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RESEARCH ARTICLE

Thermal Environments and Visitor Attendance in Zoological Parks: Observations in A Humid Continental Climate

David R. Perkins[1]

Abstract

This paper reviews associations between weather and visitor attendance at two climatically similar zoological parks. This is achieved by examining weather, climate, and attendance data at the Indianapolis and St. Louis zoological parks over a period of approximately one decade. The methodological approach utilizes tourism climatology as the foundation for information gathering, display, and analysis of results. Peak days of attendance at both zoos coincide with 'warm' and 'slightly' warm days. Regarding the lowest attendances, visitors at both locations appear to display more aversion to cold thermal stress conditions than hot thermal stress conditions, however visitors at St. Louis Zoo appear to be more averse to cold conditions. Discussions regarding how social calendars and admission pricing may interact with this relationship are introduced.

Keywords

Weather, Physiologically Equivalent Temperature, Zoological Park, Tourism, Pricing, Climate

1 **Correspondence to:** David R. Perkins (Asst. Prof.), Missouri State University, Geography Faculty, Department of Geography, Geology and Planning, Springfield, USA. E-mail: Davidperkins@missouriState.edu ORCID:0000-0001-9380-0565

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Introduction

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 access and interpret weather and climate conditions in the present. A better understanding of how tourism-sector participants currently behave during specific weather conditions and events can establish a stronger foundation by which research can forecast future behavior patterns (Rutty and Andrey, 2014; Kent and Sheridan, 2011; Nicholls *et al.*, 2008; Scott and Jones, 2006; Scott *et al.*, 2012; Hewer et. al., 2015).

Focusing on the short-term foundation of weather and tourism, this paper reviews how varied weather conditions may impact tourist behavior by considering the largely outdoor-oriented economic sector of Tourism, Recreation, and Leisure (TRL). Specifically, the focus of this paper is on a segment of the tourism sector that encompasses zoological parks and aquariums. This sector contributed over $22.5 billion to the United States economy in 2016, supporting 208,000 jobs and attracting 195 million visitors, a total number of visitors in excess of all major U.S. sporting events combined for the same time period (AZA, 2018). 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. In recent years, this type of research is beginning to take form as zoological parks are being examined in detail regarding how present-day weather conditions and future climate change scenarios might affect zoo visitor attendances over time (Rasilla Álvarez, & Crespo Barquín, 2021; Aylen et al., 2014; Perkins, 2016; Perkins and Debbage, 2016; Hewer and Gough, 2016a, 2016b, 2016c).

This paper reviews how the ambient thermal environment—assessed with Höppe's Physiologically Equivalent Temperature, (PET)—(Höppe, 1999), interfaces with daily zoo visitor attendance by comparing two American Zoological Association (AZA) accredited zoological parks in similar climate regimes: the Indianapolis and St. Louis zoos. Analysis at these two zoological parks builds on the research findings of Perkins and Debbage (2016) 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, reviewing Indianapolis and St. Louis zoos provides two new important developments in the weather-attendance relationship observed by Perkins and Debbage (2016). First, it provides using PET, an analysis of two zoos located in colder climates than previously researched but using established and repeatable methodologies. Second, because the Indianapolis and St. Louis zoos are located in similar climate regimes and are less than 250 miles apart, this paper assesses whether zoos experiencing the same general climate have consistent weather-attendance relationships.

Theoretical Background and Context

Thermal preferences in tourism

A key factor influencing tourist behavior is a tourist's personal physical comfort they experience when engaging in their chosen activity. In the event of climate change, warmer conditions, among many other variants, (Melillo et al., 2014; Pachauri et al., 2014) will likely change comfort levels which may, in turn, cause tourists and recreationists to alter their activities, perform the same activities but in different locations, or adapt to the conditions (Caldeira, 2018; Gomez-Martin, 2005). 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, 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 range of 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/recreationist preference (Scott *et al.*, 2012; Gössling et al., 2012). 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 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' cited in the literature have been converted to the closest corresponding thermal category as specified by Matzarakis and Mayer (1996). These thermal categories are displayed in the leftmost procedural item of Figure 1 as nine categories defined by the American Society of Heating and Air Conditioning Engineers (ASHRAE, 2001 and 2004) with thresholds refined by Matzarakis and Mayer (1996); the thresholds are specified with respect to the derived Physiologically Equivalent Temperature (PET) (Höppe, 1999).

The research surveyed in Table 1 used one of 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/or attendance data, and 'survey' which makes its determinations using both on-site and off-site climate preference surveys of tourists and recreationists. In

Table 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	Bsanceot	1978	25-33	Slighly Warm	Warm	General	Global
	Mieczkowski	1985	20-27	Neutral	Slightly Warm	General	Global
	Maddison	2001	30,7	Warm		General	English
	Lise and Tol	2002	21,8	Neutral	Slightly Warm	General	French
	Lise and Tol	2002	24,4	Slighly Warm		General	Italian
Observational	Hamilton and Lau	2005	24	Slighly Warm		General	Germal
	Hamilton et al.	2005	14	Slightly Cool		General	Global
	Bigano et al.	2006	16,2	Slightly Cool		General	Glow
	Perkins and Debbage	2016	-	Slightly Warm	Warm	Zoological Park	SE USA
			-	Slightly Warm	Warm	Zoological Park	SW USA
	Gomez-Martin	2006	22-28	Neutral	Slightly Warm	General	Spanish
	De Freitas 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
Survey	Wirth	2010	20-26	Neutral	Slightly Warm	Urban	German
	Moreno	2010	28	Slightly Warm		Beach	Western European
	Lin	2010	21-23	Neutral		Urban	Taiwanese
	Hewer et al	2016	<33 summer	Warm		Nature park	Canadian
			<29 shoulder	Slightly Warm			
	Hewer et al	2015	24-31	Slightly Warm	Warm	Nature park	Canadian
	Andrade et al.	2011	32-28	Slightly Warm		Urban	Portuguese
	Rutty and Scott	2015	32-39	Warm	Hot	Beach	Multicultural
	Scott et al.	2016	23-25	Slightly Warm		Urban	Multicultural

Table 1, 'tourism segment' refers to the target tourist activity of those questioned. 'General Tourism' can largely be defined as sightseeing tourism or "slow steady walking" (Mieczkowski, 1985). '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 in the literature (Table 1). First, those studies assessing either a 'global' culture or a 'general' tourism segment indicate a wide range of possibilities for 'optimal' thermal preferences. For example, Hamilton and Lau (2005) and Bigano *et al.* (2006) utilized international tourist arrival 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 general tourism demand for travelers from the United Kingdom, found an optimal temperature coinciding with the 'warm' ASHRAE category. Second, the intent and likely activity of the vacationer appeared to modify the thermal preferences (Gomez-Martin, 2005). Generally speaking, beach tourism appears to have the warmest thermal preference and mountain tourism the coldest, with urban tourism falling between these anchor points. Zoological park tourism (Perkins and Debbage, 2016) most resembled results seen in 'urban' tourism; this finding is expected given the metropolitan location of zoos in this research. Third, visitor origin also influenced the optimal thermal assessment, and, in general, tourists had a personal preference for conditions that were in higher 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. The role of culture and thermal preference is discussed in detail by Lam et al., (2016) who emphasize that there are fundamentally different preferences and sensations depending on the nationality and culture of the visitor.

