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This dissertation is comprised of three manuscripts that will be submitted to peer-reviewed academic journals. The first paper is a review of the relationship between PET-derived temperature categories and daily visitor attendance at the Phoenix and Atlanta zoos. This paper discusses trends in attendance patterns and serves as a foundation for the subsequent papers.

The second paper expands on the theories and findings of the first paper by expanding the study area to Indianapolis and St. Louis zoos regarding the response of attendance to PET-derived temperature categories. Additionally, this paper also explores the possible influence of admission pricing as it relates to visitor responses to the weather.

The final paper implements a broader scale of climate data by using the Spatial Synoptic Classification in a review of attendance response at Atlanta and Indianapolis zoos. Use of this climate classification in the realm of tourism is one of the first studies to do so.

Overall, this dissertation research provides new methodologies and illustrates findings which may allow for a better understanding of how people react to the weather. These results may assist leaders and governments to make better-informed policy and planning decisions for the future.

WEATHER IMPACTS ON VISITOR BEHAVIOR: A SPATIO-TEMPORAL STUDY

OF SELECT U.S. METROPOLITAN ZOOLOGICAL PARKS

by

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To Mom and Dad

APPROVAL PAGE

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CHAPTER I

INTRODUCTION

Addressing climate change, the United Nations World Tourism Organization (UNWTO) has stated in its 'Davos Declaration on Climate Change and Tourism' that climate is a key resource for tourism and that the sector is highly sensitive to the impacts of climate change. The UNWTO has suggested that communities and governments should 'develop regional and local climate information services tailored to the tourism sector' and implement community policy which is based on the interface between climate and the businesses/consumers within the tourism industry (UNWTO, 2009 p. 25). Literature addressing the complex interactions between varied weather and climate conditions within the tourism sector has attempted to answer many of the objectives outlined by the UNWTO through detailed research on how tourism resources could change and how people might travel to different locations under varying scenarios of climate change.

This dissertation explores how varying weather conditions influence consumer behavior in the form of visitor-attendance response. In order to better study this interface, the Tourism, Recreation, and Leisure (TRL) sector and particularly zoological parks were researched because they are largely outdoor-oriented and have significant exposure to weather. Additionally, because the sector is impacted by weather at varying scales and has many stakeholders, the findings in this dissertation have the ability to advance theory and provide useful policy-making guidelines. Expanded to wider scales, weather can affect seasonal tourist arrivals and impact the income of an entire geographic region thereby forcing communities to consider weather and climate in their comprehensive strategic planning (Scott *et al.*, 2012; Agnew and Plautikof, 2001; Gomez-Martin, 2005; de Freitas, 2002; Hale and Altalo, 2003; de Freitas et al, 2008). As a result, research in this field can advance our understanding of human response to various ambient environmental conditions while assisting in better managing visitor demand in the TRL sector.

The need for further study of the shorter-term relationships that might exist between weather and the TRL sector has been emphasized by many researchers (Nicholls *et al.*, 2008; Shih and Nicholls, 2011; Scott, 2012; Scott and Jones, 2006). However, it has been argued that before we can effectively understand how future climate change scenarios may broadly impact human behavior, we should establish in detail a present-day baseline for human behavioral response to varied weather conditions and consider long-term 'duration effects' by researching attendance trends over longer periods of time (Hynds and Smith, 1994).

To do this and provide comparable results across the tourism sector, this dissertation specifically focuses on the short-term varied weather conditions impacting a major subsector of TRL, zoological parks and aquariums, which contributed over $16 billion to the United States economy in 2012, supporting 142,000 jobs and attracting 175 million visitors (AZA, 2013). Zoological parks and aquariums represent a significant subsector of TRL, though few studies have examined in detail how weather conditions might affect zoo visitor attendance over time. Mason (2000) has remarked that zoos as tourist attractions remain under-researched, and Davey (2007) has stated that zoo attendance patterns are in need of additional research.

There are benefits for using zoological parks in weather-attendance research as zoos offer several specific advantages in research methodologies concerning how weather impacts visitor-attendance choices. First, prior to visiting a zoological park, people have certain expectations regarding the reasons why they visit and the outdoor exposure they will likely experience when on site. Although there are differing motivations for zoo patrons (Falk et al, 2007), those who visit zoological parks generally go to learn about animals, conservation, and nature, and patrons expect this to occur mostly in an outdoor setting regardless of the geographic location of the zoo. Second, unlike the wide variety of activities potentially engaged in by beach or park tourists (Grodzik, 1972; Brandenburg and Ploner, 2002; Ploner and Brandenburg, 2003; Rutty and Scott, 2014; Morgan *et al.*, 2000), activity at zoos can generally be defined as "slow steady walking" (Mieczkowski, 1985) as the main function visitors perform at most zoo locations. Third, because most zoos operate as paid-for admission venues, they keep reliable and accurate attendance data over time. Additionally, in order to maintain controlled admissions, zoological park space has definite geographic boundaries with fixed entry and exit points. Difficulties can arise when accounting for attendees at open spaces such as botanical gardens and nature parks with multiple entrances and beach fronts with undefined geographical spaces (Knez and Thorsson 2005; Rutty and Scott, 2014; Curtis, Arrigo, and Covington, 2008; Morgan *et al.*, 2000).

In this dissertation, the weather-visitor attendance relationship is explored by examining how weather impacts daily zoo visitor attendance over a period of approximately one decade by researching four AZA accredited zoological parks in different climate regimes: Zoo Atlanta, Indianapolis Zoo, Phoenix Zoo, and St. Louis Zoo. These four zoos were chosen to illustrate how differing geographies may create diverse visitor responses due to differing regional climates and weather conditions. Although dissimilar in their climates, these four metropolitan zoological parks were chosen because they are comparable regarding key points as outlined in Table 1.1:

Table 1.1. Description of Key Characteristics between Four Zoological Parks

Zoological Park	State	Data Period	Size (Acres)	2010 CSA Population	Visitor Rank (USA)	Annual Visitation	Percent Local	Average Visit Time (Hours)	ASOS Weather Station Relative to Zoo
Atlanta	Georgia	September 2001 to June 2011 (n~3564)	40	5,618,431	25+	0.8 million	67%	3	7.40 miles SSW
Indianapolis	Indiana		64	2,080,782	25+	1.0 million	85%	3 to 4	7.00 miles SW
Phoenix	Arizona		125	4,192,887	14	1.4 million	80%	3	3.87 miles WSW
St. Louis	Missouri		90	2,878,255	3	2.9 million	65%	3 to 4	8.71 miles NNW

In order to study the weather-visitor attendance interface, two complex weather variables were utilized in this dissertation. Chapters II and III use the Physiologically Equivalent Temperature (PET) because it represents a more visitor-tailored measure of the ambient environmental conditions and captures the 'feel' of the ambient thermal conditions a zoo visitor is most likely to experience. PET is well established as it is commonly used in outdoor tourism studies (Lin *et al.*, 2008, 2009; Matzarakis, 1996; Staiger *et al.*, 2011). For the purposes of this research, the PET-derived temperature variable was classified into a nine-point thermal sensation scale following standards established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (ASHRAE, 2001 and 2004) where the ambient environment is described as 'very cold' through 'very hot'. The nine categories used were specified using the standard as defined by Matzarakis and Mayer (1996) (Table 1.2).

Table 1.2. PET-Based Thermal Categories Aadapted From Matzarakis and Mayer (1996)

PET	ASHRAE THERMAL CATEGORY	PHYSIOLOGICAL STRESS
	Very cold	Extreme cold stress
4°C		
	Cold	Strong cold stress
8°C		
	Cool	Moderate cold stress
13°C		
	Slightly cool	Slight cold stress
18°C		
	Comfortable	No thermal stress
23°C		
	Slightly warm	Slight heat stress
29°C		
	Warm	Moderate heat stress
35°C		
	Hot	Strong heat stress
41°C		
	Very hot	Extreme heat stress

Chapter IV uses the Spatial Synoptic Classification (SSC), a weather type classification that captures the character of a particular synoptic regime (Sheridan, 2002). This weather variable was used to review a larger scale of the ambient atmospheric condition which incorporates a 'comprehensive treatment of climate'.

The SSC includes seven general categories further explained in Table 1.3:

Table 1.3. The Seven Categories of the Spatial Synoptic Classification (SSC) with Descriptive Definitions. Adapted from Sheridan, 2002.

Name	Description
Dry Polar (DP)	Dry air usually from polar regions; coldest temperatures during the year
Dry Moderate (DM)	Mild and dry air; often found when a traditional air mass is moderated
Dry Tropical (DT)	Dry air representing the hottest and driest conditions of the year
Moist Polar (MP)	Cloudy, humid, and cool weather types
Moist Moderate (MM)	Variable in its seasonality; considerably warmer than moist polar conditions
Moist Tropical (MT)	Warm and humid air; often oppressive conditions
Transitional (TR)	Air mass transition from one to another

All weather variables in this dissertation were paired with the daily attendance totals at each zoo from September 2001 to June 2011 over a total of 3564 days. This time period was selected because it represented a period where at each zoo there was no significant change in the array of attractions. Additionally, incorporating a period of nearly one decade helps control for impacts resulting from severe weather events. Analysis used attendance-grouping methodologies where daily attendance data from each were segmented into four attendance categories or Attendance Day Typologies (ADTs) (Figure 1.1). These attendance categories included:

- <u>Poor attendance days</u> where daily visitor attendance is less than one standard deviation below the mean daily attendance,
- <u>Average attendance days</u> which are within one standard deviation of the mean daily attendance,

- Good attendance days that are between one and two standard deviations above the overall daily attendance mean, and
- Excellent attendance days where attendance is more than two standard deviations above the daily attendance mean.

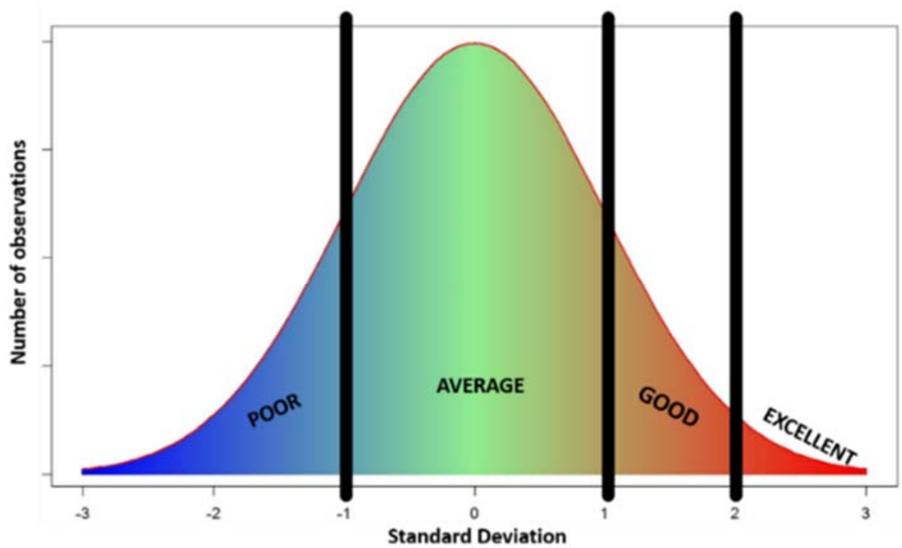

Figure 1.1. Theoretical Normalized Distribution of Attendance Data by Attendance Day Typology (ADT)

The following three chapters investigate the relationship between weather conditions and visitor behavioral response at zoological parks. Chapter II explores the relationship between PET-derived temperature categories and daily attendance at the Phoenix and Atlanta zoos. This chapter/manuscript is entitled, "Weather and Tourism: Visitor Attendance and Physiologically Equivalent Temperature (PET) at the Phoenix and Atlanta Zoos". Chapter III develops and tests the foundations of Chapter II by expanding the research of the PET-derived temperature categories and their relationship with visitor attendance through a comparison of the Indianapolis and St. Louis zoos—two zoological parks located in similar climates. This manuscript also investigates the role of price in visitor sensitivities and interpretations of the ambient thermal conditions. This chapter/manuscript is entitled, “Weather, Pricing, and Tourism at the Indianapolis and St. Louis Zoological Parks”. Chapter IV utilizes the Spatial Synoptic Classification as the weather variable to analyze visitor response to the ambient synoptic environment. This weather variable is used to expand the geographic scale of analysis and to review weather beyond the thermal component to a more comprehensive weather-typing variable. Used in this comparison are the Atlanta and Indianapolis zoos in a chapter/manuscript entitled, “Using Synoptic Weather Types to Predict Visitor Attendance at the Atlanta and Indianapolis Zoological Parks”.

CHAPTER II

WEATHER AND TOURISM: VISITOR ATTENDANCE AND PHYSIOLOGICALLY EQUIVALENT TEMPERATURE AT THE PHOENIX AND ATLANTA ZOOS

Co-authored with Dr. Keith G. Debbage for *Tourism Geographies*

[2.1] Introduction

Tourism, Recreation, and Leisure (TRL) is a largely outdoor-oriented economic sector that is particularly sensitive to weather impacts. For example, at the individual level, weather can affect peoples' attendance decisions and how businesses forecast their visitor demand. Expanded to larger scales, weather can affect seasonal tourist arrivals and impact the income of an entire geographic region thereby forcing communities to consider weather and climate in their comprehensive strategic planning (Scott *et al.*, 2012; Agnew and Plautikof, 2001; Gomez-Martin, 2005; de Freitas, 2002; Hale and Altalo, 2003; de Freitas *et al.,* 2008). An improved understanding of human response to various ambient environmental conditions can help the TRL sector better manage visitor demand and contribute to an improved understanding of the tourist-weather interface.

The focus of this paper is on the varied weather conditions that impact a major subsector of TRL, zoological parks and aquariums, which contributed over $16 billion to the United States economy in 2012, supporting 142,000 jobs and attracting 175 million visitors (AZA, 2013). While zoos and aquariums represent a significant subsector of TRL, few studies have examined in detail how weather conditions might affect zoo visitor attendances over time. In broad terms, Mason (2000) previously observed that in spite of the importance of zoos as tourist attractions, they remain under-researched. Additionally, Davey (2007), in remarking how zoo attendance patterns are the result of many influencing factors, suggested the need for additional research.

Much of the research regarding the impact of the atmospheric environment on TRL focuses less on how detailed weather conditions impact visitor attendance and more on how climate change broadly construed might impact certain TRL sectors in the long-term. This is especially the case with ski tourism where much research focuses on the future availability of physical resources such as snow and water in various alpine locations across the world (Willms, 2007; Cegnar, 2007; Endler and Matzarakis, 2007; Oehler and Matzarakis, 2007; Morehouse *et al.*, 2007; Jetzkowitz, 2007; Gajic-Capka, 2007; Tepfenhart *et al.*, 2007; Tervo, 2007; Scott *et al.*, 2007; Vrtacnik Garbas, 2007). Ski tourism is unusual because a weather scenario that includes plentiful snow may also adversely impact visitor attendances if the roads are impassable.

Before researchers can effectively understand how future climate change scenarios may broadly impact human behavior, Nicholls *et al.* (2008), Shih and Nicholls (2011), and Scott and Jones (2006) have suggested that it might be helpful to establish in detail a present-day baseline for human behavioral response to varied weather conditions. Additionally, Hynds and Smith (1994) have recommended the consideration of long-term ‘duration effects’ by researching attendance trends over longer periods of time.

In this paper, we address these points by examining how weather impacts daily zoo visitor attendance over a period of approximately one decade by comparing two AZA accredited zoological parks in very different climate regimes: the Phoenix Zoo and Zoo Atlanta. These two zoos were chosen to illustrate how differing geographies may create diverse visitor responses due to differing regional climates and weather conditions. The purpose of this paper is to determine how such varying weather conditions, specifically the ambient thermal environment (as measured by the Physiologically Equivalent Temperature, PET (Höppe, 1999), might influence visitor attendance over time. Additionally, better understanding how the prevailing climates of an area may create different visitor attendance responses to the thermal environment could provide further insight into the broader processes of human acclimatization. First, it is hypothesized that while days with the highest visitor attendances will have similar thermal profiles at both the Phoenix and Atlanta zoos, at lower levels of visitor attendance each zoo might exhibit differing attendance trends linked to locally-defined thresholds of tolerance regarding daily weather conditions (de Freitas, 2014). Second, because visitors at both zoos are in attendance for an average of three hours (Personal Communication, 2015a, 2015b), they are likely to finalize the decision to visit the zoo during the morning hours when weather conditions are likely less than ‘ideal’. As a result, it is hypothesized that days with stagnant thermal conditions will be more associated with lower attendance while days that experience a wider range of thermal conditions will be associated with higher attendance levels. The assumption here is that potential zoo visitors are likely to make a trip to the zoo on days when the weather promises to ‘improve’ as the day progresses.

[2.2] Theoretical Background and Context

A growing body of literature assessing the impacts of weather on attendance has emerged in recent years which has focused especially on the outdoor sporting industry. Much of this research includes analysis of sports such as the National Football League (NFL) (Welki and Zlatoper, 1994), club cricket (Hynds and Smith, 2010), downhill skiing (Hamilton *et al.*, 2007), soccer (Garcia and Rodriguez, 2002), baseball (Butler, 2002), Australian Rules Football (Borland and Lye, 2006), and golf (Nicholls *et al.*, 2008; Scott and Jones, 2006). Additionally, outdoor nature-parks (Grodzik, 1972; Brandenburg and Ploner, 2002; Ploner and Brandenburg, 2003) and beaches (Ibarra, 2010) are commonly used when modeling weather-attendance interactions. Other studies have focused on how weather impacts church attendance (Innaccone and Everton, 2004; Olson, 2008) as well as walk-in visitations for medical clinics (Diehl, *et al.*, 1981). Most of this type of research does not solely focus on the weather-attendance relationship, but adopts a multivariate approach that includes additional predictor variables such as the influence of holidays, day-of-week, month, season (Olson, 2008; Hynds and Smith, 2010), admission price, per-capita income, and the impact of facility capacity (Borland and Lye, 2006) on visitor attendance.

Hynds and Smith (1994) addressed the expectation that weather and weather forecasts might partially influence attendances at outdoor cricket matches. Using a data set of 52 cricket matches from 1984 to 1992, the authors created a model to predict match attendance. Among other predictor variables, they included day-of-play weather variables such as hours of sunshine, rainfall amount, and temperature. Hynds and Smith (1994, p. 105) observed that rain deterred attendance because the presence of rain created a reduction in demand resulting from both the 'disutility of sitting in the rain and disrupted match play.' By contrast, other weather variables such as temperature and 'variation in hours of sunshine', though showing positive relationships with cricket match attendance, did not contribute to large changes in attendance and was thereby less influential than rainfall.

Butler's (2002) assessment of baseball attendance involved a central concern with how baseball visitor attendance was influenced by team matchups and scheduling. However, in order to provide a clearer idea of the actual impact on attendance, an analysis of weather variables as control factors was included in a larger regression model. Butler created pre-defined weather scenarios coded as 'dummy variables' which included 'cold' (less than 55°F), 'hot' (greater than 94°F) and 'bad weather' (weather described as overcast, drizzle, or rain). All weather variables were statistically significant within the model and were inversely related to baseball attendances.

Welki and Zlatoper (1999) presented a model that explained attendances at professional National Football League (NFL) games in the United States. In the regression analysis, the authors included three weather variables: (1) rain as a dummy variable indicating if rain occurred on game day, (2) temperature as the high temperature on game day, and (3) an index variable combining temperature and rain with the goal of assessing the influence of temperature during rainy conditions. The authors found that while rain decreased game attendances, the impact of rain on attendance diminished as temperature increased leading to the conclusion that 'warm rain' had a less adverse impact on attendance.

Over the period from 1981 to 1986, Borland and Lye (1992) reviewed factors impacting visitor attendance at 132 Australian Rules Football matches. Although weather was not the central focus of this study, the authors addressed how adverse weather conditions might deter visitor attendance. Consequently, Borland and Lye (1992) included an undefined dummy variable, 'bad weather', in their analysis which was constructed using newspaper reports that indicated adverse weather conditions on the day of the matches. 'Bad weather' was found to be a statistically significant factor in the attendance model leading to the author's observation that attendances were negatively impacted by poor weather conditions. Additionally, Garcia and Rodriguez (2002) used weather within a set of variables aimed at determining the 'opportunity cost' of attending a football match in the Spanish First Division Football League. Weather conditions were assessed with dummy variables that captured temperature effects in both dry and wet conditions by using 'no-rain high temperature' and 'no-rain low temperature' categories; additionally, the impact of rain was assessed with a 'rainy days' variable indicating the presence of rainfall. Undefined scenarios of 'hot', 'cold' and 'poor weather' were addressed by the authors in the text and data tables though no detailed discussion was provided beyond the reflection that 'poor weather' discouraged attendance.

Outside the sporting industry, weather impacts on visitor attendance behavior often refer to locations which, unlike open-air stadiums, are sheltered from the weather. Because of this difference, the impacts of weather in these venues often concern access and road conditions rather than the physiological dis/comfort visitors may experience at the particular destination. Iannaccone and Everton (2004) and Olson (2008) reviewed factors influencing attendance at churches in the United States. Both studies addressed the impact of weather with a variable called 'bad weather Sundays' where bad weather was defined as the church being located within a National Weather Service (NWS) 'winter weather advisory area' on Sunday or having had substantial snowfall on Saturdays. Within their regression analysis, Iannaccone and Everton (2004) observed that bad weather had a detrimental impact on attendance. Conversely, through informal conversation with pastors and personal observations, the authors concluded that good weather can also discourage church attendance because it can make alternative recreational activities more attractive. Olson (2008) analyzed weather's impact on Protestant churches across a conservative to liberal spectrum in the United States Midwest. The results indicated that non-liturgical conservative church congregations were more negatively impacted by the 'bad weather Sunday' variable. While possible differences among church type and weather response do exist, Olson (2008) did not provide additional commentary beyond suggesting that the findings were likely attributable more to driving distance than cultural reasons.

Diehl et al (1981) focused strongly on weather parameters and modeled walk-in attendances at inner-city health clinics using calendar data (i.e., day-of-week and season variables) and weather data. Calendar data included holidays, day-of-week, and month; weather data included high and low temperatures in degrees Fahrenheit, precipitation between 6am and noon, precipitation between noon and 6pm, precipitation from 6pm to midnight, minutes of sunshine, percent sky cover, and the presence of weather hazards during the day (including fog, thunderstorms, ice pellets, hail, glaze, haze). While weather-related variables were determined to add little predictive value to the regression analysis, high and low temperatures, daytime rainfall, and winter weather events like freezing rain or 'glaze' were determined to be statistically significant for predicting walk-in attendances at clinics. Temperatures had positive relationships with turnout indicating warmer temperatures were associated with increased clinic visitation while rainfall (during daytime hours) and glaze had inverse relationships with visitation.

In order to fully understand the complex interface between weather and visitor attendance, more detailed research needs to be conducted that examines weather thresholds and their impacts on attendance. De Freitas et al (2008) and de Freitas (2002) underscore this by stating that weather-attendance research should determine weather-thresholds prior to their inclusion in larger attendance prediction models (de Freitas *et al.*, 2008; de Freitas, 2002). They argue that doing so can enhance research that tends to use 'expert-based' weather thresholds because these types of thresholds are generally arbitrary and, therefore, at best, represent only an approximation of the expected weather impacts on attendance.

More detailed research that focused primarily on the weather-attendance relationship includes Shih *et al.* (2009), Grodzik (1972), and Nicholls *et al.* (2008) who utilized multiple weather parameters to assess outdoor tourist attendance. Shih *et al.* (2009) examined weather impacts on ski lift ticket sales in Michigan by analyzing weather conditions at two ski resort locations and the respective surrounding areas where visitors most likely originated. At the ski resort site, the variables included maximum and minimum temperatures, snow depth, and wind chill, while from the surrounding areas (the most likely areas of visitor origination), snowfall and snow depth were analyzed. It was determined that local on-site snow depth and minimum temperatures were the most important weather variables determining downhill ski ticket sales. By comparison, Grodzik (1972) examined the impacts of temperature, sunshine duration, and precipitation on outdoor nature park tourism in Canada. It was found that temperature was most relevant in modeling recreational participation rates. Grodzik also stated that recreational participation may be better modeled through the use of a human heat budget as it more accurately depicts the personal 'experience' a person may have with the ambient thermal conditions.

Nicholls *et al.* (2008) advanced the study of weather-attendance relationships in a geographic comparison of how three golf courses in the state of Michigan were impacted by the weather with respect to the number of golf rounds played. Weather was central to the study as maximum temperature, minimum temperature, and precipitation were all assessed; however, weather was not the only variable analyzed as public holidays, gas prices, and the Consumer Confidence Index (CCI) were also included in analysis. The authors found that in every case maximum temperature was the most important variable having a positive impact on the number of golf rounds played per day where higher temperatures resulted in more rounds played. In comparing the differing geographies of the three courses and the subsequent differences in the relationship between rounds played and weather, Nicholls *et al.* (2008) also concluded that the courses which draw their visitors primarily from local or regional clientele are more heavily impacted by weather variability than courses primarily working with non-local consumers mainly because local residents have the ability to assess the weather conditions they will likely be exposed to simply by looking out their windows. Conversely, nonlocal visitors are not able to directly assess weather conditions at or near the location and have likely planned a trip in advance investing time and money where the investment decreases the ability for tourists to make last-minute decisions regarding the weather. This finding is further substantiated in the work of Becken and Wilson (2013) which addressed the difficulties of assessing weather-response relationships when working with non-local travelers.

