreationists' perceptions. Prolonged engagement in the field occurred as the first author conducted the interviews, and spent time reviewing and reading transcripts. Rich data and thick description are provided throughout this manuscript to describe and guide the readers through results that helped assessed the credibility of the WDF. Through comparisons of backcountry skiers and hunters perceptions of weather dependency, we were able to assess credibility by understanding the differences and similarities between these two types of activities. Activity comparisons also point to the transferability of the study findings to different outdoor recreation activities. We also sought disconfirming evidence as well as recurring behaviors and actions about outdoor recreationists' perceptions of weather dependency. The recurring behaviors or actions served to provide consideration of disconfirming evidence or contrary interpretations of the meanings of weather dependency as well as build persuasive evidence suggesting credibility (Cresswell, 2015). All of this information described above was then evaluated holistically because as Eisner suggests, researchers should "seek a confluence of evidence that breeds credibility that allows us to feel confident about our observation, interpretations, and conclusions" (p. 110). By setting these standards for evaluating credibility, we were able to understand the comparative evidence that supports and/or disconfirms the WDF, and its factors, variables, and anchors.

We employed intercoder agreement to ensure the reliability of the results, and ultimately to understand the stability of responses across several coders (Cresswell, 2015). During intercoder agreement, two researchers independently coded the data, and then ensured that the assigned codes aligned with the same passages. Based on yes or no, we calculated a percentage of agreement and aimed to establish greater than 80% agreement, as suggested by Miles and Huberman (1994).

Results and Interpretation

The results section begins with a description of the study sample, and is followed by basic-level first and second coding cycle results. Next, we address RQ1 (*in what ways do backcountry skiers' and hunters' perceptions of weather dependency confirm and disconfirm the credibility of the WDF?*) through the presentation of emergent themes. Following, we provide results about the differences and similarities between backcountry skiers' and hunters' perceptions of weather dependency, addressing RQ2 (*how do the similarities and differences between backcountry skiers and hunters' perceptions of weather dependency corroborate and contradict the credibility of the WDF?*). Finally, we answer RQ3 (*overall, what is the credibility of the WDF?*) by discussing key results that determine overall credibility of the WDF.

Study Sample Profile

The sample was comprised of 25% females and 76% males with high education levels (64.8% completed 4 years of college or more) and modest incomes (40% with annual incomes between $35,000 and $74,999). Although the average participant age was 31, the age range was 21-63. On average, backcountry skiers reported 21 ski days in the UWCNF during the last 12 months, spending approximately 4 hours per outing. Hunters reported approximately 24 days hunting in the UWCNF during last 12 months, spending about 10 hours per excursion. We assessed recreation specialization based on narrative descriptions for low, moderate, and high levels of specialization (Altschuler, Brownlee, & Bricker, 2014; Beardmore et al., 2013). Backcountry skiers mostly reported high levels of recreation specialization while most hunters reported moderate. Both types of recreationists reported possessing a moderate skill level. A description of the overall sample profile is provided in Table 3.

Coding Results

We established 92.0% intercoder agreement for first cycle coding and 96.5% intercoder agreement during second cycle coding. First cycle structural coding segmented the data into themes (i.e., factors and variables) from the WDF.

Table 3 *Outdoor Recreationists' Profile for the Study Sample*

	Backcountry Skiers (*n*=20) *M* (*S.D.*)	Ungulate Hunters (*n*=20) *M* (*S.D.*)
Experience Use History		
Days in the last 12 months	*21.05* (1.39)	*24.17* (17.39)
Days in the last 30	out-of-season	*4.53* (4.24)
Time spent (hours)	*4.25* (2.02)	*10.68* (7.13)
Recreation Specialization[a]		
Low	*2.10* (1.51)	*1.70* (0.98)
Moderate	*4.30* (2.23)	*3.53* (2.06)
High	*6.50* (1.73)	*4.71* (2.31)
Self-reported skill level[b]	*6.50* (1.73)	*6.35* (1.17)

Note [a]Recreation specialization was self-reported on a Likert scale from 1-7. [b]Self-reported skill level was assessed on a Likert scale from 1-9.

For example, responses about meteorological conditions were coded into the factor *weather conditions* and further into variables (e.g., temperature, precipitation, and wind speed).

We developed numerous emergent themes using axial coding during second cycle coding. Emergent themes from backcountry skiers' perceptions of weather dependency totaled 52, while hunters' perceptions of weather dependency revealed 58.

These emergent themes derived from the data collected for this study were in addition to the pre-existing 32 variables and seven factors from the original WDF (Chapter III). For this study, factors describe larger categories of variables, and each variable contains several emergent themes from the data (see Table 4).

The authors have elected to present an in-depth discussion and analysis of one emergent theme from each variable, within each factor of the WDF. This is partially due to the overwhelming number of interesting emergent themes within the data. To aid in the interpretation of the results, Table 4 provides a numerical guide to factors (F) and variables (V), as well as offers the emergent themes from second cycle coding for both backcountry skiers (BE) and hunters (HE), which partially addresses RQ1. Factors are numbered one through seven, while variables and emergent themes restart at one for each factor. For example, the factor *personal characteristics* is labeled as F4, within the variable *recreation experience preferences*, which is labeled V6 and backcountry skier emergent theme *community* is labeled as BE7. Therefore, the numerical guide for this sequence would be F4.V6.BE7.

The selected emergent themes include *access* (F1.V1.BE1 & HE1), *strategy* (F2.V4.BE5 & HE4), *terrain* (F3.V2.BE3 & HE2), *culture* (F4.V1.BE1 & HE1),

Table 4 *The Weather Dependency Framework Numerical Guide and Emergent Themes From Second Cycle Coding*

