FORECASTING TOURIST DECISIONS REGARDING ZOO ATTENDANCE USING WEATHER AND CLIMATE REFERENCES

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ABSTRACT

DAVID RICHARD PERKINS IV: Forecasting Tourist Decisions Regarding Zoo Attendance Using Weather and Climate References
(Under the direction of Peter Robinson)

Tourism climatology studies relationships among people, business, weather, and climate within the tourism industry. This research tests these interfaces in the southeast United States at the North Carolina Zoo and Zoo Atlanta. Historical weather data are paired with zoo attendance. Weather variables include observed variables of temperature, humidity, cloud cover, and wind speed; derived variables of wind chill and heat index; and biometeorological index variables of Physiologically Equivalent Temperature (PET), Standard Effective Temperature (SET), and Predicted Mean Vote (PMV).

Three analyses are used: correlation, multiple regression, and probabilistic. Correlation analysis compares direct relationships between weather variables and attendance. Multiple regression analysis combines standard variables in predictive models. Probabilistic analysis studies seasonal scale climate-attendance relationships. Results indicate weather influences on zoo attendances change by season, social influences, and geography of the zoo. Complex composite weather variables improve attendance predictability as they provide better assessments of how humans sense outdoor environments.

To Mom & Dad

ACKNOWLEDGEMENTS

The completion of this research has taught me many lessons, some of which I associated with graduate work and others I certainly did not expect but have experienced and learned from nonetheless. It has definitely been an unbelievable character building experience. I would like to acknowledge and deeply thank my parents, David and Margaret Perkins, for their tireless efforts to help me in this initial step to achieve my academic goals. I would also like to give my gratitude to them on a much larger and important topic than the isolated academic machine. They have given me a preeminent example of support, personal integrity, humility, and honor. These qualities enable me to be a successful and respected member of society and give me the strength to pursue, endure, and triumph all challenges and hardships.

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ABBREVIATIONS

CDD	Cooling Degree Days
CLIMOD	Climate Information for Management and Operational Decisions
CLO	Clothing value
CRONOS	Climate Retrieval and Observations Network Of the Southeast Database
DJF	Winter season: December, January, February
HDD	Heating Degree Days
(I)	Radiation Data Added
JJA	Summer Season: June, July, August
KATL	Code for the weather station at Hartsfield-Jackson International Airport
MAM	Spring Season: March, April, May
NCDC	National Climatic Data Center
NRCC	Northeast Regional Climate Center
PET	Physiologically Equivalent Temperature
PMV	Predicted Mean Vote
SERCC	Southeast Regional Climate Center
SET	Standard Effective Temperature
SON	Fall/Autumn season: September, October, November
TCI	Tourism Climate Index

Chapter I

Introduction

Weather and climate play prominent roles in the tourism and recreation industry and influence tourist decisions to visit a location and engage in outdoor activities. Once the decision is made, the “tourist experience” begins.

A “tourist experience” encompasses three stages: planning, the actual experience, and assessments. Weather and climate affect the tourist experience. The distinction between weather (shorter term) and climate (longer term) is apparent when these tourist experience stages are used. Climate information and forecasts are assessed during tourism planning; weather information supports the actual experience; assessments are combinations of weather and climate information—reconciling discrepancies between expectations and reality of the tourist experience. The following paragraphs detail these distinctions and are supported with contributing research.

Tourism planning uses weather and climate information. Hamilton and Lau (2005) and Bigano *et al*. (2006) examined tourist destination choices based upon expectations and images of a location’s climate. Tourists access weather information when making vacation decisions. A tourist’s resourcefulness in accessing weather information occurs on two temporal scales. First, longer “climate” time scales dictate the focus and theme of a trip or vacation. Describing a destination as “warm and sunny” explains the goals of a tourist’s activity and vacation intent. Second, “weather” decisions relate to shorter-term information.

Information accessed prior to departure enters into decisions and modifies expectations based on earlier determinations. Modified expectations can include different dress attire, revised activity plans, or changes in destination.

At the tourist destination, activity choices are impacted by local weather events (Gomez-Martin, 2005). Weather events influence on-site activity choices of tourists. Social factors and different activity choices diversify options for tourists and recreationalists. However, influences of weather on the availability and performance of an activity are still present. For example, if availability of an intended activity is reduced due to the influence of the weather (*e.g.* lack of snow for skiing), alternative choices are created by businesses to mitigate revenue losses and provide social outlets.

Assessments of a tourist experience reconcile discrepancies between the expected and actual experience. Assessment shows how well prepared and how close to the planned itinerary the experience coincides. Daniel Scott, chairperson of the World Meteorological Organization's Commission on Climatology, states, "Weather can ruin a holiday, but climate can ruin a destination" (Scott, 2008). This statement captures the philosophy of the assessment stage. Choice of a tourism location is in-part selected for its climate. Assessment determines how well weather coincides with the expected climate. In the event of great deviations from the intended experience, such as no snow for a ski vacation, weather can in fact, ruin a holiday.

1.1 The Field of Tourism Climatology

The academic field of tourism climatology studies relationships between tourists and the weather. One relationship is comfort preference. Researchers conduct surveys to assess different comfort preferences with respect to weather variables such as temperature, humidity, and cloud cover in outdoor environments (Hwang *et al*., 2007; Knez *et al*., 2006; Andrade *et al*., 2010; Scott *et al*., 2008; Lin, 2009; Matzarakis, 1996). Comfort is often impacted by perceptions of the outdoor environment. Activity type, spatial layout, proximity (Andrade *et al.,* 2010) and expectations are drivers of many tourist perceptions. In addition, degrees of personal autonomy, culture, and regionalized acclimatization (Lin, 2009) are assessed in the tourism climatology literature.

Another relationship is human physiological response to different atmospheric environments. Responses include sweat rate, internal body temperature, skin surface temperature, and heart rate changes. Responses are studied clinically and developed into "heat balance models" which assess the body's response to these different thermal and environmental conditions. Heat balance models (Fanger, 1972; Hoppe, 1999; Gagge *et al*., 1986; Vanos *et al.*, 2010; de Freitas, 1985; Staiger *et al.,* 2011), with results often termed "perceived temperature," are tested and applied to human behavior in varying outdoor settings. Because tourists readily adapt to weather with different selections of clothing (Sprague & Munson, 1974) and changes in behavior, there is difficulty creating accurate heat balance models.

Researchers use the RayMan model software to calculate perceived temperature.

> "The model 'RayMan' estimates the radiation fluxes and the effects of clouds and solid obstacles (urban morphologies) on short wave radiation fluxes. The model, which takes easy and complex structures into account, is suitable for land use and planning purposes on various local to regional levels. The final output of this model is the calculated mean radiant temperature, which is required in the energy balance model for humans" (Matzarakis, Rutz, Mayer, 2000).

The RayMan model can be used to calculate Physiologically Equivalent Temperature (PET) (Hoppe, 1999), Predicted Mean Vote (PMV) (Fanger, 1972), and Standard Effective Temperature (SET) (Gagge *et al.*, 1986). PET equates the heat balance of the body in the actual environment to that which is experienced indoors under light activity. PMV quantifies discomfort based on human-assessed response to physiological stresses. SET compares individual physiological comfort to a reference environment. All outputs are in degrees Celsius (Davis *et al., 2006)*. These thermal indices are calculated using atmospheric, geographical, and human-physiological inputs. Atmospheric inputs include temperature, wind speed, humidity, sky cover, and solar radiation. Geographical inputs include altitude and day length (assessed through latitude and longitude). Physiological inputs help approximate the type of person studied and include gender, age, height, weight, amount of clothing, and effort levels (measured in watts).

A third relationship rates the climatic quality of a tourist destination. The Tourism Climate Index (TCI) was pioneered in 1985 by Canadian geographer Z. Mieczkowski and is the most comprehensive climate index developed specifically for tourism (Scott, 2004). TCI rates the quality of outdoor weather conditions for “moderate sightseeing” forms of tourism (slow steady walking), and is based on monthly weather variables of temperature, sunshine, precipitation, and wind (Mieczkowski, 1985). These are combined into an index value derived by separately scoring each weather variable on a monthly basis and totaling the results in a weighted formula. TCI differs from perceived temperatures PET, PMV, and SET because TCI is an assessment variable, not a temperature output. More recent indices attempt to improve upon the application of the TCI. Prominent new indices include the “second generation climate index for tourism (CIT)” (de Freitas *et al*., 2008), the “beach comfort index” (Becker, 1998), and a “user-based beach climate index” (Morgan *et al.*, 2000).

Finally, future tourism is assessed through climate change scenarios. These assessments concern changing climatic and environmental conditions which lead to varying attendances, tourist preferences, and tourist behavior. An example is displayed in the Mediterranean and

North Sea beach areas. Under certain climate change scenarios, studies discuss the potential for Mediterranean beach locations to become warmer than current thermal thresholds bear; thus, high temperatures will depress tourism in the region. The comparatively cooler North Sea beach areas, particularly along the north coast of Germany, will become warmer and have temperatures similar to the Mediterranean shores today. Assuming adaptive thermal capabilities do not change, nor do tourist preferences, future scenarios lead to different tourism patterns across the region. Tourists who currently visit the Mediterranean Sea are projected to frequent the North Sea coastal regions as a substitute (Willms, 2007).

Less specific projections of climate change assess regional visitation making assumptions about the tourism industry, concluding that some businesses and sub-industries benefit while others, as a result of a changing climate, do not (Cegnar, 2007; Endler & Matzarakis, 2007; Oehler & Matzarakis, 2007). Studies utilize concepts of climate change to dialog with businesses and provide context for adequate adaptation planning. Quantifying and predicting potential impacts of climate change (Morehouse *et al*., 2007) and engaging businesses in adaptive strategy dialogs using climate change scenarios (Jetzkowitz, 2007) are ways research integrates business, tourism, and biometeorological science into more applied work.

Prominent examples of climate change, global warming, and tourism studies look at the ski industry due to this industry's dependence on and sensitivity to the weather. Ski recreation represents a majority of published findings in the tourism climate change literature. Research in the ski industry takes several different approaches including changing natural snowfall variability (Gajic-Capka, 2007), variations in geographic demand (Tepfenhart *et al*., 2007; Tervo, 2007), changing cost structures (Dawson *et al*., 2007; Scott *et al*., 2007), and tourist behavioral awareness (Vrtacnik Garbas, 2007).

1.2 Present research

The question "How do weather and climate impact tourist attendance at the North Carolina Zoo and Zoo Atlanta?" is what this research seeks to evaluate. Assessment of this question determines research aims and objectives for this project: At the highest level, does weather affect zoo attendance? And if it does, how strong is the effect? The results of assessing what weather factors influence attendance most can provide insight to the relationship between humans and the outdoor environment. Results are of potential use to both tourism in the southeastern United States and to zoo tourism.