Although there is a growing body of research focused on the weather attendance relationship in a wide variety of venues, there is little consensus regarding the optimal weather variables for such analysis. According to de Freitas *et al.* (2007), biometeorological variables, such as the Physiologically Equivalent Temperature (PET), are able to more accurately capture the physiological conditions a person may experience and, therefore, can serve as a "better" weather variable when assessing how tourists may react to the outdoor thermal environment. Brandenburg and Ploner (2002) and Ploner and Brandenburg (2003) addressed this when they examined the impact of meteorological variables on different park recreationalists in Austria using precipitation, vapor pressure, cloud cover, air temperature, and the biometeorological index variable PET. To better model differences across recreationalist types, they created categories of analysis (e.g. bikers, hikers, joggers, dog walkers) which resulted in better predictive modeling when estimating visitor attendance using weather variables. Their findings indicated that PET had the highest impact on visitor attendance decisions followed by precipitation and cloud cover. Additionally, comparison across categories indicated that the most active recreationalist groups were also the best modeled by weather variables, and particularly PET, as 'bikers' and 'hikers' displayed stronger weather-attendance relationships than 'dog walkers'. The differences that exist between different recreational activities indicate that the weather-human attendance relationship is a product of both the physiological experience (as observed from high PET correlations) and psychological expectations (as found by the varying weather sensitivities by activity group). Specific weather thresholds were also analyzed by Brandenburg and Ploner (2002) who found that positive relationships existed between the number of bikers and temperatures only when temperatures were above 10°C. They concluded that factors such as day-of-week might be more influential on park attendance than weather; however, they found that weather does impact visitor attendance and may be able to influence the activity choice of an outdoor recreationalist.

The research in this paper builds on the work of Grodzik (1972), Shih *et al.* (2009), Nicholls *et al.* (2008), Brandenburg and Ploner (2002), and Ploner and Brandenburg (2003) by utilizing multiple weather variables and transforming them into

Physiologically Equivalent Temperature (PET) categories that are then linked to specific zoo attendance data over time. Following de Freitas (2007), the use of a biometeorological variable such as PET should help to more accurately capture the physiological condition a person may experience, and, therefore, help develop more explicit associations between ambient environmental conditions and human responses that can be more closely determined and explained.

On a final note, much of the weather-attendance literature within the Tourism, Recreation, and Leisure (TRL) sector has focused on better understanding visitor responses to weather through various survey-response techniques that engage visitors personally by evaluating on-site preferences regarding 'ideal' weather conditions and 'satisfaction levels' during actual visits. While there are advantages to employing this survey-based active user-engaged research (Rutty and Scott, 2014; Hwang *et al.*, 2007; Knez *et al.*, 2006; Andrade *et al.*, 2011; de Freitas *et al.*, 2008; Lin, 2009; Matzarakis, 1996), the use of passive or indirect observation through already-published secondary data reports can also link visitor attendance and on-site behavior to various ambient environmental conditions. Indirect techniques can also consider both current and historical attendance where it is assumed that attendance is, to a point, based upon perceived satisfaction with the ambient environment. De Freitas (2014) has noted that visitor attendance decisions are often made in response not to ideal weather conditions but to perceived thresholds of tolerance. Consequently, the indirect observation of visitor behavior could be a better proxy for determining visitor response to the ambient environmental conditions than direct user-engagement and reports of preferences.

Indirect techniques that involve historical attendance data sets are also advantageous because they can incorporate large amounts of secondary historical data which can provide better information regarding behavior over extensive time periods that could lead to more statistically robust models given the larger number of observations.

[2.3] Methods

In this paper, it is hypothesized that those days with the highest visitor attendances at both the Phoenix Zoo and Zoo Atlanta will exhibit similar relationships with respect to the ambient thermal environment. However, at lower levels of attendance, it is also hypothesized that differing climates and regional definitions of 'bad weather' between Phoenix and Atlanta will yield different attendance outcomes. For example, when subjected to extreme heat conditions in Phoenix, rather than being willing to tolerate higher temperatures, it is projected that most Phoenix Zoo visitors will show 'heat aversion' due to an unwillingness to tolerate additional exposure to excessive heat. Conversely, in Atlanta, which has a more diverse climate with a lower occurrence of 'extreme heat stress' than Phoenix, it is projected that visitors at Zoo Atlanta will display less sensitivity to varied weather conditions because they are more accustomed to implementing adaptive strategies due to the diversity of weather conditions experienced in Atlanta. Much of this logic is tied to de Freitas (2014) who observed that visitor attendance tends to be shaped more by locally-defined thresholds of tolerance than by 'ideal' weather conditions. Furthermore, it is hypothesized that days with wider thermal ranges will experience higher attendances than days with stagnant thermal conditions. At both locations, it is projected that days with wider thermal ranges will be more aligned with cooler morning temperatures that warm to moderate afternoon temperatures. Alternatively, stagnant thermal regimes may have similar visitor responses in Phoenix and Atlanta but for differing climatic reasons. Stagnant thermal regimes in Phoenix are likely days that remain very warm throughout the daytime; in Atlanta, these regimes are likely associated with cold and/or rainy weather.

In this research, daily attendance data from each zoo were collected from September 2001 to June 2011 over a total of 3564 days. This time period was selected because it represented a period where at each zoo there was no significant change in the array of attractions. Additionally, incorporating a period of nearly one decade helps control for impacts resulting from severe weather events. Visitor attendances at each zoo were then segmented into four attendance categories or Attendance Day Typologies (ADTs). These attendance categories included:

- Poor attendance days where daily visitor attendance is less than one standard deviation below the mean daily attendance,
- Average attendance days which are within one standard deviation of the mean daily attendance,
- Good attendance days that are between one and two standard deviations above the overall daily attendance mean, and
- Excellent attendance days where attendance is more than two standard deviations above the daily attendance mean.

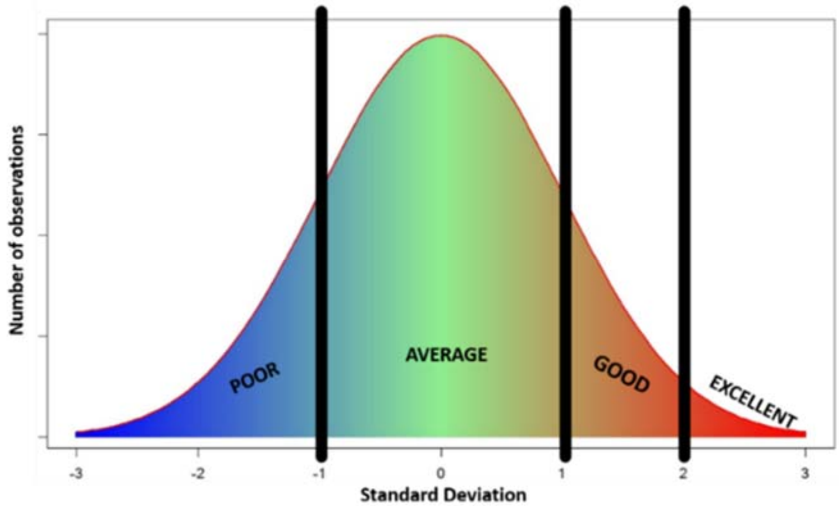

Figure 2.1. Theoretical Normalized Distribution of Attendance Data by Attendance Day Typology (ADT)

Part of the logic for including two categories of attendance more than one standard deviation above the mean attendance (i.e., ‘good’ and ‘excellent’ days) is their disproportionate impact on overall attendance. For example, while attendance at the Phoenix Zoo and Zoo Atlanta fell within the ‘good’ and ‘excellent’ categories only on an average of one day out of every seven, the total visitor attendance for these ADTs accounted for over 39% of total yearly attendance at both zoos.

Weather data at both zoos was obtained from the nearest hourly-data National Weather Service (NWS) Automated Surface Observing Systems (ASOS) station. The ASOS station used for the Phoenix Zoo is located at Phoenix Sky Harbor Airport, 3.9 miles WSW of the zoo while the weather station used for Zoo Atlanta is located at Atlanta Hartsfield Airport, 7.4 miles SSW of the zoo center. During the period of study, these stations did not change locations. Although it is acknowledged that the weather stations used in the research are not located immediately proximate to each zoological park, they are close enough to assume that the weather conditions occurring at the stations represented a reasonable proxy for the weather experienced at each zoo.

When reviewing factors contributing to attendance decisions, it is also important to consider the weather conditions from the time most visitors plan their trip to the time they return home because these are the weather conditions most likely influencing decisions regarding a trip to an outdoor venue. Consequently, we collected weather data once every hour for the variables of temperature, humidity, dew point, wind speed, and sky cover from 7am to 7pm local standard time. Nicholls *et al.* (2006 and 2008) have highlighted the importance of utilizing this type of fine resolution weather data as it assists in more fully detecting how weather conditions may impact attendances and participation at outdoor locations.

Additionally, this paper, in its calculation of the outdoor thermal environment, used the Physiologically Equivalent Temperature (PET) because it represents a more visitor-tailored measure of the ambient environmental conditions and captures the 'feel' of the ambient thermal conditions a zoo visitor is most likely to experience. PET is well established as it is commonly used in outdoor tourism studies (Lin *et al.,* 2008, 2009; Matzarakis, 1996; Staiger *et al.,* 2011). The derived temperature values of PET are often classified into a nine-point thermal sensation scale following standards established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (ASHRAE, 2001 and 2004) where the ambient environment is described as 'very cold' through 'very hot'. For the purposes of this research, the nine categories used were specified using the standard as defined by Matzarakis and Mayer (1996) (Table 2.1).

Table 2.1. PET-Based Thermal Categories Adapted from Matzarakis and Mayer (1996)

PET	ASHRAE THERMAL CATEGORY	PHYSIOLOGICAL STRESS
	Very cold	Extreme cold stress
4°C		
	Cold	Strong cold stress
8°C		
	Cool	Moderate cold stress
13°C		
	Slightly cool	Slight cold stress
18°C		
	Comfortable	No thermal stress
23°C		
	Slightly warm	Slight heat stress
29°C		
	Warm	Moderate heat stress
35°C		
	Hot	Strong heat stress
41°C		
	Very hot	Extreme heat stress

Figure 2.2 describes the methodological process used in this research where hourly weather data was converted to a derived PET value and then assigned to a PET-based thermal category. PET was calculated thirteen times every day for each hour from 7am to 7pm where its value was dependent upon atmospheric inputs of temperature, wind speed, sky cover, and relative humidity. To obtain the PET derived value, the RayMan Pro software (Matzarakis *et al.*, 2000) was used which yielded a PET-derived temperature variable in degrees Celsius. This software is commonly used in the calculation of PET, particularly within human bioclimate research and tourism (Matzarakis *et al.*, 2007). After calculation, each PET-derived temperature value was then assigned to the corresponding PET-based thermal category as defined by Matzarakis and Mayer (1996). After the thirteen hourly PET categories were determined on a particular day, the warmest and coldest thermal categories for that day were selected to represent the daily high and low PET-based thermal category values.

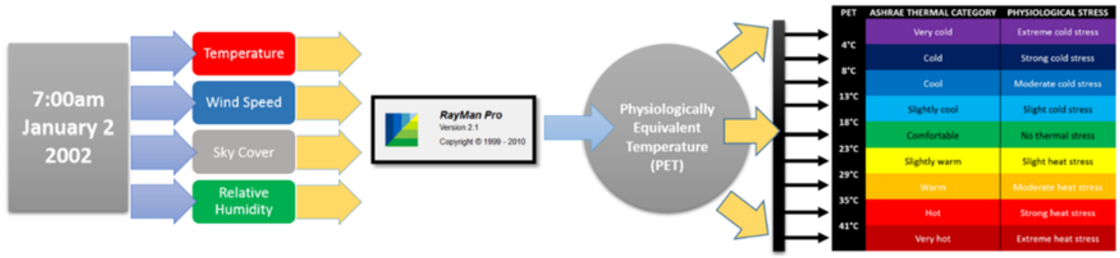

Figure 2.2. Methodological Process of Converting Hourly Weather Data to a PET-Based Thermal Category

In previous research, the warmest daily PET-derived value correlated highest with visitor attendance at zoos; additionally, it performed better than the average or low daily PET values in predicting attendance (Perkins, 2012). The warmest daily high PET worked well in predicting visitor attendance because it represented a particular day's most extreme thermal condition which tended to occur at the time most visitors were likely to be at the zoo. Furthermore, it is likely that most visitors planning to visit the zoo are attuned to the daytime high thermal condition rather than an abstract average or early-morning low temperature.

As changes in weather conditions will likely impact visitor decisions, this research also analyzed how the number of PET-derived thermal categories experienced during a day impacted visitor attendance. Rather than defining the amount of daytime thermal change by measuring the degree difference between the high and low PET values from 7am to 7pm, this research calculated a 'perceived' thermal change as measured by the number of different PET-based thermal class intervals (Table 2.1) a visitor experienced between the low and high PET from 7am to 7pm at a particular location. Because thermal category ranges were derived by survey-response techniques in accordance with the ASHRAE thermal perception scale, it was assumed that the number of thermal categories occurring during a day better represented the amount of perceptible change visitors experience from the thermal conditions.

While zoological parks are similar to other outdoor venues such as public city parks, botanical gardens, hiking trails, and beaches, they offer several specific advantages for the study of human behavior regarding the weather. First, prior to visiting a zoological park, people have certain expectations regarding the reasons why they visit and the outdoor exposure they will likely experience when on site. Although there are differing motivations for zoo patrons (Falk et al, 2007), those who visit zoological parks generally go to learn about animals, conservation, and nature, and patrons expect this to occur mostly in an outdoor setting regardless of the geographic location of the zoo. Second, unlike the wide variety of activities potentially engaged in by beach or park tourists (Grodzik, 1972; Brandenburg and Ploner, 2002; Ploner and Brandenburg, 2003; Rutty and Scott, 2014; Morgan *et al.*, 2000), activity at zoos can generally be defined as “slow steady walking” (Mieczkowski, 1985) as the main function visitors perform at most zoo locations. Because activity levels contribute to the calculation of the Physiologically Equivalent Temperature (PET), having a comparable visitor activity level across zoo locations allows for a higher level of confidence in any comparison of human thermal comfort and visitor attendance across sites. Third, because most zoos operate as paid-for admission venues, they keep reliable and accurate attendance data over time. Additionally, in order to maintain controlled admissions, zoological park space has definite geographic boundaries with fixed entry and exit points. Methodological difficulties can arise when accounting for attendees at open spaces such as botanical gardens and nature parks with multiple entrances, and beach fronts with undefined geographical spaces (Knez and Thorsson 2005; Rutty and Scott, 2014; Curtis, Arrigo, and Covington, 2008; Morgan *et al.*, 2000).

The Phoenix and Atlanta zoological parks are relatively similar in function and purpose. Both zoos are located in major urban metropolitan areas where each zoo is positioned within the urban core and occupies a portion of a larger city park system. Visitor length of stay at both zoos is comparable as the average visitor spends approximately 3.5 hours per trip. Because visitors plan to spend several hours outdoors when visiting, this most likely forces them to integrate the daily weather in their planning considerations. Furthermore, unlike the San Diego Zoo or Washington National Zoo, which are internationally renowned zoos that attract a large number of out-of-state visitors, the Phoenix and Atlanta zoos largely attract day-trippers from within the metropolitan areas of Phoenix and Atlanta. For example, at the Phoenix Zoo, 80% of the guests are from within the state of Arizona and at Zoo Atlanta, 67% of the guests are from within the state of Georgia (Personal Communication, 2015a, 2015b). Given the large numbers of local day-trippers with less fixed schedules, it is likely that visitor decisions at the Phoenix Zoo and Zoo Atlanta will be more aligned with weather conditions than they would at zoos in larger tourist venues with many nonlocal visitors. This logic follows Nicholls *et al.* (2008) who observed increased visitor sensitivities to weather conditions at golf courses with larger shares of local visitors. It should be noted that both metropolitan areas are comparable in population as the Phoenix Combined

Statistical Area (CSA) contained approximately 4.2 million residents while the Atlanta CSA had 5.6 million residents in 2012 (U.S. Census, 2012). Also, both zoos are paid-admission zoos with similar costs as parent/child admission rates (as of 2014) were $20/$14 for Phoenix and $22/$17 for Atlanta.

Finally, though the Phoenix Zoo (33.45°N) and Zoo Atlanta (33.73°N) are at equivalent latitudinal locations, their climates are very different. The Köppen-Geiger climate classification system locates the Phoenix Zoo in a dry climate with seasonal precipitation regimes while Zoo Atlanta is located in a humid continental climate with hot summers and no particular dry season (Peel *et al.*, 2007). Average annual precipitation in Phoenix totaled 204 mm while Atlanta totaled 1280 mm. The warmest month in both locations was July when the high temperature averaged 41.2°C in Phoenix and 37.7°C in Atlanta. In Phoenix the coldest month was December when the average high temperature was 18.9°C. The coldest month in Atlanta was January with an average high temperature of 11.3°C.

[2.4] Findings

Although the Phoenix Zoo and Zoo Atlanta are not regarded as national zoos in the same way as the San Diego Zoo or Washington National Zoo, they are still capable of generating a substantial number of visitors. From September 2001 to June 2011, the two zoos generated a total combined attendance of 17.5 million visitors. During this period, the Phoenix Zoo averaged slightly over one million visitors per year while Zoo Atlanta attracted approximately 0.75 million visitors on an annual basis. The Phoenix Zoo is the largest privately owned non-profit zoo in the United States and has been in operation since 1962. During its recent history, it has attracted national acclaim with ‘Ruby the elephant’ who was widely known for her ability to paint artwork which was subsequently sold for fundraising and charitable purposes. Currently, the Phoenix Zoo is known for its large diversity of animal exhibits, international conservation efforts in species re-introduction, and for a national ‘sanctuary’ which houses both ‘unwanted’ and endangered animals from throughout the world. Zoo Atlanta, established in 1889, is one of the oldest zoos in the United States. It also gained national recognition for a popular animal as it showcased the well-known ‘Willie B.’ gorilla in its renowned gorilla habitat. Today Zoo Atlanta is highly regarded for its giant panda exhibit as it is one of only four zoos in the United States with this species on exhibit. Clearly, both zoos have well-established histories and sophisticated arrays of attractions; what is less clear is how at each zoo varied weather conditions might impact average daily visitor attendance.

Table 2.2 illustrates the number of days represented at each zoo for each of the Attendance Day Typologies (‘poor’, ‘average’, ‘good’, and ‘excellent’), and Table 2.3 illustrates the total visitor attendance within each Attendance Day Typology (ADT) by zoo. The number of attendees and the number of days are additive across each row, indicating the total number of days analyzed (Table 2.2) and the total number of visitors in attendance (Table 2.3) at each zoo from September 2001 to June 2011. Due to the statistical nature of the ADT groupings, the ‘average’ ADT is the largest single grouping both in terms of number of days represented at the zoos and total visitor attendance. In Table 2.2, the ‘average’ ADT represented 75.8% of all days at the Phoenix Zoo and

76.1% of all days at Zoo Atlanta. In comparison, the ‘average’ ADT represented 56.7% of the total visitor attendance at the Phoenix Zoo and 61.0% of the total visitor attendance at Zoo Atlanta (Table 2.3). These percentages do not completely resemble the theoretical normalized distribution because the attendance data was positively skewed, typical of much attendance data. The ‘sweet spot’ days of maximum attendance are typically only one in five of all days analyzed when compared to the poor and average distributions. Furthermore, the daily average attendances for ‘good’ and ‘excellent’ days at both zoos were three and four times the attendance levels on average attendance days.

In Table 2.2, while the ‘good’ and ‘excellent’ ADTs combined only accounted for 17.1% of the total days represented at the Phoenix Zoo and 14.1% of total days represented at Zoo Atlanta, these days accounted for 42.4% and 38.6% of the total visitor attendances (Table 2.3) at the Phoenix Zoo and Zoo Atlanta, respectively. Consequently, a large portion of total visitor attendance (and thus revenue) occurs on only a select few number of days during the year. Both the ‘good’ and ‘excellent’ ADTs, then, are of high importance when attempting to forecast visitor attendance. By contrast, the ‘poor’ ADT accounted for less than 1% of the total number of visitors at both the Phoenix Zoo and Zoo Atlanta. While direct comparisons of the weather conditions on days within the ‘poor’ and ‘excellent’ ADT groupings are important when understanding the weather-attendance interface, from the perspective of the probable revenue share within the different ADT groupings, both zoos in this research would likely most benefit from a more detailed analysis of differences in weather conditions between ‘excellent’ and ‘good’ ADTs.

Table 2.2. Number of Days by Attendance Day Typology (ADT) September 2001 – June 2011

	Poor	Average	Good	Excellent
Phoenix Zoo	257 (7.2%)	2,721 (75.8%)	404 (11.3%)	208 (5.8%)
Zoo Atlanta	349 (9.7%)	2,727 (76.1%)	338 (9.4%)	170 (4.7%)

Table 2.3. Total Visitor Attendance by Attendance Day Typology (ADT) September 2001 – June 2011

	Poor	Average	Good	Excellent
Phoenix Zoo	93,333 (0.9%)	5,721,080 (56.7%)	2,486,641 (24.7%)	1,784,993 (17.7%)
Zoo Atlanta	26,827 (0.4%)	4,522,693 (61.0%)	1,595,615 (21.5%)	1,265,605 (17.1%)

The categories in Figure 2.3 represent the proportion of the number of days at the Phoenix and Atlanta zoos falling within a particular PET-based thermal category from September 2001 to June 2011 where the day in question was represented by the warmest PET-based thermal category that occurred between 7am and 7pm on each day.

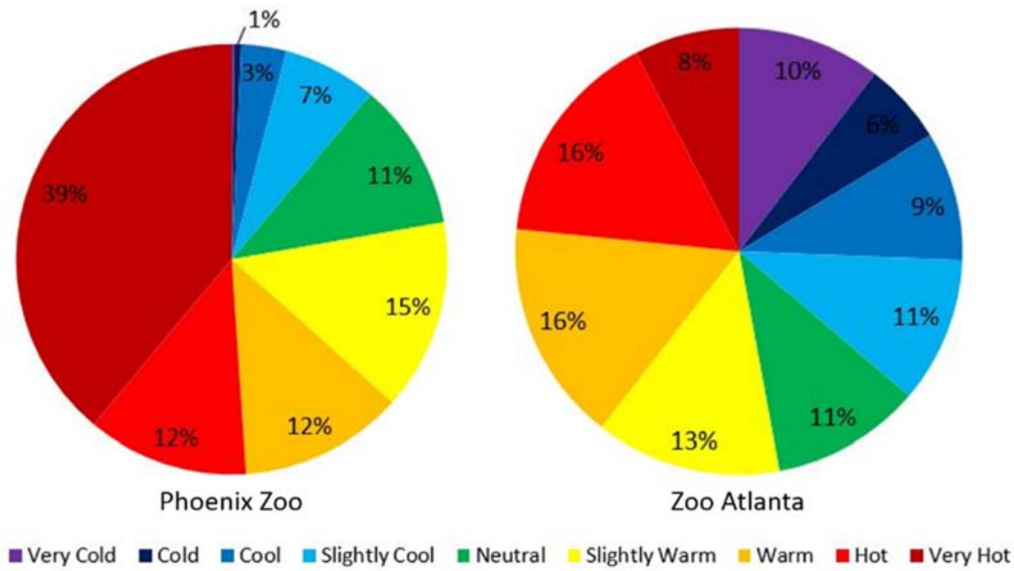

Figure 2.3. Daily Observed Thermal Categories at the Phoenix and Atlanta Zoos September 2001 – June 2011 as Measured by the Thermal Category Representing the Warmest Daytime PET (7am to 7pm)

It is clear from Figure 2.3 that Phoenix and Atlanta have very distinct thermal profiles. In Phoenix, the 'very hot' thermal category occurred 39% of the time, making this the most frequently occurring thermal category. By contrast, this same type of 'extreme heat stress' was not observed as frequently in Atlanta where the 'very hot' thermal category occurred only 8% of the time. At the other thermal extreme, Phoenix reported a negligible number of 'very cold' days, while in Atlanta 10% of all days fell within the 'very cold' thermal category. Despite these differences, both Phoenix and Atlanta are comparable regarding the more moderate thermal conditions. The proportion of days falling between the 'slightly cool' through 'slightly warm' thermal categories was 33% in Phoenix and 35% in Atlanta. Overall, the thermal conditions in Phoenix are largely defined by high proportions of days falling within the warmer thermal categories and lower proportions of colder days. The thermal conditions in Atlanta are largely defined as a relatively even representation of all the thermal categories from ‘very cold’ to ‘very hot’. Less clear is how these different thermal regimes may shape and influence daily visitor attendance at each zoo during the study period.