Factors (F)	Variables (V)	Emergent Themes Backcountry Skiers (BE)	Emergent Themes Ungulate Hunters (HE)
F1: Site characteristics			
	V1: Site Infrastructure	BE1: Access BE2: Conditions BE3: Crowded	HE1: Access
	V2: Resiliency to weather (adaptive capacity, vulnerability, resources to support extreme weather events)	BE4: Managed BE5: Shifting conditions BE6: Subverted by use	HE2: Personal adaptation HE3: Wildlife adaptation
	V3: Management Practices	BE7: Land ownership BE8: Allows access BE9: Reduce weather BE10: Dependency	HE4: Extended Season HE5: Tags HE6: Unaware HE7: Permit System HE8: Species Specific Season HE9: Weapon Season
F2: Trip characteristics			
	V1: Transportation mode	BE1: Human-powered	HE1: Human-powered
	V2: Length of stay	BE2: Day Trips BE3: Extended Trips	HE1: Day Trips HE2: Extended Trips
	V3: Route traveled (distance at site and topography)	BE4: Avalanche conditions	HE3: Scouting
	V4: Planning (distance to site, group characteristics such as group type and size)	BE5: Strategy BE6: Typical trip	HE4: Strategy HE5: Typical Trip
F3: Resource characteristics			
	V1: Regional climate variability	BE1: Warming winters	HE1: Specific Species

Table 4. continued

Factors (F)	Variables (V)	Emergent Themes Backcountry Skiers (BE)	Emergent Themes Ungulate Hunters (HE)
	V2: Resource dependency	BE2: Aspects	HE2: Terrain
		BE3: Terrain	HE3: Water
			HE4: Wildlife Habitat
	V3: Natural environment (push factors)	BE4: Unaware	HE5: Unaware
		BE5: Urban Environment	HE6: Urban Environment
	V4: Natural environment (pull factors)	BE6: Nature itself	HE7: Wildlife
			HE8: Nature itself
F4: Personal Characteristics			
	V1: Experience use history	BE1: Culture	HE1: Culture
	V2: Recreation specialization	BE2: High specialization	HE2: Highly specialized
	V3: Past use history	BE3: Avalanche conditions	HE3: Lottery
	V4: Place attachment	BE4: Success	HE4: Success
		BE5: Beauty	HE5: Beauty
			HE6: Novelty
	V5: Satisfaction (of recreation experiences)	BE6: Influenced by success	HE7: Influenced by success
	V6: Recreation experience preferences	BE7: Community	HE8: Community
		BE8: Family	HE9: Constraints
		BE9: Peaceful	HE10: Fitness
		BE10: Skill acquisition	HE11: Food in freezer
			HE12: Fresh air
			HE13: Less people
			HE14: Skill acquisition
F5 : Season			
	V1: Natural Seasonality	BE1: Decreased predictability	HE1: Decreased predictability
		BE2: Shortened seasons	HE2: Rut
	V2: Institutional Seasonality	BE3: Avoid crowding	HE3: Opportunity
		BE4: Opportunity	

Table. 4 continued

Factors (F)	Variables (V)	Emergent Themes Backcountry Skiers (BE)	Emergent Themes Ungulate Hunters (HE)
F6 : Experiences with Weather			
	V1: Perceptions of weather[a]	N/A[a]	N/A[a]
	V2: Expectations of weather	BE1: Personal Adaptation	HE1: Personal Adaptation
	V3: Weather preferences	BE2: Weather preference profile	HE2: Weather preference profile
	V4: Engagement with weather and climate information	BE3: High Engagement	HE3: High Engagement
	V5: Encountered weather[a]	N/A[a]	N/A[a]
	V6: Behavioral reactions to weather	BE4: Personal Compensation	HE4: Personal Compensation
		BE5: Activity Cessation	HE5: Activity Cessation
		BE6: Strategy	HE6: Strategy
F7: Weather Conditions			
	V1: Temperature	BE1: Snow conditions	HE1: Wildlife movement
	V2: Relative humidity[a]	N/A[a]	N/A[a]
	V3: Wind speed	BE2: Deterrent for Participation	HE2: Deterrent for Participation
	V4: Precipitation	BE3: Snow - Will shirk responsibilities to go skiing	HE3: Mask scent and sound
	V5: Physiological Equivalent Temperature (PET)	BE4: Function of equipment	HE4: Temperature thresholds
		BE5: Too cold	HE5: Too cold
		BE6: Too warm	HE6: Too warm
	V6: Extreme weather events	BE7: Exciting	HE7: Effect hunting while out
		BE8: Unsafe conditions	HE8: Wildlife migration events
			HE9: Personal preparation
	V7: Climate variability	BE9: Effect on behavior	HE10: Climate vs. Weather
		BE10: Stories of what 'used to be'	HE11: Will not change hunting
			HE12: Changes tactics

Note: [a]Difficult for participants to articulate this variable and how it influences their primary activity.

opportunity (F5.V2.BE4 & HE3), *high engagement* (F6.V4.BE3 & HE3), and *deterrent for participation* (F7.V3.BE2 & HE2). These emergent themes also partially address RQ1. We selected these emergent themes because they provide rich thick descriptive and comparative support as well as disconfirming evidence to assess the credibility of the WDF following qualitative standards of credibility (Cresswell, 2015). Each of these emergent themes are displayed in Table 5 accompanied by representative quotes. We provide additional details for each emergent theme below.

Access F1.V1.BE1 & HE1

Backcountry skiers and hunters discussed the ease of *access*, which developed as an emergent theme from the variable *site infrastructure* and factor *site characteristics* in the WDF (Table 2 and 3). *Access* for skiers entailed traveling through controlled avalanche terrain to plowed parking lots with easy access to backcountry routes, which was reported to decrease overall weather dependency. *Access* also included safety bailouts and condition availability to achieve desired experiential outcomes. Hunters discussed *access* as reliance on roads and trails to enter permitted hunting regions, which allowed hunters to cover terrain quickly, and was reported to decrease weather dependency. Overall, skiers and hunters indicated that increased *access* through site infrastructure contributed to decreased dependence on weather, a finding that aligns with the anchors and concepts in the initial WDF developed by expert consultation (Chapter III).