This research is guided with common principles and knowledge used in the tourism climatology field mentioned above. However, the research provides new information to an unexplored niche within the tourism climatology field. Research regarding tourist attendances at zoological parks has not yet been investigated. This study uses little-explored temporal scales. Historical attendance data are collected in daily resolution and paired with weather data. Geographical variables of spatial layout and location are included in analysis of the results. Zoos have been selected because of their outdoor activity.

The research method used in this project compares observed weather to attendance and is called retrospective flow analysis (similar to Moreno, 2007; Bigano *et al*., 2006; Scott & Jones, 2006). Tourist attendance and weather are studied through predictive models of attendance. Three techniques are used in data analysis: correlation analysis, multiple regression analysis, and probabilistic analysis. Correlation analysis compares direct relationships between weather variables and attendance on a daily scale. Multiple regression analysis combines standard variables in predictive daily-scale models. Probabilistic analysis studies seasonal scale climate-attendance relationships.

An important infusion of new knowledge to the tourism climatology field is provided by this research. Using grounded methods outlined above and applying them to a relatively unexplored tourist and geographic population is important to the growth and understanding of the field. The southeast United States has many climatic similarities to other world regions but with key differences which can help bridge previous findings. For expansion, Matzarakis and Mayer (1996) and Lin and Hwang (2009) created relative scales for thermal preferences in Western Europe and Taiwan. The southeast United States contains elements of both locations—culturally similar to Western Europe, but hot and humid—climatically similar to parts of Southeast Asia. Testing attendance and temperature variables in the tourism climatology field (*e.g.* "perceived temperature") help determine need for a more advanced weather variable tailored to the human.

Zoos and zoological parks exist worldwide. Use of zoos provides an unexplored tourism sub-industry and a baseline of similar activity, effort levels, demography, and personal goals on a global scale. Zoos attract parents with children and surround them with an outdoor learning environment across a park-like space. This specific industry genre allows for assessment in similar activities which require relatively the same effort and clientele schemas.

The research aims and research questions are as follow:

- Do weather and/or climate factors influence zoo attendance?
- What weather variables or prevailing conditions are most influential on decisions of whether to attend the zoo?
- Are indices established within the tourism climatology literature helpful in prediction of zoo attendance?

- What social influences coalesce with weather factors in tourist decisions to visit the zoo?

Chapter II, Sites, Data and Methods, describes the study sites and provides details for analysis of differing weather and attendance relationships. Weather information is displayed in American units of degrees Fahrenheit and inches of precipitation. Next, details the methods used in data analysis including correlation analysis, multiple regression analysis, and probabilistic analysis. Chapter III, Results, displays information arising directly from methods. Chapter IV Discussion and Chapter V Summary and Conclusions investigate with geographical and meteorological concepts to assist explanation in relationships between tourists and weather.

Chapter II

Sites, Data, and Methods

2.1 Study sites

This research encompasses two zoos in the southeastern United States: the North Carolina Zoo and Zoo Atlanta. These zoos are selected for their diverse socio-geographical appeal—one zoo in a rural location but with metropolitan visitors, the other in an urban location with metropolitan visitors. Different social contexts of the zoos are studied with respect to their spatial layout, zoological park path design, geographical location, and regional accessibility.

The North Carolina Zoo (35.63°N, 79.765°W) is located one mile south of Asheboro, North Carolina, a community of approximately 25,000 residents. Attendance at the zoo varies greatly with season and the regional school schedule. Typically, the greatest average attendances and single attendance days occur in the spring (MAM), with winter (DJF) markedly the lowest in both categories. Annual attendance at the North Carolina Zoo often exceeds 700,000. Zoo Atlanta (33.733°N, 84.37°W) is located inside Grant Park in Atlanta, Georgia. Atlanta is a large metropolitan area in the southeast United States with a population nearing 6 million residents. Its attendance characteristics are similar in number and seasonal distribution to the North Carolina Zoo. The prominent difference between the two zoos with respect to attendance characteristics is that the North Carolina Zoo tends to have higher peak attendance days, but also lower attendance valley days.

The layout of the North Carolina Zoo is a linear path leading along exhibits. It is considered the longest walk-through zoo in the world. The typical exhibit type is a conservation/wild park theme with plentiful roaming acreage for the animals. End-to-end using the pedestrian path, the zoo measures approximately 3.85 miles (figure 1).

Figure 1: North Carolina Zoo Layout

While the zoo does have a tram connecting each end point along the linear path, visitors still have significant exposure to the outdoor environment. In events of sudden weather change, visitors are too far away from parking lots to seek personal shelter; however, exhibits and overhangs exist on the zoo premises for such situations. The walking path has a rolling topography making it moderately strenuous (figure 2).

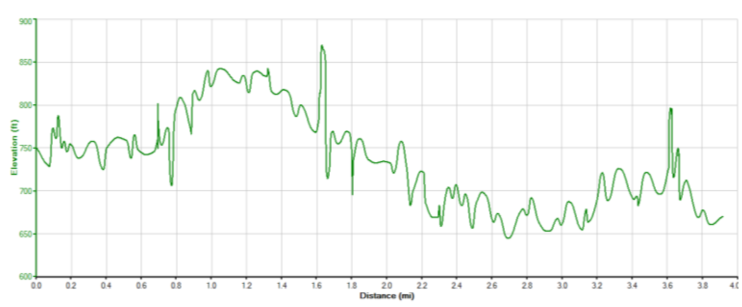


Figure 2: North Carolina Zoo Topography

Zoo Atlanta has a circular path and is a compact zoo (figure 3).

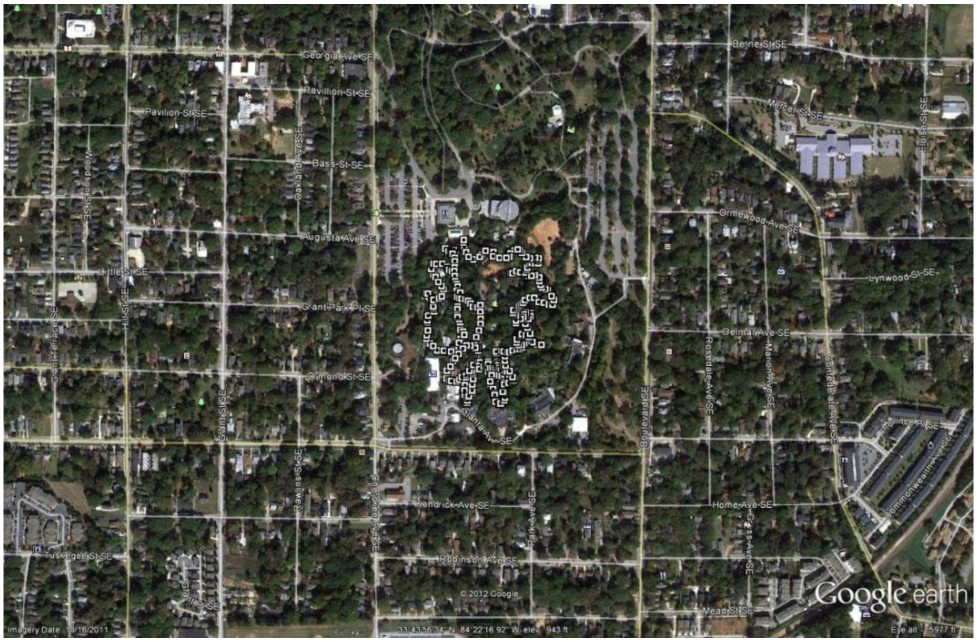


Figure 3: Zoo Atlanta Layout

There are distinct walking routes which are interconnected and lead visitors along paths that pass conservation/wild park atmospheres and caged exhibits. Paths are relatively flat with slight elevation changes. Walking Zoo Atlanta and visiting all exhibits measure approximately 1.3-2.0 miles based upon the choice of the tourist's route (figure 3). There is no tram or in-house transportation to return guests to the entrance, but, in the event of sudden weather change, all guests are within a 5 to 10 minute walk to the parking lot and/or personal shelter. Most paths have significant shading and sheltered areas are many, some of which offer air-conditioning.

The North Carolina Zoo derives its daily attendance from Charlotte, NC; the "triad" consisting of Greensboro, Winston Salem, and High Point; the "triangle" consisting of Raleigh, Durham, Cary, and Chapel Hill; and Fayetteville, NC. Charlotte is the largest city in North Carolina and the 18th largest city in the United States. The general Charlotte metropolitan area consists of approximately 2.4 million people as of 2009 (US Census). The "triad" has an estimated metropolitan statistical area (MSA) population of 1,581,122 according to the 2009 US

Census “making it the 30th largest metropolitan area in the USA.” The “triangle” has a MSA population of 1,742,816. Garner, Apex, Hillsborough and other small, suburban towns expand the triangle’s MSA population to exceed 2 million. Fayetteville, NC is the location of United States Army Installation FT. Bragg as well as Pope Air Force Base. The town is of particular benefit to the North Carolina Zoo because it has many families with children who frequent the zoo. These visits are usually on a cyclical schedule because attendances spike immediately prior to military deployments and after convoy returns. The Fayetteville metropolitan area has a population of 341,363 as of 2009.

Figure 4 displays zoo membership—a proxy for attendance—for the origination point of most visitors to the North Carolina Zoo. The population of these areas is approximately 6 million residents.

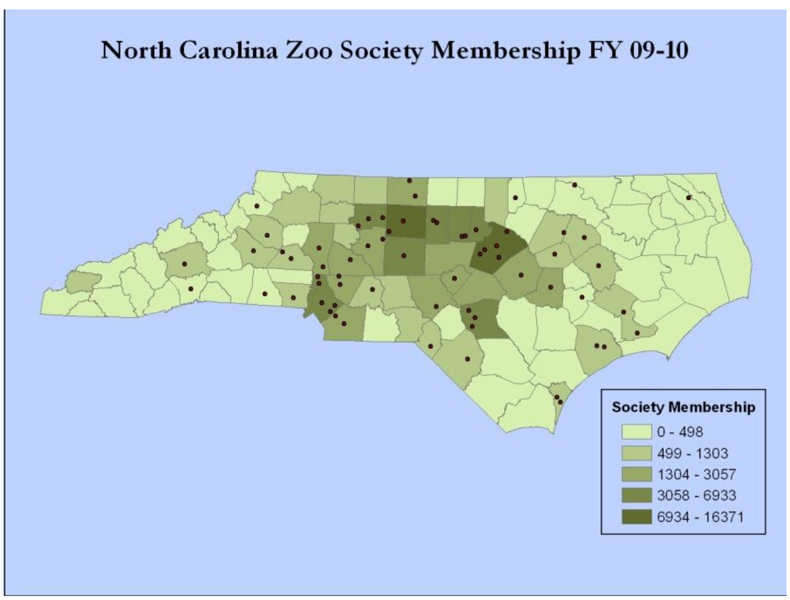


Figure 4: North Carolina Zoo Society Membership

Figure 5 shows the average one-way drive times to the North Carolina Zoo. Drive times are calculated based on spatial analysis encompassing average speed limits. The nearest high-population area is the “triad,” approximately 45 minutes from the zoo. The North Carolina Zoo is only accessible via private vehicle; public transportation is not available. To encompass this full region and its 6 million population, the 120 minute drive time zone must be included. Lengthened drive times affect tourism and increase a tourist’s need for better planning and higher awareness of the weather when visiting the North Carolina Zoo.