The distribution of PET-based thermal categories based on the percent share of each Attendance Day Typology (ADT) for both zoos is displayed in Figure 2.4, where the large share of ‘poor’ attendance days at opposite thermal extremes is vividly illustrated and indicates a potential ‘thermal aversion effect’. Attendance at both zoos appears to show ‘extreme temperature aversion’ refined by the location’s most commonly occurring thermal extreme category (Figure 2.3). At the Phoenix Zoo, 84% of the ‘poor’ ADT is represented by the ‘very hot’ thermal category indicating potential ‘heat aversion’; at Zoo Atlanta, 54% of the ‘poor’ ADT occurred within the ‘very cold’ thermal category indicating potential ‘cold aversion’. Although Phoenix residents are more accustomed to warmer thermal conditions and Atlanta residents have more experience with colder thermal profiles, this does not mean that they have adapted to these conditions or that either have developed elevated thermal tolerance levels. In fact, quite the opposite trend appears to be occurring where ‘very hot’ daily thermal classifications are more predictive of ‘poor’ attendance in Phoenix while ‘very cold’ thermal conditions indicate ‘poor’ attendance figures in Atlanta. This finding may suggest that because zoo visitors in Phoenix display potential ‘heat aversion’ and in Atlanta display potential ‘cold aversion’, visitors could be reacting to a ‘saturation point’ where they choose to no longer tolerate the location’s prevailing thermal extreme regarding their discretionary leisure time.

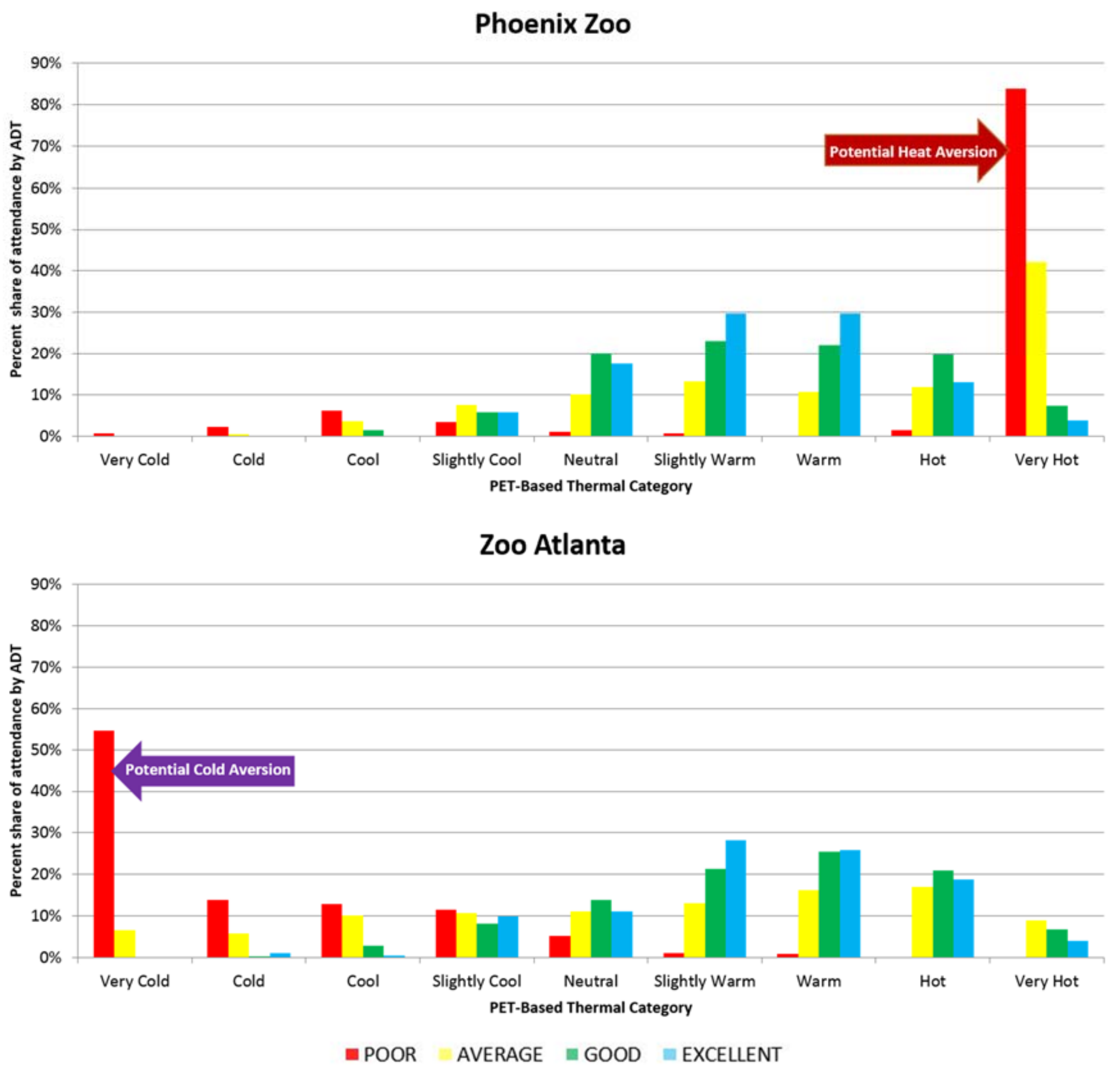

Figure 2.4. Distribution of Warmest Daytime PET-Based Thermal Categories Based on the Percent Share of Attendance Day Typology (ADT) by Zoo.

By contrast, the distribution of PET-based thermal categories across the 'excellent' ADT shows a definitive pattern that is shared by both Phoenix and Atlanta zoos. At the Phoenix Zoo, the peak representations of the highest days of attendance on record are within the 'slightly warm' and 'warm' thermal categories, where both categories combined represented 60% of all the days within the 'excellent' ADT. Zoo

Atlanta's peak representations in the highest attendances are also within the 'slightly warm' and 'warm' thermal categories and combined represented 54% of all the days within the 'excellent' ADT. Despite the differences in prevailing climates and the stark differences observed in the thermal category representations across the 'poor' ADTs, what is apparent in the findings from the 'excellent' ADT is that both zoos are very comparable in terms of visitor thermal category preference on days with the highest attendances. Generally speaking, both zoos display visitor preferences for 'slightly warm' and 'warm' thermal conditions that are apparently the 'thermally optimum' conditions for peak visitor attendance at both zoos. That said, there are still key differences between the Phoenix Zoo and Zoo Atlanta regarding the nuances observed between the 'good' and 'excellent' ADT categories.

Figure 2.5 provides a direct visual comparison of the 'good' and 'excellent' ADT categories at the Phoenix Zoo and Zoo Atlanta with respect to the warmest daytime PET-based thermal category. In both zoos 'good' and 'excellent' attendance days are mainly concentrated in thermal categories warmer than 'slightly cool', therefore, the potential 'heat aversion' observed at the Phoenix Zoo is more apparent.

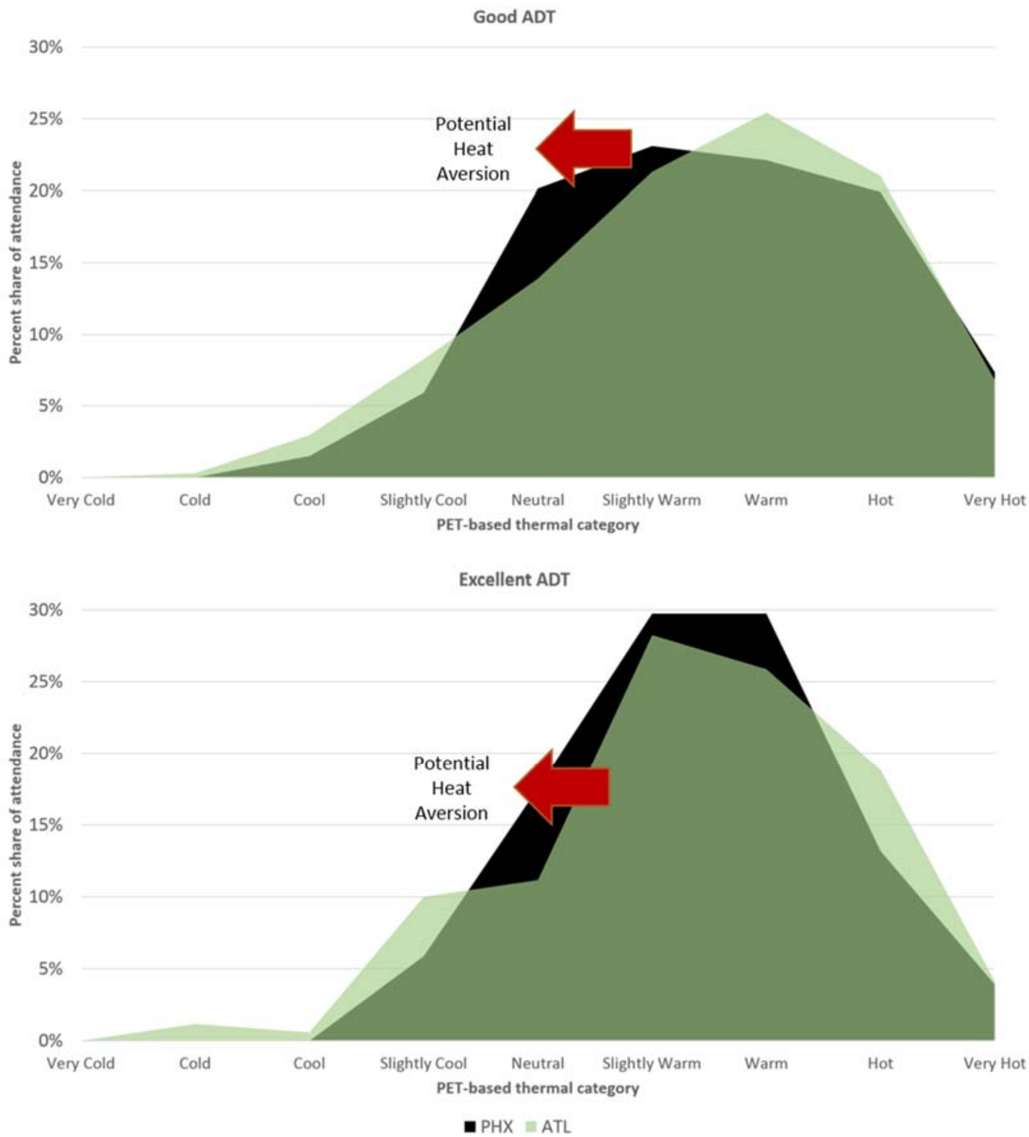

Figure 2.5. Geographic Comparison of Atlanta (ATL) and Phoenix (PHX) Zoos for Percent Share of Attendances within 'Good' and 'Excellent' ADT Categories with Respect to the Highest Daytime PET-Based Thermal Categories

Specifically, regarding the 'good' ADT category, the Phoenix Zoo shows a slightly lower representation of 'hot' days and a much higher representation of 'neutral' days when compared with Zoo Atlanta. This relationship is observed again in the 'excellent' ADT category where the Phoenix Zoo shows a lower representation of 'hot' days and a higher representation of ‘warm’ through ‘neutral’ days than observed at Zoo Atlanta. Figure 2.5 seems to suggest that on peak attendance days the Phoenix Zoo visitor is more ‘heat averse’ than the Zoo Atlanta visitor. In fact, concerning discretionary time, Phoenix Zoo visitors appear unwilling to tolerate additional heat stress in a setting where 39% of the thermal regime is already classified as ‘very hot’ (Figure 2.3). This finding could be a manifestation of results from Figure 2.4 where, within the ‘poor’ ADT, the respective zoo visitors appear to be reacting aversely to each location’s prevailing thermal extreme. Phoenix Zoo visitors, then, likely will display more potential ‘heat aversion’ than zoo visitors in Atlanta who more often experience extreme cold conditions than extreme heat conditions (Figure 2.3).

Much of the analysis thus far has focused solely on the connections that exist between zoo visitor attendances and the highest daytime PET-based thermal conditions, however, because visits to both the Phoenix and Atlanta zoos last approximately three hours on average (Personal Communication, 2015a, 2015b), most visitors likely assess the weather based upon the conditions they might experience throughout their entire time at the zoo location. Because of this, conditions throughout the day, particularly any potential changes in the atmospheric environment, may directly influence a decision to visit. To test for this, the average number of PET-based thermal categories experienced during each day (7am to 7pm) by ADT is shown in Table 2.4 at both the Phoenix Zoo and Zoo Atlanta. Additionally, illustrated in Figure 2.6 is the percent share of each ADT by number of PET-based thermal categories experienced by a visitor per day. To illustrate, if the highest PET derived value obtained for the day at one of the zoos occurred in the ‘very hot’ category and the lowest PET derived value occurred in the ‘neutral’ category, it would represent 5 thermal categories experienced by a zoo visitor. Table 2.4 gives further detail regarding the average number of thermal categories experienced in a day for each ADT category.

In Table 2.4 it is clear that poorly attended days experienced fewer thermal categories during a day while peak attendance was directly related to those days that experienced a larger number of PET-based thermal categories. For example, at the Phoenix Zoo, ‘poor’ attendance days averaged only 2.4 PET-based thermal categories while ‘excellent’ attendance days experienced more than four PET-based thermal categories on average.

Table 2.4. Average Number of Perceived Thermal Categories Experienced During a Day for Each ADT

	Poor	Average	Good	Excellent
Phoenix Zoo	2.4	3.5	4.1	4.2
Zoo Atlanta	1.7	3.1	3.6	3.9

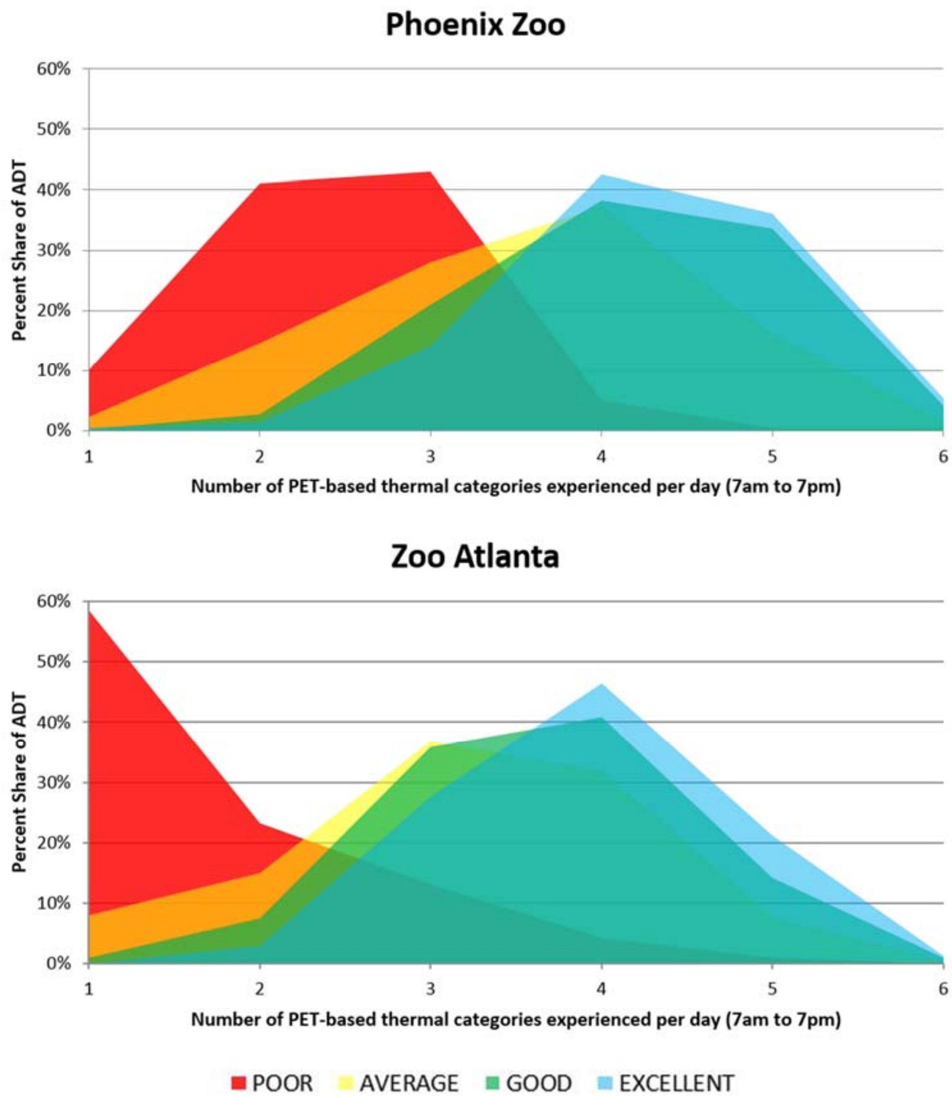

Figure 2.6. Percent Share of Attendance Day Typology (ADT) by Number of PET-Based Thermal Categories Experienced by a Visitor per Day (7am to 7pm)

In Phoenix, poorly attended days when the number of PET-based thermal categories experienced was less than three would most likely be representative of an atmospheric condition where early morning low temperatures were already quite warm. After sunrise with a dry desert heating regime present, these hot morning temperatures would quickly warm to the 'very hot' thermal category representing 'extreme heat stress' where they would remain for the duration of the day. Such an early-morning condition is likely related to periods of southerly wind flow where hot desert air from the Sonoran and Chihuahuan Deserts in Arizona and Mexico is advected into Phoenix thereby inhibiting significant nighttime cooling. By contrast, peak attendance days tended to occur on days that experienced four or five PET-based thermal categories. Such a scenario likely implies a situation when cooler temperatures were experienced first thing in the morning and gradual warming occurred throughout the day. Thermal conditions at the Phoenix Zoo seem to appeal most to zoo visitors when they wake-up to a welcome break from the very hot thermal regimes that predominate in the region and a decision is made to visit the zoo based on the expectation that 'very hot' conditions are unlikely to occur later in the day.

Much of the same dynamic is happening at Zoo Atlanta, with some notable exceptions. For example, at Zoo Atlanta poor attendances tended to occur on thermally stagnant days when the number of PET-based thermal categories experienced was two or fewer. In Atlanta, the most likely weather conditions contributing to a day with little to no thermal change are either days which begin as 'very cold' and do not warm much and/or days with significant cloud cover and possible rain which lead to little daytime warming. Additionally, these cloudy days, regardless of the presence of rainfall, are not aesthetically pleasant conditions for outdoor zoo visits, thereby further decreasing zoo attendance. Much like Phoenix, well attended days tended to occur on days when approximately four thermal categories were experienced. Such days are most likely represented by moderate to fair weather conditions in the early morning which typically evolve to relatively clear skies and ample sunshine by mid-afternoon.

A possible reason why daily thermal conditions require slightly more change in Phoenix than in Atlanta to boost attendance likely relates to the differences in prevailing climates (Table 2.4). Phoenix, a drier and warmer climate than Atlanta, on most days has more potential for significant daytime heating; therefore, a day which falls within the 'optimal' thermal categories regarding higher levels of attendance requires cooler morning temperatures. Atlanta, alternatively, could see the daytime high PET falling within the 'optimal' thermal categories without the need for as much daytime heating as in Phoenix and, therefore, requires fewer thermal categories to generate 'good' or 'excellent' attendance days.

[2.5] Conclusions and Future Direction

The United Nations World Tourism Organization (UNWTO) in its report discussing tourism's response to climate change has suggested that "As climate defines the length and quality of tourism seasons, affects tourism operations, and influences environmental conditions that both attract and deter visitors, the sector is considered to be highly climate sensitive. These effects of a changing climate will have considerable impacts on tourism and travel businesses" (UNWTO, 2009, p. 2).

Many authors have suggested, however, that in order to better understand how tourism communities can become more resilient to climate change, society must first better understand how weather and climate factors impact tourists today (Nicholls *et al.*, 2008; Shih and Nicholls, 2011; Scott and Jones, 2006; Scott, 2012). This paper has sought to partially address these concerns by examining in detail how zoo visitors have responded to the ambient atmospheric conditions over an extended period of time. By focusing on zoological parks, this research has also addressed a large and important part of the tourism industry since annual visitations at U.S. zoos surpass those of all major sporting venues combined (AZA, 2013). Additionally, zoos cater to an important demographic of the population that can be impacted negatively by future climate change weather—namely large family groups that include both children and the elderly. As a result, the use of zoological parks as indicators of human thermal comfort preferences can give insights into how future generations may respond to climate change scenarios.

Specific findings in this research have helped provide foundational information concerning both human thermal preferences and how those preferences may vary across diverse climates. As an example, it was found that the 'optimal thermal conditions' regarding peak visitor attendance were relatively consistent across both the Phoenix and Atlanta zoos despite their differing climates. In detail the PET-based thermal categories of 'slightly warm' and 'warm' were found to best describe the 'optimal thermal conditions' for visitor attendance at both zoos. Regarding thermal conditions which depress attendance turnout, both zoos showed a consistent 'thermal aversion effect', and specifically an 'extreme temperature aversion' where visitors avoided the respective location's most common thermal extreme condition. To illustrate, Phoenix Zoo visitors displayed potential 'heat aversion'; conversely, Zoo Atlanta visitors displayed potential 'cold aversion'. The potential 'heat aversion' observed at the Phoenix Zoo also appeared to influence visitor preferences on days of higher attendance within the ‘good’ and ‘excellent’ ADT categories. A result of this potential ‘heat aversion’, visitors at the Phoenix Zoo displayed preferences for cooler thermal conditions than did visitors at Zoo Atlanta.

Given the prevailing climates of the Phoenix and Atlanta zoos, it was expected that visitors in Phoenix would be somewhat better acclimatized to hot thermal conditions, and visitors in Atlanta may display cooler thermal preferences. However, we observed Phoenix Zoo visitors to be less tolerant of excessive heat and Zoo Atlanta visitors less tolerant of excessive cold, at least regarding their discretionary leisure time. Overall, the type of ‘extreme temperature aversion’ appeared to be linked to the prevailing climate of a location where visitor displays of ‘heat aversion’ or ‘cold aversion’ may have been reactions to ‘saturation points’ when visitors no longer tolerated the location’s most common thermal extreme.

Regarding daytime changes in the weather, visitors to both zoos indicated that in addition to the daily high PET-based thermal conditions, they might also be well attuned to the dynamic change in thermal categories during a day. Both zoos experienced peak attendance on days when visitors experienced four or more PET-based thermal categories for a given day, suggesting that days which promised improving weather conditions were more likely to stimulate attendance.

While zoological parks can be excellent ‘test laboratories’ in the ongoing assessment of how weather and climate might impact visitor behavior, this paper raises additional research questions. If an ‘optimal thermal condition’ exists regarding peak zoo visitor attendance, how will climate change impact zoo visitor demands in the future beyond just the Phoenix and Atlanta zoos? Will zoos located in different climate zones display visitor preferences similar to those found in Phoenix and Atlanta? Furthermore, if the 'heat aversion effect' demonstrated in Phoenix is replicable in other locations with similar thermal regimes, what might this imply for the geography of zoo attractions in the long-term?

By building our understanding of how weather events and thermal regimes influence visitor behavior, we can begin to use this and other research as a foundation for modeling future visitor behavior under varying scenarios of climate change. By better understanding how tourists and recreationalists behave in response to changing patterns of weather and climate, leaders and governments have an increased ability to make better informed policy and planning decisions for the future.

CHAPTER III

WEATHER, PRICING, AND TOURISM AT THE INDIANAPOLIS AND ST. LOUIS ZOOLOGICAL PARKS

Co-authored with Dr. Keith G. Debbage for *Weather, Climate & Society*

[3.1] Introduction

Identified by the United Nations (UN) as "presenting significant threats to the achievement of the Millennium Development Goals" (UN, 2013), climate change and the variability of future weather events are projected to have large impacts on the health, well-being, behavior, and security of human society. These impacts are broad-reaching and specifically affect many sectors of the global economy. In particular, the United Nations World Tourism Organization (UNWTO) has stated in its 'Davos Declaration on Climate Change and Tourism' that climate is a key resource for tourism and the sector is highly sensitive to the impacts of climate change. The UNWTO has suggested that communities and governments should 'develop regional and local climate information services tailored to the tourism sector' and implement community policy which is based on the interface between climate and the businesses and consumers within the tourism industry (UNWTO, 2009 pg. 25).

Literature addressing the complex interactions between varied weather and climate conditions within the tourism sector has attempted to answer many of the objectives outlined by the UNWTO through detailed research on how tourism resources could change and how people might travel to different locations under varying scenarios of climate change. In particular, various alpine communities across the world that house the ski industry have been a focus of much research which has found that under global warming, low-elevation resorts may be stressed in their physical snow and water resources, and higher alpine locations may incur excessive crowding due to a shift in recreationalist behavior as they abandon unreliable low-elevation ski resorts. (Cegnar, 2007; Tepfenhart *et al.*, 2007; Scott *et al.*, 2007).

Although research providing insight into the impacts of climate change on tourism have been important, many authors have indicated that in order to better understand how future climate change scenarios may broadly impact human behavior, society must first better understand how people interpret the weather and climate conditions of today (Nicholls *et al.*, 2008; Scott and Jones, 2006; Scott, 2012). Additional understanding of the behavioral choices tourists make regarding the weather can establish a stronger foundation by which research can forecast future tourist behavior.