Table 5 *Selected Emergent Themes From Second Cycle Coding*

Factor (F), Variable (V), Emergent Themes Backcountry Skier (BE) and Hunter (HE) Numbers	Backcountry Skier (BCS) Typical Emergent Quote Hunter (H) Typical Emergent Quote
F1.V1.BE1 & HE1 Access	*A lot of times you have to travel through avalanche terrain by vehicle to get to a spot to start. So access, obviously when you're backcountry skiing, you're in avalanche terrain…I feel for infrastructure I think Salt Lake City and the Wasatch are probably some of the best environments for that. (BCS 15)* *Definitely accessibility, to me, and plus there is just something, something about it about being up there; it feels a lot more remote… So I would say I like the accessibility of the Uinta's, but at the same time I like to feel like I am in a remote area out in the wilderness and it's not going to be crowded. (H 18)*
F2.V4.BE5 & HE4 Strategy	*I'll tailor my trip based on who I'm with. If I am someone who is less experienced, we might just be doing a shorter trip, and we might be doing something that's just trying to get some good snow and stuff like that. If you're with someone more experienced, you might try and go bag a peak or something like that or do something that might have a bit of exposure. (BCS 15)* *If it's warmer weather, if it's hotter outside we will try to find water holes. Because obviously the animals need some water, they are going to need to drink. So, they are going to come there to bigger water holes. If it's warmer, obviously, we are going to hunt higher. If it's colder we will hunt lower. It just all depends on weather and everything. (H 20)*
F3.V2.BE3 & HE2 Terrain	*Usually if there's a weather event like snow or a storm, within the first couple days of the storm, that'll change it from being more open terrain than skiing trees…that'll put you to skiing out of Little Cottonwood to out of Big Cottonwood or out of Millcreek, even. It will lower the angle that you ski. It will increase the density of trees and color and force the terrain to be less extreme. (BCS1)*

Table 5 continued

Factor (F), Variable (V), Emergent Themes Backcountry Skier (BE) and Hunter (HE) Numbers	Backcountry Skier (BCS) Typical Emergent Quote Hunter (H) Typical Emergent Quote
F3.V2.BE3 & HE2 Terrain	*Generally I spend sometimes on Google earth looking at maps and just trying to identify terrain features where animals are going to be and then I will go to some of those spots that I see (H 17)*
F4.V1.BE1 & HE1 Culture	*Okay, so in my head, there are a lot of times where the ritual of back country skiing like what a trip is starts when I'm up early and I know I'm going to be loading my gear in the car and then I'm going to be drinking coffee on the way up to where I'm going. And either picking someone up or meeting someone there and reading the avie reports. So there are things that happen before the trip, before I actually get on the skis that I consider part of the backcountry day. (BCS1)* *Because I am not a trophy hunter, I am not a rack hunter, I am a meat hunter. So this is for me a provision. Of course the by product is fellowship and community and experiences. It's just immeasurable. (H11)*
F5.V2.BE4 & HE3 Opportunity	*Well, I mean, I guess the main thing is the weekends, which is an institutional thing. And sometimes when the resorts are more crowded, I'm more likely to do backcountry. (BCS2)* *My brother drew an elk permit in a very limited entry, very good area, it took him I think 9 years to draw, so it's very good area. And he was hunting with a bow and our tactic is that we like to sit waterholes so if the weather is bad and say it just pours and pours for the days that we are there, there's water everywhere and they don't need come to a specific spot to drink, go drink in puddles out of the road, they can drink anywhere. So that it I mean, it ruined our hunt in that sense. We don't know what to do, so it's very dependent. (H 14)*

Table 5 continued

Factor (F), Variable (V), Emergent Themes Backcountry Skier (BE) and Hunter (HE) Numbers	Backcountry Skier (BCS) Typical Emergent Quote Hunter (H) Typical Emergent Quote
F6.V4.BE3 & HE3 High Engagement	*Yeah, I have just a folder of marks everything from weather to obviously the avalanche bulletin. And then information coming from the ski resorts, as well as the helicopter guide service up there- they have information about the day before- where they found good snow and dangerous snow. I look into weather, and that kind of covers it. In those subcategories, there is like probably five different places I go to figure out what's going on. (BCS 9)* *I would say constantly in peak weeks or days prior. I definitely try and get a handle on what's going on up there and the week before hunting starts but I guess that's just more for thinking about where the animals would have been pushed. But in the immediate time before hunting time its more just fill myself to what's going on and what kind of like gear I'm going to have to bring out there and stuff like that. (H 17)*
F7.V3.BE2 & HE2 Deterrent for Participation	*I think you can definitely find the wind will keep you from doing anything sometimes. If I know it's going to be 50 miles an hour wind all day, I'm not going to skiing. (BCS 18)* *When the wind is too high I'll sometimes leave just because you can't hear anything, leaves are rustling, trees are making noise. I had it happen when I've done that and pretty soon there would be a deer or something that will walk right behind you and you don't even notice them because you can't hear it. (H 10)*

Strategy F2.V4.BE5 & HE4

Strategy was a theme that emerged from the variable *planning* and factor *trip characteristics* within the WDF. Interviewees reported a variety of *strategies* that varied based on the weather. Backcountry skiers reported *strategies* that involved knowledge of a variety of sites and aspect. *Strategies* for backcountry skiers varied based on the personal characteristics of their travel companions. *Strategies* for hunters varied according to previous scouting and their perceived availability of wildlife at a site. The previous day's weather also influenced hunters' *strategies*. Both backcountry skiers and hunters reported a higher likelihood to vary their *strategies* according to *planning*, which included knowledge of recent weather conditions, travel companions' personal characteristics, and past use history. Overall, varying *strategies* were reported to decrease participants' overall weather dependency and increase recreation participation days. The finding that extensive *planning* decreases weather dependency appears incongruent with expert opinion (see Chapter III). Specifically, in the initial WDF developed by expert consultation, it was hypothesized that extensive *planning* would contribute to higher weather dependency (see Chapter III).

Terrain F3.V9.BE19 & HE19

Backcountry skiers and hunters reported *terrain* as an emergent characteristic of the *resource dependency* variable and *resource characteristic* factor from the WDF. Backcountry skiers discussed *terrain* and aspect while hunters considered *terrain* features such as elevation, topography, wildlife habitat, and ideal vantage points to employ a variety of hunting techniques. For both activity groups, an increase in knowledge of *terrain* contributed to a decrease in weather dependency. For example, hunters reported analyzing *terrain* from the context of weather to determine the best areas to hunt within their permitted region. Backcountry skiers reported analyzing *terrain* for snow stability and safety (i.e., avalanche conditions). Similar to expert opinion (Chapter III), outdoor recreationists indicate that increases in *resource dependency*, as a function of *terrain* knowledge, result in high weather dependency.