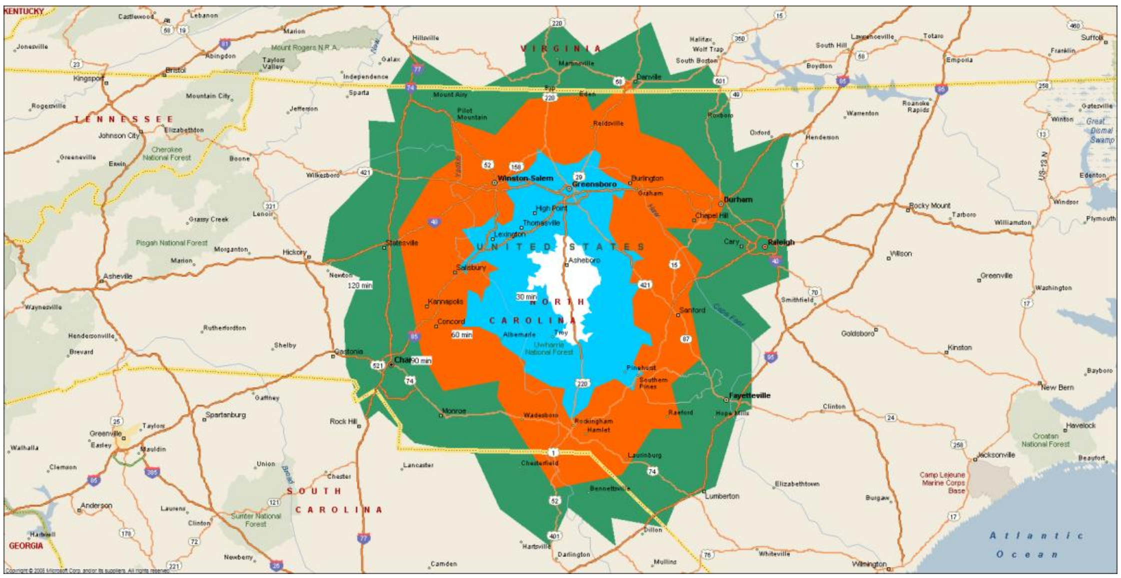


Figure 5: Drive Times to the North Carolina Zoo

Zoo Atlanta is located two miles from the city center of Atlanta, Georgia, and approximately three miles from Hartsfield Jackson international airport. It is accessible via private vehicle and public transportation bus line which services other tourist attractions within the downtown Atlanta region. A large proportion of the visitors to the zoo come from the immediate area surrounding the zoo. Memberships are used as a proxy for attendance origination due to lack of admission gate sampling (figure 6).

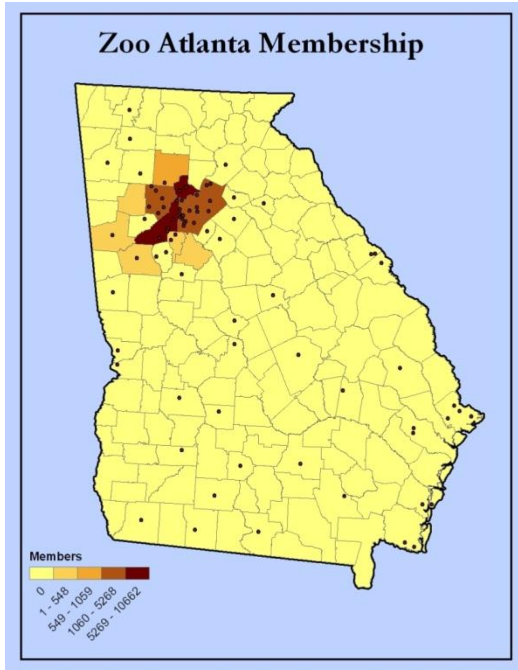


Figure 6: Zoo Atlanta Membership

Drive-time zones show that the majority of those visiting Zoo Atlanta are within 30 to 45 minutes of the zoo (figure 7). This increases the accessibility of the zoo to its visitors and decreases required planning for a trip. In addition, close proximity of other tourist attractions in Atlanta facilitates both competition and complementary visitation. A visit to the zoo is a partial-day activity, part of a tourist itinerary rather than a planned day-trip.

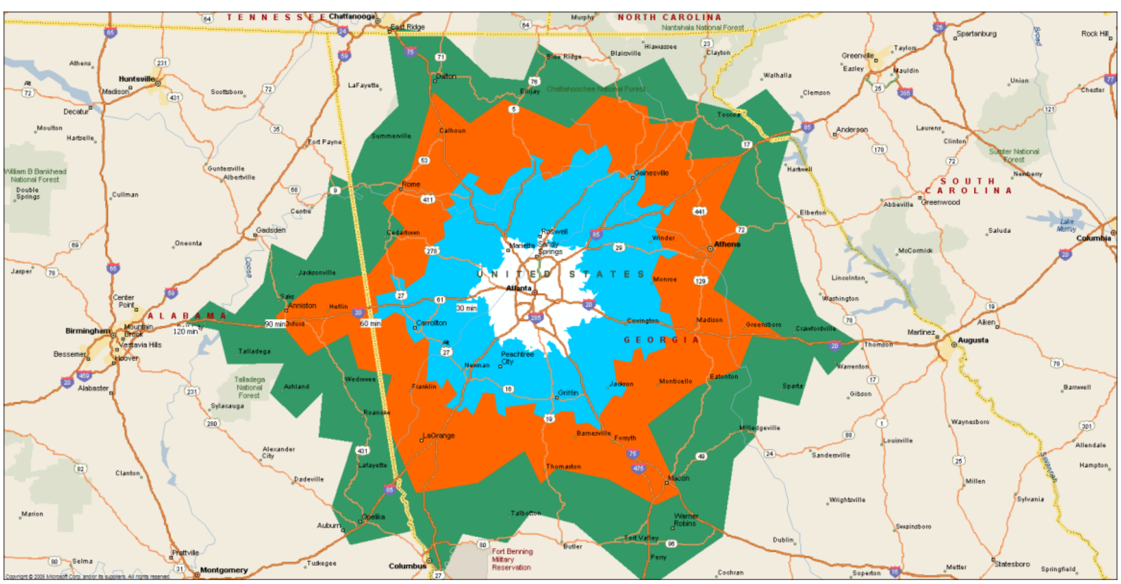


Figure 7: Drive Times to Zoo Atlanta

Asheboro, North Carolina has a seasonal climate with distinct climate regimes through the year. High temperatures in the summer average in the upper 80s, with days 90 to 100 degrees Fahrenheit not uncommon. Winter does not have extended periods below freezing; however, January low temperatures average near 30 degrees Fahrenheit with high temperatures in the low 50s. Precipitation is relatively stable through the year with no drastically distinct wet or dry season. Total precipitation varies from a maximum of 4.43 inches in January to a minimum of 3.16 in November.

Figure 8 explains the experienced climate at the North Carolina Zoo using monthly PET frequencies. PET is a commonly used method of expressing temperature as felt by humans. Categories are established with Matzarakis and Mayer's 1996 thermal sensation classes based on a Middle Europe classification scheme of thermal perceptions experienced by Europeans in different temperature bands. It can be assumed that the range of highest comfort for patrons of the North Carolina Zoo exists between "Warm" and "Slightly Cool." This assumption takes into consideration that people in the southeast United States are acclimatized to a warmer and more humid region than those tested in Europe.

The climate of Atlanta, Georgia is very similar to that of Asheboro, North Carolina. Atlanta is 350 feet higher in elevation and is located approximately 300 miles southwest of Asheboro. It is seasonal in its temperature and precipitation and has equivalent summers to Asheboro but slightly warmer winters with low temperatures averaging above freezing. Precipitation amounts vary more in Atlanta than in Asheboro with a minimum precipitation of 3.1 inches in October to a maximum precipitation of 5.3 inches in March. Figure 9 explains the "experienced climate" at Zoo Atlanta using monthly PET frequencies. Classifications, like the North Carolina Zoo, are established using Matzarakis and Mayer's 1996 Middle European thermal sensation scheme. It can be assumed that patron comfort is highest between “Warm” and “Slightly Cool.”