This paper, in particular, focuses on the shorter-term impacts varied weather conditions may have on tourist behavior by considering the largely outdoor-oriented economic sector of Tourism, Recreation, and Leisure (TRL). Specifically, the focus of this paper is on the large and important TRL sector encompassing zoological parks and aquariums which contributed over $16 billion to the United States economy in 2012, supporting 142,000 jobs and attracting 175 million visitors, a total number of visitors in excess of all the major U.S. sporting events combined for the same time period (AZA, 2013). Few studies have examined in detail how weather conditions might affect zoo visitor attendances over time though Mason (2000) has remarked that zoos as tourist attractions remain under-researched and Davey (2007) has stated that zoo attendance patterns are in need of additional research. Additionally, Perkins and Debbage (2016a) identified in their research that zoological parks might be settings well-suited for the study of outdoor tourist behavior and subsequent weather events.

To address these points, we study how varying weather conditions, specifically the ambient thermal environment (as measured by the Physiologically Equivalent Temperature, PET) (Höppe, 1999), might influence visitor attendance over time. In doing so, we review how weather impacts daily zoo visitor attendance over a period of approximately one decade by comparing two AZA accredited zoological parks in similar climate regimes: the Indianapolis and St. Louis zoos.

These two zoological parks were chosen to build on the research findings of Perkins and Debbage (2016a) who examined the Phoenix and Atlanta zoos to better understand how visitor attendances in differing geographic settings are impacted by the ambient thermal environment as described by the Physiologically Equivalent Temperature (PET). In particular, results from the Indianapolis and St. Louis zoos will provide a comparison of the weather-attendance relationship at zoos located within climates colder than in the original work by Perkins and Debbage (2016a). It will do so by assessing if the ‘thermally optimum’ conditions found earlier in Phoenix and Atlanta are translatable to other climatic regions. Additionally, because the Indianapolis and St. Louis zoos are located in similar climate regimes, this research will also assess whether zoos located in the same general climate have consistent weather-attendance relationships.

Better understanding how the prevailing climates of an area may create different visitor attendance responses to thermal environments could provide further insight into the broader processes of human acclimatization. First, in both the Indianapolis and St. Louis zoos, it is hypothesized that days with highest visitor attendance will be similar between zoos and, further, they will have similar thermal profiles to what was found in Phoenix and Atlanta by Perkins and Debbage (2016a). Because the climates are cooler in Indianapolis and St. Louis than in the zoos studied by Perkins and Debbage (2016a), it is also projected that visitors at Indianapolis and St. Louis zoos might show less cold tolerance than visitors in Phoenix or Atlanta, based on regional expectations regarding what zoo attendees may perceive as weather conditions that are not thought to be 'pleasant'. Second, because visitors at both zoos are in attendance for an average of three to four hours (Personal Communication, 2015c, 2015d) and are exposed to outdoor conditions over an extended period of time, it is hypothesized that days with wider ranges of thermal conditions will be associated with higher attendance, and days with 'stagnant' thermal conditions will be associated with lower attendance. Third, because Indianapolis Zoo is paid-admission and St. Louis Zoo is free-admission, it is hypothesized that pricing will likely impact how visitors interpret the weather conditions where lower cost will potentially decrease weather sensitivities.

[3.2] Theoretical Background and Context

One of the key factors driving tourist behavior relates to the general comfort a tourist or recreationalist experiences when engaging in a chosen activity. In the event of climate change, warmer conditions will likely change comfort levels which may, in turn, cause tourists and recreationalists to alter their activities, perform the same activities but in different locations, or adapt to the thermal conditions. For a better understanding of the thresholds and preferences tourists have regarding the outdoor environment and the activities they engage in during their discretionary leisure time, much research has been performed to identify the thermal conditions most tourists prefer (Scott *et al.*, 2012).

In order to better understand the thermal conditions coinciding with the highest visitor attendances in Tourism, Recreation, and Leisure (TRL) settings, (termed here, the ‘optimal’ thermal condition), one must first gauge the thermal preferences of those visitors. Extensive research in the TRL sector has been performed that aimed to determine the thermal conditions which are most preferred by tourists in outdoor settings. Due to the wide activities engaged in by TRL participants, no single universal thermal preference has been agreed upon; however, several activity-specific ranges have been outlined in the literature which assist in better determining an envelope of tourist/recreationalist preference (Scott, 2012).

Table 3.1. A Summary Review of the Preferred Thermal Conditions of Varying Visitors Within the Tourism Sector

Method	Study	Year	Optimal Temperature °C	Closest ASHRAE Category		Tourism Segment	Culture
Expert-Based	Besancenot	1978	25-33	Slightly Warm	Warm	General	Global
	Mieczkowski	1985	20-27	Neutral	Slightly Warm	General	Global
Observational	Maddison	2001	30.7	Warm		General	English
	Lise and Tol	2002	21.8	Neutral	Slightly Warm	General	French
	Lise and Tol	2002	24.4	Slightly Warm		General	Italian
	Hamilton and Lau	2005	24	Slightly Warm		General	German
	Hamilton et al.	2005	14	Slightly Cool		General	Global
	Bigano et al.	2006	16.2	Slightly Cool		General	Global
	Perkins and Debbage	2016	-	Slightly Warm	Warm	Zoological Park	SW USA
			-	Slightly Warm	Warm	Zoological Park	SE USA
Survey	Gomez-Martin	2006	22-28	Neutral	Slightly Warm	General	Spanish
	Defreitas et al.	2008	-	Slightly Warm	Warm	Beach	Canadian
	Scott et al.	2008	23	Slightly Warm		Urban	Multicultural
			21	Neutral		Mountain	Multicultural
			25	Slightly Warm		Beach	New Zealand
			27	Slightly Warm		Beach	Canadian
			29	Warm		Beach	Swedish
	Rutty and Scott	2010	27-32	Slightly Warm	Warm	Beach	Multicultural
			20-26	Neutral	Slightly Warm	Beach	Multicultural
	Wirth	2010	20-26	Neutral	Slightly Warm	Urban	German
	Moreno	2010	28	Slightly Warm		Beach	W European
	Lin	2010	21-23	Neutral		Urban	Taiwanese
	Hewer and Scott	2011	24-30	Slightly Warm	Warm	Nature park	Canadian
	Andrade et al.	2011	23-28	Slightly Warm		Urban	Portuguese

It must be noted that the focus here is on the thermal component of the ambient environmental condition. As mentioned by de Freitas (1990), there are several weather-related parameters that are important when examining the atmosphere a tourist will experience when outdoors including rainfall, wind speed, and sunshine. Table 3.1 is an update to the work of Scott *et al.* (2012) and outlines several studies within the TRL sector which define 'optimum' weather conditions for tourism. Excerpted from each study is the optimal temperature or temperature range for tourism.

To provide comparison, the 'optimal temperatures' in the literature have been converted to the closest thermal category as specified by Matzarakis and Mayer (1996). Table 3.2 displays the nine thermal categories defined by the American Society of

Heating and Air Conditioning Engineers (ASHRAE) with the thresholds defined by Matzarakis and Mayer (1996); the thresholds were specified with respect to the derived Physiologically Equivalent Temperature (PET) (Höppe, 1999).

Table 3.2. PET-Based Thermal Categories Adapted from Matzarakis and Mayer (1996)

PET	ASHRAE THERMAL CATEGORY	PHYSIOLOGICAL STRESS
	Very cold	Extreme cold stress
4°C		
	Cold	Strong cold stress
8°C		
	Cool	Moderate cold stress
13°C		
	Slightly cool	Slight cold stress
18°C		
	Comfortable	No thermal stress
23°C		
	Slightly warm	Slight heat stress
29°C		
	Warm	Moderate heat stress
35°C		
	Hot	Strong heat stress
41°C		
	Very hot	Extreme heat stress

The research surveyed in Table 3.1 is performed using three distinct methods: ‘expert-based’ which defines its optimal temperatures based upon the author’s best determination, ‘observational’ which defines optimal weather and temperatures based on tourist travel departure and attendance data, and ‘survey’ which makes its determinations regarding on-site surveys of tourists and recreationalists. As discussed by Perkins and Debbage (2016a), each method has its advantages and disadvantages; however, all are of use when considering the ‘optimal’ temperatures and weather conditions within the TRL sector. Further, Table 3.1 describes the ‘tourism segment’ and the ‘culture’ in focus for each study. The ‘tourism segment’ refers to the target tourist audience of the study or intended visit-location of those questioned where 'general tourism' can largely be defined as sightseeing tourism or "slow steady walking" (Mieczkowski, 1985) as the main activity visitors perform. 'Culture' describes the origin of the people who were either observed or surveyed to obtain the results.

While there is a large array of differing results, some key points emerge from an overall survey of the findings (Table 3.1). First, those studies assessing either a 'global' culture or a 'general' tourism segment indicate a wide range of possibility for 'optimal' thermal preferences. For example, Hamilton *et al.* (2005) and Bigano *et al.* (2006) utilized international tourist departure data to determine the thermal preferences of tourists; both resulted in the optimal thermal temperature coinciding with the 'slightly cool' ASHRAE category. Conversely, Maddison (2001), in a review of global tourism demand for travelers from the United Kingdom, found a much warmer optimal temperature coinciding with the 'warm' ASHRAE category. Second, the intent of the vacationer appeared to modify the thermal preferences (Gomez-Martin, 2005). Generally speaking, beach tourism has the warmest thermal preference and mountain tourism the coldest, with urban tourism falling between these anchor points. Zoological park tourism (Perkins and Debbage, 2016a) most resembled results seen in 'urban' tourism; this finding is expected given the metropolitan location of both zoos in the research. Third, visitor origin also influenced the optimal thermal assessment, and, in general, tourists traveling to a location normally preferred conditions that were more in contrast to the prevailing climate of their home locations. Among beach vacationers, Scott *et al.* (2008) found that Swedish respondents had a stated thermal preference (29°C) which was warmer than both New Zealand (25°C) and Canadian (27°C) respondents. Furthermore, New Zealand, the warmest location among those in the study reported the coldest preference. This finding is further substantiated in the work of Perkins and Debbage (2016a) where it was found that the optimal thermal conditions for zoological park visitors in the United States were warmer in the mild climate of Atlanta, Georgia, than in the hot desert climate of Phoenix, Arizona, by approximately one PET-based thermal category. Finally, while the present trend of research is away from expert-based determinations of the tourism-climate, the work of Besancenot (1978) and Mieczkowski (1985) show that expert-based methodologies are useful as they do indicate results similar to what is found in more advanced mixed-methods research.

With these thermal comfort preferences in mind, a growing body of literature assessing the impacts of weather on attendance has emerged in recent years. Nicholls *et al.* (2008), and Perkins and Debbage (2016a) utilized multiple weather parameters to assess outdoor tourist attendances. Nicholls *et al.* (2008) reviewed how weather impacted the number of golf rounds played at three golf courses in the state of Michigan. Weather impact was the central focus of the study as variables of maximum temperature, minimum temperature, and precipitation were all assessed; however, other variables were also incorporated in the analysis including public holidays, gas prices, and the Consumer Confidence Index (CCI). The authors found that at every golf course in the study, maximum temperature was the most influential weather variable on rounds of golf played where higher temperatures resulted in more rounds played. In comparison across the three golf courses in the research, Nicholls *et al.* (2008) also concluded that the courses with a higher percentage-share of visitors who live locally were more heavily impacted by weather variability than the courses which drew more visitors from non-local areas. This is primarily because local residents, simply by looking out their windows, had the convenience of assessing weather conditions they would likely experience when golfing. Conversely, non-local golfers did not have that same convenience of directly assessing weather conditions at or near the location and had likely planned their trip in advance, investing time and money; this investment decreases the ability for tourists to make last-minute decisions regarding the weather. Becken and Wilson (2013) further substantiated this finding as they addressed how non-local travelers often do not have much flexibility in their schedules to adapt to changing weather conditions.

Although there is a growing body of research focused on the relationship between weather and visitor attendance in a wide variety of tourist venues, there is little consensus regarding the optimal weather variables for this type of analysis. With this in mind, de Freitas *et al.* (2007) suggested the use of biometeorological variables such as the Physiologically Equivalent Temperature (PET) to more accurately capture the physiological conditions a person may experience. They concluded that this type of weather variable may serve as a 'better' assessment of how tourists may react to the outdoor thermal environment. Brandenburg and Ploner (2002) and Ploner and Brandenburg (2003) used PET, among other meteorological variables of precipitation, vapor pressure, cloud cover, and temperature, when they examined the impact of weather on different outdoor park recreationalists in Austria. The authors explored how varying recreationalist activities may cause visitors to interpret weather conditions differently by creating activity categories segmenting park visitors into ‘bikers’, ‘hikers’, ‘joggers’, and ‘dog walkers’. Their findings indicated that among all weather variables, PET had the greatest impact on visitor attendance decisions followed by precipitation and cloud cover. Comparison between activity categories indicated the most active recreationalist groups, specifically, ‘bikers’ and ‘hikers’ displayed stronger weather-attendance relationships than ‘dog walkers’. These findings may indicate that the weather-human attendance relationship is a product of both physiological experiences (as observed from high PET correlations) and psychological expectations (as found by the different weather sensitivities by activity group). Brandenburg and Ploner (2002) also found that positive relationships existed between temperatures and number of bikers only when temperatures were above 10°C, indicating a possibility of activity-specific weather thresholds. They concluded that while non-weather factors such as day-of-week might be most influential on park attendances, weather had a substantial impact on visitors.

Perkins and Debbage (2016a) focused on the relationship between visitor attendance and coinciding ambient thermal conditions as measured by PET-based thermal categories at the Phoenix and Atlanta zoos. In their research, the authors segmented attendances at each zoo with respect to four statistically-based categories called Attendance Day Typologies (ADTs) which were linked to ‘poor’, ‘average’, ‘good’, and ‘excellent’ levels of visitor attendance. At each zoo, within each of the ADT categories, they performed separate analysis to determine the PET-based thermal category most associated with the particular level of high or low visitor attendances. In their findings they highlighted universal preferences across zoo locations and suggested the possibility that visitors at each zoo may display differences in weather preference as a result of the prevailing climates of each location. Regarding universal preferences, they concluded that, generally speaking, there could be a 'universal thermal preference' in the PET-based thermal categories of 'slightly warm' and 'warm' in both Phoenix and Atlanta where attendances are highest during these thermal conditions. Further, the lowest attendances on record coincide with the predominating thermal extreme condition for a particular location. Low attendance days in Phoenix coincided with 'very hot' thermal conditions, while in Atlanta, the lowest attendance days coincided with 'very cold' thermal conditions.

Interpreting the differences in visitor attendances concerning thermal conditions between geographic locations, Perkins and Debbage (2016a) stated that attendance-weather relationships may be a product of the climatology of the extreme thermal conditions. For example, visitor attendance at the Phoenix Zoo appeared to indicate a greater amount of 'heat aversion' than visitors in Atlanta. It was hypothesized that this occurred because residents of Phoenix might be reacting to a possible 'saturation point' where they chose not to adapt to or tolerate the prevailing thermal extreme when it came to their discretionary leisure time. In their conclusion, Perkins and Debbage (2016a) called for an expansion of this type of research into different climate geographies, particularly those in colder climates, to further assess the relationships between visitor attendance and the ambient thermal environment.

On a final note, Perkins and Debbage (2016a) used zoological parks with very different climates but with comparable admission prices. In this research, the opposite is true as Indianapolis and St. Louis zoos are located in very similar climates; however, Indianapolis Zoo is pay-for-admission while St. Louis Zoo is a free-admission facility. Price is not the central focus in this research, though this difference across zoos must be placed into context in order to help determine if price may have an impact on both attendance patterns and on how people may change their interpretation of ambient thermal conditions based on the cost of visiting a particular zoological park.

In order to place the role of pricing within tourism and leisure activities in the appropriate context, an overview of admission ticket pricing should be explored. Sporting event attendance with respect to ticket prices is a well-researched field detailing topics concerning drivers of attendance, econometric modeling, and pricing strategy (Villar and Guerrero, 2009). Theoretically, other factors being equal, higher ticket prices should lower the expected visitor attendance. This very relationship was found by Donihue *et al.* (2007) where, in Major League Baseball (MLB) spring training games, higher ticket prices resulted in lower game attendances. This was true even during spring training games which sold low-cost tickets averaging $10.64 for a paying adult. Kahane and Shmanske (1997) found a similar relationship within MLB regular-season play where they determined that for each major league team, an increase of one-dollar in the average ticket price will decrease yearly attendance by approximately 180,000 people.

While within the sporting industry it appears that increasing ticket prices decreases visitor attendances, the proportion between the increase in ticket price and decrease in visitor attendance (elasticity) is much debated. In a study of ticket prices within the Brazilian Football League, Madalozzo (2008) determined that while ticket discounts would increase public attendance, a fifty-percent discount on ticket prices would only increase the public attendance by sixteen percent. Additionally, Donihue *et al.* (2007), Kahane and Shamanske (1997), and Miller and Palmer (2008) refer to tickets sold within Major League Baseball as priced in an 'inelastic' range of the demand curve. Pricing in an inelastic range indicates that if ticket prices are increased, the loss in public attendance due to this price increase will not decrease enough to result in a net loss in profit; consequently, profit maximizing strategies would suggest increasing ticket prices. Kahane and Shmanske (1997) also note, however, that the marginal cost of an extra spectator in an unfilled stadium is negligible, and unsold seats do not yield any profit; therefore, it is not always necessary to control attendance through increased pricing strategies.

Macdonald (2006), Luksetich and Partridge (1997), Nedzela and Lane (1990) and Steiner (1997) found the same relationship in an overview of ticket pricing, attendance, and profit at museums where current admission prices were low enough that an increase in price would not yield an equivalent decrease in museum attendance. Additionally, Nedzela and Lane (1990, p. 191) stated that 'Experience at North American museums suggests that modest admission fees have no long-term negative impact on attendance.' Short of crowding, museums share the same situation with sports venues where the marginal cost of an extra person in attendance is negligible. Steiner (1997) furthered the discussion by addressing the concept of free admission at museums by highlighting the multifaceted complexity of this relationship. For example, paid admission increases museum profit while simultaneously decreasing overall attendance; free admission decreases immediate profit but increases attendance which can then increase museum recognition due to increased word-of-mouth advertisement. Additionally, similar to zoological parks, other services such as gift shop sales, special events, and concessions often supplement the limited yield from admission tickets.

Further complicating the relationship between attendance figures and admission prices, zoos have had to establish a balance between public education and revenue-generating pricing strategies. Cain and Meritt (1998) addressed zoological park and aquarium pricing strategies and gave insight into the role of pricing on attendance in the United States. The authors noted that, largely, zoos and aquariums are deemed 'merit goods' because they are goods which the public demands but is unwilling to purchase at prices that cover costs; this results in ticket prices which are below 'market value'. Additionally, the 1965 Association of Zoos and Aquariums (AZA) officials suggested that members keep their admission prices low in order to make facilities accessible to low-income families and school groups (Lindemann *et al.*, 1965). Cain and Meritt (1998, p. 306) emphasized inelastic pricing points observed in other leisure activities: 'the fact that zoos and aquariums operate in the inelastic portion of their demand curves suggests that they do not set price to maximize profits' but to raise marginal amounts of money to 'help defray the cost of constructing new exhibits'. Additionally, as seen with sports stadiums and museums, the marginal cost of an additional visitor to the zoo does not warrant significant cause to raise admission prices. As a result, it is reasonable to assume that the admission prices of zoos do not present a significant barrier to entry for most visitors. Because of these factors, 'free-admission' zoos should reflect additional attendances over 'paid-for' admission zoos only in certain circumstances. First, free zoos should reflect an increased number of visitors from very low-income groups. Second, free zoos should have more visitors who visit frequently and utilize the zoo for shorter periods of time. Third, free zoos should have higher attendances on marginal weather days because there is little financial risk in attending. Unfortunately, despite much research on the link between attendance and ticket pricing, there is very little publicly-available research on how ticket pricing may mitigate or enhance human response to weather conditions (Hale and Altalo, 2003, Maddison and Bigano, 2003).

[3.3] Methods

The methods in this paper borrow from the earlier work of Perkins and Debbage (2016a) regarding their research of the impact the ambient thermal environment (as measured by PET-based thermal categories) had on attendances at Phoenix Zoo and Zoo Atlanta. Similar methods were employed in this research regarding the Indianapolis and St. Louis zoos. Findings from Perkins and Debbage (2016a) helped shape the hypotheses which guided the development of this paper regarding visitor relationships with (1) thermal environment, (2) changes in the thermal environment during the daytime, and (3) price impacts on responsiveness to the weather conditions. First, this paper hypothesizes that days with highest visitor attendance at both Indianapolis and St. Louis zoos will exhibit similar findings concerning the ambient thermal conditions most preferred by visitors in Perkins and Debbage (2016a) and these preferences will likely show little variation with what was found in Phoenix and Atlanta. Conversely, at lower levels of attendance, it is also hypothesized that Indianapolis and St. Louis zoo visitors will display similar visitor responses to the ambient thermal environment regarding poor days. Specifically, because Indianapolis and St. Louis are located in a climate regime where the most prevalent thermal extreme results in cold-stress conditions, it is projected that most zoo visitors at both locations will simply avoid cold thermal extremes due to an unwillingness to tolerate additional exposure to excessive cold, indicating a potential 'cold aversion'. This expectation is based on the findings of de Freitas (2014) that visitor attendance in outdoor tourist locations tended to be shaped more by locally-defined thresholds of tolerance than by 'ideal' weather conditions and also the findings of Perkins and Debbage (2016a) who stated that the prevailing thermal extreme of a location will be most associated with visitor tendencies to display either 'cold aversion' or 'heat aversion' in their attendance responses. Second, because visitors are attuned to the range of conditions they may experience throughout their visit to a zoo, it is hypothesized that days experiencing a wider range of thermal conditions will also result in higher attendances than days with relatively stagnant thermal conditions. As found by Perkins and Debbage (2016a), days with wide thermal ranges are more associated with cool morning temperatures warming to mild afternoon temperatures. Conversely, 'stagnant thermal regimes' in continental (non-desert) climates are most associated with conditions that are either very cold and remain cold throughout the day and/or days with significant clouds and possible rainfall. Third, a key difference between the Indianapolis and St. Louis zoos is admission pricing. It is hypothesized the role of zoo admission pricing will impact attendances predominately at lower attendances and specifically when weather conditions are not ‘ideal’ for outdoor tourism. Much of this logic is tied to Cain and Meritt (1998) who noted that admission prices to zoos are generally priced below market value. Therefore, only in conditions when zoo admission is less valuable to visitors, such as in the event of ‘poor weather’, would price become enough of a factor to possibly influence visitor decisions to attend.

Visitor attendances were calculated using daily attendance data collected from September, 2001, to June, 2011, at each zoo. This time period was selected because it represented a period where at each zoo there was no significant change in the array of attractions. Additionally, incorporating a period of nearly one decade helps control for impacts resulting from severe weather events. Following the methods of Perkins and Debbage (2016a), each zoo’s visitor attendances were segmented into four statistically-based attendance categories called Attendance Day Typologies (ADTs):

- Poor attendance days: daily visitor attendance less than one standard deviation below the mean daily attendance
- Average attendance days: within one standard deviation of the mean daily attendance
- Good attendance days: between one and two standard deviations above the overall daily attendance mean
- Excellent attendance days: attendance more than two standard deviations above the daily attendance mean

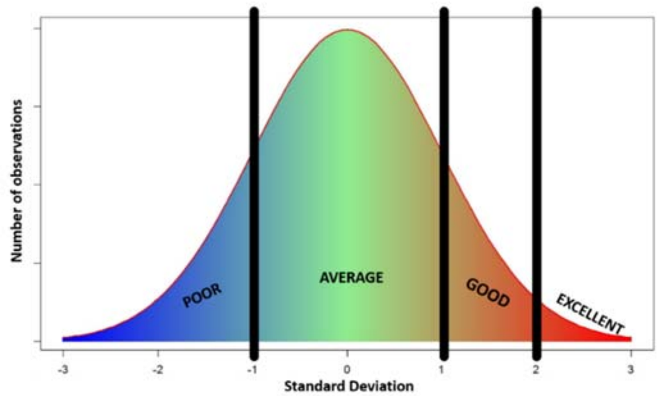

Figure 3.1. Theoretical Normalized Distribution of Attendance Data by Attendance Day Typology (ADT). Adapted from Perkins and Debbage, 2016a

There are two ADT categories above the 'average' category and only one ADT category below the 'average' category. Perkins and Debbage (2016a, p. 9) observed that "part of the logic for including two categories of attendance more than one standard deviation above the mean attendance (i.e., 'good' and 'excellent' days) is their disproportionate impact on overall attendance." For example, though attendances at the Indianapolis and St. Louis zoos fell within the 'good' and 'excellent' categories an average of only one day out of every seven, the total visitor attendance for these two ADTs accounted for an average of 43.5% of the total yearly visitor attendance.