Weather and attendance at zoological parks

With these thermal comfort preferences in mind, a growing body of literature assessing the impact of weather on attendance has emerged in recent years, however, there is little consensus regarding the appropriate combination of weather variables used in this type of analysis (Perkins and Debbage, 2016). De Freitas *et al.* (2008) 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 personalized weather variable may provide a more concrete link to how tourists might react to the outdoor thermal environment.

Following this suggestion, Perkins and Debbage (2016) 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 this research, it was concluded, 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. The lowest attendances on record appeared to coincide with the most common thermal extreme condition for each location where low attendance days in Phoenix coincided with 'very hot' thermal conditions, while in Atlanta, the lowest attendance days coincided with 'very cold' thermal conditions. Perkins and Debbage (2016) concluded that overall attendance-weather relationships may be partially a product of the climatology of the "extreme thermal" conditions (p. 13). For example, visitor attendance at 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" (p. 10) where they chose not to adapt to or tolerate the prevailing thermal extreme, particularly regarding their discretionary leisure time; instead, they may have been employing "short-term coping measures" (Hayden *et al.,* 2011 p. 278).

Other studies assessing how weather impacts attendances at zoos have integrated a different set of assessment variables to connect the ambient atmospheric environment to zoo attendance. Aylen et al., (2014) assessed this impact at Chester Zoo in North West England over a period of thirty three years, January 1978 to December 2010. The weather variables assessed in this research were daily rainfall and temperature and were controlled by taking into consideration other elements such as seasons, holidays, response lags, special events, and social factors such as fuel shortages. Overall, it was found that the relationship between temperature and visitation is non-linear where 21°C served as the peak attendance threshold, with falling attendances regarding both cooler and warmer temperatures. Rainfall impacted attendance by discouraging attendance, but also by redistributing attendance as visitors tended to arrive a day after weather improved. Overall, however, social factors and seasonal trends were the overriding non-weather variable in these models.

Hewer and Gough (2016a) analyzed temperature, wind, and precipitation data coupled with daily attendance data at Toronto Zoo and found a variety of nuances in the relationship. For example, while temperature was the most influential variable in their analysis, it varied based on the season indicating that the interpretation of or response to temperature might be contextual rather than absolute. During the shoulder season 26°C appeared to be a temperature threshold, however, in the peak season this changed to 28°C. Among precipitation, they found that there was also a nonlinear relationship as small amounts of precipitation less than 2mm would result in a 50% reduction in attendance, while additional amounts of precipitation would generally have little impact on further attendance decreases. Research by Hewer and Gough (2016a, 2016b, 2016c) has also incorporated non-weather factors in predictive models to better account for influential social aspects that likely modify a visitor's interpretation of the weather, or even overrides their consideration of the weather such as holidays, day of week, off/peak/shoulder seasons and special events.

Methods

Climate data are displayed at each zoo within the context of the visitor/tourist where the visitor is consuming an experience in the ambient environment and therefore can be considered as 'part' and 'subject to' their environment. Therefore, the weather conditions should have a direct impact on their behaviors. As a result, a physiological atmospheric variable assessing the well-being of the tourist likely contributes to whether they decide to spend time and money at a zoological park.

To assess the thermal physiological conditions the tourist was most likely experiencing during their visit, the Physiologically Equivalent Temperature (PET) was used. This variable choice was made following the suggestions of de Freitas *et al.* (2008) and the methods of Ploner and Brandenburg (2003), Brandenburg and Ploner (2002) and Perkins and Debbage (2016) because the PET represented a more specified measure of ambient thermal conditions that a visitor may 'feel' during their visit to the zoo. The thermal condition, though not entirely encapsulating the whole of the weather condition, is seen as an important variable in tourism (Scott et al., 2008) research and provides additional specificity frequently used in outdoor tourism studies (Lin *et al.,* 2009, 2009; Matzarakis and Mayer, 1996).

In this research, PET was used to ensure comparability with the Perkins and Debbage (2016) findings at Phoenix and Atlanta zoos. Pantavou et al., (2018) however, explain key differences between the PET and the Universal Thermal Climate Index (UTCI) (Blazejczyk, 2012), another commonly used thermal index in research. Applied today, PET and UTCI are both used in outdoor thermal comfort research, (Rozbicka and Rozbicki, 2020; Klock et al., 2019; Manavvi and Rajasekar, 2021; Baruti et al., 2019) among others such as the Weather Suitability Index (WSI) (Anna et al., 2020) and the Thermal Sensation Vote (TSV) (Sharmin and Steemers, 2020). Notably, none of these indices is agreed upon in exclusivity (Lenzholzer and Nikolopoulou, 2020) and in some instances such indices may be further adapted (Wang et al., 2021; Talhi et al., 2020; Chen et al., 2020) for application.

Weather data:

To calculate the PET, weather data at both zoos were 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. Ideally the weather data would be obtained on-site at each zoo as there will inevitably be differences across space. Generally, while spatial variation in the thermal component is slight over distances less than 10 miles (which have limited topographic changes), the same assumptions cannot be made for precipitation and wind data. Given the design elements of each zoo, it is likely that zoo visitors experience increased shading at each location compared with the ASOS location. Elnabawi and colleagues (2016) highlight in a park setting the shading benefits during hot summer months but also emphasize decreased wind flow and evaporative cooling from a dense canopy leading to some degree mixed results. Additionally, in the winter, depending on the tree type (evergreen versus deciduous) shading may occur to the discomfort of the visitor. With these limitations in mind, the authors of this research surmise that 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, particularly for a study focused on the thermal condition.