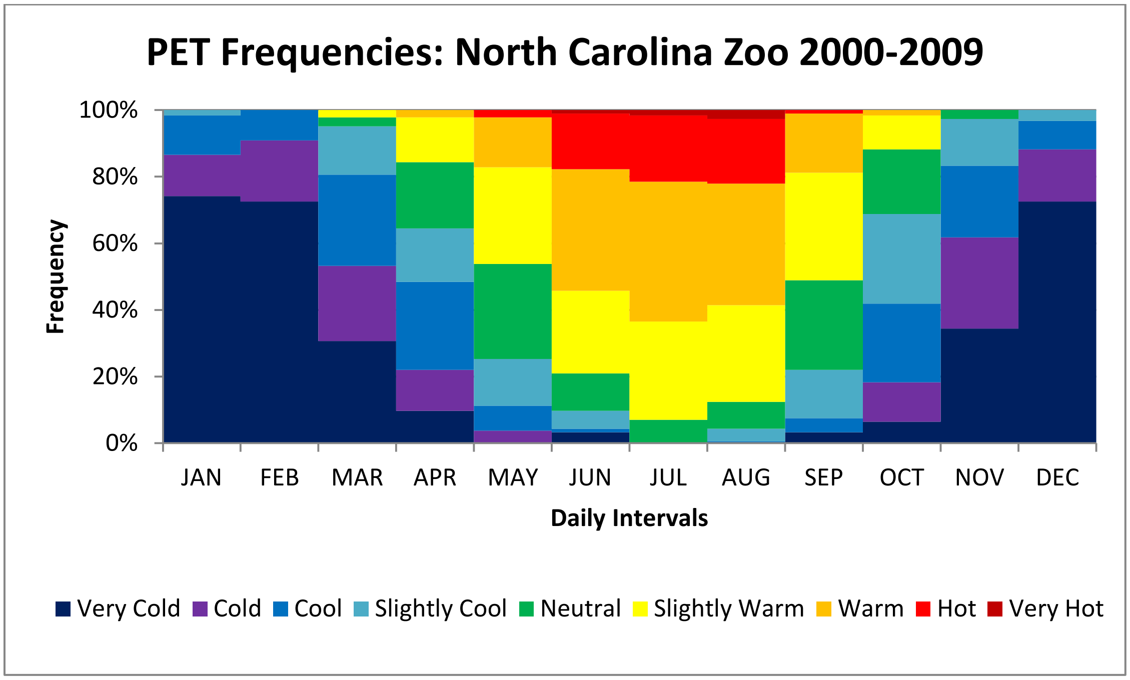


Figure 8: PET Frequencies for the North Carolina Zoo

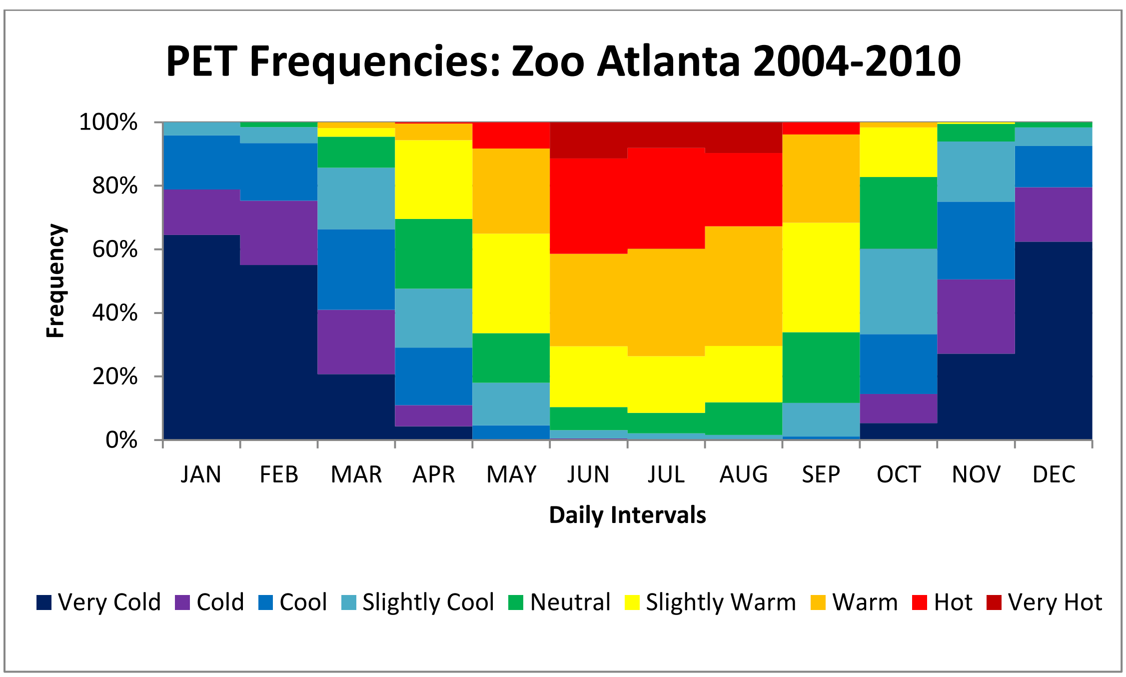


Figure 9: PET Frequencies for Zoo Atlanta

Table 1 displays a succinct comparison between Zoo Atlanta and the North Carolina Zoo emphasizing pertinent factors.

	Shelter	Air Conditioning	Mass Transit	Layout	Walking Distance	Closest Metro Area	Farthest Metro Area	Local Attendance Population	Parking	Park Area	Number of Species
Zoo Atlanta	Y	Y	Y	Linear	3.85 miles	5 min	60 minutes	6 million	Tight when busy	40 acres	220
North Carolina Zoo	Y	Y	N	Circular	1.3 miles	45 min	120 minutes	6 million	Ample spaces	1371 acres	250

Table 1: Zoo Comparison

2.2 Data

Ideally, hourly scale weather and attendance data would be utilized assess the time periods when the zoos are open. Because tourists rely on weather forecasts days in advance, historical forecasts are important to the analysis of how weather affects attendances at the zoo. Unfortunately, data available do not meet all these needs.

All daily weather data are obtained through the use of the CLIMOD tool from the Southeast Regional Climate Center (SERCC). Finer scale hourly weather data are obtained from the CLIMOD tool maintained by the Northeast Regional Climate Center (NRCC). Solar radiation data are obtained from the CRONOS tool at the North Carolina State Climate Office. CLIMOD and CRONOS tools are internet-based data clearinghouses that source their weather information from the National Climatic Data Center (NCDC). Weather data are quality controlled by these aforementioned organizations; however, lack of direct comparable weather stations in rural locations, such as Asheboro and stations which capture solar radiation, limit complete quality assurance. No modifications were made and data were used as received.

Asheboro, North Carolina, has one weather station with a period of record of 85 years. This station is located at a water treatment plant within five miles of the center of the zoo and reports precipitation and daily high and low temperatures (figure 10).

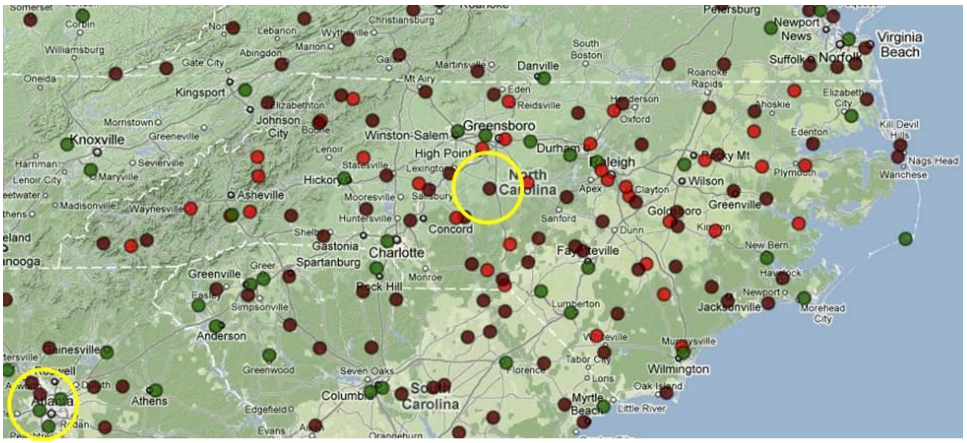


Figure 10: Regional Location of Study Sites

Weather data for Zoo Atlanta are obtained from a weather station located at the Hartsfield Jackson International Airport 3 miles southwest of the zoo property (figure 10). This weather station has a period of record in excess of 65 years and provides hourly data for temperature, precipitation, humidity, cloud cover, and wind speed. Solar radiation data are limited in the region and are obtained from Athens, Georgia, located approximately 55 miles east of Zoo Atlanta. This station has a period of record January, 2004 to the present.

Table 2 shows the weather variables available to each zoo in data analysis. “Daytime” indicates use of hourly values from 9am to 6pm—the times when zoos are open. At the North Carolina Zoo, all daytime calculations are based on the “piedmont composite” detailed in table 4 and further explained in section 2.3. “Assessment Groups” functionally group weather variables to facilitate analysis and discussion in Chapters III and IV; these are noted in table 3 and further explained in Methods, 2.3.

Directly Observed Variables	Variables Derived from Observations	Biometeorological Index Variables
Maximum Temperature	Wind Chill/Daytime Low	Predicted Mean Vote (PMV)
Minimum Temperature	Heat Index/Daytime High	PMV(I)
Average Temperature	Heating Degree Days (HDD)	Physiologically Equivalent Temperature (PET)
Precipitation	Cooling Degree Days (CDD)	PET(I)
Maximum Daytime Temperature		Standard Effective Temperature (SET)
Minimum Daytime Temperature		SET(I)
Average Daytime Winds		
Average Daytime Sky Cover		
Daytime Precipitation*		
Average Relative Humidity*		
Daytime Average*		
Temperature Range*		

*Variable used only at the North Carolina Zoo

(I) Solar radiation data used in calculation

"Daytime" weather data from 9am to 6pm

Table 2: Weather Variables Used

Assessment Groups				
High Temperature Variables	**Low Temperature Variables**	**Degree Day Variables**	**Other Variables**	**Biometeorological Index Variables**
Maximum Temperature	Minimum Temperature	Heating Degree Days (HDD)	Precipitation	PET
Maximum Daytime Temperature	Minimum Daytime Temperature	Cooling Degree Days (CDD)	Average Daytime Winds	PET(I)
Heat Index/Daytime High	Wind Chill/Daytime Low		Average Daytime Sky Cover	SET
			Daytime Precipitation*	SET(I)
			Average Relative Humidity*	PMV
			Daytime Average*	PMV(I)

*Variables used only at the North Carolina Zoo

Table3: Assessment Groups

A comparison between Asheboro and Atlanta weather stations is shown in figure 11. Variables compared include high temperature, low temperature, and precipitation totals.

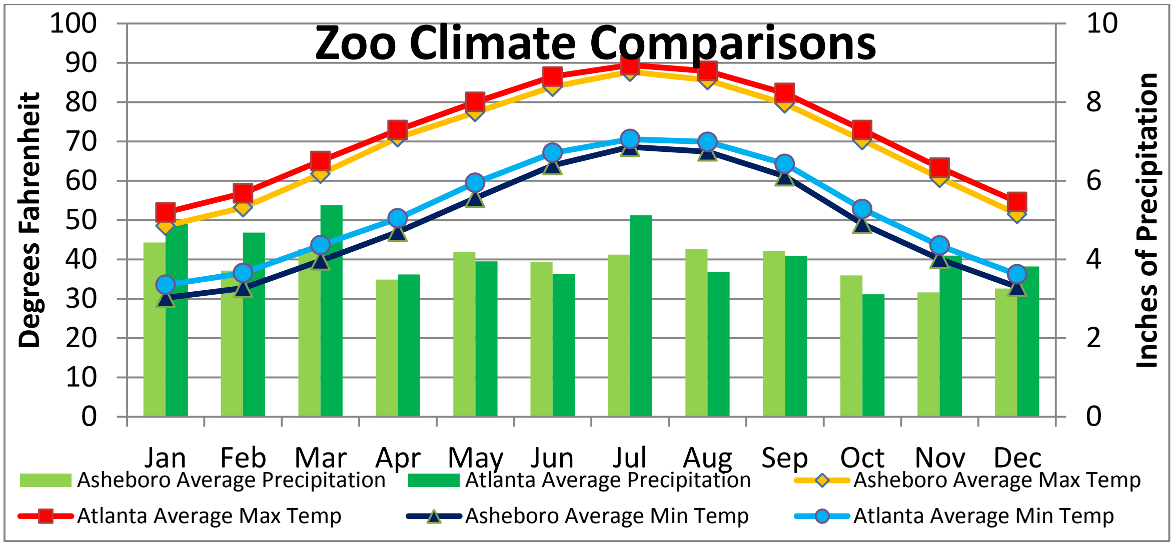


Figure 11: Zoo Climate Comparisons

Figure 12 displays average attendances and peak attendances by season. Attendance averages for Zoo Atlanta are calculated from the period 2004-2010; North Carolina Zoo data are calculated from 2000-2009. Data show the average annual attendances were 622,184 at Zoo Atlanta and 679,661 at the North Carolina Zoo. Attendance data are provided by the general administration of each zoo and are daily counts of admissions through entry gates. Data are based upon ticket sales, free admissions, and groups. Data are available in finer grained analysis with free admissions, paid admissions, and group promotional admissions. Such level of detail is beyond the immediate scope of the study, therefore daily totals are used. Time of entry is not available at either zoo; the finest temporal scale exists at the daily scale.