Weather data at both zoos was obtained from the nearest hourly-data National Weather Service (NWS) Automated Surface Observing Systems (ASOS) station. The ASOS station used for Indianapolis Zoo is located at Indianapolis International Airport 7.0 miles SW of the zoo; the weather station used for St. Louis Zoo is located at Lambert-St. Louis International Airport 8.7 miles NNW of the zoo. Although the weather stations are not located inside each zoological park, they are close enough to assume that weather conditions occurring at the weather stations represented a reasonable proxy for weather experienced at each zoo.

When considering the many factors contributing to attendance decisions, it is important to include weather conditions from early morning, when most visitors plan their trip, to afternoon, when they return home, because weather conditions within this entire time period most likely influence initial decisions regarding a trip to an outdoor venue. Consequently, we collected weather data once every hour for the variables of temperature, humidity, dew point, wind speed, and sky cover only for the hours from 7am to 7pm local standard time. Nicholls *et al.* (2008) highlighted the importance of utilizing this type of fine-resolution weather data because it helped to more fully detect how weather conditions may impact attendances at outdoor locations.

Additionally, this paper, following suggestions of de Freitas *et al.* (2007) and the methods of Ploner and Brandenburg (2003), Brandenburg and Ploner (2002) and Perkins and Debbage (2016a), used as its weather variable the Physiologically Equivalent Temperature (PET) because it represented a more specified measure of ambient thermal conditions that a visitor may 'feel' while visiting the zoo. PET is well established because it is frequently used in outdoor tourism studies (Lin *et al.,* 2008, 2009; Matzarakis, 1996; Staiger *et al.,* 2011). The derived temperature values of PET are often classified into a nine-point thermal sensation scale following the standards established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2001 and 2004) where thermal environments are described as 'very cold' through 'very hot'. For the purposes of this research, the nine categories are defined in Table 3.2 using the standard established by Matzarakis and Mayer (1996).

To calculate each derived PET value for every hour between 7am and 7pm, a specific method was followed. Figure 3.2 describes this methodological process where hourly weather data was converted to a derived PET value and then assigned to a PET-based thermal category. PET was calculated thirteen times every day for each hour from 7am to 7pm; its value was dependent upon atmospheric inputs of temperature, wind speed, sky cover, and relative humidity. The RayMan Pro software (Matzarakis *et al.*, 2000) used atmospheric inputs and calculated the PET derived temperature value in degrees Celsius. This software is commonly used in the calculation of PET, particularly within human bioclimate research and tourism (Matzarakis *et al.*, 2007). After calculation, each PET-derived temperature value was assigned to the corresponding PET-based thermal category as defined by Matzarakis and Mayer (1996). The thirteen hourly PET thermal categories were displayed for a particular day and the warmest and coldest thermal categories for that day were selected to represent the daily high and low PET-based thermal category values.

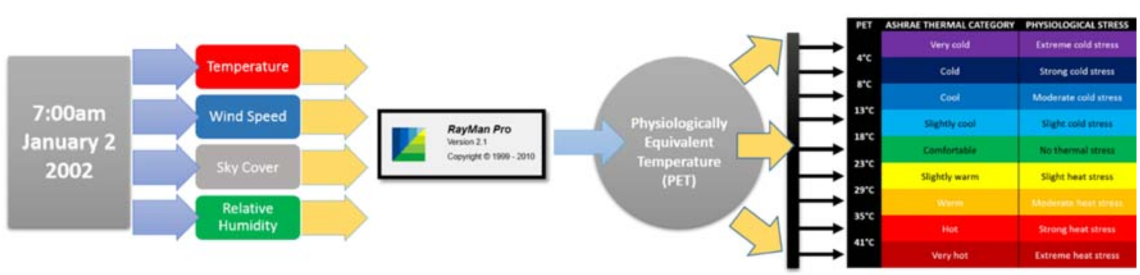

Figure 3.2. Methodological Process of Converting Hourly Weather Data to a PET-Based Thermal Category

In previous research, Perkins (2012) found that when compared with daily average and daily low PET values, the daily high PET value performed best when predicting visitor attendances. The warmest daily PET likely worked well when predicting visitor attendance because it represented the most extreme thermal condition on a particular day and because it tended to occur at the time most visitors were likely to be at the zoo. Furthermore, it is probable that most visitors planning to visit the zoo are attuned to the warmest thermal condition rather than an abstract average or early-morning low temperature.

As changes in thermal conditions throughout the day will likely impact visitors, this research also analyzed the number of PET-derived thermal categories a visitor experienced in a day and how it coincided with varying levels of visitor attendances. Rather than calculating daytime thermal change by determining the difference in degrees between the high and low PET temperature values from 7am to 7pm, this research calculated a 'perceived' thermal change measured by the number of PET-based thermal categories a visitor experienced between the low and high PET from 7am to 7pm at a particular location. Because the thermal categories were derived by people's opinions in survey-response techniques in accordance with the ASHRAE thermal perception scale, it is assumed that the number of thermal categories experienced in a day should also represent the total number of perceived thermal conditions a zoo visitor experienced during that same day.

The theory behind using zoological parks as the tourist locations in weather-attendance research is substantiated by Perkins and Debbage (2016a) who discussed several methodological advantages gained when using zoological parks as ‘test laboratories’ for the assessment of weather’s impact on visitor behavior. As an example, zoological park visitors generally have certain expectations regarding why they visit a zoo and the outdoor exposure to the weather they will likely experience when on site. While there are different motivations among zoo visitors, they generally visit to learn about animals, conservation, and nature in an outdoor setting regardless of the zoo’s geographic location (Falk et al, 2007). Research concerning zoological park visitors also involves a relatively standardized visitor who usually engages in sightseeing at a “slow steady walking” pace (Mieczkowski, 1985). By contrast, research in beach or park tourism must consider a variety of visitors who engage in different activities and may interpret the ambient thermal conditions differently depending on their goals (Grodzik, 1972; Brandenburg and Ploner, 2002; Ploner and Brandenburg, 2003; Rutty and Scott, 2014; Morgan *et al.*, 2000). Regarding visitor attendance data, zoo locations provide accurate sources of data over time because they must count visitors for financial accounting purposes. Additionally, because zoological parks are managed properties, the park space has fixed geographic boundaries with entry and exit points. In other venues with open-boundary spaces, multiple entrances, and undefined geographical spaces, accurate attendance counting can be very difficult (Knez and Thorsson 2005; Rutty and Scott, 2014; Curtis, Arrigo, and Covington, 2008; Morgan *et al.*, 2000).

Indianapolis and St. Louis zoos have many comparable attributes that may allow for better isolation of the weather-visitor attendance relationship. Both zoos are located in major urban metropolitan areas and each zoo is positioned within the urban downtown.

Visitor length-of-stay is comparable as the average visitor spends approximately three to four hours per trip (Personal communication, 2015c, 2015d). Because visitors plan to spend several hours outdoors when visiting, they most likely consider the daily weather in their planning decisions. The Indianapolis and St. Louis zoos largely attract day-trippers from within the metropolitan areas of Indianapolis and St. Louis. For example, at Indianapolis Zoo, 85% of the guests are from within the state of Indiana (Personal Communication, 2015c); at St. Louis Zoo 65% of guests are classified as 'area residents' from the local ten-county metropolitan area (Personal Communication, 2015d). Given the large percentage of visitors who are local and have less fixed schedules, it is likely that visitor decisions may be more aligned with weather conditions than they would in other outdoor tourist venues with larger shares of nonlocal visitors. This logic is supported by findings from Nicholls *et al.* (2008) who observed that tourist locations with larger percent shares of local visitors were more sensitive to weather conditions than those tourist locations with higher percent shares of nonlocal visitors. Additionally, both zoos are located in large metropolitan areas with similar populations. The Indianapolis Combined Statistical Area (CSA) contained approximately 2.1 million residents; the St. Louis CSA had 2.9 million residents in 2012 (U.S. Census, 2012). As mentioned earlier, however, a key difference between both zoos is price; adult admission rates were $14 in Indianapolis and there was no admission charge in St. Louis.

Finally, it is hypothesized that, because the prevailing climates of Indianapolis and St. Louis are similar, there may also be similarities between the zoos concerning how visitors behave in response to varied weather conditions. Outlined in Table 3.3 are several key climate variables in Indianapolis and St. Louis. To capture the general climates, thirty-year climate normals from 1981 to 2010 were used in the comparison (NOAA, 2014).

Table 3.3. Climate Comparison of Indianapolis and St. Louis (Data from NOAA, 2014)

Climate Comparison: 30 Year Normals 1981-2010	Indianapolis	St. Louis
Warmest Conditions	July	July
	24.1°C	31.7°C
Coldest Conditions	January	January
	-2.2°C	4.4°C
Driest Conditions	February	January
	58.9mm	61.0mm
Wettest Conditions	May	May
	128.3mm	119.9mm
Annual Precipitation	1,078mm	1,040mm
Days above 32°C	18	43
Days below 0°C	103	84
Köppen-Geiger Classification	Dfa	Dfa/Cfa

What is apparent from the comparison in Table 3.3 is that both locations have similar climates; however, St. Louis, in general, is slightly warmer in both the warmest and coldest months. Further, St. Louis has more hot days above 32°C and fewer cold days when low temperatures dip below freezing. Precipitation regimes between the locations are very similar both in their temporal distributions of the wettest and driest months and in annual precipitation totals. The Köppen-Geiger climate classification system places Indianapolis in a location defined as a 'humid continental climate' (Dfa) while St. Louis is located on the margin between a 'humid continental climate' (Dfa) and a 'humid subtropical climate' (Cfa).

[3.4] Findings

Although the Indianapolis and St. Louis Zoos do not attract a large number of international visitors as do San Diego or Washington National zoos, they still generate a substantial number of visitors. From September 2001 to June 2011 the two zoos attracted a total combined attendance of over 39 million visitors. During this period, Indianapolis Zoo averaged approximately one million visitors per year while St. Louis Zoo attracted over 2.9 million visitors on an annual basis. Indianapolis Zoo has been operating since 1964 and is one of the only zoos in the United States to have both an accredited zoological park and botanical garden on the same site. Presently, Indianapolis Zoo is widely known for its new International Orangutan Exhibit, constructed to be one of the premiere orangutan exhibits in the world. St. Louis Zoo, one of the oldest zoological parks in the United States, has been in operation since opening in conjunction with the 1904 St. Louis World's Fair. It gained national fame in the 1960s when zoo director Marlin Perkins hosted a television special on animals and nature. Today, St. Louis Zoo is recognized as one of the leading zoos in animal research and conservation education. Clearly, both zoos have well-established histories and diverse arrays of attractions; what is less clear is how at each zoo the ambient thermal environment might impact average daily visitor attendance.

Table 3.4 illustrates the number of days represented at each zoo for each of the Attendance Day Typologies ('poor', 'average', 'good', and 'excellent') and Table 3.5 illustrates total visitor attendances within every Attendance Day Typology (ADT). The table rows are additive indicating the total number of days analyzed (Table 3.4) and the total number of visitors in attendance (Table 3.5) at each zoo from September 2001 to June 2011. Due to the statistical methodology used to define the ADT categories, the ‘average’ ADT is the largest single grouping both in terms of number of days represented and total visitor attendance. In Table 3.4, the ‘average’ ADT represented 68.9% of all days at Indianapolis Zoo and 69.0% of the days at St. Louis Zoo. In comparison, the ‘average’ ADT represented 54.1% of the total visitor attendance at Indianapolis Zoo and 57.0% of the total visitor attendance at St. Louis Zoo (Table 3.5).

However, while the ‘good’ and ‘excellent’ ADTs combined accounted for only 16.5% of the total days represented at Indianapolis Zoo and 16.9% of total days represented at St. Louis Zoo (Table 3.4), these days accounted for 45.6% and 41.4% of the total visitor attendances (Table 3.5) at Indianapolis and St. Louis zoos respectively. Consequently, a large portion of total visitor attendance occurs only on a select few days during the year. ‘Good’ and ‘excellent’ ADTs, then, are likely of high importance when attempting to forecast visitor attendance. In contrast, the ‘poor’ ADT accounted for less than 2% of the total number of visitors at both Indianapolis and St. Louis zoos. As a result, a more detailed analysis of the differences in ambient thermal conditions between the ‘good’ and ‘excellent’ ADT categories might be theoretically illuminating and of particular use to the zoos within this study.

Table 3.4. Number of Days Represented by Each Attendance Day Typology (ADT) from September 2001 to June 2011

	Poor	**Average**	**Good**	**Excellent**
Indianapolis Zoo	526 (14.7%)	2474 (68.9%)	426 (11.9%)	164 (4.6%)
St. Louis Zoo	504 (14.1%)	2467 (69.0%)	437 (12.2%)	168 (4.7%)

Table 3.5. Total Visitor Attendances by Each Attendance Day Typology (ADT) from September 2001 to June 2011

	Poor	Average	Good	Excellent
Indianapolis Zoo	31,863 (0.3%)	5,369,595 (54.1%)	2,903,326 (29.3%)	1,614,481 (16.3%)
St. Louis Zoo	454,110 (1.6%)	16,596,336 (57.0%)	7,804,123 (26.8%)	4,247,332 (14.6%)

Table 3.6 illustrates the average daily attendance by Attendance Day Typology (ADT) and provides ratios indicating what percentage of the attendance in St. Louis is matched by Indianapolis. For example, within the 'poor' ADT, Indianapolis Zoo attendance only matches 7% of the attendance at St. Louis Zoo; for the highest days of attendance in the 'excellent' ADT, daily attendance in Indianapolis comprises only 39% of the attendance in St. Louis. Most significant, though, is the trend across ADT categories in the Indianapolis to St. Louis ratios where a large drop is observed between the 'average' and 'poor' ADT categories. This drop may be tied to the difference in admission fees between the two zoos and may indicate that for 'poor' days of attendance, the 'free-admission' policy of St. Louis Zoo could encourage more people to attend because there is no substantial financial loss in the event poor weather conditions shorten a visit. Because the Indianapolis to St. Louis attendance ratio does not significantly drop until the 'poor' ADT, this may indicate that weather conditions most associated with the 'average' ADT category, though not 'ideal', are still sufficiently acceptable for visitors to be willing to pay the $14 admission price in Indianapolis. Therefore, understanding differences in weather conditions between 'average' and 'poor' days of attendance could better illustrate how visitors may value weather conditions.

Table 3.6. Average Daily Attendances by Attendance Day Typology (ADT) and the Ratio of the Average Attendances between the Indianapolis and St. Louis Zoos

	Poor	**Average**	**Good**	**Excellent**
Indianapolis	60	2,171	6,815	9,844
St. Louis	877	6,727	17,858	25,282
IND/STL	0.07	0.32	0.38	0.39

To provide further context for the attendance differences between Indianapolis and St. Louis zoos, Figure 3.3 illustrates average monthly attendances at both zoos. What is clear from this comparison is that while there are significant absolute differences in attendance volumes, with respect to the seasonal pattern in visitation, these two zoos are very similar. Particularly, the peak months of attendance at both zoos occur from May through July with lower levels of attendance in the adjacent 'shoulder seasons'. The lowest attendance occurs during the winter months from November to February suggesting that the ambient thermal conditions may contribute to these attendance patterns at both zoos.

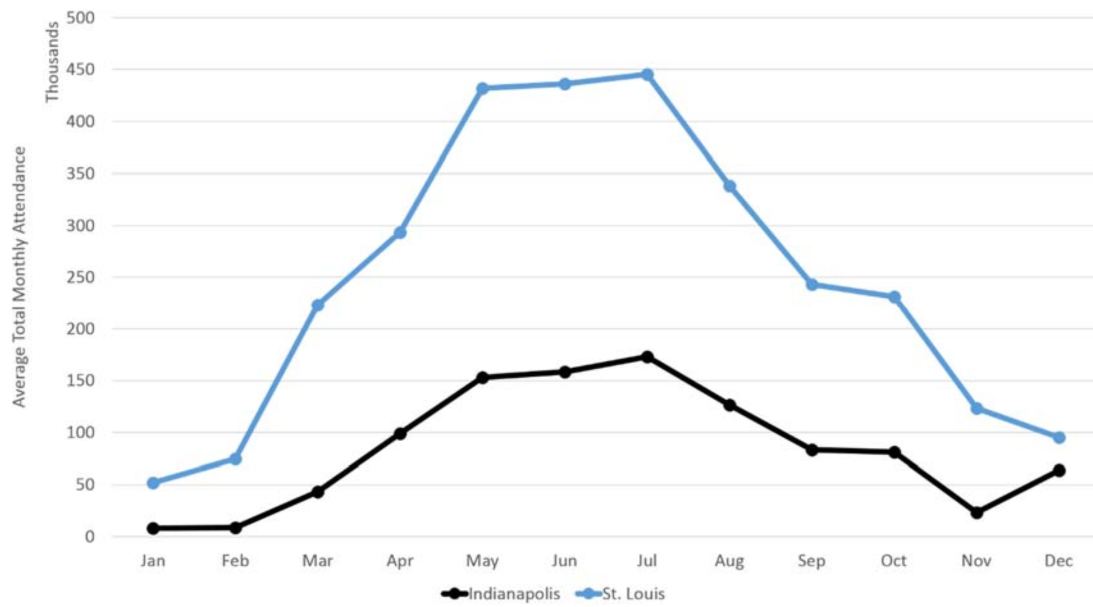

Figure 3.3. Comparison of the Average Total Monthly Attendances at the Indianapolis and St. Louis Zoos

Figure 3.4 displays the percent share of daily PET-based thermal categories at each zoo from September 2001 to June 2011. The categories in Figure 3.4 represent the proportion of the number of days falling within a particular PET-based thermal category where the day in question was represented by the warmest PET-based thermal category occurring between 7am and 7pm.

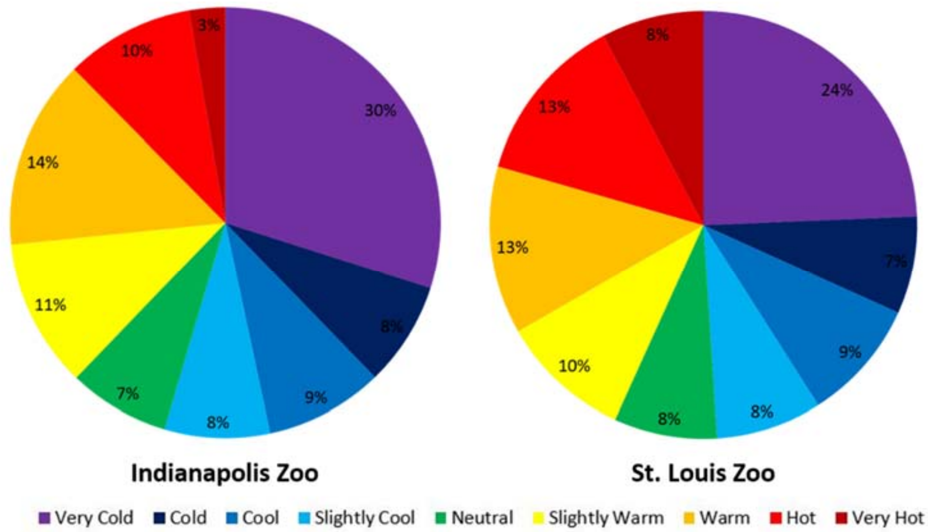

Figure 3.4. Daily Observed Thermal Categories at the Indianapolis and St. Louis Zoos September 2001 – June 2011 as Measured by the Thermal Category Representing the Warmest Daytime PET (7am to 7pm)

Figure 3.4 shows that Indianapolis and St. Louis have similar thermal profiles. In both locations, the most frequently occurring thermal category was ‘very cold’ which occurred 30% of the time in Indianapolis and 24% of the time in St. Louis. The two zoos are also comparable regarding the more moderate thermal conditions. The proportion of days falling within ‘warm’ through ‘cool’ thermal categories was 49% in Indianapolis and 48% in St. Louis. The difference is greatest between zoos in the thermal categories representing the warmest conditions where ‘hot’ and ‘very hot’ thermal categories combined represented only 13% of all the days in Indianapolis but 21% of the days in St. Louis. How these thermal regimes shape and influence daily visitor attendance at each zoo during the study period is less clear.

Distribution of PET-based thermal categories based on the percent share of each Attendance Day Typology (ADT) for both zoos is illustrated in Figure 3.5. Consistent across both zoos, the largest share of ‘poor’ attendance days are within the ‘very cold’ PET-based thermal category. In Indianapolis and St. Louis, respectively, 85% and 87% of the ‘poor’ ADT was comprised of days that experienced ‘very cold’ thermal conditions. This finding indicates the possibility of the ‘thermal aversion effect’ (Perkins and Debbage, 2016a) where, specifically, ‘cold aversion’ may have influenced visitor attendance choices. Though residents of Indianapolis and St. Louis are exposed to ’very cold’ thermal conditions more than any other thermal category (Figure 3.4), this does not mean that zoo visitors have adapted to these conditions or have developed elevated thermal tolerance levels. In fact, because of the high shares of ‘very cold’ thermal conditions observed in the ‘poor’ days of attendance, quite the opposite trend appears to be happening. This further suggests that residents of both Indianapolis and St. Louis may have reacted to a possible ‘saturation point’ where zoo visitors displayed ‘extreme temperature aversion’ (Perkins and Debbage, 2016a) and chose not to tolerate the prevailing cold extremes with respect to their discretionary leisure time.

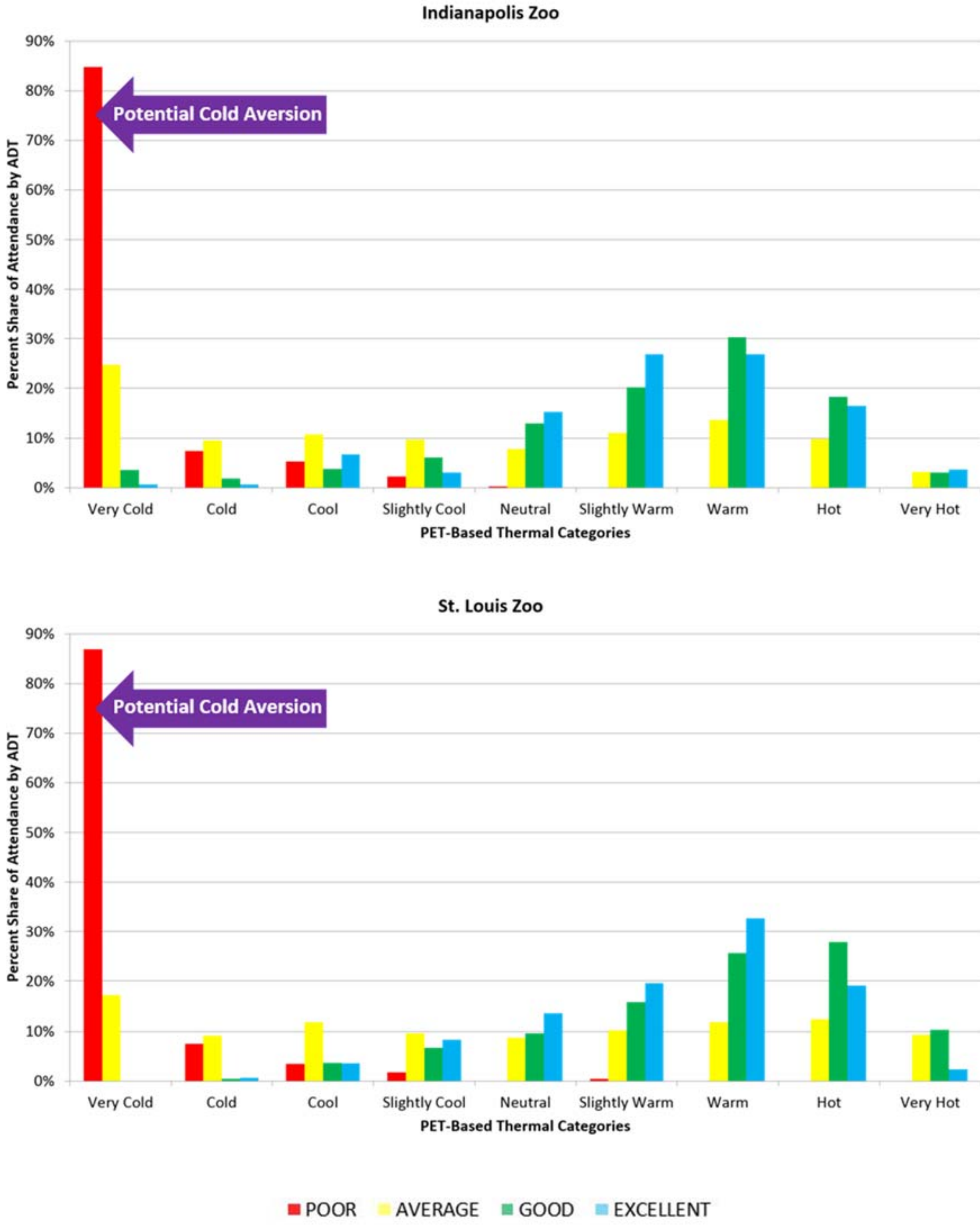

Figure 3.5. Distribution of Warmest Daytime PET-Based Thermal Categories Based on the Percent Share of Attendance Day Typology (ADT) by Zoo

Additional similarities between the Indianapolis and St. Louis zoos are observed within the distribution of PET-based thermal categories across the ‘excellent’ ADT. At Indianapolis Zoo, the peak representations of the highest days of attendance on record are within the ‘slightly warm’ and ‘warm’ thermal categories, both of which represented 27% of all the days within the ‘excellent’ ADT. By contrast, a clear bias toward the ‘warm’ thermal regime was observed in St. Louis with respect to the ‘excellent’ ADT where ‘warm’ days accounted for 33% of this ADT and their percent shares dropped to 19% within the ‘slightly warm’ thermal category. What is apparent in the findings from the ‘excellent’ ADT is both zoos are very comparable in terms of the thermal category generating the highest visitor attendances. Specifically, though, visitors at Indianapolis Zoo appear to be ‘indifferent’ regarding ‘slightly warm’ and ‘warm’ days, whereas visitors to St. Louis Zoo have a demonstrated preference for ‘warm’ thermal regimes on excellent attendance days. Overall, while ‘warm’ may be indicative of an ‘optimal thermal condition’ across zoo locations, key differences between zoos are more pronounced when highlighting the nuances that might exist between ‘good’ and ‘excellent’ ADT categories.