Adapted from Perkins and Debbage (2016), Figure 1 describes the methodological process where hourly weather data were converted to the derived PET values and then assigned to a nine-point thermal sensation scale. This scale uses the European standard established by Matzarakis and Mayer (1996). Overall, PET was calculated every hour from 7am to 7pm using temperature, wind speed, sky cover, and relative humidity, yielding thirteen data points per day. Of these thirteen data points, the warmest and coldest thermal categories were selected to represent the daily high and low PET-based thermal category values.

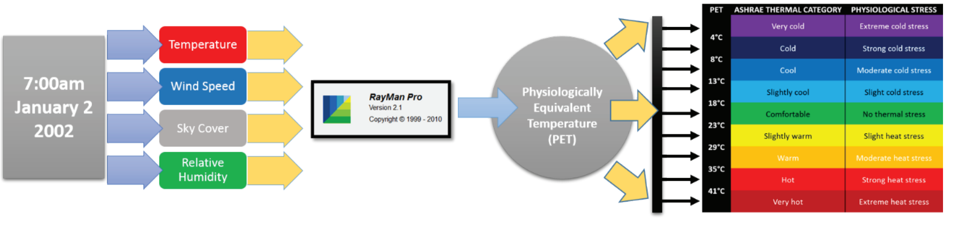

Figure 1: Methodological process of converting hourly weather data to a PET-based thermal category from Perkins and Debbage (2016)

In previous research, Perkins (2012) determined that when compared with daily average and daily low PET values, daily high PET value predicted visitor attendances best. This is because the daily high PET represented thermal conditions when most visitors were likely to be at the zoo. While not part of the PET calculation, this research also utilizes 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), additionally, using hourly ASOS station rainfall measures, rainfall occurring during the open hours of each zoo is included in a separate analysis.

Visitor data

Visitor attendance was 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 or in the admission pricing structure. Both zoos are located in major metropolitan areas and each zoo is positioned within the urban downtown area. The visitor length-of-stay is comparable as the average visitor spends approximately three to four hours per trip (Personal communication, 2015a, 2015b). 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 within the metropolitan areas of Indianapolis and St. Louis. For example, at Indianapolis Zoo, 85% of the guests are from 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). Due to 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 non-local visitors. This logic is supported by findings from Nicholls *et al.* (2008) and Hewer et al. (2017, 2018) who observed that tourists who traveled longer distances were more sensitive to weather conditions than those tourists who were more proximate to the tourism location. These relationships can be complicated however because it should also be noted that there is a possibility that visitors from outside the immediate areas (15% Indianapolis; 45% St. Louis) could, instead, be less sensitive to the weather due to fixed vacation schedules. Such tourists who are non-local can contribute to lower correlations between expected attendances and the weather. In fact, Rasilla Alvarez and Crespo Barquin (2021) found in a zoo in Northern Spain that the "sensitivity of zoo visitation to weather variability was seasonally dependent" and less sensitivity was seen in summer months, indicating that varying socio-economic factors interact with the impact of the weather. Regarding populations, 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).

Data analysis:

The seasons as defined in this study consist of a 'high season' (May, June, July), a 'shoulder season' (March, April, August, September, October), and a 'low season' (November, December, January, February) of attendance. 'Seasonal' divisions were made with respect to both zoological parks and their attendance records.

Seasonal analysis does not capture the entire social calendar of availability. Because of this, within each of these seasons, days were subsequently divided into weekends and weekdays. Weekends consisted of Saturdays and Sundays, weekdays consisted of Mondays through Fridays. This distinction was based on the belief that potential attendees would have more time availability on weekends and therefore this time availability might have an influencing factor on their attendance despite the weather conditions.

Pursuant to Perkins and Debbage (2016), attendances were subsequently grouped within each season and for weekend/weekday, and grouped accordingly 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

The imbalanced nature of these groupings is purposeful. Two ADT categories exist above the 'average' category with only one ADT category below the 'average' category. This is because high attendance days' have a "disproportionate impact on overall attendance" (Perkins and Debbage, 2016 p.5). 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 (14.3%), the total visitor attendance for these two ADTs accounted for an average of 43.5% of the total yearly visitor attendance. Additionally, attendance groupings were made in their respective isolated groups to account for predicable social constructs (day of week and month) where a 'poor' attendance on a high season weekend might actually be higher than an 'excellent' attendance on a low season weekday. This was done in order to determine if certain weather fluctuations in the context of the social calendar might have an impact on attendance. Without these distinctions, the impact of weather has the potential to be conflated with differences in the day of the week or month, decreasing the reliability of results.

Dividing good and excellent attendances within small categories such as 'weekends' unfortunately decreased the number of observations to where the statistical reliability of any meaningful results was compromised. As a result, a 'top attendances' category was created that encompassed the top two standard deviations of attendances ('good and 'excellent') for a given season and weekend/weekday. Doing so yielded more observations while still capturing the research intent of a 'top attendances' variable.

Results

Overview of attendances

From September 2001 to June 2011 Indianapolis and St. Louis 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. An Independent t-test was conducted, and overall, there is a significant difference between attendance at the IND and STL zoos ($t(22) = 3.77$, $p = .001$); MSTL = 254.58; MIND = 86.67), with STL having significantly greater attendance than IND.

To provide further context for the attendance differences between Indianapolis and St. Louis zoos, Figure 2 illustrates the 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 in spite of various holidays, suggesting that the ambient thermal conditions may contribute to these attendance patterns at both zoos.

To verify this, a Pearson correlation was conducted assessing the relationship between IND and STL attendance by month. A significant positive relationship was observed ($r^2 = .92$, $p < .001$), indicating that the rank order of attendance was the same for both zoos. To assess the curvilinear relationship between attendance and months, two separate curve estimations were conducted, one for each of the zoos. For both IND and STL zoos a significant quadratic function/correlation was observed; for the STL zoo ($r^2 = .88$; $F(2,9) = 31.53$, $p < .001$), for the IND zoo ($r^2 = .70$; $F(2,9) = 10.51$, $p = .004$). As can be seen there is a stronger curvilinear relationship in attendance for STL vs that of IND. Additionally, the magnitude of increase from January to June was greater for STL vs IND ($b = 150$ vs $b = 59$) and the magnitude of decrease in attendance from June to December was greater for STL vs IND ($b = -12.12$ vs $b = -4.2$).

Figure 2 also illustrates the average daily attendance by Attendance Day Typology (ADT) of all days in the period of record and provides ratios indicating what percentage of the attendance in St. Louis is matched by Indianapolis. For example, within the ‘poor’ ADT, average daily Indianapolis Zoo attendance only matches 7% of the attendance at St. Louis Zoo; for the highest days of attendance in the ‘excellent’ ADT, the 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. It is hypothesized that this sudden change in ratios may be tied to the difference in admission fees between the two zoos. If admission pricing is the reason behind this sudden change in ratio, it would 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. Conversely, this would also indicate that on ‘poor’ days of attendance, the $14 admission price at the Indianapolis Zoo may be higher than most visitors are willing to pay, given the environmental conditions. Though not conclusive here, understanding differences in weather conditions between ‘average’ and ‘poor’ days of attendance could better illustrate how visitors may value weather conditions.