Culture F4.V1.BE1 & HE1

Recreationists discussed *culture* often, and included stories of initial introductions into their recreation activity as a theme in the *experience use history* variable and *personal characteristics* factor from the WDF. Backcountry skiers discussed their friends and family who initially introduced them to backcountry skiing and the ritual of multiphasic recreation experiences that begin before and continue long after recreation activities conclude. Hunters discussed the *culture* of ethical hunting, skill progression taught by family, and the communal nature of hunting. Backcountry skiers and hunters that exhibited less *experience use history* discussed higher dependence on weather as a feature of *culture*. For example, an increased reliance on backcountry skiers' and hunters' family and friends was linked to low levels of *experience use history*, which resulted in higher weather dependency. In alignment with expert opinion (Chapter III), outdoor recreationists indicated that relatively low *experience use history*, as discussed through *culture*, results in high weather dependency.

Opportunity F5.V2.BE4 & HE3

Opportunity was discussed often by backcountry skiers and hunters, which emerged as a theme under the *institutional seasonality* variable and *season* factor of the

WDF. Backcountry skiers reported *opportunities* for skiing on nonweekend low volume days that allowed them to avoid crowds. Some backcountry skiers reported avoiding weekends with long traffic lines and additional people in the backcountry. Their knowledge of *institutional seasons* provided opportunity to rely on desirable weather conditions to ski and increase weather dependency. Conversely, *institutional seasonality* created opportunity bounded by management practices for hunters. For example, hunters navigated the permit system, species-specific seasons, and weapons seasons prior to recreation participation. Hunters' *opportunity* for recreation began well before the season, during the lottery, and continued into the season once they acquired tags and a hunting permit. Hunters' knowledge of *institutional seasons* provided them with hunting rights that bound them to specific areas and permits. Because *institutional season* was highly predictable and hunters were bound to season specific permit areas, hunters were less weather dependent. For hunters' this meant that pending specific permits and hunting regions, the weather had significantly less influence on their decision to go hunting. Hunters' reported that in short seasons, such as the bull elk season, no weather-related conditions could influence if they participated in hunting. This finding contrasts experts' conceptualization that higher predictability of institutional seasonality contributes to lower weather dependency (Chapter III).

High Engagement F6.V4.BE3 & HE3

Interviewees often discussed *high engagement* with weather and climate information, which emerged from the variable *engagement with weather and climate information* within the *experiences with weather* factor of the WDF. Backcountry skiers discussed *high engagement* with weather information that included checking avalanche conditions and making recreation decisions based on the stability of the snowpack. Meanwhile, hunters' *high engagement* with weather information provided insight into wildlife movement. Hunters' suggested that *high engagement* included checking weather forecasts daily. For both, *high engagement* with weather information was a function of high levels of weather dependency. This finding is congruent with experts' speculation that high levels of *engagement with weather and climate information* are associated with high levels of weather dependency (Chapter III).

Deterrent for Participation F7.V3.BE2 & HE2

The emergent theme of *deterrent for participation* originated within the variable *wind speed* and the factor *weather conditions* from the WDF. Many participants cited *wind speed* as a *deterrent for participation* in backcountry skiing and hunting. For backcountry skiers, *wind speed* often created unstable and unpleasant conditions, which was reported to potentially *deter participation* or force skiers into more protected areas. Hunters reported *wind speed* as a *deterrent for participation* because high winds tended to obscure humans' ability to hear but enhanced wildlife's ability to smell. Both hunters and backcountry skiers reported *wind speed* as highly significant, which contributed to high levels of weather dependency. This finding is also consistent with experts' evaluations that if *wind speed* is highly significant for an activity, then the activity is likely to be more weather dependent (Chapter III).

The Credibility of the WDF Through Backcountry Skiers' Perceptions of Weather Dependency

Although these emergent themes, and many others, confirmed the credibility of several of the WDF variables, a comparison between hunters and skiers responses revealed strong similarities and some differences. These similarities and differences allowed for another avenue to evaluate the credibility of the WDF, and ultimately helped answer RQ2. For example, hunters reported *culture* (F4.V1.BE1 & HE1) as communal, including friend and family communities, especially for those with young children, while backcountry skiers tended to report culture as small ski groups and were highly selective of their skiing companions. The expert created WDF indicates participants with less *experience use history* will exhibit higher levels of weather dependency, which the interview data confirmed for both groups. While hunters and backcountry skiers differed on their conceptualization of the emergent theme *culture,* the interview data supported the credibility of the variable *experience use history*.

Additionally, this study confirmed the credibility of the WDF variable *wind speed* based on a comparison of backcountry skiers' and hunters' perceptions of weather dependency. Hunters and backcountry skiers were most similar on the emergent theme *deterrent for participation* (F7.V3.BE2 & HE2). *Wind speed* was cited as a highly significant *deterrent of recreation participation*, which indicated high levels of weather dependency.

Conversely, *opportunity* as a component of *institutional seasonality* was not confirmed when comparing interview results between activity groups. Strong differences existed in the ways *institutional seasonality* provided *opportunity* (F5.V2.BE4 & HE3) for backcountry skiers and hunters. It is because of these strong differences that the credibility of this variable was disconfirmed, at least based on this current investigation. Backcountry skiers' knowledge of *institutional seasons* provided *opportunity* to rely on desirable weather conditions to ski and increase weather dependency (i.e., providing option and flexibility to pursue "powder days"). Meanwhile, hunters were more likely to be bound to hunting during their permitted season regardless of the weather and other people. Other hunters also reported a strict adherence to permits that resulted in decreased weather dependency. In other words, if hunters drew the coveted bull elk tag and were permitted a 15-day season to hunt, their weather dependency decreased because regardless of weather-related variables, they would hunt during that season. In this instance, hunters' levels of weather dependency were in alignment with the original assentation of the WDF (Chapter III); however, backcountry skiers' perceptions of how institutional seasonality influenced weather dependency contrasted with expert opinion. Due to these differences, the credibility of *institutional seasonality* cannot be confirmed.