Figure 3.6 provides a more direct visual comparison of the ‘good’ and ‘excellent’ ADTs with respect to the warmest daytime PET-based thermal category and appears to show warmer preferences at the St. Louis Zoo relative to Indianapolis.

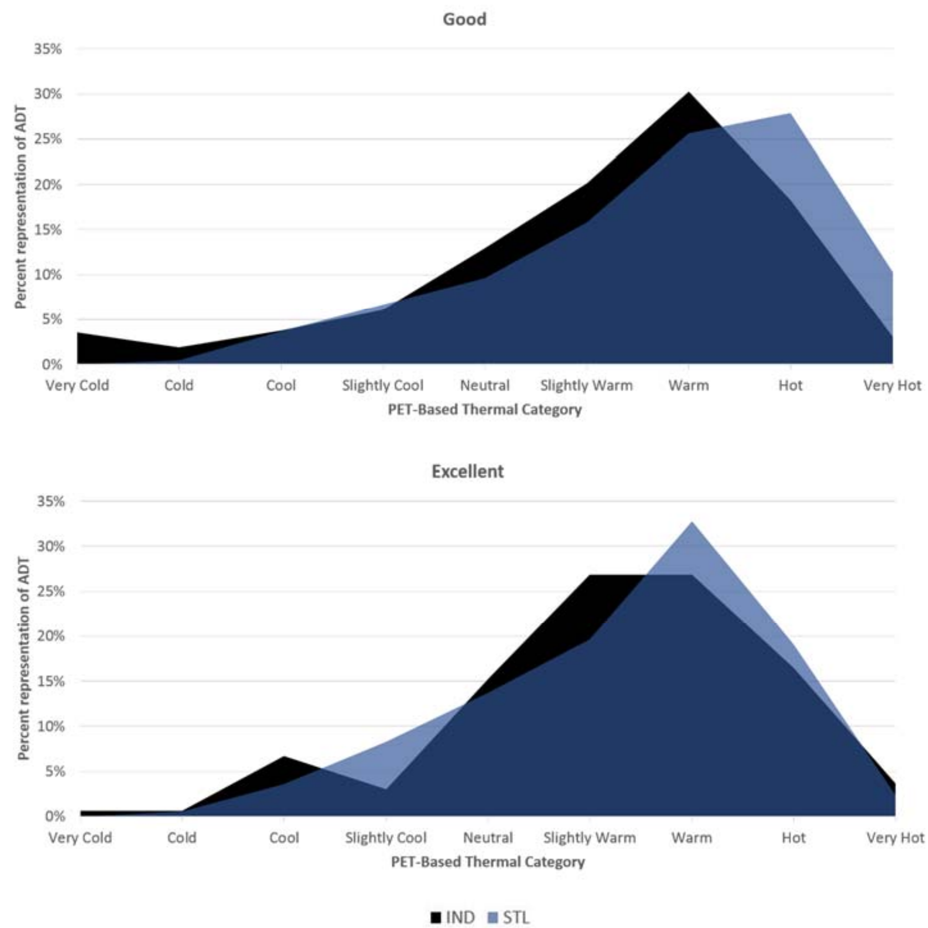

Figure 3.6. Geographic Comparison of Indianapolis (IND) and St. Louis (STL) Zoos for Percent Share of Attendances for 'Good' and 'Excellent' ADT Categories with respect to Highest Daytime PET-Based Thermal Categories

Regarding the 'good' ADT category, St. Louis Zoo showed a much higher representation of 'hot' days and a slightly lower representation of 'warm' and 'slightly warm' days when compared with Indianapolis Zoo indicating that St. Louis visitors may have preferred slightly warmer thermal regimes. Again, in the 'excellent' ADT category, St. Louis Zoo visitors appeared to prefer warmer thermal regimes as Figure 3.6 indicates a higher representation of 'hot' and 'warm' days and a lower representation of 'slightly warm’ and ‘neutral’ days than observed at Indianapolis Zoo. Figure 3.6 seems to suggest that on peak attendance days St. Louis Zoo visitors may have acclimatized to become more ‘heat tolerant’ than visitors to Indianapolis Zoo.

Although physiological acclimatization may be occurring, what also could be driving the warmer temperature preferences in St. Louis is free-admission pricing. For example, on hot days, visitors to the St. Louis Zoo may still visit despite ‘hot’ thermal conditions, because, if it becomes too uncomfortable, they can leave with limited financial repercussions. Conversely, at Indianapolis, while ‘hot’ thermal regimes do not severely decrease attendance, to some visitors, the ‘strong heat stress’ in ‘hot’ thermal conditions may be too uncomfortable to justify paying a non-refundable $14 admission, and, therefore, they do not attend.

Much of the analysis thus far has focused on the connections that exist between zoo visitor attendance and the highest daytime PET-based thermal conditions; however, visits to both Indianapolis and St. Louis zoos last three to four hours on average (Personal Communication, 2015c; 2015d). As a result, most zoo visitors likely assess the weather based on conditions they might experience throughout their time at the zoo location. Because of this, any potential changes in the atmospheric environment during the day may directly influence a decision to visit. To test this, the number of PET-based thermal categories experienced by a visitor during a day (7am to 7pm) is shown in Figure 3.7 with respect to the percent share for each ADT at the Indianapolis and St. Louis Zoos. To illustrate, if the highest PET-derived value obtained for the day occurred in the ‘very hot’ category and the lowest PET-derived value occurred in the ‘neutral’ category, it would represent a day where five thermal categories were experienced by a zoo visitor. Table 3.7 gives further detail regarding the average number of thermal categories experienced in a day for each ADT category.

In Table 3.7 and Figure 3.7 it is apparent that at both zoos, poorly attended days appear to experience fewer thermal categories across the day, while peak visitor attendance is directly related to those days that experience a wide range of PET-based thermal regimes. For example, 'poor' days of attendance at Indianapolis and St. Louis zoos experienced an average of only 1.20 and 1.18 thermal categories; further, 'poor' days in general almost exclusively experienced fewer than two thermal categories. Considering the climates of both Indianapolis and St. Louis, the most likely weather conditions contributing to a day with these 'thermally-stagnant' conditions are either days which began as 'very cold' and did not warm much and/or days with significant cloud cover and possibly rain which led to little daytime warming. Additionally, cloudy days are not aesthetically pleasant conditions for outdoor zoo visits, thereby further decreasing zoo attendances.

Table 3.7. Average number of PET-Based Thermal Categories Experienced during a day for each Attendance Day Typology (ADT)

	Poor	Average	Good	Excellent
Indianapolis Zoo	1.20	2.69	3.46	3.67
St. Louis Zoo	1.18	2.76	3.42	3.48

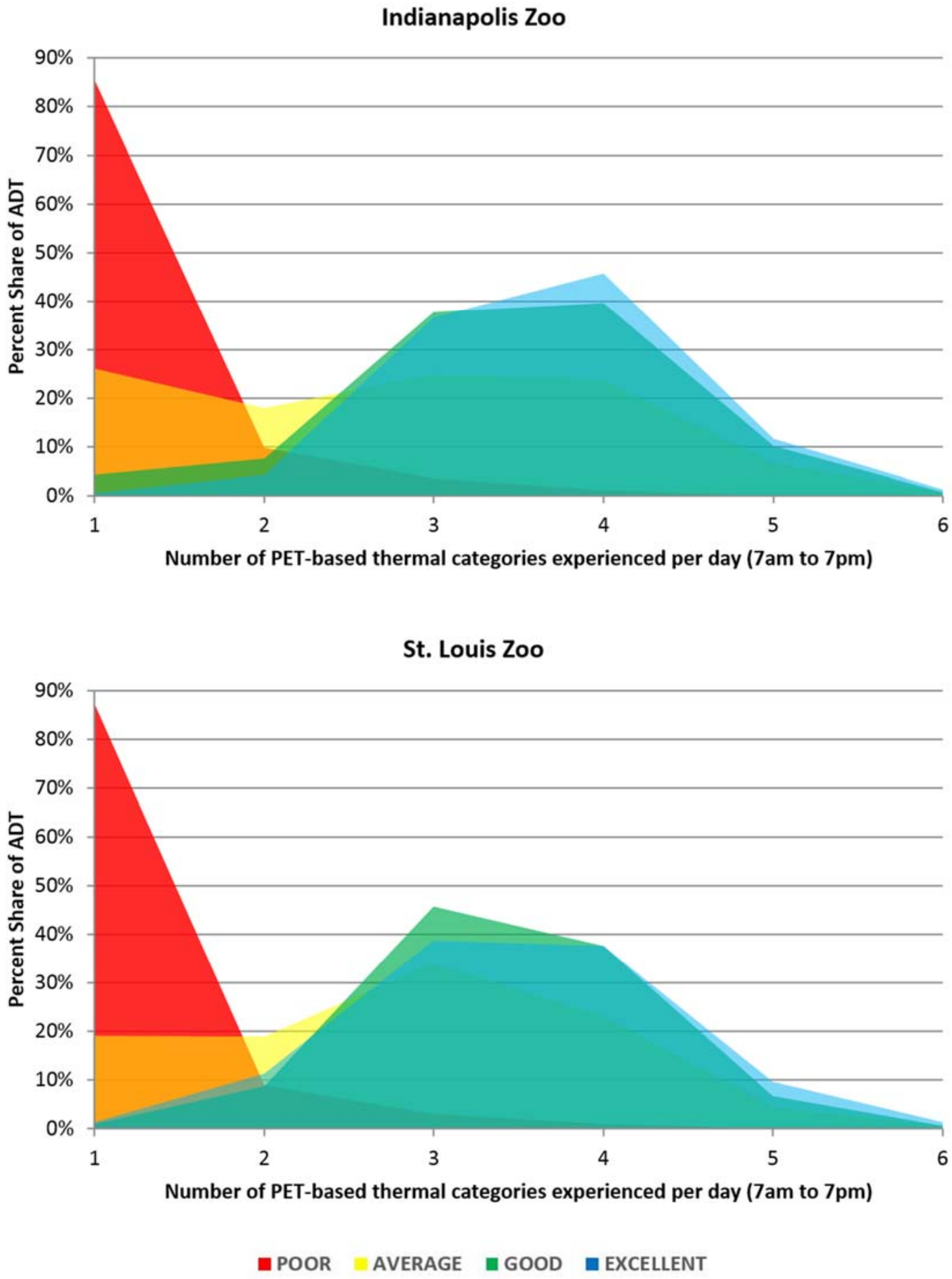

Figure 3.7. Percent Share of Attendance Day Typology (ADT) by Number of Different PET-Based Thermal Categories Experienced by a Visitor per Day (7am to 7pm)

In contrast to the 'poor' attendance days, 'excellent' attendance days experienced a wider range of PET-based thermal regimes. Within the 'excellent' ADT, Indianapolis Zoo experienced an average of 3.67 thermal categories during a day and St. Louis zoo averaged 3.48. Additionally, the highest days of visitor attendance rarely experienced fewer than three PET-based thermal categories. In both Indianapolis and St. Louis, days which experienced three or more PET-based thermal categories would generally experience conditions which were dry, partly cloudy to clear, and began with early morning temperatures that were not within a thermal extreme. As an example, because 'warm' and 'slightly warm' thermal categories are most associated with high attendances at both zoos, a day where morning low temperatures likely began in the 'cool' to 'slightly cool' range and gradually warmed throughout the day should accurately describe many days which experienced three or more thermal categories.

[3.5] Conclusions and Future Direction

In consideration of the implications of climate change, the United Nations World Tourism Organization suggested that governments and communities should develop climate information tailored to the tourism sector and implement policy based on the interactions between weather and tourists (UNWTO, 2014). This paper has outlined research which has addressed both long-term climate implications on tourism and short-term impacts weather has on tourism participants. The particular purpose of this paper was to build on the original work of Perkins and Debbage (2016a) whose research addressed the interfaces between ambient thermal conditions and visitor attendances at zoological parks. This original work was begun as a response to the suggestions of Nicholls *et al.* (2008), Scott and Jones (2006), and Scott *et al.* (2012), all of whom suggested that before undertaking significant research on the implications of climate change in the tourism industry, we must first better understand how different weather and climate factors impact tourists. Further, as originally argued by Perkins and Debbage (2016a), a focus on zoological parks addresses a large and important sector of the Tourism, Recreation, and Leisure (TRL) sector. Moreover, because zoological parks cater to both children and the elderly, zoos have the potential to serve as a 'canary in the coalmine', indicating how the most vulnerable populations in society may react to the outdoor thermal conditions.

Specific findings of this research provide a broader geographic context to the original work of Perkins and Debbage (2016a) and help provide foundational information regarding human thermal preferences and how those preferences may vary across diverse climates. For example, similar to the Phoenix and Atlanta zoos (Perkins and Debbage, 2016a), it was found that 'optimal thermal conditions' for peak attendances at both the Indianapolis and St. Louis zoos generally occurred within the 'slightly warm' and 'warm' thermal categories.

While there was a general agreement in the 'optimal' thermal categories for attendance, the two zoos showed nuanced differences in visitor thermal preference within the highest days of attendance. In particular, within the 'good' and 'excellent' ADT categories, visitors at St. Louis Zoo indicated a greater preference for warmer thermal regimes than visitors at both Indianapolis Zoo. While it is possible that these warmer thermal preferences observed in St. Louis were due to physiological acclimatization, they appear more likely to be visitor responses to free-admission pricing.

Among those thermal conditions most associated with 'poor' levels of attendance, this research also confirmed findings from the original Perkins and Debbage (2016a) research which concluded that the most common thermal extreme condition at a location tends to be associated with the lowest visitor attendances on record, resulting in an 'extreme temperature aversion'. Both Indianapolis and St. Louis zoos experienced 'very cold' conditions in greater frequency than 'very hot' days, and appeared to experience 'cold aversion' on the lowest days of attendance. Visitors also appeared to show attunement to the number of thermal categories experienced throughout a day. It was determined that Indianapolis and St. Louis zoos saw highest attendances when three or more thermal categories were experienced in a day.

Price serves in many ways to control visitor attendances at zoological parks and other similar TRL venues. While price may directly impact the ability of low-income groups to attend, its impacts on how people may change their interpretations of the weather is less certain. Although 'very cold' thermal regimes and 'thermally-stagnant' weather seem to be detrimental to visitor attendance, price may also play a role. It appears that visitors to St. Louis Zoo are more likely to take a chance and visit the zoo even if the weather is not 'optimal' because admission is free and the financial implications are lessened.

Although slight differences in the thermal preferences of visitors between the Indianapolis and St. Louis zoological parks have been identified, and a comparison with the work of Perkins and Debbage (2016a) has been provided, future research incorporating metropolitan zoos in more diverse climates would be excellent tests to determine if local climates continue to influence ‘poor’ attendance days and whether a ‘universal optimal thermal condition’ continues to persist regarding the highest days of attendance. Moreover, this paper suggested that admission pricing may have an impact on how people interpret the weather. To test this hypothesis in increased detail, a more complete analysis of admission pricing would be useful in determining how price may contribute to ways in which people interpret the ambient environmental conditions. Other metropolitan zoos that offer free-admission, such as Lincoln Park Zoo in Chicago, Illinois or Como Zoo in Saint Paul, Minnesota, could be useful case-studies when studying the interface of price, attendance, and weather.

Better understanding how tourists and recreationalists behave today in response to weather will give insights into how they will also respond to a changing climate. Such information can potentially be used by communities and businesses to make better-informed policy and planning decisions moving forward.

CHAPTER IV

USING SYNOPTIC WEATHER TYPES TO PREDICT VISITOR ATTENDANCE AT THE ATLANTA AND INDIANAPOLIS ZOOLOGICAL PARKS

Single Authorship for *International Journal of Biometeorology*

[4.1] Introduction

Weather impacts on outdoor tourists and recreationalists are multifaceted and complex not only because humans can respond differently to similar outdoor conditions (Lin and Matzarakis, 2008; Knez and Thorsson 2006; Matzarakis and Mayer, 1996; Nikolopoulou and Lyoudis, 2006), but also because complexities exist when attempting to describe the ambient atmospheric environment (Scott, 2008; de Fretias, 2008). Human psychological interpretation and physiological sense of the weather cannot be completely explained by a single weather variable such as temperature, rain, or humidity because the ambient atmospheric environmental conditions are reflections of multiple weather variables acting in concert to produce a particular weather condition. Because of this complexity, an index incorporating weather variables to describe the ambient atmospheric conditions is often used for an improved approximation of the weather (Scott *et al.*, 2004; de Freitas *et al.*, 2008, Mieczkowski, 1985; Hwang *et al.*, 2007; Andrade *et al.*, 2011; Scott *et al.*, 2008; Lin, 2009; Matzarakis, 1996) though the appropriate scale and scope of such an index has been much discussed (Scott *et al.*, 2004, Scott *et al.,* 2008, de Freitas *et al.*, 2008).

Despite these challenges, economic sectors encompassing Tourism, Recreation, and Leisure (TRL) can benefit from better understanding the complex relationships that exist between weather and consumer behavior (Nicholls, 2008; Gomez-Martin, 2006; Scott, 2008; Hale and Altalo, 2002; Perkins and Debbage, 2016a; 2016b). Additionally, an index using weather variables reflecting the activities of participants within the TRL sector could lead to an improved business decision-making process as a result of an increased understanding of the complex weather-tourist relationship (Nicholls, 2008; Perkins and Debbage, 2016a; 2016b).

Research on the relationships that exist between weather, climate, and tourism has largely assumed that weather directly impacts tourists in both indoor and outdoor venues where indoor tourist venues are impacted more by accessibility issues in the event of inclement weather (Olson, 2008; Tepfenhart *et al.*, 2007), and outdoor venues are impacted more by the comfort levels a tourist or recreationalist will likely experience when exposed to the ambient environment (Scott *et al.*, 2008; Gomez-Martin, 2005; Raukem *et al.*, 2010). Additionally, regional climates which create expectations of the most likely weather conditions a traveler will experience can also impact tourist travel decisions even prior to the visit (Agnew and Palutikof, 2001; Hamilton and Lau 2005; Bigano, *et al.*, 2006). While there is general agreement that weather will impact vacation decisions prior to an actual visit and influence tourist behavior and comfort once at a location (Gomez-Martin, 2005), there is not consistent agreement as to how the concept of a ‘tourism climate’ should be best quantified. Quantifying weather impacts to yield a ‘tourism index’ to describe a particular location are frequently broad-based but are also refined to business interests, economic development, climate change implications, and the physical well-being of non-local tourists (Scott, 2008; Hale and Altalo 2002; Mieczkowski, 1985; Curtis, Arrigo, and Covington, 2008).

Current research in this realm is frequently discussed in the International Society of Biometeorology’s Commission on Climate, Tourism and Recreation and within the research field of ‘Tourism Climatology’ (Scott, 2008; Matzarakis and de Freitas, 2001; Matzarakis *et al.,* 2004; Matzarakis *et al.,* 2007). Recent research has attempted to improve foundational tourism climate indices such as Miezckowski’s (1985) global ‘Tourism Climate Index’ (TCI) to better reflect the physiological and psychological conditions experienced by a tourist or recreationalist (Scott, 2008; de Freitas *et al.*, 2008). Other improvements address geographic precision by considering potential acclimatizations, urban/rural location, cultural preferences for particular environmental conditions (de Freitas, 2014; Rutty and Scott, 2009; Knez and Thorsson 2006; Nikolopoulou and Lyoudis, 2005; Matzarakis and Mayer, 1996; Lin and Matzarakis, 2008), and levels of physical exertion by considering the different activities tourists perform (Brandenburg and Ploner, 2002; Suminski *et al.*, 2008). Unfortunately, as indices have become increasingly location-specific and depart from global models (e.g., the TCI) their use becomes less translatable across geographies as they only describe specific activities, sites, climates, or populations which have potentially adapted to a particular climatology.

The purpose of this paper is to propose and test the applicability of the Spatial Synoptic Classification (SSC) (Sheridan, 2002) as a tool to predict visitor attendance response in the TRL sector across different climate regimes. Specific choice of this weather-type classification is in response to the need for a translatable meteorologically-based index which captures generalized ambient atmospheric conditions but still considers local climatology. In detail, this paper examines how approximately one decade of daily synoptic weather conditions impacts daily zoo visitor attendance. It does so by examining Zoo Atlanta and Indianapolis Zoo, two zoological parks similar in annual attendance and physical size but located in different climates.

[4.2] Theoretical Background and Context

Classifications of the ambient atmospheric environment began as efforts to better comprehend nature and to help create generalized guides of a global environment. One of the earliest but still prevalent (with recent modifications) environmental classifications is Köppen's (1931) system of climate classifications which described the world in general classes based on local measures of native vegetation, temperature, precipitation, and the seasonality of precipitation regimes. The purpose of such classifications changed, however, from a focus on describing the natural environment in general, to a focus on describing the natural environment from a more applied humanistic point of view. As discussed by Miezckowski (1985), following original nature-oriented classification systems of Köppen (1931), Thornthwaite (1931 and 1948) and others, some classifications became more human-oriented than nature-oriented. Research by Brazol in

Argentina (1952), Davis in Great Britain (1968), and Gates in the United States (1973) concerned outdoor human comfort classifications and were precursors of a new type of research that was beginning to focus more on geographically-specific human-oriented classifications of the climate.

The emerging focus on human-oriented descriptions of the environment echoed the applied research of the time and the related growth of international tourism (Mieczkowski, 1985). Perhaps one of the first classifications of weather with regards to a tourist resort destination in this ‘new era’, Burnet (1963) addressed the climatic regionalization of seaside resorts in France and was followed by research describing the ‘tourism climate’ of the Mediterranean region (Heurtier, 1968) and Canada (Crowe, 1976). Generally, the goal of these new descriptions of a ‘tourism climate’ was to address the needs of temporary visitors who would be interested in climatic conditions during specific times of the year (Mieczkowski, 1985), in essence, to educate the general public as to the ‘nature’ of a place.

To provide global context for a ‘tourism climate’, Mieczkowski (1985) published the Tourism Climate Index (TCI) which was regarded as the most comprehensive climate index developed specifically for tourism (Scott, 2004). The goal of the TCI was to provide a universal measure for the ‘climatic well-being’ of a tourist recreating at a level of ‘moderate sightseeing’ or the equivalent of a ‘slow, steady walking’ pace. The TCI was based on monthly weather variables of temperature, sunshine, precipitation, and wind speed which were combined into an index value derived by separately scoring each weather variable on a monthly basis and totaling the results in a weighted formula. Final

TCI results scored a particular month at a location between -10 and 100 to reflect the climatic suitability for a tourist's well-being (Mieczkowski, 1985). The primary factor considered in the TCI index was thermal comfort as it comprised 50% of the formula weighting. To calculate thermal comfort, TCI utilized a 'modified thermal comfort' rating system based upon biometeorological studies by the American Society of Heating and Air Conditioning Engineers (ASHRAE, 1972). Gradations of thermal comfort based upon temperature and humidity (effective temperature) were adjusted for the TCI by utilizing a scale derived from a 'psychrometric' chart. Precipitation was assessed as having a negative relationship with the overall TCI score and 'mean monthly hours of sunshine' was considered to have a positive relationship with the TCI score. Precipitation and sunshine each accounted for 20% of the weight within the overall index. Although the lowest represented weather variable within the TCI formula at 10%, wind was assessed in a more complex manner regarding the outdoor tourist because it was dependent upon the ambient temperature and is threshold-based. For example, too much wind and too little wind have negative impacts on tourist comfort; however, the relationship with wind changes when temperatures are low and a 'wind chill' factor exists.

While Miezckowski's TCI (1985) has served as a foundation index within tourism climate studies, more recent indices attempted to specify and improve upon the application of the TCI. One commonly used improvement adjusted the weighting schemes of meteorological variables to reflect the preferences of the tourist/recreationalist through survey-response methodologies (Rutty and Scott, 2014;

Hwang *et al.*, 2007; Andrade *et al.*, 2011; Scott *et al.*, 2008; Lin, 2009; Matzarakis, 1996). Prominent indices of note which have been published recently and attempted to advance the original TCI included the "user-based beach climate index" (Morgan *et al.*, 2000), and the "second generation climate index for tourism (CIT)" (de Freitas *et al.*, 2008) which proposed both a tourism index and a conceptual framework for future tourism climate indexes.