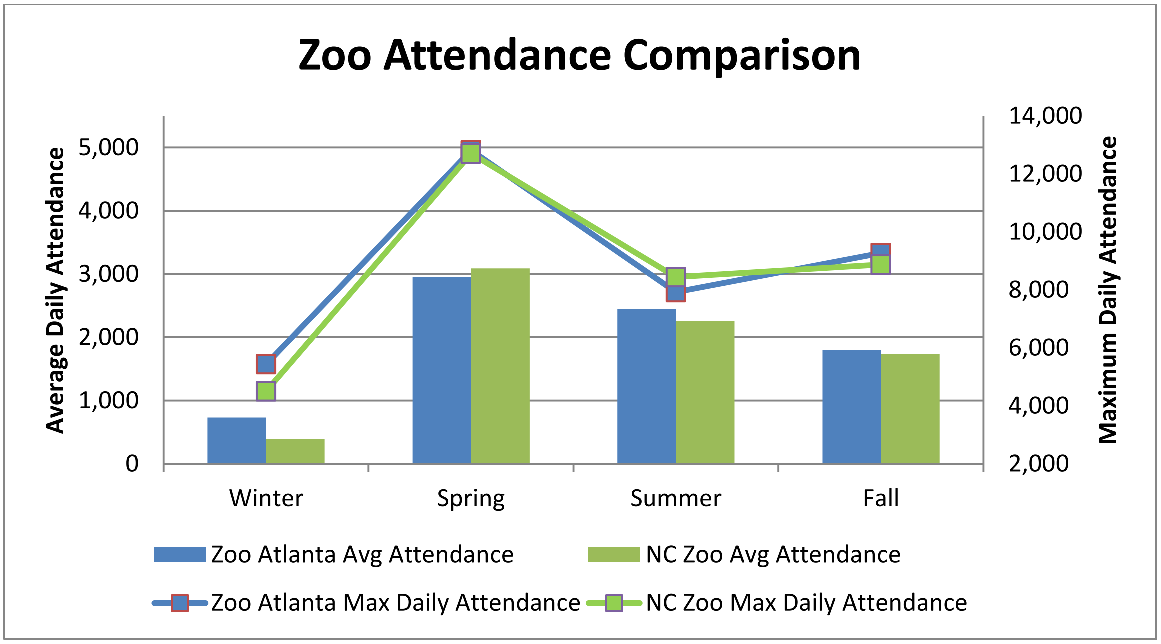


Figure 12: Zoo Attendance Comparison

Data exclusions are days in which the zoos are closed; closures occur for either holidays or severe weather. The most recent closure at Zoo Atlanta was due to a winter season ice storm. Hurricanes have caused closures at both zoos for the safety and security of the animals, employees, and visitors. In both locations the zoo scheduled closings on Christmas. Other day exclusions are promotional periods when zoo admission is free. Both zoos are pay-entry zoos, and free entry days cause very large spikes in attendance regardless of weather events.

2.3 Methods

To determine how weather and climate influence attendances at zoos, several methods are used to answer the research questions. These include attendance data pre-processing, weather data pre-processing, correlation analysis, multiple regression analysis, and probabilistic analysis.

Attendance data are serially complete, without missing days, and maintained by zoo guest service officers. Attendance numbers are based on ticket sales in conjunction with gate admissions. Methods to collect attendance data are consistent throughout the period of record, creating a high degree of precision. Few pre-processing considerations are needed to prepare the data for statistical analysis. First, assessments are made to determine the appropriateness of excluding holidays, holiday weekends, and school group attendances (Parilla, 2007). Second, a seasonal analysis is made at both zoos comparing average attendance on holidays, holiday weekends, weekends, and all days. Results show that a “holiday” or “holiday weekend” classification do not necessitate exclusion because attendance does not show a consistent trend indicating anomalously high holiday attendances compared with all weekends (figures 13 & 14). Excluding school group and special event attendance does not improve relationships between weather variables and attendance. School group attendances stay in the total attendance numbers to maintain uniformity across the study period. Third, frequency distributions of attendance indicate needs for normalized data due to non-normal attendance data. Multiple linear regression (a method used in this thesis) requires skewed data sets to be given logistic treatments to normalize dependent variables (Kleinbaum, 2008). In instances with non-normal attendance, log(attendance) is used to satisfy statistical requirements.

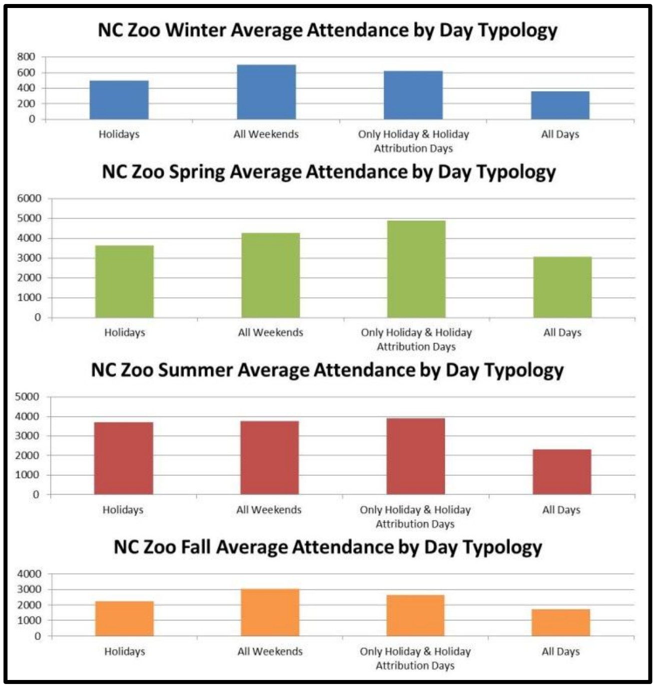


Figure 13: North Carolina Zoo Holiday Analysis

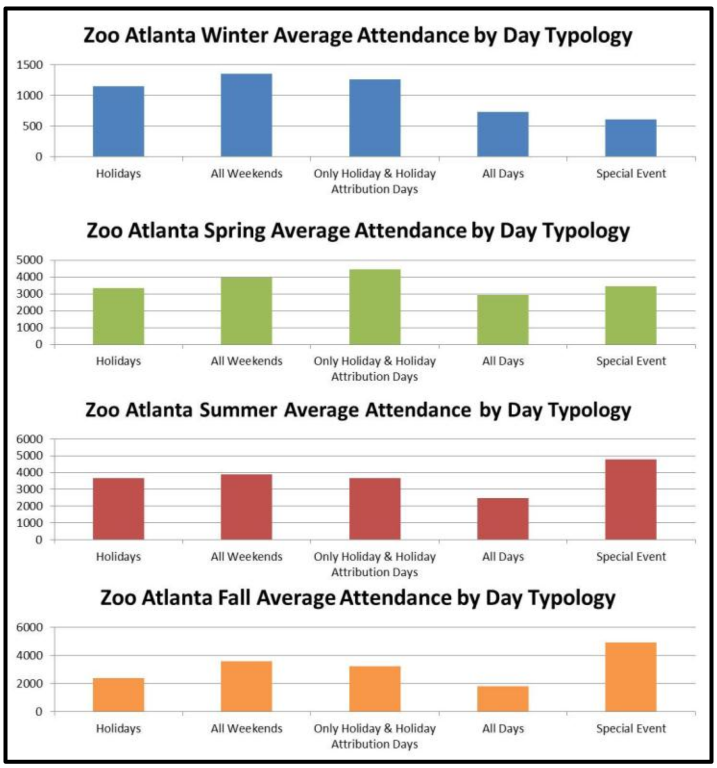


Figure 14: Zoo Atlanta Holiday Analysis

Weather data pre-processing is needed for the North Carolina Zoo because serially complete hourly weather data is unavailable from any Asheboro weather station. As a result, the "piedmont composite" was created in North Carolina utilizing surrounding stations which provide hourly weather information. Two goals are satisfied with the "piedmont composite": one, to simulate the probable weather conditions at the zoo during business hours, and two, to represent the weather at tourists' most likely points of origin. Stations used in the "piedmont composite" are located in Charlotte, Greensboro, Raleigh, and Fayetteville. Accuracy of projected Asheboro weather is the primary goal of the composite. Weighting of each station is based on the closest possible fit between composite data and actual daily data obtained at the Asheboro station. Best fit is determined by the highest obtainable Pearson correlation statistic squared (r-squared). The Pearson correlation statistic measures the strength of linear dependence between two variables (Burkard, 2012). Table 4 displays weightings used for each weather variable in the "piedmont composite."

High Temperature			
Pearson Fit: 0.989			
Charlotte	Greensboro	Fayetteville	Raleigh
0.3	0.55	0.05	0.1

Low Temperature			
Pearson fit: 0.988			
Charlotte	Greensboro	Fayetteville	Raleigh
0.1	0.45	0.05	0.4

Average Temperature			
Pearson Fit: 0.993			
Charlotte	Greensboro	Fayetteville	Raleigh
0.2	0.5	0.05	0.25

Precipitation			
Pearson Fit: 0.75			
Charlotte	Greensboro	Fayetteville	Raleigh
0.2	0.35	0.05	0.4

Table 4: Piedmont Composite

Due to the potential for temporal and spatial misalignments in data capture, these composite indices are used and compared with daily data from the Asheboro weather station; they are not used as a data replacement in the event they do not adequately correlate with attendance. A secondary use is that the piedmont composite weather station locations coincide with gateway points for many visitors of the North Carolina Zoo. It can be assumed that the composite does not always capture the weather in Asheboro; however, if it does not, it is likely that it will reasonably capture the weather throughout the region. People may make decisions to visit the zoo based on weather at their starting location, not on the actual weather at Asheboro. This is beneficial because it considers weather in departure cities.