The Overall Credibility of the WDF

Although the emergent themes and the comparison between backcountry skiers' and hunters' perceptions help elucidate the depth of inquiry and provide examples, Table 6 provides the overall results of the credibility analysis, which are presented and discussed in this section. This is a macrolevel discussion aimed at linking the previous detailed descriptions of emergent themes back to the purpose of the article, assessing the overall credibility of the WDF. We accomplish this by first discussing the total number of variables confirmed, disconfirmed, and inconclusive based on backcountry skiers' and hunters' perceptions of weather dependency. Next, we discuss the factors that are

Table 6 *The Overall Credibility of the Weather Dependency Framework*

	Backcountry Skiers			Ungulate Hunters		
Confirmation Factors (F) and Variables	Confirmed[b]	Disconfirmed[c]	Inconclusive[d]	Confirmed[b]	Disconfirmed[c]	Inconclusive[d]
F1: Site characteristics	*X*			*X*		
V1: Site Infrastructure	X			X		
V2: Resiliency to weather			X			X
V3: Management Practices	X			X		
F2: Trip characteristics	*X*			*X*		
V1: Transportation mode	X			X		
V2: Length of stay	X			X		
V3: Route traveled	X			X		
V4: Planning		X			X	
F3: Resource characteristics	*X*			*X*		
V1: Regional climate variability			X			X
V2: Resource dependency	X			X		
V3: Natural environment (push)	X			X		
V4: Natural environment (pull)	X			X		
F4: Personal characteristics	*X*			*X*		
V1: Experience use history	X			X		
V2: Recreation specialization	X			X		
V3: Past use history			X			X
V4: Place attachment			X			X
V5: Satisfaction	X			X		
V6: Recreation experience preferences	X			X		
F5 : Season		*X*				*X*
V1: Natural Seasonality	X					X

Table 6 continued

Confirmation Factors (F) and Variables	Backcountry Skiers			Ungulate Hunters		
	Confirmed[b]	Disconfirmed[c]	Inconclusive[d]	Confirmed[b]	Disconfirmed[c]	Inconclusive[d]
F5: Season		*X*				*X*
V2: Institutional Seasonality		X		X		
F6: Experiences with weather			*X*			*X*
V1: Perceptions of weather[a]			X			X
V2: Expectation of weather			X			X
V3: Weather Preferences			X			X
V4: Engagement with weather and climate information	X			X		
V5: Encountered weather[a]			X	X		
V6: Behavioral reactions to weather	X			X		
F7: Weather conditions	*X*					*X*
V1: Temperature	X			X		
V2: Relative Humidity		X			X	
V3: Wind Speed	X			X		
V4: Precipitation	X			X		
V5: Physiological Equivalent Temperature (PET)	X					X
V6: Extreme weather events	X			X		
V7: Climate Variability			X			X

Note: [a] Difficult for participants to articulate this variable and how it influences their primary activity; [b] We deemed variables to be 'confirmed' if the variable was clearly addressed by more than 70% of interviewees and if most of the interviewees' responses aligned with experts' opinions about the variables' relationship to weather dependency; [c] Disconfirmation was assigned to a variable if less than 70% of interviewees discussed the variable with responses that contrasted with experts' opinions about the variables' relationship to weather dependency; [d] The available data and interpretation did not allow for confirmation or disconfirmation for this variable. Factors were confirmed if at least two-thirds of their variables for were confirmed. The italics *X* is used to denote a factor's credibility.

confirmed, disconfirmed, and inconclusive. We then present the overall credibility of the WDF and conclude with implications for future research.

Because qualitative credibility analyses should be contextualized to context, research purpose, and population (Cresswell, 2015), the following criteria for confirmation, disconfirmation, and to determine inconclusive results were developed through iterative discussion within the research team (Cresswell, 2015) and by adapting recommendations by Marshall and Rossman (2011). We deemed variables to be 'confirmed' if the variable was clearly addressed by more than 70% of interviewees with responses that aligned with experts' opinions about the variables' relationship to weather dependency. A variable was 'disconfirmed' if approximately less than 70% of interviewees discussed the variable with responses that contrasted experts' opinions about the variables' relationship to weather dependency. A variable was deemed 'inconclusive' if the available data and interpretation did not allow for clear confirmation or disconfirmation. For example, some responses were significantly influenced by novel situational factors and some respondents lacked clear understanding about the interviewer's questions. Researchers concluded that factors were confirmed if at least two-thirds of their variables were also confirmed.

Backcountry skiers' perceptions of weather dependency aided in confirming the credibility of 20 variables with one less confirmed variable for hunters (19). Primary differences in confirming credibility between backcountry skiers and hunters occurred for the following variables *natural seasonality, institutional seasonality,* and *physiological equivalent temperature (PET).* Backcountry skiers' perceptions of weather dependency confirmed the credibility of *natural seasonality*, while hunters' perceptions led to inconclusive findings for the same variable. Likewise, hunters' perceptions led to confirming the credibility of *institutional seasonality* and backcountry skiers' perceptions led to disconfirming experts' original assessments of the relationships between weather dependency and *institutional seasonality. PET* was confirmed by backcountry skiers and inconclusive for hunters.

This study also disconfirmed three variables for backcountry skiers and two for hunters. Both groups of recreationists' disconfirmed the *planning* variable from the *trip characteristics* factor. Evidence of this particular disconfirmation was thoroughly illustrated by the emergent theme *strategy,* which indicated *strategies* were reported to decrease overall weather dependency. Both groups also disconfirmed *relative humidity*, as irrelevant to recreation participation in the UWCNF.

Nine variables for backcountry skiers and 11 variables for hunters were deemed inconclusive in regards to their credibility. For both groups, findings were inconclusive for the variables *resiliency to weather, regional climate variability, past use history, place attachment, perceptions of weather, expectations of weather, weather preferences, encountered weather,* and *climate variability.* From hunters' perspectives, *natural seasonality* and *PET* were added to the inconclusive findings. The inconclusive findings primarily refer to intragroup differences that could not be resolved sufficiently to confirm credibility.

As a result of these variable-level findings, responses from backcountry skiers confirmed the credibility of five factors, disconfirmed one factor, and left one inconclusive. Interview data from hunters confirmed four factors and left the credibility of three inconclusive. The factors *site characteristics, trip characteristics, resource* *characteristics*, and *personal characteristics* were confirmed by the findings from backcountry skiers' and hunters' perceptions of weather dependency. Conversely, the factors *season* and *experiences with weather* were inconclusive as a result of this study. The factor *season* was deemed inconclusive based on hunters' responses and disconfirmed for backcountry skiers. For both groups, the credibility of *experiences with weather* was inconclusive, primarily because many of the factor's variables were also inconclusive. The factor *weather conditions* was confirmed for backcountry skiers but was found inconclusive for hunters.