Number of days represented by ADT				
	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%)
Total attendance by ADT				
	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%)
Average daily attendance and attendance ratio by ADT				
	Poor	Average	Good	Excellent
Indianapolis Zoo	60	2,171	6,815	9,844
St. Louis Zoo	877	6,727	17,858	25,282
IND/STL	0.07	0.32	0.38	0.39

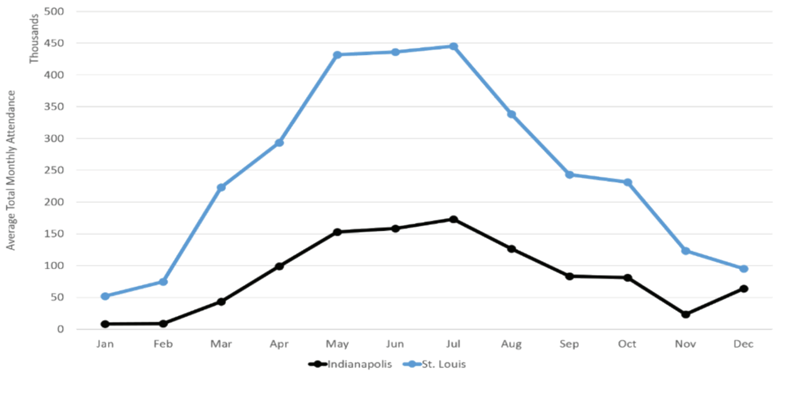

Figure 2: Attendance comparisons at Indianapolis and St. Louis Zoos 2001-2011

Looking deeper at the results, Table 2 displays the attendance 'seasons' used in this research and the relative differences across categories. These groupings are likely due to both meteorological factors and the increased availability of school-aged children during the traditional 'summer vacation' within the United States. The number of days analyzed is not equal across seasons because months have been selected due to their overall attendance patterns throughout the study. The shoulder seasons comprise a period of falling attendance in the months of August, September, and October and a period of increasing attendance in the months of March and April. While the moving average trends are different within these two aspects of the shoulder season, the average daily attendances within the increasing and decreasing portions of the shoulder seasons were similar and did not necessitate a different seasonal analysis. Within all seasons, the St. Louis Zoo has significantly higher attendances. Comparing weekend and weekday average attendances within the high season, daily weekday attendances comprise between 68% (STL) and 75% (IND) of weekend days. Differences in the weekday to weekend ratios are observed more in the low and shoulder seasons where weekday attendances are approximately half (between 45% and 52%) the magnitude of weekend daily attendances. This is, again a likely product of the social calendar and time availability during these months.

Table 2
Attendances at the St. Louis and Indianapolis Zoos

Season	High		Low		Shoulder	
Months Represented	MAY; JUN; JUL		NOV; DEC; JAN; FEB		MAR; APR; AUG; SEPT; OCT	
	STL	IND	STL	IND	STL	IND
Average Daily Attendance	14,272.89	5,255.14	2,923.03	999.30	8,646.57	2,805.19
Total Attendance	12,688,597	4,671,822	3,452,098	1,045,272	12,961,206	4,202,171
Number of days	889	889	1,181	1,046	1,499	1,498
Average weekend	18,554.04	6,375.44	4,508.42	1,490.65	13,898.19	4,623.82
Average weekday	12,561.63	4,807.02	2,287.37	768.81	6,547.88	2,077.73
Weekday attendance % of wknd	68%	75%	51%	52%	47%	45%

More detail is provided in Table 2 where attendances at the St. Louis Zoo are significantly higher than those at the Indianapolis Zoo on a consistent basis. Table 2 shows the average daily attendances and the percentage of days occurring within each thermal category within all six divisions of the tourism climatology representing weekends and weekdays within the high, low, and shoulder seasons. The ratio between the Indianapolis Zoo and St. Louis Zoo attendances is displayed for the categories and varies between 38% and 32% indicating the fraction of visitors at the Indianapolis Zoo as compared with the St. Louis Zoo during the same periods of time. What is apparent from these representations is that there exists no meaningful trend or impactful difference within these individual groupings indicating roughly the same attendance patterns over the social calendar. Increases/decreases of attendances on weekends/weekdays or in the high/low season appear to be mimicked across zoos at this level of analysis.

Overview of tourism climatology

Outlined in Table 3 are several key general 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). What is apparent from Figure 3, is that both locations have similar climates; however, St. Louis, in general, is 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 drop 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.

Table 3
Climate comparisons of Indianapolis and St. Louis

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

Figure 3 displays the percent share of daily PET-based thermal categories at each zoo from September 2001 to June 2011. The categories in Figure 3 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. Table 3 and Figure 3 indicate 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.

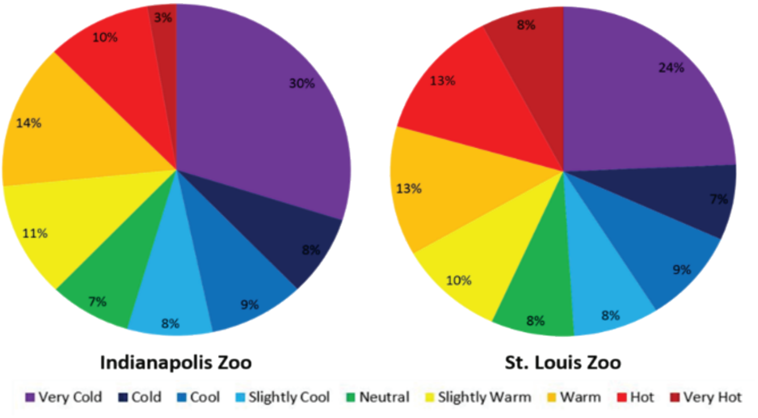

Figure 3: Proportion of PET categories experienced by zoo

The tourism climatology derived for visitors for the St. Louis and Indianapolis Zoos is displayed in Table 4. What is apparent in this table is there is little difference between the zoological parks regardless of season or day-of-week. The largest differences between the zoos emerge in the proportions of 'very hot' days in both the weekend and weekdays of the high season where St. Louis Zoo visitors experience 13% and 14% greater incidences of this event than do the visitors at Indianapolis Zoo. This corroborates climate normal data, highlighting that St. Louis is generally a slightly warmer location than Indianapolis. The same phenomenon is observed in low season weekends and weekdays where Indianapolis Zoo visitors experience 17% and 8% more 'very cold' days than those in St. Louis. All other observations exhibit differences of 8% or less in terms of the thermal category representation. Although not analyzed in this research, precipitation was recorded for comparative purposes to establish knowledge regarding the similar climates between zoos. As determined, precipitation days (defined as greater than 'trace': .01in) are similar across zoos as the maximum difference between the number of precipitation days is 6% occurrence in the high season weekends and the low season weekdays.