Pre-processing is needed for the biometeorological variable outputs of the RayMan Model software (Matzarakis, Rutz, Mayer, 2000). Default RayMan solar radiation values are modeled from latitude; however, as established in Data, section 2.2, radiation data from nearby agricultural weather stations are available. This data is used in calculations of these indices, when indices are renamed VARIABLE(I). It is determined that usage of radiation improves correlation with attendance in all circumstances except the summer season.

The discussion of analysis methods begins with correlation analysis. Correlation analysis uses tables to assess the relationship of each weather variable with the dependent variable attendance or log(attendance). This method is used to assess weather variables singly and determine each variable's strength of correlation with attendance. All variables used are described in table 2. "Assessment groups" were developed to allow comparisons between the performance of measures having similar characteristics (table 3). Assessment groups include biometeorological indices, high temperature variables, low temperature variables, degree day variables, and "other" variables which include precipitation, humidity, sky cover, and wind. Perceived temperature index variables of Physiologically Equivalent Temperature (PET) (Hoppe, 1999), Predicted Mean Vote (PMV) (Fanger, 1972), and Standard Effective Temperature (SET) (Gagge *et. al*, 1986) assess realistic thermal profiles of zoo visitors. Their application is only within the correlation analysis of the study, and they are calculated with the RayMan software using meteorological and atmospheric data, which include temperature, wind velocity, solar radiation, relative humidity, and cloud cover.

As referenced in Chapter I, creation of physiological indices requires demographic and geographic inputs to accurately depict the experience of a zoo visitor. Tables 5 and 6 demonstrate the thermal, physical, and effort classifications chosen for zoo visitors. Because there is inadequate information on the size of the group and the number of children accompanying the adult guardian, it is determined that the most accurate choice of physiology is that of the adult. “Child” classifications are left as a reference but not used in this research. Using adult data makes the reasonable assumption that children are always accompanied with an adult and that the adult makes the decision to visit the zoo. Interviews with zoo employees indicate that the most common description of an adult is a young mother with elementary aged children. Because of this, generalized physical and age determinants are assigned to accurately capture this demographic. Clothing (CLO) values are used to assess thermal insulation of people.

For reference, “one CLO is the amount of thermal resistance which is necessary to maintain thermal comfort for a sitting-resting subject in a normally ventilated room at a temperature of 70 degrees Fahrenheit” (Hedge, 2011). CLO values are divided into three seasons—winter, summer, and shoulder seasons. Shoulder seasons of spring and fall have similar temperature variations, and finer scale categories will not lead to beneficial conclusions. Clothing amounts (CLO) are assumed based on observations made at individual zoos and general trends in the southeast United States. Effort level (in watts) is based on moderate paced walking and slightly augmented due to increased physical constraints of a “mother with child” zoo visitor. Physiological index variables are included in the analysis of the “primary weather variable,” which is the best single weather predictor for attendance.

Clothing Values (CLO)		
Season	Parent	Child
Winter	1.1	1.5
Shoulder Seasons	0.8	1
Summer	0.3	0.4

Table 5: RayMan CLO Value Inputs

Physical Input	Parent	Child
Age	37	7
Gender	Female	Male
Effort	145W	90W
Height	1.65m	1.16m
Weight	63kg	20.4kg

Table 6: RayMan Physical Value Inputs

Multiple regression is a statistical method used to examine the relationship between one dependent variable and one or more independent variables (MedCalc, 2012). Due to the automatic choice of predictive variables in stepwise regression (Draper *et al.,* 1981), data cleaning occurs to remove extraneous or inappropriate variable choices. Model outputs are sorted by descending r-squared statistic and displayed with weather variables used within the multiple regressions. The r-squared statistic, or coefficient of determination, indicates how well the model explains variance and can predict future outcomes (Steel *et al.,* 1980).

Stepwise multiple regression analysis modeling is used in this research of weather and attendance data to determine the primary weather variables statistically explaining attendance variations. A multiple regression allows the simultaneous testing and modeling of multiple independent variables (Palmer, 2007). This method is used to determine how combinations of weather variables interact to produce the strongest relationships between weather and attendance. Results help determine which particular weather situations have larger impacts on attendances.

Below is an example of an output equation from the multiple regression analysis:

$$\boldsymbol{Y = \alpha + \beta_1\theta_1 + \beta_1\delta_1 + \beta_1\gamma_1 + \beta_1\mu_1 + \beta_1\varepsilon_1}$$

Y= attendance
α= constant
β= beta coefficient/slope
θ= amount of precipitation
δ= high temperature
γ= average cloud cover
μ=average wind speed
ε= average relative humidity

Both correlation analysis and multiple regression analysis use weather and attendance data on a day-temporal scale. Segmentations of weather and attendance data are required to allow for appropriate analysis. Because there is no clear or consistent guidance concerning attendance in the literature, exploratory analyses to reach these conclusions involve several statistical observations, outlined next. Correlation tables are created comparing attendances and weather variables. Review of variables show the need for sixteen attendance prediction models per zoo per year. These sixteen models are divided by season, weekend days or weekday days, and wet or dry days (figure 15).

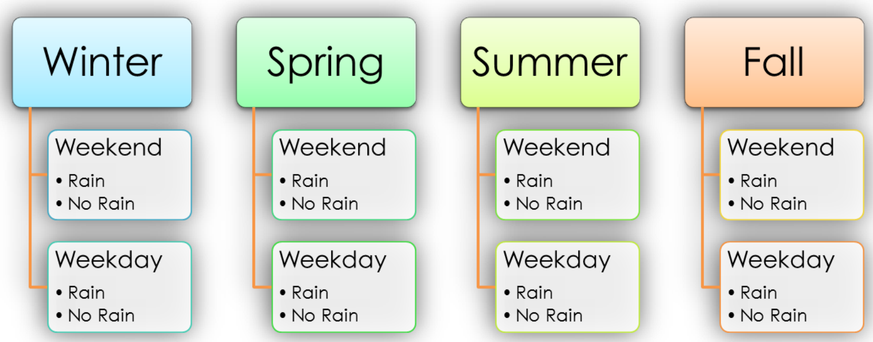


Figure 15: Multiple Regression Annual Scenarios

A single annual attendance model where individual weather variables are used as predictors of attendance does not adequately predict attendance. This method is too coarse to provide useful information. Further analysis indicates that social factors relating to typical work weeks (Parrilla, 2007), different seasons, and confounding relationships between temperature and precipitation result in an annual model not appropriate for analysis.

For this study seasons are separated because each zoo experiences seasons with varying climates and attendance distributions. Seasonal acclimatization (Lin, 2008; Armstrong *et al*., 1987) expresses changing weather perceptions and expectations humans have in each season. Seasons are established as typical meteorological blocks of three month increments: December, January, February (DJF) for winter; March, April, May (MAM) for spring; June, July, August (JJA) for summer; and September, October, November (SON) for autumn. Weekend and weekdays are separated after reviews of attendance determined significant differences between weekend and weekday attendance. Each day of the week is plotted separately on a scatterplot grid pairing attendance with temperature (high and low temperatures are tested separately). This is performed for each season, and results confirm that slopes of the linear fit-lines exist in two groups. Saturday and Sunday, in every scenario, have different slopes than weekdays. Day of week review indicates that the separation between weekend days and weekday days is necessary in modeling. Results show that separating in finer groupings, such as Mondays and Fridays as peripheral weekend days, is unnecessary. Weekend attendances appear to have decreasing dependence on the weather. It can be reasonably assumed that this relationship is socially driven as weekends are often the only time away from work and school for typical zoo visitors. Rain and no rain days are separated because controlling for wet and dry day scenarios drastically improves predictability (r-squared) of weather-attendance models. In addition, the presence of rain introduces different temperature relationships which can confound analysis.

Probabilistic analysis is performed in longer-term temporal scales than the daily scales used in correlation and multiple regression analyses. This method of analysis is only briefly applied in this study, indicating the potential for further work with zoos. This method is used to assess whether long-term climate forecasts can be of use to attendance relationships with weather. Also, this method evaluates the potential for seasonal acclimatization based on visitor expectations (further explained in Chapter IV). Long-term seasonal climate forecasting is displayed probabilistically, showing above normal, equal chance, or below normal scenarios. Methods are sought to replicate a probabilistic climate forecast using monthly values and compiling them in three month seasonal climate forecast groups.

Data in this study are treated in the same fashion as Climate Prediction Center climate forecasts (using above, below probabilities), but diverging from a climatological "normal" by using the previous year as the baseline (Planalytics, 2010). A previous year baseline method uses a monthly calculation of percentage attendance departure from the previous analog year (i.e., March 2001 compared with March 2000). Scatter diagrams show above and below previous year results for attendance and respective weather variables (figure 16). Use of previous year departures helps to capture a social memory in the relationship and normalizes data. Comparison with the previous year allows results to capture short-term expectation adjustments patrons may make based on a previous year.

For example, an unfavorable winter season during one year will be taken into consideration the next winter season with increased sensitivity and appreciation of any favorable conditions. Large attendance changes during one year, with respect to zoo marketing or exhibit openings, will only be realized in one point rather than the whole period. Probabilistic analysis periods are 1982-2010 at the North Carolina Zoo and 2004-2010 at Zoo Atlanta. Scatter diagrams are the display output for results in the longer temporal scale analysis. Diagrams are designed to be read in only the upper half (positive y-axis) or the lower half (negative y-axis) of the figures. Upper half—positive y-axis—indicates that weather variables of interest are above a defined "normal"—the lower half indicates the opposite. Diagrams coincide with long-range climate forecast conventions. Such forecasts predict weather variables as either above or below a "climate normal" or previous season normal.

Figure 16 is an example of output from probabilistic analysis. Individual points match month attendance departures from a previous year baseline and the respective weather variable departure from its previous year baseline. As an example, one point on the graph uses data created from an attendance departure—March 2009 to March 2008. This point of data compares the temperature departure of March 2009 and March 2008. Seasonal presentation uses standard three-month climatological classifications, referred to earlier in this chapter. Figure 16 also provides an example of application. A climate forecast for any month where high temperatures in the MAM period are below the previous year's MAM period facilitates readings from the negative y-axis region. Probabilities based on distributions between positive and negative x-axis values follow to complete the analysis.