Overall, the WDF has fairly high levels of credibility based on backcountry skiers' and hunters' perceptions of weather dependency. Backcountry skiers' perceptions of weather dependency confirmed 20 out of 32 variables, only disconfirming three with nine resulting in inconclusive findings. Hunters' perceptions of weather dependency confirmed 19 out of 32 variables, only disconfirming two with 11 resulting in inconclusive findings. Overall, five out of seven of the factors were confirmed while only one factor was disconfirmed. The inconclusive factors require additional investigation that future research might address.

Discussion and Research Recommendations

The purpose of this study was to assess the credibility of the Weather Dependency Framework (WDF; Chapter III), a tool that combines multidimensional weather-related variables to aid in the interpretation of the weather dependency of outdoor recreation activities. The need for this work was evident because the WDF was created using prior literature (Chapter II) and an expert panel (Chapter III), and therefore required an inquiry into its credibility (Cresswell, 2015). Credibility was assessed following standards for determining qualitative credibility (Cresswell, 2015), using emergent themes, comparing two activity groups, and identifying the confirmation, disconfirmation, or inconclusive nature of specific factors and their variables. Results suggest that overall the WDF has high levels of credibility based on backcountry skiers' and hunters' perceptions of weather dependency. We first discuss the implications of the qualitative credibility of the WDF for weather-related literature. However, as with any new line of inquiry, many opportunities for future research exist, five of which are discussed in this section. Additionally, we reflect on the strengths, challenges, and implications of conducting a qualitative credibility analysis as well as provide recommendations for researchers.

Credibility and Future Research

The credibility analysis reveals several areas that warrant additional research. First, future research might investigate some of the variables within the two factors (*season* and *experiences with weather*) this study found to be inconclusive. Backcountry skiers' and hunters' reported differences in their perceptions of weather dependency for *institutional seasonality* and *natural seasonality*. Therefore, studies might further assess the credibility of the factor *season* and specifically the variables *institutional seasonality* and *natural seasonality*. Additionally, the *experiences with weather* factor and its associated variables were found to be largely inconclusive, which may warrant additional investigation. The largely inconclusive nature of the *experiences with weather* factor was also evidenced in prior studies. For example, the intertwining of tourists' perceptions, expectations, and preferences throughout the literature (e.g., Becken & Wilson, 2013; Denstadli et al., 2011, Hübner & Gössling, 2012) led to difficulties in predicting outdoor recreation behaviors. Therefore, experts might strive to understand the uniqueness of each variable's contribution to weather dependency as well as recreationists' interpretations of these concepts.

Second, researchers can link and further investigate any one of the factors, variables, or emergent themes discussed in this study. Future studies might consider investigating recreationists' *activity cessation* (F6.V25.BE41 & HE45) as behavioral reactions to weather and incorporating *past use history* to conduct specific site assessments. Other research might investigate *satisfaction of recreation experiences* as influenced by *success* (F4.V16.BE28 & HE30) and the role of *weather conditions*. Furthermore, *recreation specialization* and weather dependency appear highly related and some results from this study hint that as *recreation specialization* increases, weather dependency may decrease due to an increase in knowledge and personal preparedness that accompanies *recreation specialization*. Future research could continue to investigate the connection between *recreation specialization* and weather dependency.

Third, future research might continue to use the WDF to understand the weather dependency of outdoor recreation activities in new settings and with new activities. Researchers could replicate the current credibility analysis presented in this study in a different location with the same population. For example, researchers could assess the credibility of the WDF through backcountry skiers' and hunters' perceptions of weather dependency in mountains in the Northeast. Alternatively, researchers might consider assessing the WDF in the UWCNF with different populations, such as ice climbers and snowmobilers.

Fourth, future research could also aim to quantify the WDF, which would allow for quantitative comparisons across activities and regions. For example, researchers could compare backcountry skiers' perceptions of weather dependency in distinctively different cultural and ecosystems contexts (e.g., Utah, Michigan, and Vermont). Additionally, future research might replicate this study by assessing and comparing multiple activities in one region. For instance, researchers might compare outdoor cycling and backpacking in one region such as the Pacific Northwest.

Fifth, the framework was developed by experts (Chapter III) based on prior literature (Chapter II); however, there are a number of other stakeholder groups who were not considered throughout the development and credibility analysis of the WDF. For example, the utility of the framework for managers has yet to be assessed. Future research might investigate how natural resource and outdoor recreation managers operationalize the WDF to plan, mange, and assess the influences of weather dependency for outdoor recreation activities. Additionally, the framework might have utility for tour operators that the credibility analysis did not address. Researchers could investigate the implications of the WDF and its' credibility for tour operations and programming extending research on tourism destination development and the effects of weather on business operations (e.g., Rauken & Kelman, 2012), the impacts of weather events on destination and temporal substitution (e.g., Windle & Rolfe, 2013), and potential behavior of winter tourists to changing meteorological conditions (e.g., Tervo-Kankare, Hall, & Saarinen, 2012).

The overall credibility of the WDF based on backcountry skiers' and hunters' perceptions of weather dependency has several implications that relate to the literature. Credibility implies recreationists' understandings and interpretations align with experts to a high degree. This is significant for weather-research that has identified these variables as important indicators for operations and development at specific recreation or tourism areas (Barbieri & Sotomayor, 2013; Lemieux, Beechey, Scott, & Gray, 2011). Also, research investigating *natural environment push* and *pull factors* could rely on the credibility of these variables to further understand these variables, such as extending Pomfret's (2006) work on destination or site selection and social psychological factors that motivate travel. Research could extend studies on *trip characteristics*, continuing work by Becken (2003) and colleagues that connects *transportation mode*, *length of stay*, and *route traveled* to weather conditions and tourists' visitation patterns.

Like any method, the qualitative credibility analysis has several strengths. Strengths of conducting a qualitative credibility analysis lie in researchers' ability to capture authentic representations of participants' meanings (Cresswell, 2015). In this study, we were able to portray the level of accuracy to which the WDF reflects backcountry skiers' and hunters' perceptions of weather dependency. We were also able to present in-depth analysis of backcountry skiers' and hunters' perceptions of weather dependency that resulted from the qualitative credibility analysis.