The 'user-based beach climate index' (Morgan *et al.*, 2000) was a survey-based specification of Mieczkowski's TCI which reviewed tourist preferences of thermal sensation, bathing water, sunshine, wind speed, and precipitation. This index utilized the foundations of the TCI but specified them regarding tourist activities in an attempt to lead to a better understanding of the weather preferences of recreationalists as end-users. Morgan *et al.* (2000) altered the weights of the TCI weather variables based on survey responses which allowed the end-users to weight the factors in the tourism index rather than imposing a top-down 'expert based' approach to the index.

The 'second generation climate index for tourism' (CIT) (de Freitas *et al.*, 2008) provided both a conceptual framework and an applied index for the future development of tourism climate indices where it defined the 'essential features' needed in a tourism climate index. The authors listed guidelines and several key needs for tourism climate indices that included (1) theoretical soundness, (2) a comprehensive treatment of climate, (3) simplicity in calculation, (4) a user-friendly display, (5) use of threshold overriding effects, and (6) empirical testing. First, 'theoretical soundness' was defined as having consideration of past studies which aimed to better understand tourism and weather/climate relationships. Additionally it required using a multidisciplinary approach combining physical and social sciences to create a more 'complete' index. Second, the 'comprehensive treatment of climate' identified the need to consider the thermal relationship the human has with the environment as the prominent factor when studying tourist comfort; namely it suggests the use of biometeorological temperature models. Further, de Freitas *et al.* (2007) suggested the nine-point thermal scale established by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE, 2001, 2004) be used because it is one of the primary tools by which biometeorology conveys thermal sensation categories. These nine thermal categorizations of the ASHRAE scale are continuous and are described as: 'very cold', 'cold', 'cool', 'slightly cool', 'neutral', 'slightly warm', 'warm', 'hot', 'very hot'. Third, 'simplicity in calculation' guidelines suggested that models incorporate readily-available meteorological data on daily or hourly intervals. Fourth, a 'user-friendly display' referred to the need for attention to the 'nature and form' of the tourism index output since the purpose of the index is to be accessible and understandable to all users both inside and outside academia. Fifth, 'threshold overriding effects' relates to better integrating the nonlinear impacts of a climate system. For example, certain weather conditions such as the presence of heavy rain or high winds can profoundly impact a tourist environment regardless of the prevailing thermal conditions. Sixth, 'empirical testing' suggested implementing end-user surveys to derive index weightings rather than expert-defined determinations. An index following these guidelines, de Freitas *et al.* (2008) argued, should have a higher degree of 'ground truth' and would likely be more accurate with respect to the targeted audiences.

With these theoretical guidelines in mind, de Freitas *et al.* (2008) proposed the CIT index, a weighted combination of thermal (T), aesthetic (A), and physical (P) measures of the environment. The thermal measures (T) were biometeorological assessments of the body-atmosphere energy balance. The authors did not specify a particular index but recommended using a human heat balance model that is presented following the nine factor ASHRAE scale. The aesthetic factors (A) referred to the visual 'appeal' of the sky conditions (cloudiness). For example, in beach tourism venues a large amount of cloud cover is not preferred by tourists. The physical measurement (P) incorporated 'overriding threshold effects' defined by the authors as events with greater than three millimeters of rain within a particular hour and/or wind speeds higher than six meters/second. In the event of these physical thresholds being satisfied, the physical facet (P) of the CIT equation assumed greatest weighting. Normal weighting of the CIT is a result of interviews with tourists and recreationalists where questions are asked regarding the relative importance of sunshine, absence of strong wind, absence of rain, importance of comfortable temperature, preferred wind speed, and preferred percentage of cloud cover. Overall CIT ratings (1 poor, 7 ideal) are displayed by de Freitas *et al.* (2008) in a three-dimensional matrix (Figure 4.1) showing index scores in correspondence with the nine point thermal sensation scale (T) and the relative aesthetic (A) and physical (P) ratings components.

Empirically tested for beach tourism, results from the CIT ratings, seen in Figure 4.1 (de Freitas *et al.*, 2008), indicate that for sedentary beach tourists/recreationalists there is a thermal preference for ‘hot’ and ‘warm’ conditions; however, the magnitude of the overall tourism rating is modified based upon varying combinations of weather variables.

ASHRAE scale TSN [T]		Cloud (≤40%) [A]	Cloud (≥50%) [A]	Rain (>3mm or >1hr duration) [P]	Wind (≥6m/s at ground) [P]
Very hot	(+4)	4	3	2	3
Hot	(+3)	6	5	2	4
Warm	(+2)	7	5	2	4
Slightly warm	(+1)	6	4	1	4
Indifferent	(0)	5	3	1	2
Slightly cool	(-1)	4	3	1	2
Cool	(-2)				
Cold	(-3)				
Very cold	(-4)				

Figure 4.1. Example of CIT Ratings in a Beach Tourism Climate where 1 is Poor and 7 is Ideal. Thermal conditions (T) are based on the ASHRAE Thermal Sensation Scale, also included in the Overall Index Score are Aesthetic Variables (A), and Physical Factors (P) Adapted from de Freitas et al. (2008).

In order to address the need for a holistic meteorologically-based variable capturing the present ambient atmospheric environment yet still considering the climatology of a location, this paper proposes and tests the Spatial Synoptic Classification in the realm of tourism. The Spatial Synoptic Classification (SSC) originated as a weather classification system designed to identify the character of a particular air mass (Kalkstein et al, 1996). While the SSC classification relies on the logic of an ‘air mass’, described by Crowe (1971 p. 589) as a volume of air which has acquired “characteristics of temperature and humidity related to the condition of the sea, land, or ice beneath it”, it is not an air mass classification. Instead, the SSC is a weather type classification that captures the character of a particular synoptic regime (Sheridan, 2002), based on the Temporal Synoptic Index (TSI) (Kalkstein and Webber, 1990). Meteorological variables utilized in the calculation of the SSC include temperature, dew point, east/west and north/south wind vector components, cloud cover, and sea-level pressure where each variable is assessed four times daily at standardized local times. Analysis also includes a climatological examination of ‘seed days’ that incorporate local and historical weather readings to categorize a particular air mass in a region. ‘Seed days’ are defined as days in a location’s climatological period of record containing ‘typical’ meteorological characteristics of a particular weather type. The calculation of ‘seed days’, therefore, relies on the climatology of a particular location. Basing its definition on local and historical data allows the SSC to be an index that is geographically scaled and ‘relative’, rather than ‘absolute’, as it accounts for the climatology of a location or region (Hondula *et al.*, 2014).

The SSC includes seven general categories further explained in Table 4.1:

Table 4.1 The Seven Categories of the Spatial Synoptic Classification (SSC) with Descriptive Definitions. Adapted from Sheridan, 2002.

Name	Description
Dry Polar (DP)	Dry air usually from polar regions; coldest temperatures during the year
Dry Moderate (DM)	Mild and dry air; often found when a traditional air mass is moderated
Dry Tropical (DT)	Dry air representing the hottest and driest conditions of the year

Moist Polar (MP)	Cloudy, humid, and cool weather types
Moist Moderate (MM)	Variable in its seasonality; considerably warmer than moist polar conditions
Moist Tropical (MT)	Warm and humid air; often oppressive conditions
Transitional (TR)	Air mass transition from one to another

Most applied research using the SSC has focused on studies pertaining to weather, climate, and human health, particularly heat-health warning systems and morbidity/mortality studies (Hondula *et al.*, 2014). The SSC has also been used in research throughout the globe and in many differing climates including cold regions concerned with how cold weather impacts human mortality (Rainham *et al.*; 2005 Kalkstein and Sheridan, 2011). In a review of the SSC, Hondula *et al.* (2014, p. 109) have noted, "It has been used in a diverse range of climatological investigations, including analysis of air quality variability, human health, vegetation growth, precipitation and snowfall trends, and broader analyses of historical and future climatic variability and trends." Little research, though, considers the SSC outside the field of weather, climate, and human health, though Hondula *et al.* (2014) addressed the need for future development in more diverse research fields.

In response to de Freitas *et al.* (2008) and Mieczkowski (1985) who expressed that tourism-climate research needs to develop a more comprehensive index aimed at reflecting the 'well-being' of tourists, this paper tests the ability of the Synoptic Scale Classification (SSC) to serve as an index which incorporates a 'comprehensive treatment of climate' regarding outdoor-oriented zoo tourism. The SSC has potential use within tourism studies for several reasons. First, it bridges the gap between global indices (TCI) and geographically-tailored indices that may not be translatable across cultures or locations. Second, because its calculation methodology is relative to the location it is describing, the SSC is a variable that may consider regionalized acclimatization of local tourists and recreationalists. Third, as the SSC has been found to be associated with health outcomes in environmental health research, it may reflect a component of the decision-making process tourists likely undergo when participating in outside tourist or recreationalist activities. As an example, it can be reasonably assumed that people regard personal comfort and well-being in their decisions to be outdoors; attendance turnout in outdoor venues should, therefore, be at least partially reflective of these personal health considerations. Fourth, because the SSC captures multiple factors of an atmospheric environment and single weather variables are not entirely reflective of the actual ambient atmospheric environment experienced by a human when outdoors, the SSC will likely better reflect conditions on which tourists base their decisions pertaining to the weather. Fifth, because the SSC reports a generalized weather condition rather than specific numerical thermal or humidity thresholds, it may be more applicable to use in research where human 'indifference' is a contributing factor. For example, as observed in Perkins and Debbage (2016a; 2016b), ranges exist where attendances appear steady despite changing thermal regimes, indicating some degree of visitor 'indifference' regarding weather conditions. This suggests that people may take generalized weather conditions into consideration rather than just one single aspect of the weather. As a result, the SSC may be a useful variable in attendance prediction as it potentially reflects a generalized ambient environment to which people react.

[4.3] Methods

In this paper it is hypothesized that the Spatial Synoptic Classification (SSC) will act as an element that can be used to help predict visitor attendances in outdoor zoological parks. Although the SSC does not report actual precipitation or temperature metrics but, instead, classifies generalized synoptic-scale weather types over large spatial extents, certain categories of the SSC still will likely coincide with visitor attendances because visitors respond not to individual facets of the weather, but to an overall atmospheric condition. Because the SSC captures this overall atmospheric condition, it is likely, particularly when comparing high and low days of visitor attendances, that there will be key associations between the SSC and visitor attendances. Specifically, it is hypothesized that warmer and drier SSC categories such as 'Dry Moderate' ('DM') and 'Dry Tropical' ('DT') will be associated with the highest days of visitor attendance, and SSC categories, such as 'Moist Polar' ('MP') and 'Dry Polar' ('DP') describing cold/wet conditions, will be most associated with lower days of visitor turnout. Although there will be general associations between SSC categories and visitor attendance, it is less clear when considering the large spatial-scale of the SSC, if it will provide detailed insight into visitor behavior between varying geographic locations. Additionally, it is also unclear if the SSC will provide detailed analysis on any subtle attendance variations as was observed in the research of Perkins and Debbage (2016a; 2016b) concerning thermal environments. Regarding the possible difficulty in geographic comparison, it is hypothesized that the calculation process of the SSC may mask differences across geographical locations in the behavior of zoo visitors. The reason behind this is the SSC calculates its categories with respect to local climatology and, in essence, 'acclimates' its synoptic categories for each location. As a result, any small-scale acclimations zoo visitors have developed for a particular location may already be integrated into the SSC categories, and, therefore, these acclimations may not be apparent when comparing weather preferences across locations.

Visitor attendances were calculated at each zoological park using daily attendance data collected from September 2001 to June 2011. This time period was selected because it represented a period where at each zoo there was no significant change in the array of attractions. Additionally, incorporating a period of nearly one decade helps control for impacts resulting from severe weather events. Using the methods of Perkins and Debbage (2016a; 2016b), visitor attendances at each zoo were segmented into four statistically-based attendance categories called Attendance Day Typologies (ADTs) (Figure 4.2). These attendance categories included:

- Poor attendance days: daily visitor attendance is less than one standard deviation below the mean daily attendance
- Average attendance days: within one standard deviation of the mean daily attendance
- Good attendance days: between one and two standard deviations above the overall daily attendance mean
- Excellent attendance days: attendance is more than two standard deviations above the daily attendance mean

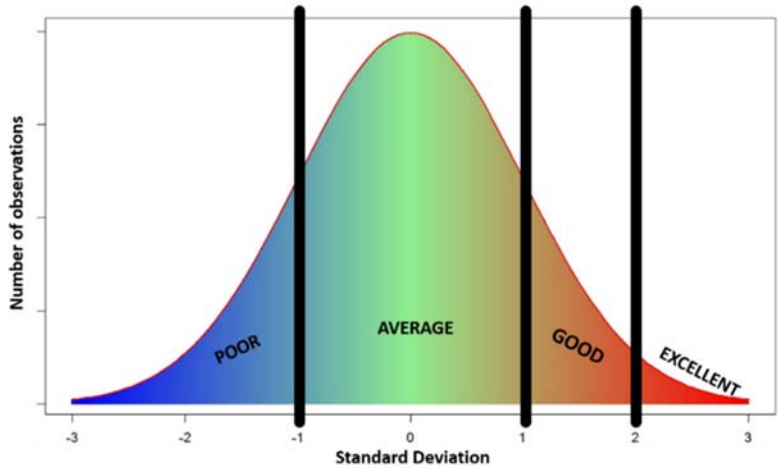

Figure 4.2. Theoretical Normalized Distribution of Attendance Data by Attendance Day Typology (ADT). Adapted from Perkins and Debbage, 2016a; 2016b

More ADT categories exist above the mean than below the mean. This was explained by Perkins and Debbage (2015, p. 9) who observed that "part of the logic for including two categories of attendance more than one standard deviation above the mean attendance (i.e., 'good' and 'excellent' days) is their disproportionate impact on overall attendance." For example, though attendances at Zoo Atlanta and Indianapolis Zoo fell within the 'good' and 'excellent' categories an average of only one day out of every seven, the total visitor attendance for these two ADTs accounted for an average of 42.1% of the total yearly visitor attendance.

The Synoptic Scale Classification (SSC) data used in this paper were obtained online as daily data from Sheridan's "Spatial Synoptic Classification Homepage" (Sheridan, 2014). For the study period, every day was assigned a specific SSC category identifying the synoptic condition most associated with the prevailing weather conditions at the location. In the event of more than one synoptic weather type occurring on one day, the SSC system classifies the day as a 'Transition' ('T') category; as a result, there is never more than one SSC for any day. For further illustration of the spatial extent of the SSC categories, Figure 4.3 illustrates an example of a map obtained from Sheridan's "Spatial Synoptic Classification Homepage" (Sheridan, 2014) that displays the distribution of SSC conditions across the contiguous United States on August 14, 2004, a day when both Indianapolis and Atlanta zoos experienced 'excellent' attendances over 10,000 visitors.

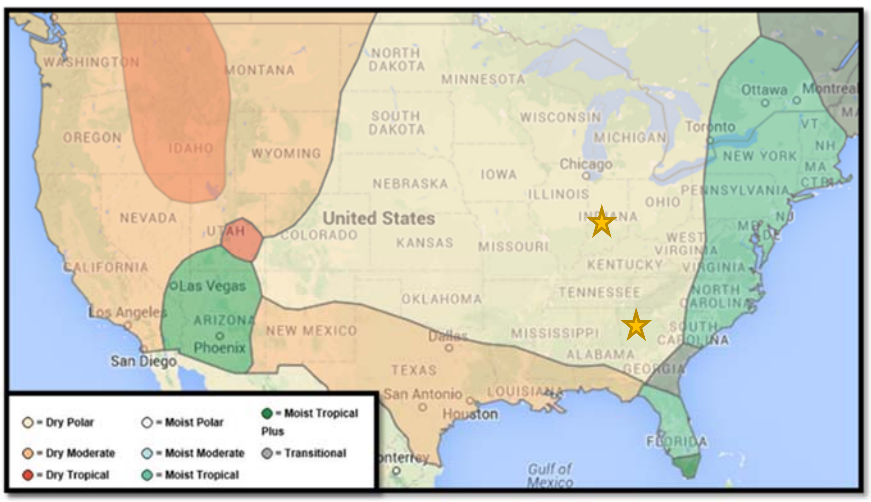

Figure 4.3. An Example Map of the Spatial Distribution of SSC Conditions Across the Contiguous United States on August 14, 2004. Obtained from Sheridan's "Spatial Synoptic Classification Homepage" (Sheridan, 2014).

For each day at each zoo location the Synoptic Scale Classification (SSC) category was paired with the total daily visitor attendance. After these pairings were made, analysis was performed within each of the four established Attendance Day Typology (ADT) categories of 'poor', 'average', 'good', and 'excellent' to determine what SSC type occurred most often regarding particular levels of visitor attendances. For example, findings will provide evidence of what SSC categories are most associated with high and low visitor attendances. Additionally, after observing the general trends between SSC categories and attendance volumes, more detailed analysis compares the relationships seen at Zoo Atlanta with those found at Indianapolis Zoo to determine if there are differences between Atlanta and Indianapolis in how visitors respond to the synoptic weather conditions.

Using zoological parks as the tourist locations in this research is substantiated by Perkins and Debbage (2016a; 2016b) who discussed the methodological advantages of using zoological parks as 'test laboratories' for the assessment of weather impacts on visitor behavior. Those same advantages can be found in this research which compares the visitor attendances and prevailing synoptic weather categories at Zoo Atlanta and Indianapolis Zoo. For example, zoological park visitors generally have certain expectations regarding the reasons why they visit and the outdoor exposure they will likely experience when on site. Although there are differing motivations for zoo visitors, they generally go to learn about animals, conservation, and nature, and patrons expect this to occur mostly in an outdoor setting regardless of the geographic location of the zoo (Falk et al, 2007). Research concerning zoological park visitors involves a more standardized visitor who engages in sightseeing at a "slow steady walking" (Mieczkowski, 1985) pace. By contrast, other tourist venues, such as beaches or parks, assess visitors who engage in a wide variety of activities, many of whom may interpret the ambient environment differently depending on their goals (Brandenburg and Ploner, 2002; Ploner and Brandenburg, 2003; Rutty and Scott, 2014; Morgan *et al.* 2000). Zoo locations provide accurate sources of visitor attendance data over time because they must account for all visitors on their property and for financial accounting reasons. Additionally, because zoological parks are managed properties, the park space has definite geographic boundaries with fixed entry and exit points. In other venues methodological difficulties can arise when counting attendees in open-boundary spaces, such as botanical gardens and nature parks with multiple entrances and beach fronts with undefined geographical spaces (Knez and Thorsson 2006; Rutty and Scott, 2014; Curtis, Arrigo, and Covington, 2008; Morgan *et al.*, 2000).

Atlanta and Indianapolis zoos have many relatable aspects which should allow for better isolation of the weather-visitor attendance relationship. Both zoological parks are located in major metropolitan areas and each is positioned within the urban downtown. Visitor length-of-stay is comparable as the average visitor spends approximately three to four hours per trip at both zoos (Personal Communication, 2015a; 2015c). Because visitors plan to spend several hours outdoors when visiting, this most likely forces them to consider the daily weather in their planning considerations. The Atlanta and Indianapolis zoos largely attract day-trippers from within the respective metropolitan areas. To illustrate, at Zoo Atlanta 67% of the guests are from within the state of Georgia (Personal Communication, 2015a); at Indianapolis Zoo 85% of guests are from the state of Indiana (Personal Communication, 2015c). Given the large numbers of local 'day-trippers' with less fixed schedules, it is likely that visitor decisions may be more aligned with weather conditions than they would in other outdoor tourist venues with many nonlocal visitors. This is supported by findings from Nicholls *et al.* (2008) who observed that locations with larger shares of local visitors were more sensitive to the prevailing weather conditions than those with non-local visitors. Additionally, both zoos are located in large metropolitan areas and charge moderate admission fees.

The prevailing climate of each zoo location may contribute to the way in which visitors to the zoo interpret the synoptic conditions; furthermore, these climate differences across zoo locations may give insight regarding potential human acclimatizations. Atlanta is classified by the Köppen-Geiger climate classification system as a location with a 'humid subtropical climate' (Cfa). This type of climate has four distinct seasons where precipitation occurs throughout the year without any predominant rainy season. The warmest month in Atlanta is July which averages 26.8°C; however there are also periods of significantly warm conditions as approximately 44 days per year exceed 32°C. The coldest month in Atlanta is January, averaging 6.4°C; additionally, approximately 40 days per year have low temperatures below freezing. While precipitation is relatively steady throughout the year, the driest month in Atlanta is October which averages 86.6mm and the wettest month is July which averages 133.9mm. Total yearly precipitation averages 1,262mm. Precipitation in Atlanta generally falls as rain. Winter precipitation can come in the form of snowfall, though Atlanta generally experiences a mix of freezing rain and sleet conditions that can negatively impact transportation in the region (NOAA, 2014).

The climate of Indianapolis is similar to Atlanta but generally cooler, slightly drier, and more variable. It is classified by the Köppen-Geiger climate classification system as a location with a 'humid continental climate' (Dfa). Again, this climate has four distinct seasons with precipitation occurring throughout the year with no particular rainy season. The warmest month in Indianapolis is July which averages 24.1°C; however, there are also periods of significantly warm conditions as approximately 18 days per year exceed 32°C. The coldest month in Indianapolis is January which averages -2.2°C; additionally, approximately 103 days per year have low temperatures below freezing. Precipitation in Indianapolis is relatively steady throughout the year, though there is some variation as the driest month is February which averages 58.9mm and the wettest month is May which averages 128.3mm. Total yearly precipitation averages 1,078mm. Precipitation in Indianapolis generally falls as rain. Winter precipitation in Indianapolis comes in the form of snowfall more often than in Atlanta; however, Indianapolis also periodically experiences a mix of freezing rain and sleet conditions (NOAA, 2014).

[4.4] Findings

From September 2001 to June 2011, the Atlanta and Indianapolis zoological parks generated a total combined attendance of 17.3 million visitors. During this period, Zoo Atlanta averaged slightly over 0.75 million visitors per year, and Indianapolis Zoo attracted approximately one million visitors on an annual basis. Zoo Atlanta, established in 1889, is one of the oldest zoos in the United States and today is highly regarded for its giant panda exhibit, one of only four zoos in the U.S. with this species on exhibit. The Indianapolis Zoo has been in operation since 1964 and is one of the few zoos to have both an accredited zoological park and botanical garden on the same site. Presently, Indianapolis Zoo is widely known for its $21.5 million International Orangutan Exhibit, one of the premiere orangutan exhibits in the world. Clearly, both zoos have well-established histories and sophisticated arrays of attractions; what is less clear is how at each zoo varied synoptic weather conditions might impact average daily visitor attendance.

Illustrated by zoo in Table 4.2 and Table 4.3 are the total number of days represented (Table 4.2) and the total visitor attendances (Table 4.3) within each of the four Attendance Day Typologies (ADTs) ‘poor’, ‘average’, ‘good’, and ‘excellent’. The statistical grouping methodology to define ADT categories expectedly makes the ‘average’ ADT the largest category in terms of number of days and in terms of total visitor attendances at both zoos. A comparison between Tables 4.2 and 4.3 shows a key difference in the percent representations between number of days and total visitor attendances where the total visitor attendances are lower than would be expected considering the number of days analyzed. For example, in Zoo Atlanta ‘average’ days represent 76.1% of the total days analyzed but only 61.0% of total visitor attendances; at Indianapolis Zoo the ‘average’ ADT represents 68.9% of the days analyzed but only 54.1% of the total visitor attendances. This discrepancy in percent representations can be readily explained by observing the higher days of attendance in the ‘good’ and ‘excellent’ ADT categories. In Table 4.2, combining ‘good’ and ‘excellent’ ADT categories accounted for only 14.1% of the total number of days represented in Atlanta and only 16.5% in Indianapolis; however, in terms of total visitor attendances (Table 4.3), the ‘good’ and ‘excellent’ ADT categories accounted for 38.6% in Atlanta and 45.6% in

Indianapolis. Subsequently, a large portion of total visitor attendance occurs only on a select few number of days. As a result, the ‘good’ and ‘excellent’ ADTs are very important categories regarding visitor attendance analysis. By contrast, while the ‘poor’ ADT represented 9.7% and 14.7% of the total days of attendance at Zoo Atlanta and Indianapolis Zoo respectively, this ADT accounted for less than 0.5% of the total number of visitors at both Atlanta and Indianapolis zoos. From this finding, a more detailed analysis of the differences in synoptic weather conditions between the ‘good’ and ‘excellent’ ADT categories might be of particular use to the zoos within this study.