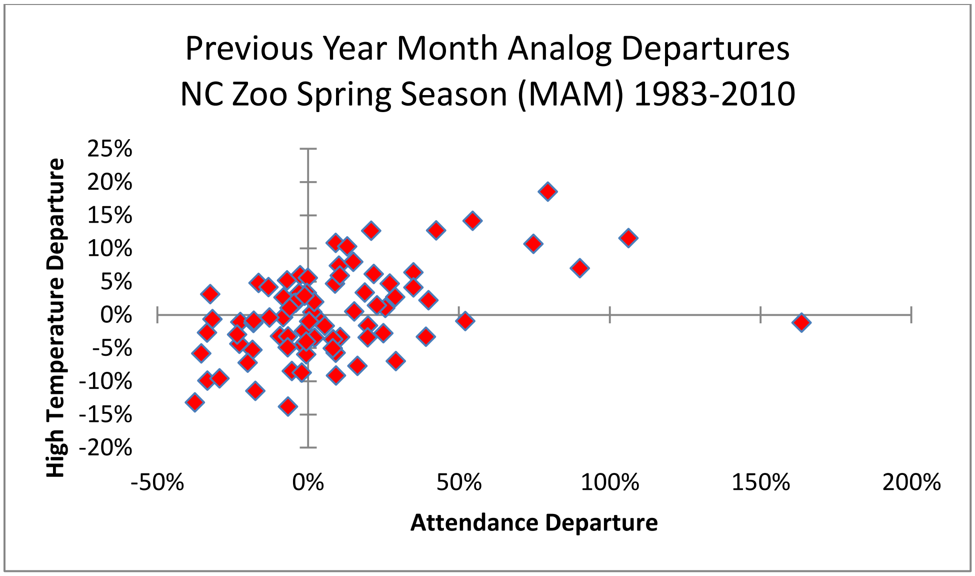


Figure 16: Previous Year Month Analog Departures NC Zoo Spring Season

The Tourism Climate Index (TCI) is studied in probabilistic analysis. It is an assessment index of tourism conditions "equivalent to walking outdoors at a speed of 2.5-3.0 km/h…" (Mieczkowski, 1985) and is appropriate to apply in the overview of zoo tourism. Meteorological inputs in the index are assessed separately and scored on predefined scoring tables. Sum of the scores constitutes the index value. Index values vary from -30 to 100 with scores in excess of 70 being considered "very good" through "ideal" tourism climates. Figure 17 is an adapted chart from "Climate Change and the Distribution of Climatic Resources for Tourism in North America" (Scott *et al.,* 2004) describing Mieczkowski's TCI scale scores. Meteorological inputs in the TCI are temperature, humidity, sunshine, wind, and precipitation. TCI is a monthly score and is only applied in this temporal scale.

TCI score	Category
90 to 100	Ideal
80 to 89	Excellent
70 to 79	Very good
60 to 69	Good
50 to 59	Acceptable
40 to 49	Marginal
30 to 39	Unfavourable
20 to 29	Very unfavourable
10 to 19	Extremely unfavourable
–30 to 9	Impossible

Figure 17: TCI Scoring System

Chapter III

Results

Chapter III presents and reviews results for the data and methods presented in Chapter II and evidence is provided to answer the research aims and questions of the study. Results will be presented as follows: First (3.1), results from daily multiple regression modeling help to answer whether combinations of weather variables can predict zoo attendance and how well they predict. Next (3.2), correlations between individual weather variables and attendance are presented to answer which single variables are the strongest and most influential on zoo attendances. In addition (3.3), month and seasonal variables integrate climate and attendance and explore whether climatic factors influence decisions to visit a zoo. Finally (3.4), review and application of Mieczkowski's TCI helps evaluate application of tourism climate indices established in the literature. How social influences coalesce with weather factors in tourist decisions is discussed in Chapter IV.

3.1 Multiple regression weather modeling

Results from multiple regression analyses are presented in tables 7 and 8 and arranged from highest r-squared value to lowest. Sixteen scenarios per zoo are presented and differentiated by day of week, season, and wet or dry scenarios. The single variable with the highest r-squared value with attendance is located in the fifth column. Multiple regression models are based solely on observed or derived weather variables (see table 2).

SET(I) and other biometeorological variables are not used in statistical modeling because they are combinations of observed weather variables. Biometeorological indices are only assessed in correlation analysis. Results are displayed in the fifth column of tables 7 and 8 for completeness.

North Carolina Zoo					
Day of Week	Season	Wet/Dry	Multiple Regression R^2	Best Single Variable Correlation with Attendance	Number of Observations
WEEKEND	SPRING	WET	0.720	Daytime High Temperature	98
WEEKEND	WINTER	WET	0.643	SET(I)	76
WEEKEND	FALL	WET	0.599	Daytime High Temperature	60
WEEKEND	WINTER	DRY	0.548	SET(I)	162
WEEKEND	SPRING	DRY	0.424	SET(I)	163
WEEKDAY	SPRING	WET	0.409	SET(I)	215
WEEKEND	SUMMER	WET	0.334	Daytime High Temperature	86
WEEKDAY	WINTER	DRY	0.331	SET(I)	421
WEEKEND	FALL	DRY	0.302	Daytime Low/Wind Chill	200
WEEKDAY	WINTER	WET	0.301	SET(I)	171
WEEKEND	SUMMER	DRY	0.274	Daily High Temperature	177
WEEKDAY	FALL	WET	0.223	Daytime Precipitation	198
WEEKDAY	SPRING	DRY	0.222	Daytime Low/Wind Chill	439
WEEKDAY	SUMMER	WET	0.160	Average RH	247
WEEKDAY	SUMMER	DRY	0.134	Average Temperature	410
WEEKDAY	FALL	DRY	0.024	Average Sky Cover	452

Table 7: North Carolina Zoo Regression Results

Zoo Atlanta					
Day of Week	Season	Wet/Dry	Multiple Regression R^2	Best Single Variable Correlation with Attendance	Number of Observations
WEEKEND	WINTER	WET	0.653	SET(I)	60
WEEKEND	SPRING	WET	0.651	Day High Temperature	59
WEEKEND	FALL	WET	0.614	SET(I)	22
WEEKEND	WINTER	DRY	0.583	Daytime High Temperature	104
WEEKDAY	SPRING	WET	0.532	SET(I)	116
WEEKDAY	FALL	WET	0.445	Precipitation	94
WEEKDAY	WINTER	WET	0.424	SET(I)	129
WEEKDAY	WINTER	DRY	0.357	Daytime High Temperature	290
WEEKEND	SPRING	DRY	0.226	Average Daytime Winds	125
WEEKDAY	SUMMER	WET	0.158	SET(I)	144
WEEKEND	FALL	DRY	0.152	SET(I)	134
WEEKDAY	SUMMER	DRY	0.129	Minimum Temperature	260
WEEKEND	SUMMER	WET	0.129	SET(I)	56
WEEKEND	SUMMER	DRY	0.118	Daytime High/Heat Index	105
WEEKDAY	SPRING	DRY	0.058	Max Daytime Temperature	343
WEEKDAY	FALL	DRY	0.055	Max Temperature	287

Table 8: Zoo Atlanta Regression Results

Additional tables that include all weather variables used in each multiple regression model scenario can be found in the Appendices. To maintain statistical integrity, when the r-squared between two weather variables is in excess of 0.6, those variables are not included in the same scenario.

Models of the North Carolina Zoo have r-squared values ranging from 0.720 to 0.024. Scenarios with the highest correlations are wet weekends with lower observation values. All summer scenarios have low correlations, and weekends are better correlated than weekdays. Because fewer observations exist for weekend days, this higher correlation may be due to small sample sizes and care must be taken before justifying differences in results. In Zoo Atlanta models r-squared values range from 0.653 to 0.055. Scenarios with highest weather-attendance correlations are rainy weekends. This is partially due to lower numbers of observations. In the seven highest-correlated model scenarios at Zoo Atlanta, only one is attributed to dry conditions. All summer scenarios are poorly predicted as the highest r-squared value is 0.158.

3.2 Correlation analysis of individual weather variables

Assessment groups established in Methods, 2.3 and table 3 are used in the display of results of individual weather variables and their relationships with zoo attendance. At the North Carolina Zoo, among all biometeorological indices, SET(I) has a superior correlation with attendance in 11/16 of the scenarios. When SET(I) and SET are grouped, these variables have higher correlation with attendance than PET/PET(I) and PMV/PMV(I) indices in 13/16 of the scenarios. The high temperature category compares day high temperature, the "piedmont composite" of daytime high temperature between 9am and 6pm, and the daytime high/heat index (Steadman, 1979). In wet summer scenarios, addition of the heat index to daytime high does not improve correlation with attendance, though in dry summer scenarios the heat index addition improves correlation. Because heat index occasionally occurs during shoulder seasons, it is tested as well, and results show that the addition of heat index to daytime high does not improve correlations in shoulder seasons.

Comparing all three high temperature variables, daytime high temperature has the superior correlation in 9 of the 16 total scenarios, while daily high temperature is superior in 5 of the 16 scenarios, indicating a gained benefit when using a daytime high variable. The low temperature category includes low daytime temperature, low daily temperature, and the variable of daytime low or lowest wind chill temperature (Eagan, 1964). In non-summer scenarios, addition of a wind chill component to daytime low improves correlations with attendance in 11 of the 12 scenarios. Heating degree days (HDD) and cooling degree days (CDD)—departures from a daily average temperature of 65 degrees Fahrenheit—are analyzed during shoulder seasons.

While the numbers of observations are not equal, it is observed that of the 8 shoulder season scenarios, heating degree days have higher correlations to attendance in 7 of the 8 scenarios. Cooling degree days are superior only during dry fall weekdays. “Other variables” include wind speed, sky cover, relative humidity, and precipitation. Relative humidity is the best correlated variable in four scenarios; amount of precipitation is in three. Comparing all weather variables at the North Carolina Zoo, SET(I) is the superior variable in 6/16 of the scenarios, followed by average relative humidity and daytime high temperature, both superior in 2/16 of all scenarios.

At Zoo Atlanta, SET(I) has the highest correlation with attendance of all the biometeorological indices in 13 of the 16 scenarios. Two exceptions are the dry summer scenarios when added radiation data decreased correlations. PET(I) is the superior predictive variable in one scenario, though the advantage over SET(I) is not statistically significant. The high temperature grouping includes daily high, daytime high, and the daytime high/heat index variable. Addition of heat index to dry summer scenarios improves correlations with attendance, while wet summer scenarios are not assisted. During shoulder seasons, 2 of the 8 scenarios are benefited by the addition of heat index to the daytime high temperature. In these two scenarios, the conditions are wet.

Benefits of using daytime high temperature (temperature between 9am and 6pm) versus daily high temperatures are slight. Daytime high temperature is the best variable in 6 of the 16 scenarios and daily high temperature is the best variable in 5 of the 16 scenarios. Variables within the low temperature category, when compared to the high temperature category, have higher correlations with attendance in 2 of the 16 scenarios. This indicates that high temperature variables are more useful to predict attendances at Zoo Atlanta than low temperature variables. Addition of wind chill to daytime low temperature shows improvement in 12 of 12 tested scenarios. Degree days (CDD and HDD) are assessed during shoulder seasons. Of the 8 shoulder season scenarios, HDD is higher correlated with attendance in seven of these scenarios. "Other variables" at Zoo Atlanta include precipitation, sky cover, and average humidity.