Table 4

Season	High						Low						Shoulder					
Time	Weekend			Weekday			Weekend			Weekday			Weekend			Weekday		
Zoo	Indianapolis	St. Louis	Difference	Indianapolis	St. Louis	Difference	Indianapolis	St. Louis	Difference	Indianapolis	St. Louis	Difference	Indianapolis	St. Louis	Difference	Indianapolis	St. Louis	Difference
Very Cold	0%	0%	0%	0%	0%	0%	74%	58%	17%	72%	64%	8%	14%	10%	4%	12%	8%	4%
Cold	2%	1%	1%	1%	0%	1%	10%	18%	-8%	14%	12%	1%	9%	7%	3%	8%	6%	2%
Cool	5%	4%	1%	3%	2%	1%	10%	10%	0%	9%	11%	-3%	12%	11%	0%	12%	12%	1%
Slightly Cool	7%	5%	2%	7%	4%	3%	3%	8%	-5%	4%	6%	-2%	10%	11%	0%	13%	12%	1%
Neutral	12%	8%	4%	11%	9%	3%	1%	4%	-2%	2%	4%	-3%	12%	7%	4%	10%	12%	-2%
Slightly Warm	19%	13%	7%	19%	14%	5%	1%	2%	-1%	1%	2%	-1%	14%	16%	-1%	15%	14%	2%
Warm	26%	25%	0%	31%	24%	8%	0%	0%	0%	0%	0%	0%	17%	17%	0%	16%	16%	1%
Hot	23%	25%	-2%	24%	29%	-6%	0%	0%	0%	0%	0%	0%	9%	13%	-4%	9%	14%	-5%
Very Hot	6%	20%	-13%	5%	19%	-14%	0%	0%	0%	0%	0%	0%	4%	8%	-4%	3%	7%	-4%
Precipitation Days	27%	21%	6%	28%	28%	0%	22%	18%	4%	24%	18%	6%	19%	18%	1%	23%	22%	1%
Average Daily Attendance	6.375	18.551		4.807	12.562		1.491	4.508		769	2.287		4.624	13.898		2.078	6.548	
IND:STL Attendance Ratio	34%			38%			33%			34%			33%			32%		

Overview of attendances with respect to varying meteorological parameters

As a general overview, distribution of PET-based thermal categories based on the percentage share of each Attendance Day Typology (ADT) for both zoos is also illustrated in Figure 4. ADT categories in Figure 4 are based on the entirety of the dataset and not sectioned by season or day-of-week in this overview. 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, 2016) where, specifically, 'cold aversion' may have influenced visitor attendance choices. For example, though residents of Indianapolis and St. Louis are exposed to 'very cold' thermal conditions more than any other thermal category, 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 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, 2016) and chose not to tolerate the prevailing cold extremes with respect to their discretionary leisure time. This concept of a 'saturation point' or thermal threshold is further underlined with findings regarding the nonlinearity of temperature-tourism relationships (Rossello and Santana-Gallego, 2014; Hewer et al, 2015; Hewer et al., 2016a; Aylen et al., 2014; Falk, 2014).

Peak representations of the highest days of attendance on record at the Indianapolis Zoo 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 percentage 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.

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, in general, may have preferred slightly warmer thermal regimes. Again, in the 'excellent' ADT category, St. Louis Zoo visitors appeared to prefer warmer

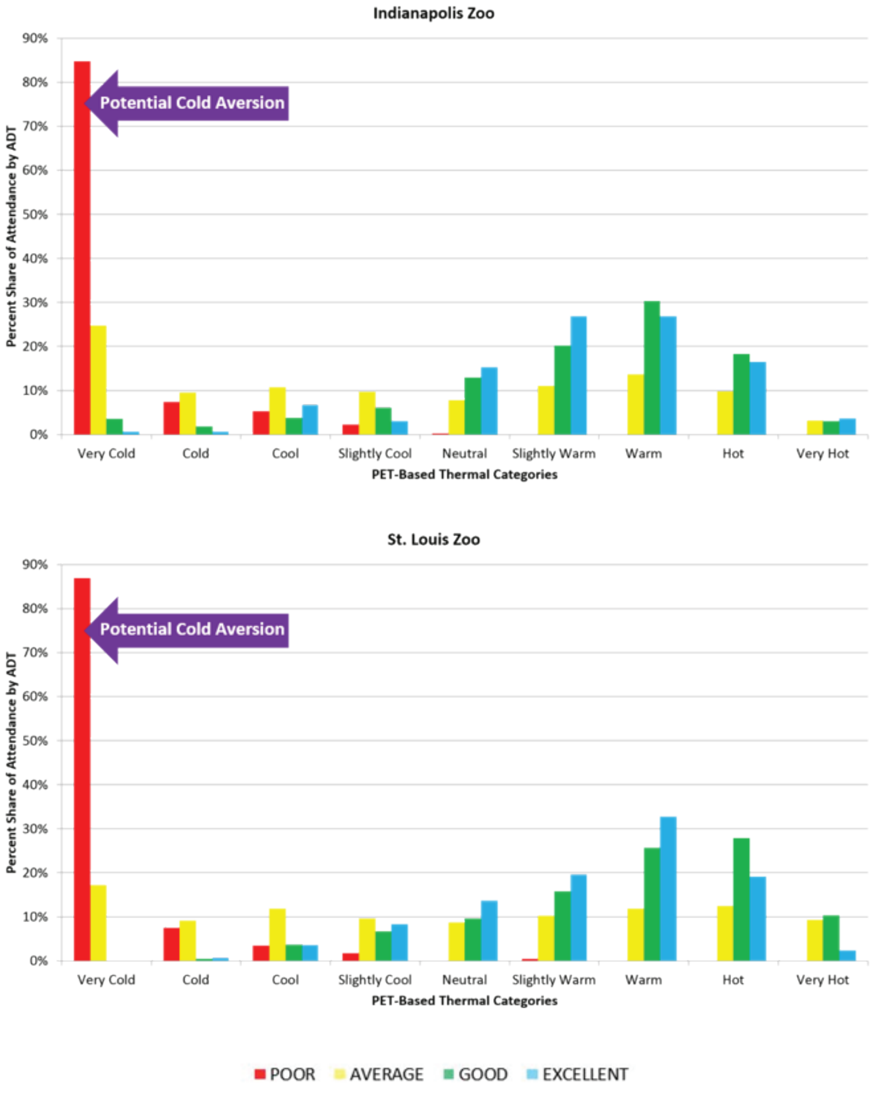

Figure 4: Overview of PET-based thermal categories and attendance

thermal regimes as Figure 3 indicates a higher representation of 'hot' and 'warm' days and a lower representation of 'slightly warm' and 'neutral' days than observed at Indianapolis Zoo. Data seem 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 and schedule availability. For example, visitors to the St. Louis Zoo may 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, particularly in the summer months which tend to have more 'available' days for typical zoo visitors.