Next, we provide reflections and recommendations on the challenges of qualitative credibility analyses for researchers interested in replicating this study or applying credibility analyses to other areas of research. A challenge of conducting a qualitative credibility analysis lies in the researchers' ability to state with finality the credibility of the framework. Specifically for the WDF, some of the variables and factors might require expert knowledge to really understand and identify their contributions to weather dependency. For instance, researchers whose expertise connects understanding the relationships between those variables and outdoor recreation behaviors might investigate variables and factors with inconclusive findings (e.g., climate variability). Further, inconclusive findings might be a function of outdoor recreationists' lack of knowledge about some of the variables as opposed to lacking credibility. For example, many variables within the WDF are complex and laden with expert terminology, resulting in years of study to comprehend fully. It is therefore understandable that a qualitative credibility analysis would result in inconclusive findings for more complex variables. Past use history, is an example of an expert-laden term. We also recommend researchers pursing future qualitative credibility analyses to consider the language associated with key terms and concepts within the study. Complex terms and concepts might need to be reframed to aid participants' responses and collect data that more accurately reflects participant meaning. Last, as possible, we recommend employing member checking as suggested by standards of qualitative credibility (Cresswell, 2015; Cresswell & Miller, 2000; Marshall & Rossman, 2011). While member checking requires extensive time on the researchers' behalf, it can greatly enhance understandings of disconfirmed and inconclusive findings in particular.

Conclusion

The purpose of this article was to assess the credibility of the WDF. We accomplished this purpose by conducting an exploratory analysis comparing backcountry skiers' and hunters' perceptions of weather dependency. The findings presented here might aid researchers in better understanding the factors, variables, and emergent themes influencing weather dependency in outdoor recreation. Researchers can also use this work as a springboard for future investigations.

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CHAPTER V

SUMMARY AND SYNTHESIS

The intent of the chapter is to summarize and synthesize the findings from the previous three chapters. I present an overview of what we now know about the influences of weather, the Weather Dependency Framework (WDF), and the credibility of the WDF as well as implications for future research.

This dissertation began to address the deficiency of knowledge about how weather influences outdoor recreation. We now have a state-of-knowledge paper synthesizing weather studies in outdoor recreation and nature-based tourism (Chapter II of this dissertation). We also have a Weather Dependency Framework (WDF) that is a mechanism to begin to understand the weather dependency of outdoor recreation activities (Chapter III). We know that parts of the WDF are highly credible, and like any new framework, other elements require additional investigation (Chapter IV). The findings from each study are reviewed below along with implications for future research.

Weather Studies in Outdoor Recreation and Nature-based Tourism: A Research Synthesis and Gap Analysis

The research synthesis of weather studies in outdoor recreation and nature-based tourism revealed three primary emergent themes and associated trends. The first emergent theme was weather-related salient factors and variables. The factors included *site characteristics*, *trip characteristics*, *resource characteristics*, *personal characteristics*, *season*, *experiences with weather*, and *weather conditions*. *Site characteristics* encompass the variables of site infrastructure, community infrastructure, vulnerability, adaptive capacity, and resources to support extreme weather events. The second salient factor was *trip characteristics* and included the variables of transportation mode, length of stay, route traveled (i.e., distance at site and covered topography), activity day, and, distance. The third factor, *resource characteristics*, considered regional climate variability, resource dependency, natural environment, and management practices. The factor *personal characteristics* is in addition to standard demographic information and includes experience use history, past use history, place attachment, quality and satisfaction of recreation experiences, recreation specialization, beliefs in climate change, and recreation experience preferences. *Season* was examined in the literature through the lens of natural seasonality and institutional seasonality. *Experiences with weather* characterizes the research about recreationists' and tourists' connections with weather, including weather perceptions, expectations and preferences, encountered weather, behavioral reactions to weather, and weather and climate information that were significant variables investigated throughout the research data. The factor *weather conditions* includes temperature, precipitation, relative humidity, wind speed, precipitation, and Physiological Equivalent Temperature (PET). The research indicates that temperature was the most studied variable throughout weather-related research and the overwhelming majority of the weather studies used secondary meteorological data that were infrequently paired with recreation or tourism use data.

Second, Study 1 results indicated that geographic research context is important and categorized into three larger nonmutually exclusive categories. These three categories included North American land-based context, European winter and land-based context, and islands marine-based context. The trend for this finding arose out of the growing body of research originating from the European ski tourism context.

The third finding from Study 1concerns predominate activity types examined throughout weather studies. Activity categories included skiing, nature-based tourism, residential and/or community oriented activities, and lastly, visitors to parks and protected areas. The trend for this finding was overwhelmingly skiing, which was the most studied activity.

The research synthesis was coupled with a gap analysis of weather studies in outdoor recreation and nature-based tourism that indicated knowledge deficiencies about weather within each of these three findings, gaps in methodological approaches, as well as other under-researched areas. First, gaps from the salient factors and variables included limited knowledge about how outdoor recreationists engage with and integrate weather information, and how this engagement and integration influences decision-making, travel motivation and activity participation. Second, few weather studies have occurred in developing nations and even more limited studies have focused on Central and South America, Asia, and Africa. Third, large portions of outdoor recreation activities were under-researched excluding golf and skiing. Methodological gaps revealed a primary focus on top-down methods including case-based, expert-based, and descriptive qualitative methods. Less commonly, investigators inquiries paired secondary data with in situ questionnaires. Other under-researched areas included the links between tourism fashion and weather (Gómez-Martin, 2005), the effects of technology on outdoor recreationists' adaptation strategies, and the impact of technological advances to outdoor gear on recreation behavior (Clawson, 1966).

The findings presented from Study 1 pointed to the need for future research as well as the need to understand the weather dependency of outdoor recreation. The salient factors and variables uncovered in the research synthesis and gap analysis led to the development of the Weather Dependency Framework (WDF).

A Weather Dependency Framework (WDF) for Outdoor Recreation Activities

Study 2 described a modified Delphi process that resulted in an interpretive framework aimed to help managers and researchers understand the weather dependency of outdoor recreation activities. The Weather Dependency Framework (WDF) contains the most salient factors and variables that influence weather dependency. The chapter also included three outdoor recreation activity examples of how researchers and managers might use the framework. Social science research recommendations included using the WDF as a tool to interpret and make sense of the weather dependency of outdoor recreation activities, to predict recreation participation for specific activities under certain weather conditions, to conduct site and programmatic assessments, and to understand the dynamic nature of weather dependency. Meanwhile, managers of parks and protected areas might use the WDF as a planning tool, to increase or decrease weather dependency by manipulating certain variables, to understand change in outdoor recreation at the activity level, and to gather and provide weather-related information to visitors.