Table 4.2. Number of Days Represented for each Attendance Day Typology (ADT) from September 2001 to June 2011

	Poor	Average	Good	Excellent
Zoo Atlanta	349 (9.7%)	2,727 (76.1%)	338 (9.4%)	170 (4.7%)
Indianapolis Zoo	526 (14.7%)	2,474 (68.9%)	426 (11.9%)	164 (4.6%)

Table 4.3. Total Visitor Attendances for each Attendance Day Typology (ADT) from September 2001 to June 2011

	Poor	Average	Good	Excellent
Zoo Atlanta	26,827 (0.4%)	4,522,693 (61.0%)	1,595,615 (21.5%)	1,265,605 (17.1%)
Indianapolis Zoo	31,863 (0.3%)	5,369,595 (54.1%)	2,903,326 (29.3%)	1,614,481 (16.3%)

Figure 4.4 presents the percent share of the Synoptic Scale Classification (SSC) categories found at Atlanta and Indianapolis zoos from September 2001 to June 2011.

The categories in Figure 4.4 represent the proportion of days falling within a particular SSC category where every day was represented by a single SSC category.

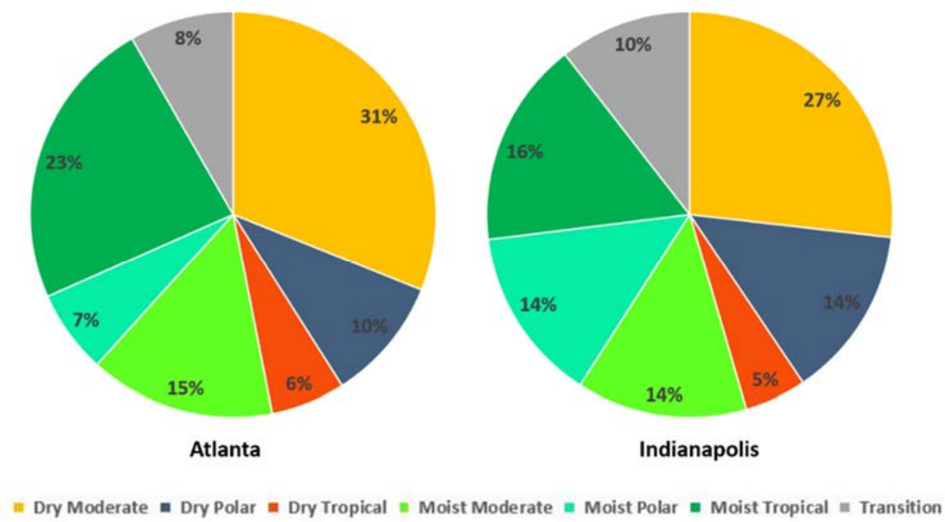

Figure 4.4. Percent Share of Daily Observed Synoptic Scale Classification (SSC) Conditions at the Atlanta and Indianapolis Zoos from September 2001 to June 2011

Percent shares of the SSC categories between Atlanta and Indianapolis in Figure 4.4 largely demonstrate two similar continental climates, both with varied synoptic weather regimes. First, the ‘Dry Moderate’ (‘DM’) SSC category is the highest represented regime at both locations with representations of 31% at Atlanta and 27% at Indianapolis. Second, when comparing ‘moist’ (‘MP’, ‘MM’, ‘MT’) and ‘dry’ (‘DP’, ‘DM’, ‘DT’) synoptic regimes, both zoo locations are very similar. Atlanta observes 45% of its synoptic conditions describing a ‘moist’ regime compared with 44% in Indianapolis; conversely, within ‘dry’ synoptic conditions Atlanta observes 47% compared with 46% in Indianapolis.

Similar in synoptic regimes, these locations also possess key climatic differences regarding the thermal component of the synoptic conditions that may be driving relationships observed with visitor behavior. The two synoptic categories with the largest differences in percent representation between Atlanta and Indianapolis are ‘Moist Tropical’ (‘MT’) where Atlanta showed a seven percentage-point higher occurrence and ‘Moist Polar’ (‘MP’) where Indianapolis showed a seven percentage-point higher occurrence. Beyond these singular categories, Atlanta also experienced a greater amount of ‘tropical’ SSC regimes than did Indianapolis (29% vs 21%), and Indianapolis experienced a greater amount of ‘polar’ SSC regimes than did Atlanta (28% vs 17%). Synoptically, Atlanta appears to have experienced a warmer profile than Indianapolis. This climatic difference may help clarify the differences observed across locations regarding how synoptic regimes impact visitor attendances.

Displayed in Figure 4.5 is the percent share of each Attendance Day Typology (ADT) by Synoptic Scale Category (SSC) for Atlanta and Indianapolis zoos. Prominent in this description is that both zoos display strikingly similar patterns across the relationship of synoptic weather conditions and the respective ADT categories.

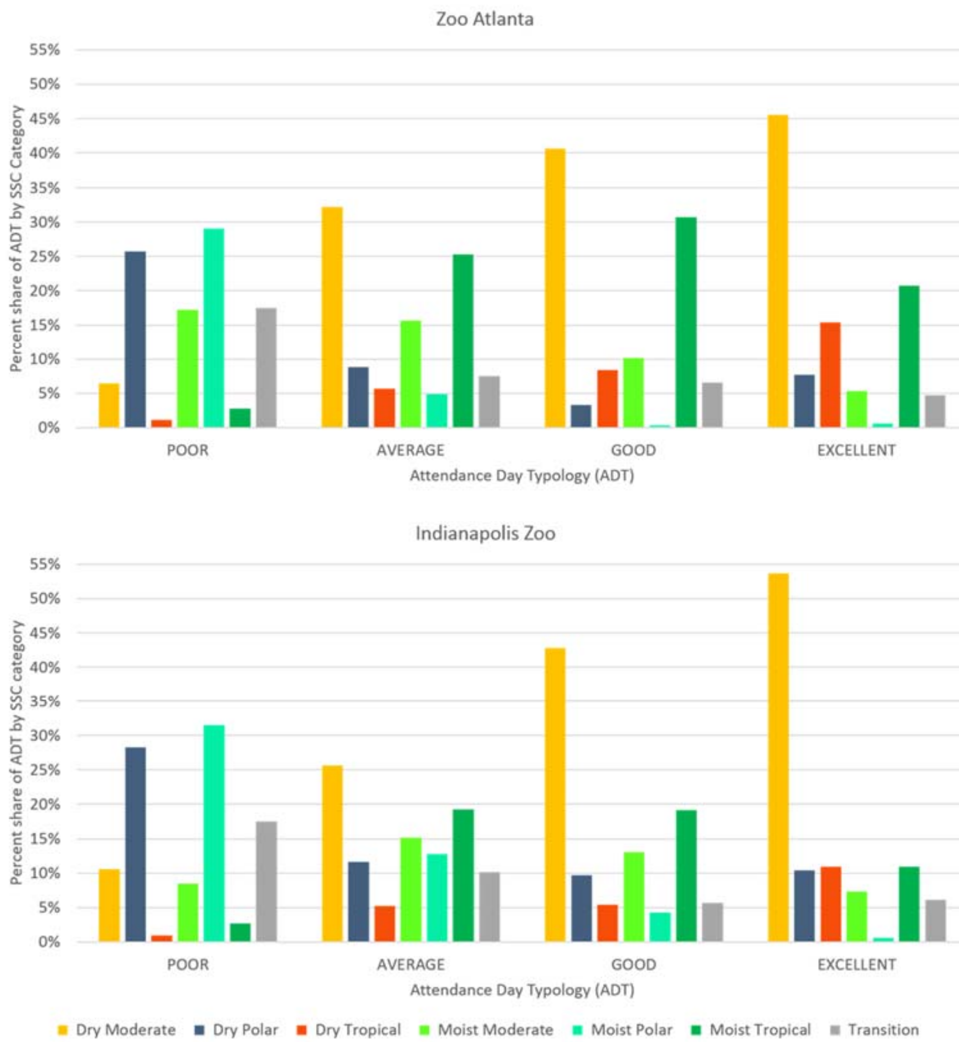

Figure 4.5. Distribution of SSC Categories based on the Percent Share of Attendance Day Typology (ADT) by Zoo

The synoptic regimes most commonly associated with 'excellent' attendance at both zoos included 'Dry Moderate' ('DM'), 'Moist Tropical' ('MT') and 'Dry Tropical' ('DT'). At Zoo Atlanta 46% of the 'excellent' ADT occurred on 'DM' days compared to 54% at Indianapolis Zoo. Although the SSC integrates local climatology in its calculation of each synoptic regime, it is likely that at both zoos 'DM' days would result in partly cloudy to clear skies and moderate temperatures. Such conditions may be 'ideal' for zoo visits which require significant outdoor exposure to the elements. However, it should also be noted that while Atlanta experienced a disproportionately larger share of 'Dry Moderate' ('DM') days relative to Indianapolis (i.e., 31% versus 27% respectively), this did not equate to a higher share of 'excellent' attendance days in Atlanta than in Indianapolis while under 'DM' conditions (i.e., 46% versus 54% respectively). From this, Atlanta appears not as 'reliant' on 'DM' conditions as is Indianapolis to generate its highest attendances. This could indicate that zoo visitors in Atlanta are either more resilient to a wider array SSC conditions or visitors in Indianapolis have a higher degree of sensitivity to synoptic conditions that are not 'ideal'.

The second most commonly occurring synoptic regime in the 'excellent' ADT was the 'MT' regime representing 21% of all 'excellent' days at Zoo Atlanta and 11% at Indianapolis Zoo. 'MT' days represent synoptic regimes that are capable of generating cloudy skies with both wet and warm conditions. While the warm thermal component of 'MT' conditions may stimulate attendance, the potential for precipitation can simultaneously dampen attendance levels. One reason that could partially explain why 'MT' days occur more frequently in Atlanta than in Indianapolis during the 'excellent' ADT may be linked to the simple fact that Atlanta experienced more 'MT' days in total than did Indianapolis (i.e., 23% versus 16% of the days respectively).

The third most commonly-occurring SSC category associated with 'excellent' levels of attendance is 'Dry Tropical' ('DT'). Although 'DT' only occurred on 6% of the days of record in Atlanta and on 5% of the days in Indianapolis, 'DT' comprised 15% of the ‘excellent’ ADT in Atlanta and 11% of the ‘excellent’ ADT in Indianapolis. Weather accompanying ‘Dry Tropical’ (‘DT’) regimes can represent the hottest and driest conditions during a year, however, they are almost always associated with dry, clear conditions. Given the relatively mild continental climates of both Atlanta and Indianapolis it is likely, despite ‘DT’ conditions representing warmer thermal profiles, that temperatures usually were not high enough to trigger ‘heat aversion’. Of particular question regarding differences across zoo locations is why ‘DT’ was four percentage points higher in Atlanta than in Indianapolis on ‘excellent’ attendance days despite having very similar profiles regarding overall ‘DT’ conditions (6% in Atlanta versus 5% in Indianapolis). Findings across both ‘tropical’ synoptic regimes (‘MT’ and ‘DT’) may give an explanation for this difference. Results suggest that Atlanta visitors may have a preference and/or tolerance for warmer synoptic regimes than do visitors in Indianapolis. In the ‘excellent’ ADT category, both ‘tropical’ synoptic regimes, ‘Dry Tropical’ (‘DT’) and ‘Moist Tropical’ (‘MT’), have higher representations in Atlanta than in Indianapolis where ‘DT’ is four percentage-points higher and ‘MT’ is ten percentage-points higher.

Regarding the ‘good’ ADT a similar dynamic seems to be at play. Both zoos were more likely to experience ‘DM’ conditions on ‘good’ attendance days followed by ‘MT’ regimes. At Zoo Atlanta 41% of all ‘good’ attendance days occurred under a ‘DM’ synoptic regime compared to 43% of all such days in Indianapolis. By contrast, ‘MT’ conditions accounted for 31% of all ‘good’ attendance days compared to 19% of all such days in Indianapolis.

The SSC categories most associated with ‘poor’ levels of attendance at both zoos were ‘MP’, ‘DP’, ‘T’, and ‘MM’. In Atlanta and Indianapolis zoos, the SSC regime with the highest representation in the ‘poor’ ADT was the ‘Moist Polar’ (‘MP’) condition as it comprised 29% of the ‘poor’ attendances at Zoo Atlanta and 32% at Indianapolis Zoo. The ‘Dry Polar’ (‘DP’) condition was the second-most commonly occurring synoptic regime, representing 26% and 28% of all the ‘poor’ attendances at Atlanta and Indianapolis zoos respectively. These two SSC categories are similar as they represented synoptic regimes displaying cold and/or wet conditions which occurred mostly in the winter seasons. The ‘poor’ ADT indicated that visitors to Indianapolis Zoo may be less tolerant of ‘polar’ synoptic regimes than visitors to Zoo Atlanta. Within the ‘Dry Polar’ (‘DP) and ‘Moist Polar’ (‘MP’) synoptic categories, Indianapolis consistently had higher representations than Atlanta in both of these categories by an average of three percentage-points. Because Indianapolis experiences a continental climate that is generally colder than Atlanta, this finding may indicate that zoo visitors in Indianapolis do not adapt to the prevailing thermal extreme conditions, but rather, in their discretionary leisure time, avoid such conditions. Further, it is likely, given the climatology-based methodology of the SSC, that ‘DP’ and ‘MP’ conditions in Indianapolis are, in fact, colder (but not wetter) than those experienced in Atlanta. This indicates that the thermal component within these SSC categories could be the key difference affecting attendance turnout.

‘Transition’ (‘T’) conditions represented 18% of the ‘poor’ ADT at both zoological parks. These conditions are associated with a change in the synoptic air mass

(Table 4.1). In the continental climates of Atlanta and Indianapolis, this condition is highly variable but can be associated with weather changes during frontal passages. Many frontal passages can be accompanied with rain, drizzle, or even thunderstorm conditions, all of which are not good for attendance turnout at outdoor zoo locations.

The 'Moist Moderate' ('MM') regime was also associated with lower attendance as it represented 17% and 8% of the synoptic regimes within the 'poor' ADT at Atlanta and Indianapolis zoos respectively. This regime, however, did not adversely impact attendance to the same degree as did 'MP' or 'DP' or 'T' synoptic conditions. This is likely due to the fact that 'MM' conditions are variable with wet or cloudy weather but not usually accompanied with harsh temperatures. One prominent note is that 'MM' conditions represented a disproportionately high share of 'poor' days in Atlanta relative to Indianapolis (17% versus 8% respectively) despite their relatively similar overall representation of total days (15% in Atlanta versus 14% in Indianapolis). This indicates that the presence of 'MM' regimes are likely more detrimental to attendances in Atlanta than in Indianapolis. A possible reason for this geographic difference may be that zoo visitors in Atlanta favor 'tropical' regimes however a 'MM' regime represents cooler and wetter temperatures producing an 'unwelcome' departure from the preferred thermal regimes. Conversely, in Indianapolis much the same dynamic is occurring. Because Indianapolis experiences a greater amount of 'polar' SSC regimes and visitors appear to dislike these 'polar' conditions, 'MM' conditions may come as a 'welcome' departure from the harsh temperatures experienced during 'polar' synoptic conditions in Indianapolis.

Because it is probable that above ‘average’ attendance days can be roughly predicted by zoo administrators using ‘non-weather’ factors such as ‘weekends’, ‘holidays’, etc., a better understanding of the differences that exist between synoptic conditions coinciding with ‘good’ or ‘excellent’ attendances might improve attendance forecasting. Regarding synoptic conditions at both Atlanta and Indianapolis Zoos, ‘excellent’ attendances had higher percentage shares than ‘good’ attendances in the SSC categories of ‘DM’, ‘DP’, and ‘DT’. This indicates that on higher days of attendance, the presence of ‘DM’, ‘DP’, or ‘DT’ conditions may elevate attendances beyond ‘good’ levels to ‘excellent’ levels of attendance. The synoptic regimes most associated with raising attendances to ‘excellent’ levels were ‘DT’ in Atlanta and ‘DM’ in Indianapolis. Conversely, for ‘MM’ and ‘MT’ regimes, ‘good’ attendances had higher percentage shares than ‘excellent’ attendances. On higher days of attendance, the presence of ‘MM’ or ‘MT’ conditions may be more likely to yield ‘good’ levels of attendance than ‘excellent’ levels of attendance. The synoptic regime most associated with a likelihood to keep attendances in the ‘good’ ADT category and not elevate them to the ‘excellent’ ADT category was the ‘MT’ SSC category for both zoos.

Generally speaking, it appears that at both zoos, even with higher attendance levels, ‘moist’ synoptic regimes still negatively impact attendances, and, while they do not necessarily preclude higher days of attendance, when directly comparing ‘good’ and ‘excellent’ ADTs, ‘moist’ synoptic regimes are not beneficial. Further, ‘dry’ regimes, in spite of the thermal component, appear to be helpful for increasing visitor attendances.

[4.5] Conclusions and Future Direction

The United Nations World Tourism Organization's (UNWTO) background paper, "Advancing Tourism's Response to Climate Change", outlines several impacts that climate variability has on tourism destinations and operators. In particular, future weather and climate variability will have direct impacts on the length and quality of tourism seasons and on tourist decision-making. The ability to better interpret changes in global tourism demand and tourist behavior under future scenarios of climate change could be enhanced by developing a comprehensive climate index for tourism. De Freitas *et al.* (2008) outlined the need for a climate index that is translatable across a diverse range of climates and one which is also attuned to the potential acclimatizations people may have developed as a result of their culture or local environments.

Because people have a tendency to react to their environment regarding their own personal well-being, it is likely that to some degree, tourist decisions incorporate healthful decisions. This paper explored the possibility of using a human health-oriented weather classification, the Spatial Synoptic Classification (SSC), in the context of outdoor tourist behavior to determine if different synoptic weather conditions described by the SSC align with visitor attendance at zoological parks.

It was found that 'Dry Moderate' conditions appeared to be the 'optimal' synoptic conditions for outdoor zoological park tourism. Specifically, 'Dry Moderate', 'Moist Tropical, and 'Dry Tropical' conditions were highly represented in 'excellent' and 'good' levels of attendance, and 'poor' levels of attendance were highly represented by 'Moist Polar', 'Dry Polar', 'Transition', and 'Moist Moderate' synoptic regimes. This finding was consistent across Atlanta and Indianapolis geographies. SSC categories associated with 'moist' conditions were also associated with low attendance, and those associated with 'dry' conditions were associated with high attendance. Results from the 'Moist Tropical' SSC, however, indicated that warmer temperatures can lessen the negative attendance impacts of 'moist' conditions. This finding is substantiated by the work of Welki and Zlatoper (1999) who also found, in the event of rain-conditions, warmer temperatures mitigated losses in visitor attendance. Using the SSC to illuminate geographic differences in the weather-attendance relationship indicated that zoo visitors in Indianapolis were more averse to 'Dry Polar' and 'Moist Polar' conditions than zoo visitors in Atlanta. This relationship between zoos is consistent with results from Perkins and Debbage (2016a; 2016b) who found that visitors in locations with higher occurrences of extreme thermal conditions tend to display more aversion to those extreme conditions instead of tolerating or adapting to them.

Overall, this research indicates that the SSC is a reasonably good variable for predicting tourist behavior. Though not specific or offering a great detail of nuanced variations when interpreting potential acclimatizations or weather preferences across diverse geographies, the SSC does have the potential for development as part of a tourism index. Given its large spatial extent, this type of weather metric may be useful in longer-term attendance forecasting where exact temperature forecasts are not reliable. Future research should test the SSC across more diverse climatic regimes to determine its ability to be used in multiple tourism geographies. Regarding development within the field of 'tourism climatology', future research could test the ability of the SSC to be used as a ‘first step’ categorization to identify the general synoptic regime. After this categorization, specific tourism indices could then be developed for each SSC condition.

This paper utilized a weather index associated with ‘climate and human health’ and applied it in the realm of ‘climate tourism and recreation’. While differences exist across these biometeorological realms, methodologies can be shared that may yield novel applications and findings. As found in this research, an interdisciplinary use of a health-oriented index in ‘tourism climatology’ resulted in both an improved understanding of how tourists respond to synoptic weather conditions and the potential for future interdisciplinary research. This cross-collaboration may lead to research which helps tourists and operators improve decision-making.

CHAPTER V

CONCLUSION

This dissertation, in its review of differing weather factors as they impacted visitor attendance at four large metropolitan AZA accredited zoological parks across the United States, revealed novel findings regarding how weather conditions impact consumer behavior in the form of visitor attendance response.

Generally, in the research, the potential presence of a 'thermal aversion effect' and, in particular, an 'extreme temperature aversion' where visitors avoided a location's most common thermal extreme condition was found across all zoos. Based upon these findings, 'cold locations' appeared to show 'cold aversion' in their attendance responses to the ambient thermal environment, and 'warm locations' appeared to show 'heat aversion' in their attendance responses to the ambient thermal environment. This may mean that visitors to zoological parks may not acclimate to the prevailing climates, but instead, may become less tolerant by choosing not to expose themselves to any additional thermal stresses regarding their discretionary leisure time. Also, consistent across all four zoological parks in the research, it was found that days which promised 'thermally stagnant' weather conditions were more likely to be accompanied with low visitor turnout. Conversely, days with weather conditions which experienced multiple thermal categories and significant daytime heating appeared to promise higher visitor turnout. While not tested across all four zoological parks, results from this dissertation may indicate that admission pricing could contribute to how potential zoo visitors interpret the atmospheric environment.

Table 5.1 displays specific findings through the explorations of all three manuscripts:

Table 5.1. Comparison of Key Findings from Chapters 1 – 3

Zoological Park	Optimal Thermal Regime(s) for Attendance		Thermal Aversion Effect	Most Common Thermal Extreme	Experienced Thermal Categories for Peak Attendance	Optimal Synoptic Condition for Attendance
Atlanta	Slightly Warm	Warm	Cold Aversion	Very Cold (10%)	3+	Dry Moderate (DM)
Indianapolis	Slightly Warm	Warm	Cold Aversion	Very Cold (30%)	3+	Dry Moderate (DM)
Phoenix	Slightly Warm	Warm	Heat Aversion	Very Hot (39%)	4+	-
St. Louis	Warm	Hot	Cold Aversion	Very Cold (24%)	3+	-

Specific findings in this research have provided foundational information concerning both human thermal preferences and how those preferences may vary across diverse climates within outdoor zoological park tourism.

It was found in Chapters II and III that 'optimal thermal regimes for attendance' were relatively consistent across all four zoos despite their differing climates. The PET-based thermal category of 'warm' was found to be the only 'optimal thermal condition' for visitor attendance consistent across all four zoos. There were slight nuances, though, as Atlanta, Indianapolis, and Phoenix zoo visitors demonstrated a preference for both 'slightly warm' and 'warm' thermal regimes and St. Louis a preference for 'warm' and 'hot' thermal regimes. A potential key describing a possible cause for the warmer thermal preferences in St. Louis was free-admission pricing. The consistencies found in the 'optimal' thermal regimes may indicate that despite the differences in prevailing climates of the locations, regarding outdoor zoo tourism, there could be a global optimal thermal condition most preferred by those visiting a zoological park.

The 'thermal aversion effect' was most apparent on the lowest days of visitor attendance where these 'poor' days of attendance largely coincided with the most common thermal extreme condition. Atlanta, Indianapolis, and St. Louis zoological parks all showed 'cold aversion' and had their most common thermal extreme occurring in the 'very cold' thermal category. Phoenix Zoo, conversely, displayed 'heat aversion' as most of its 'poor' days of attendance occurred in the 'very hot' thermal category. Moreover, this 'very hot' thermal category was the most common thermal extreme in Phoenix over the study period.

Because zoo visitors may assess the weather based on the entirety of conditions they could experience throughout their time at the zoo location, any potential changes in the daily atmospheric environment may influence decisions to visit. Days which experienced more thermal categories, in general, saw higher attendances. Days which did not experience many thermal categories saw 'thermally stagnant' weather conditions resulting in lower attendances. Atlanta, Indianapolis, and St. Louis zoos, in order to cross a 'threshold' between lower days of attendance and higher days of attendance, needed to experience at least three thermal categories during the daytime. Phoenix, likely due to its arid desert climate, needed to experience at least four thermal categories and cooler morning temperatures than the other locations in order to realize higher daily attendance volumes.

In Chapter IV the Atlanta and Indianapolis zoos were studied using the Synoptic Scale Classification, and it was determined that 'Dry Moderate' conditions appeared to be the 'optimal' synoptic conditions for outdoor zoological park tourism. Specifically, at both zoos, 'Dry Moderate' and 'Dry Tropical' conditions were precursors for 'excellent' attendance levels, 'Moist Tropical' for 'good but not excellent' attendance levels, and 'Dry Polar', 'Moist Moderate', 'Moist Polar', and 'Transition' for 'poor' attendance levels. Overall, it was found that the SSC was a reasonably good variable for predicting tourist behavior and it potentially could be developed as part of a tourism index.

By looking at visitor attendance response to multiple weather variables at outdoor zoological parks, this dissertation research provided new methodologies and illustrated new findings which may allow for a better understanding of how people react to the weather. Further, this research provided additional examples to add to a foundation of research which tests regional visitor acclimatization and adaptation to ambient environmental conditions.

By building an understanding of how weather influences consumer behavior, this research can be used as a foundation for modeling future visitor behavior under varying scenarios of climate change. Doing so may be a key in improving the abilities of leaders and governments to make better-informed policy and planning decisions for the future.

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