Figure 5 shows the variance of the thermal PET categories with attendance within each of the three established attendance 'seasons'. Similar results were found within each weekend/weekday grouping but are not included in Figure 5. Because this is a PET thermal analysis, days with precipitation were purposefully excluded to remove additional confounding variables. Table 5 does show however, the importance of precipitation on attendance in that top attendance days had lower representations of precipitation days than the climatology of the record. What is apparent overall in Figure 5 is that there is a preference for slightly warm and warm conditions at both zoos across all seasons. In the shoulder and high seasons, when conditions hotter than 'warm' occur, attendances begin to decrease at both zoos. Additionally, attendances begin to decrease in the shoulder seasons when the thermal condition is cooler than 'neutral'. This decrease is seen more gradually in Indianapolis where neutral thermal conditions are peak conditions for attendance and more drastically in St. Louis where neutral thermal conditions are detrimental. Conditions cooler than 'neutral' see declines in attendance at both zoos. In the low season where conditions hotter than 'slightly warm' are rare, at both zoos the trend is positive where the warmer the thermal condition is, generally the higher the attendances. The presence of outliers, while not explained in this research do indicate that there are many other unaccounted variables influencing attendances at the zoological parks that trump the influence of the thermal conditions on attendance patterns. Overall, however, slightly warm and warm days do tend to produce the highest levels of attendance in both averages and outlier attendance increases.

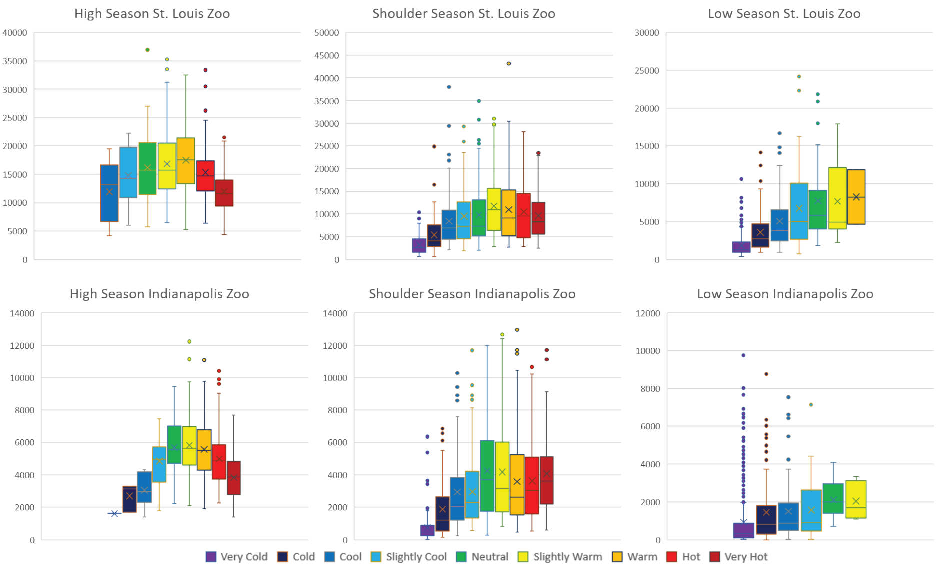

Figure 5: Thermal category and attendance thresholds by season

When comparing Table 4 and Table 5, the differences between the tourism climatology for all days and that for the top attendances are subtle in both high and shoulder seasons. In these seasons, though, there are increasing proportions of 'warm' and 'slightly warm' categories indicating their positive influence on attendance. Within the high season, differences between climatology and top attendances in the thermal category representations vary from 0% upwards to 18%, where the maximum difference is on weekdays for the 'hot' thermal category. This difference can be partially explained with the differences in climates between locations (St. Louis slightly hotter) but also points to St. Louis potentially having a hotter thermal preference than Indianapolis. Additionally, within shoulder seasons, when comparing all attendances to top attendance days, differences vary from 0% to 13% where the maximum difference is the increased incidence of 'slightly warm' days on shoulder season weekends at Indianapolis Zoo. This result indicates a potential for visitor preferences in the 'slightly warm' category. Overall, within the shoulder season, the presence of days warmer than an 'ideal' thermal condition tends to have less of a negative impact on top attendance days than presence of days cooler than an 'ideal' thermal category (Figure 6).

Table 5

Season	High						Low						Shoulder					
Time	Weekend			Weekday			Weekend			Weekday			Weekend			Weekday		
Zoo	Indiana-polis	St. Louis	Differ-ence	Indiana-polis	St. Louis	Differ-ence	Indiana-polis	St. Louis	Differ-ence	Indiana-polis	St. Louis	Differ-ence	Indiana-polis	St. Louis	Differ-ence	Indiana-polis	St. Louis	Differ-ence
Very Cold	0%	0%	0%	0%	0%	0%	64%	2%	62%	67%	20%	47%	0%	0%	0%	0%	0%	0%
Cold	0%	0%	0%	0%	0%	0%	6%	7%	-2%	18%	15%	3%	0%	1%	-1%	4%	0%	4%
Cool	0%	0%	0%	0%	1%	-1%	15%	28%	-13%	4%	21%	-16%	9%	7%	1%	11%	4%	6%
Slightly Cool	0%	3%	-3%	4%	2%	2%	8%	31%	-24%	4%	16%	-12%	3%	13%	-10%	16%	11%	5%
Neutral	15%	15%	0%	16%	12%	4%	4%	19%	-15%	5%	20%	-15%	16%	10%	6%	16%	14%	2%
Slightly Warm	28%	18%	10%	24%	18%	6%	4%	11%	-7%	2%	7%	-6%	29%	16%	13%	21%	23%	-2%
Warm	35%	43%	-8%	40%	29%	11%	0%	2%	-2%	0%	1%	-1%	24%	26%	-3%	11%	19%	-8%
Hot	20%	23%	-3%	16%	34%	-18%	0%	0%	0%	0%	0%	0%	12%	15%	-3%	13%	25%	-12%
Very Hot	3%	0%	3%	1%	5%	-4%	0%	0%	0%	0%	0%	0%	7%	10%	-3%	9%	4%	5%
Average Daily Attendance	10.547	26.726	39%	7.991	19.627	41%	4.952	12.378	40%	3.130	6.365	49%	9.634	25.129	38%	5.617	14.501	39%
Precipitation Days	5%	13%		10%	8%		8%	4%		8%	8%		6%	0%		7%	9%	