Beyond credibility, the findings point to a number of areas for future development of the WDF such as developing place-paced activity assessments for multiple activities and developing standard measurement techniques for specific variables within the WDF. The recommendations for future research because of Study 2 included testing the WDF with a multitude of other weather dependent activities, exploring variables unintentionally excluded, and validating the WDF by assessing recreationists' perceptions of weather dependency.

Assessing the Credibility of the Weather Dependency Framework (WDF): Comparing Backcountry Skiers' and Hunters' Perceptions

Study 3 described the credibility of the WDF based on backcountry skiers' and hunters' perceptions of weather dependency. Backcountry skiers' perceptions of weather dependency aided in confirming 20 variables, disconfirming three, and resulting in nine inconclusive credibility findings. Meanwhile, hunters' perceptions of weather dependency assisted in confirming 19 variables, disconfirming two, and resulting in 11 inconclusive credibility findings. Overall, the WDF was reported to have fairly high levels of credibility based on backcountry skiers' and hunters' perceptions of weather dependency.

The findings point to a number of areas for future research. This includes investigations within the two inconclusive factors (*season* and *experiences with weather*). Also, research might link any one of the factors, variables, or emergent themes discussed within Study 3. Research might use the WDF to understand the weather dependency of outdoor recreation activities in new settings and with new activities or aim to quantify the WDF. Additionally, research might continue to develop or investigate the credibility of the WDF with other stakeholder groups. I conclude by providing strengths and challenges of credibility analyses and providing recommendations for researchers pursing this method in the future.

Overall Implications for Future Research

A number of potential areas for future research exist as a result of these three studies. Future research could focus on a diverse range of weather-related variables and factors influencing outdoor recreation. The WDF might be developed through additional studies. Moreover, weather studies could benefit from explorations employing diverse methods in new research contexts.

First, as a whole, the dissertation presented a diverse range of weather-related factors and variables influencing outdoor recreation. These, along with emergent themes from Study 3 could continue to be addressed. Factors and variables might be linked together to quantify, develop standard measurement techniques, and understand interrelationships. This research might focus on the broad influences of weather on outdoor recreation, or more specifically the weather dependency of outdoor recreation activities. For example, research might use the WDF as a tool to understand variables contributing to the weather dependency of outdoor recreation activities.

Findings from these studies pointed to under-investigated areas of outdoor recreation. For example, the literature base on skiing and golfing is adequate, yet we know fairly little about the weather's influence on other outdoor recreation activities such as water-based sports and alpine pursuits. As a subcategory of outdoor recreation, we know little about urban outdoor recreation or how weather might influence recreation activities in that setting. As technology continues to advance, examining the effects of technology on outdoor recreation, specifically in relation to adaptation strategies, might be a fruitful area of future research. For example, research has yet to investigate the impacts of technological advances to outdoor gear on outdoor recreation participation, under a range of weather scenarios.

Second, future research might focus specifically on developing the WDF through a variety of studies. Future research might test the WDF with a multitude of other weather dependent activities, exploring variables unintentionally excluded, and validating portions of the WDF. Future studies could continue to develop place-based activity specific assessments and understand how weather dependency can predict outdoor recreation behavior. For example, the WDF could be tested in new settings with new activities, such as surfing in Baja, Mexico or mountaineering in the Brooks Range.

Third, future research could continue to use diverse methods to explore the multidimensional influences of weather on outdoor recreation in these new research contexts. Researchers might couple recreationists' perceptions of weather with climate prediction modeling data to understand holistically the weather dependency of key outdoor recreation and nature-based tourism activities. Alternatively, using standard measurement techniques, researchers might test the WDF by exploring one activity across three settings and quantify the weather dependency of that one activity. This would help determine the degree that setting influences weather dependency. Additionally, this research was created and developed in a North-American context and findings from these studies indicated under-research international contexts. For example, an interesting cultural comparison might exist in comparing North-American based ski-context to that of the Japanese culture. Therefore, research can continue to expand by investigating cultural implications of weather dependency and test the framework in a variety of international settings.

Conclusion

The purpose of this dissertation was to 1) understand the current state of knowledge of weather studies in outdoor recreation and nature-based tourism, 2) develop a weather dependency framework (WDF) combining factors and variables influencing the weather dependency of outdoor recreation activities, and 3) assess the credibility of the WDF by investigating backcountry skiers' and ungulate hunters' perceptions of weather dependency. In summary, findings suggest that the weather influences outdoor recreation activities and outdoor recreation activities possess varying levels of weather dependency. The findings also indicate that the newly developed WDF has credibility, and potentially requires some adjustment, based on backcountry skiers' and ungulate hunters' perceptions of weather dependency.

This dissertation represents a substantial contribution to the field because past research had not yet synthesized weather studies in outdoor recreation, directly investigated the weather dependency of outdoor recreation activities, or used outdoor recreationists' perceptions of weather dependency to help evaluate the qualitative credibility of a framework developed by experts and prior literature. The research synthesis and gap analysis was a significant contribution due to the diversity, variability, and increasing attention to the multidimensional influences of weather on outdoor recreation and nature-based tourism. The Weather Dependency Framework (WDF) is the first of its kind to include the multidimensional variables and factors influencing the weather dependency of outdoor recreation. The WDF can provide a valuable framework for researchers or mangers interested in understanding the weather dependency of outdoor recreation activities. The third study begins to fill the gap in knowledge of understanding outdoor recreationists' perceptions of weather dependency. Backcountry skiers' and ungulate hunters' perceptions of weather dependency aided in assessing the qualitative credibility of the WDF.

Research gaps were present because until this dissertation little was known about the weather influences on outdoor recreation and how weather dependency influences outdoor recreation activities. Additionally, limited studies were conducted to investigate how backcountry skiers' and ungulate hunters' perceptions of weather dependency can speak to the qualitative credibility of newly developed frameworks. The series of studies in this dissertation began addressing the lack of empirical research regarding the influences of weather on outdoor recreation activities. As outdoor recreation activities become increasingly influenced by the weather, these studies provide a valuable framework for conducting future research about the influences of weather and the weather dependency of outdoor recreation activities.

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