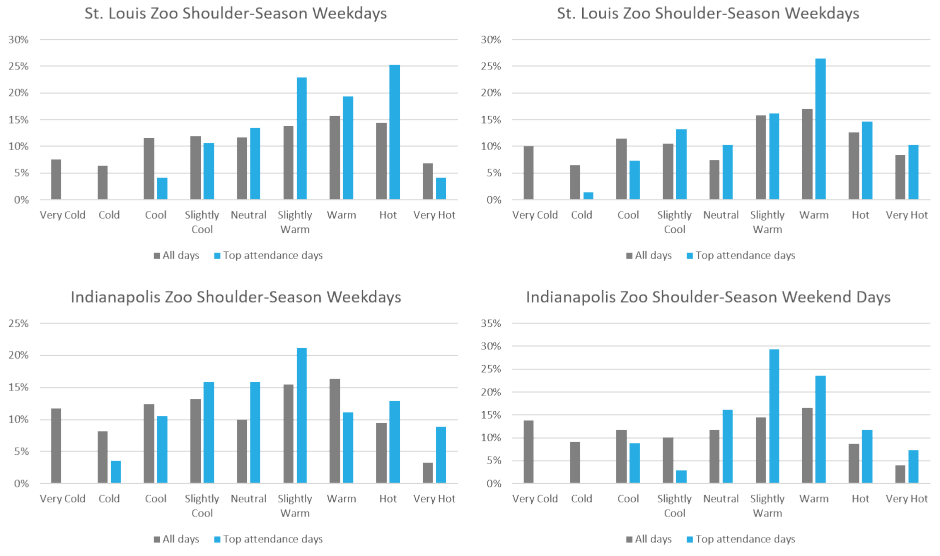

Figure 6: Comparison of shoulder-season top attendance relationships

Comparing differences across zoological parks in Table 5, the highest contrast in top attendance days occurs within the low season where a difference between zoos occurs in nearly every represented PET thermal category. This change is anomalous to other seasons and is displayed in Table 5. Within low season weekdays at the St. Louis Zoo, climatology indicates 64% of days represented as 'very cold' however, within top attendances, only 20% of days are 'very cold' (Figure 6). This result is perpetuated at this location as while 'neutral' days represent only 4% of all days, they represent 20% of top attendance days. Although this trend is present at the Indianapolis Zoo as well, within low-season weekend days, the differences are much less stark as very cold days represent 72% of climatology and 67% of top attendance days, and neutral days represent 2% of climatology and 5% of top attendance days. The same results are apparent for weekends with equivalent and drastic differences. Very cold days represent 58% of low-season weekends at the St. Louis Zoo but only 2% of the top attendance days in the same period; neutral days represent only 4% of days but 19% of top attendance days. Again, at Indianapolis Zoo, while the trends are similar, the vast differences are not present. This result indicates a sensitivity visitors in St. Louis may have with respect to cold days. Although it might make sense to be explained conversely that visitors in St. Louis may possess affinity for warmer days within the low season, this conclusion is not verified by Figure 5 and the representation of attendances across thermal categories.

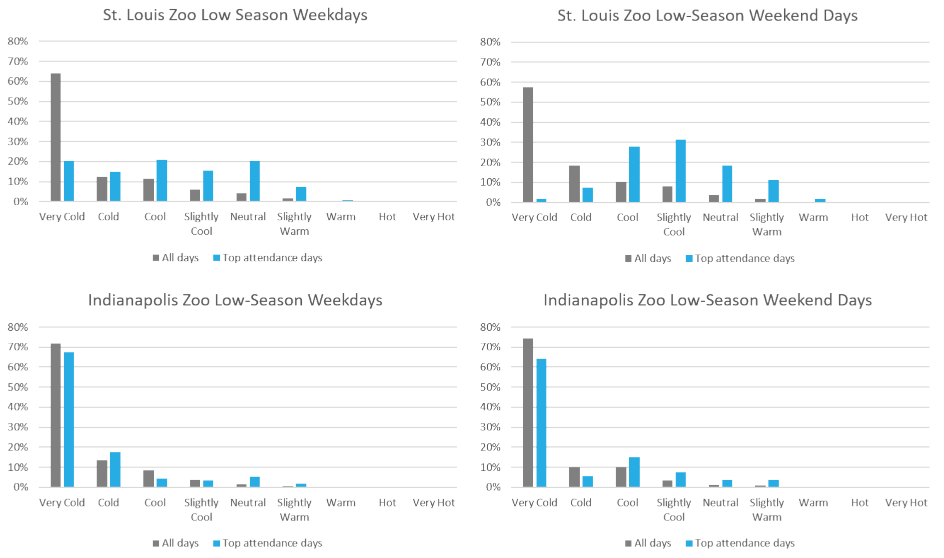

Figure 7: Comparison of low-season top attendance relationships

Conclusions and Future Direction

This paper has outlined research which addressed both long-term climate implications on tourism and the short-term impact weather has on tourism participants. This research largely began as a response to the suggestions of Nicholls *et al.* (2008), Scott and Jones (2006), Scott *et al.* (2012), and Perkins and Debbage (2016), 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.

Specific findings of this research provide a broader geographic context to the original work of Perkins and Debbage (2016) and help provide foundational information regarding human thermal preferences and how those preferences may vary across diverse climates within the broader tourism sector. For example, although Indianapolis and St. Louis zoological parks are within different climate zones than Phoenix and Atlanta zoos (Perkins and Debbage, 2016), it was found that top attendances at both the Indianapolis and St. Louis zoos corroborated results across climate zones and within the humid continental climate. Thermal categories 'slightly warm' and 'warm' seem to be universally preferred with only small differences between the zoos. This is a consistent finding with other literature as evidenced in Table 1. The thermal preference for 'warm' and 'slightly warm' conditions was consistent across all seasons and days of the week.

Among those thermal conditions most associated with 'poor' levels of attendance, this research also confirmed findings from the original Perkins and Debbage (2016) 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'. This phenomenon is underscored in broader literature which discusses thermal aversion (Gomez-Martin, 2005; Olya and Alipour, 2015). Additionally, Caldeira and Kastenholz (2018) establish that tourists enjoy visiting places which provide the "highest level of comfort and well-being" and "tourist activities…are significantly influenced by the weather." (P.1533). Given the humid continental climates, 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. In addition, it was found at the St. Louis Zoo during the 'low' season with corresponding 'very cold' thermal conditions, attendances appeared to suffer more than in Indianapolis. Both zoological parks had holiday events and promotions during this time period; however, the attendances still were proportionally lower at the St. Louis Zoo. The author believes this may indicate a higher degree of cold thermal aversion at St. Louis. Given the similar climates of each zoo such aversion may be generated less by acclimatization and more by the different pricing structures between the zoos. In short, the free admission of the St. Louis Zoo might decrease personal investment in a visit and therefore depress turnouts on days of 'poor' thermal conditions. This finding should be further developed and analyzed in future research, particularly if it can be better explained by the pricing structure of admission.

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. Knowledge of 'thresholds' would also be beneficial for understanding 'trigger points' in the ambient thermal environment that may significantly influence attendances in a non-linear manner. Such methods as utilized by Aylen (2014) and Hewer et al. (2016) help determine climate preferences. A limitation to this research in this area is that the climates of Indianapolis and St. Louis, while similar, are not identical and patrons experience differing thermal conditions throughout the year. Though the comparison is more direct than Phoenix and Atlanta (Perkins and Debbage, 2016), this lack of complete comparability decreases the ability for assumptions to be made about 'general' zoo visitors and their like interpretations of the weather conditions. Without direct surveys of those visitors, only inferences can be made based on attendance flow patterns.

When creating a fine-tuned analysis of weather-based decision-making, future research in this field should account for the possibility that weather conditions have differing levels of impact based on demographic variables (Hewer et. al., 2018) and timing of visitor arrivals based on weekends and holidays (Aylen et al., 2014; Falk, 2015; Hewer & Gough, 2018). While the Western European standard was used to craft the thermal bands in this study, (a reasonable proxy for the typical zoo visitors of Indianapolis and St. Louis) in order to properly utilize thermal categories the categories should be calibrated using survey-based data to encompass the actual on-site culture and acclimatization preferences of the 'typical' zoo visitor. Furthermore, weather conditions that occur anomalously such as a 'warm winter day' or a 'cool summer day' are undoubtedly important to better understand tourist attendance decisions. As such, a synoptic-level weather variable such as the Spatial Synoptic Classification (SSC) (Kalkstein et al., 1996; Sheridan, 2002) might be of note for the future development of weather-attendance indices. The SSC serves as a broader weather-type classification that captures the character of a particular synoptic regime (Sheridan, 2002) and has been used in diverse research areas such as weather climate and health (Hondula, 2014) and zoological park attendances (Perkins, 2016).

Notably, inclusion of precipitation and the subsequent length and nature of such events is an important factor in analyzing tourist behavior. Precipitation can serve as an 'overriding' factor because once a certain amount of rainfall does occur, attendance levels tend to drop. Though not analyzed in-depth it was apparent in this study that top attendance days tended to experience fewer days of precipitation as a percentage. Scott et al. (2008) has incorporated this idea among others such as atmospheric aesthetics into the Climate Index for Tourism (CIT), which still serves as a baseline for a more comprehensive overview of the ambient weather condition at a tourist site (de Freitas et al., 2008). Within tourism, along with aesthetic factors, integrating elements that consider perception in thermal experience (Lenzholzer and de Vries, 2020; Cortesao and Raaphorst, 2020) have also become more prevalent in recent years.

Beyond the inclusion of additional weather variables, understanding how weather forecasts may shape attendance decisions (regardless of the actual weather conditions) is of importance. Katz and Murphy (1997) write in-depth regarding how weather and climate forecasts can shape decisions and subsequently local economies. Furthermore, additional research within the tourism sector (Wilson, 2011; Zirulia, 2015; Rutty and Andrey, 2014) shows that tourists and recreationists do utilize weather forecasts in their decision-making and are influenced by those forecasts in their participation decisions.

Upgrades to the technical methodologies of this research are necessary to fully realize the relationships between weather and attendance. Specifically, the use of sophisticated statistical modeling such as time series analysis can help with the interpretation of datasets with comparable decade-long temporality. Such advanced regression techniques have been utilized in previous research in tourism (Brida and

Pulina, 2010) such as those accounting for annual volatility using ARCH-GARCH (Jere et al., 2019; Coşkun and Özer, 2014) or others reviewing decision lags using ARDL methods (Falk and Lin, 2018). Furthermore, Paudyal et al., (2019) created a time-series model to analyze how varying aspects of weather such as temperature, humidity and rainfall impact recreationist use in the context of a humid subtropical climate by analyzing the Florida National Scenic Trail. Expanding such a study to the humid continental climate observed in Indianapolis and St. Louis would prove added context to understanding potential differences across climate zones.

Moreover, this paper suggested that admission pricing may have an impact on how people interpret and/or value the weather. It should be noted that the timing of extreme weather events, holidays (Hewer & Gough, 2016a), special zoo attractions and new exhibits (Hewer & Gough 2016c) may also influence visitor interpretation, thereby changing possible price elasticities and the relationship with admission pricing (Falk & Hagsten, 2016; Falk & Vieru, 2017; Cellini and Cuccia, 2018). To test this hypothesis in increased detail, 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 may also respond to a changing climate. Zoological parks can use this information to determine a variety of elements to help improve operational efficiency. For example, understanding the impact of weather can induce a better prediction of attendances, subsequently assisting in adjusting staffing levels. Understanding how price may moderate weather-induced attendance fluctuations can help zoos utilize promotions to facilitate increased attendance on 'marginal weather days.' Projecting how future climate change may impact long-term attendance levels can assist with adjusting exhibit or building design (Salata et al., 2017) in the context of thermal comfort (Santos Nouri et. al., 2018). Beyond zoological parks, this type of information—linking attendances and weather—can potentially be used by communities and businesses in other outdoor areas of the tourism sector. Such areas include sporting events, concerts, and festivals. Beyond immediate events, a better understanding of how thermal conditions impact choice and participation can integrate with longer-term planning such as in urban design characteristics to assist with better-informed policy and planning decisions.

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