Eight (wet) scenarios are available for comparison. Sky cover is better correlated with attendance than amount of precipitation in 4 of the 8 scenarios. Overall, the highest correlated weather variable with attendance is SET(I) in 4 of the 16 scenarios. Daytime high temperature is highest correlated in 2 of the 16 scenarios. While no variable consistently is the best correlated variable, these two variables are among the highest in every scenario, and therefore can be determined as the best overall single variables for Zoo Atlanta attendance prediction. Results for both zoos are graphically explained in table 9.

North Carolina Zoo											
Biometeorological Variables		**High Temperature Variables**		**Low Temperature Variables (winter only)**		**Degree Day Variables**		**Other Variables**		**Overall**	
SET(I)/SET	13/16	Daytime High Temp	9/16	Daytime Low/Wind Chill	11/12	HDD	7/8	Relative Humidity	4/8	SET(I)	6/16
PET(I)/PET	3/16	Daily High Temp	5/16	Daytime Low	1/12	CDD	1/8	Amount of Precip	3/8	Daytime High Temp	2/16
Zoo Atlanta											
Biometeorological Variables		**High Temperature Variables**		**Low Temperature Variables (winter only)**		**Degree Day Variables**		**Other Variables**		**Overall**	
SET(I)/SET	13/16	Daytime High Temp	6/16	Daytime Low/Wind Chill	12/12	HDD	7/8	Sky Cover	4/8	SET(I)	4/16
PET(I)/PET	1/16	Daily High Temp	5/16	N/A	N/A	CDD	1/8	Amount of Precip	3/8	Daytime High Temp	2/16

Table 9: Summary of individual weather variable comparison

3.3 Probabilistic climate-attendance relationships

Month and seasonal variables are used to explore climate and attendance relationships. Tables 10 and 11 summarize yearly results for each season at the North Carolina Zoo and Zoo Atlanta observed from scatter diagrams outlined in Methods, 2.3. Percentages in the table are based on historical observations of departures. Resultant points in the scatter diagrams were counted and converted to percentages. The tables have two different metrics for attendance predictability: greater attendance predictability and lower attendance predictability. Greater attendance predictability indicates that attendances are comparatively higher with the previous analog year, and the associated variable yields the best prediction. Lower attendance predictability indicates that the variable observed yields the best prediction for lower attendances when compared with the previous year.

The purpose of dividing greater and lower attendance predictabilities is that different weather variables have different influences on people. Rain, for example, has negative impacts on zoo attendance. Assumption of the opposite does not yield the best possible result—lack of rain does indicate positive impacts for zoo attendance, but is not as strong an indicator as high temperature. As a result, the need for greater and lower attendance influences is important to the overall results. Negative percentages indicate negative relationships between attendance and the respective variable.

Weather variables tested at the North Carolina Zoo are high temperature, low temperature, amount of precipitation, days of precipitation, and in the summer season, days over 90 degrees Fahrenheit. The highest predictable period for greater attendance departures is the winter season (DJF). Results show that if high temperature is above the previous year baseline, there is a 78% probability that attendance will be above the previous season's month baselines. Summer season displays the strongest lower attendance predictability of -69% with the variable "days over 90 degrees F."

Results from Zoo Atlanta are displayed in table 11. In the spring season, compared with previous spring months, greater attendance is predicted 80% with decreased days of precipitation; lower attendance is predicted 89% with increased amounts of precipitation. Summer season (JJA) results show low temperature as the best variable on a month/seasonal time scale. When low temperatures are cooler than the previous year baseline, there is a 75% probability that attendance is also reduced.

North Carolina Zoo				
Season	DJF	MAM	JJA	SON
Highest Greater Attendance Predictability (Previous Year)	78%	64%	-74%	-75%
Variable	High Temperature	High Temperature	Days over 90°F	Days of Precipitation
Highest Lower Attendance Predictability (Previous Year)	56%	-63%	-69%	-66%
Variable	High Temperature	Days of Precipitation	Days over 90°F	Days of Precipitation

Table 10: North Carolina Zoo Scatter Diagram Results

Zoo Atlanta				
Season	DJF	MAM	JJA	SON
Highest Greater Attendance Predictability (Previous Year)	-63%	-80%	67%	78%
Variable	Amount of Precipitation	Days of Precipitation	Low Temperature	High Temperature
Highest Lower Attendance Predictability (Previous Year)	-67%	-89%	75%	80%
Variable	Amount of Precipitation	Amount of Precipitation	Low Temperature	High Temperature

Table 11: Zoo Atlanta Scatter Diagram Results

Included in the appendix to this thesis are two panels, each with six scatter diagrams of interest. Various weather variables are selected and six examples per zoo are offered. Scatter diagrams include examples from all seasons paired with differing variables of interest such as high temperature departure, low temperature departure, precipitation amount departure, and number of precipitation days departure.

3.4 TCI analysis

The monthly TCI variable is tested in two contexts. First, TCI scores are paired with monthly attendance throughout the period of study. Second, departures using probabilistic methodologies are presented. Figure 18 compares TCI scores with average daily attendance (converted from month totals) at the North Carolina Zoo. TCI scores are lowest in the winter season and highest in the spring season. TCI favors thermal conditions which are more representative of the shoulder seasons in Asheboro—with summer temperatures too high for a high TCI score, and winter temperatures too low for a high TCI score. The lowest score in the study period is within the "marginal" tourism classification scheme while other scores are in favorable tourism classifications. It appears that the most favorable TCI scores for high attendances at the North Carolina Zoo are above 80.

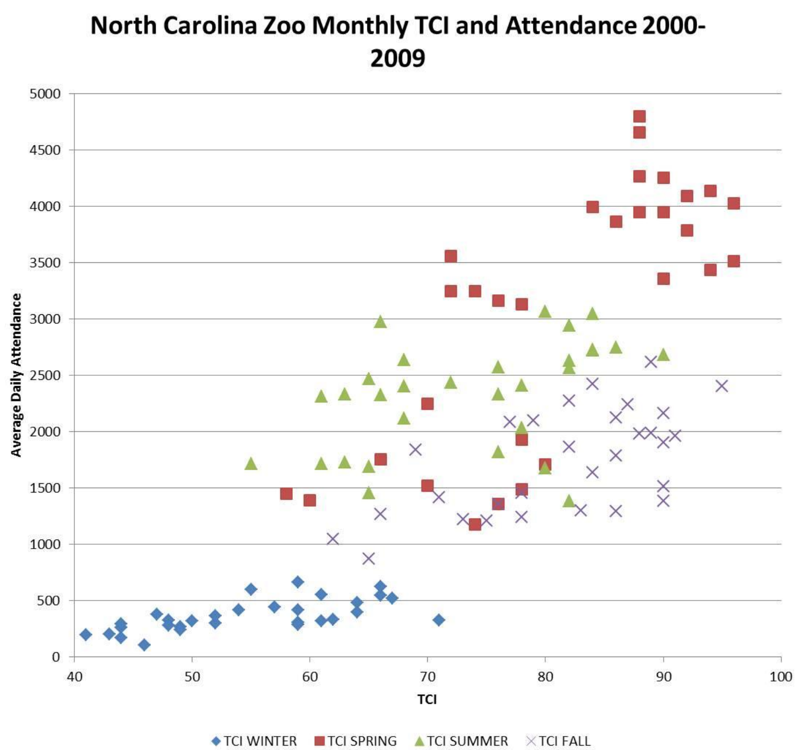


Figure 18: North Carolina Zoo Monthly TCI & Attendance

Figure 19 shows the relationship between monthly TCI scores and average daily attendance at Zoo Atlanta. Higher TCI scores indicate higher average attendances. One month of the 2004-2010 study period is rated as "unfavourable." All other scores indicate "marginal" conditions or better. Spring season results display three distinct groupings with respect to increasing TCI scores. Spring and fall have, in general, the highest TCI scores, followed by summer; winter is lowest. Favorable spring conditions outperform all other seasons.

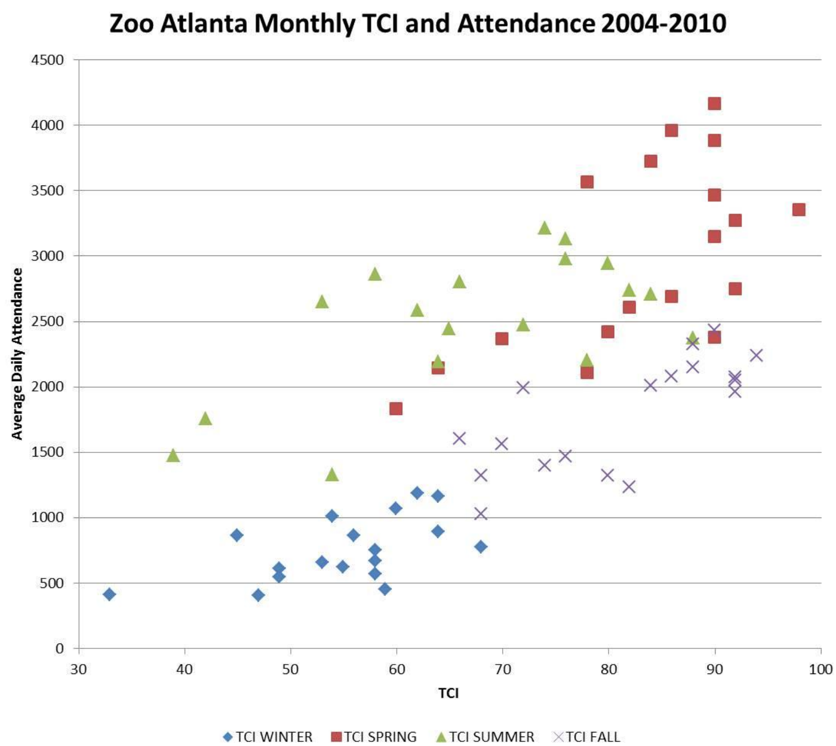


Figure 19: Zoo Atlanta Monthly TCI & Attendance

Figures 20 and 21 display the relationships between both monthly TCI score departures and attendance departures at the North Carolina Zoo and Zoo Atlanta. Attendance departures are based on the month averages for the entire periods of study, rather than previous year baselines. Probabilities are calculated from the number of observations in the scatter diagram quadrants and converted to percentages.

At the North Carolina Zoo, in any month where the TCI index is higher than the month average for the period of study (61 instances), there is a 69% (42/61) probability that monthly attendance will also be greater than the average for that month. Conversely, if TCI is below the month average, there is a 70% probability that attendance will also be below the average attendance for that month.

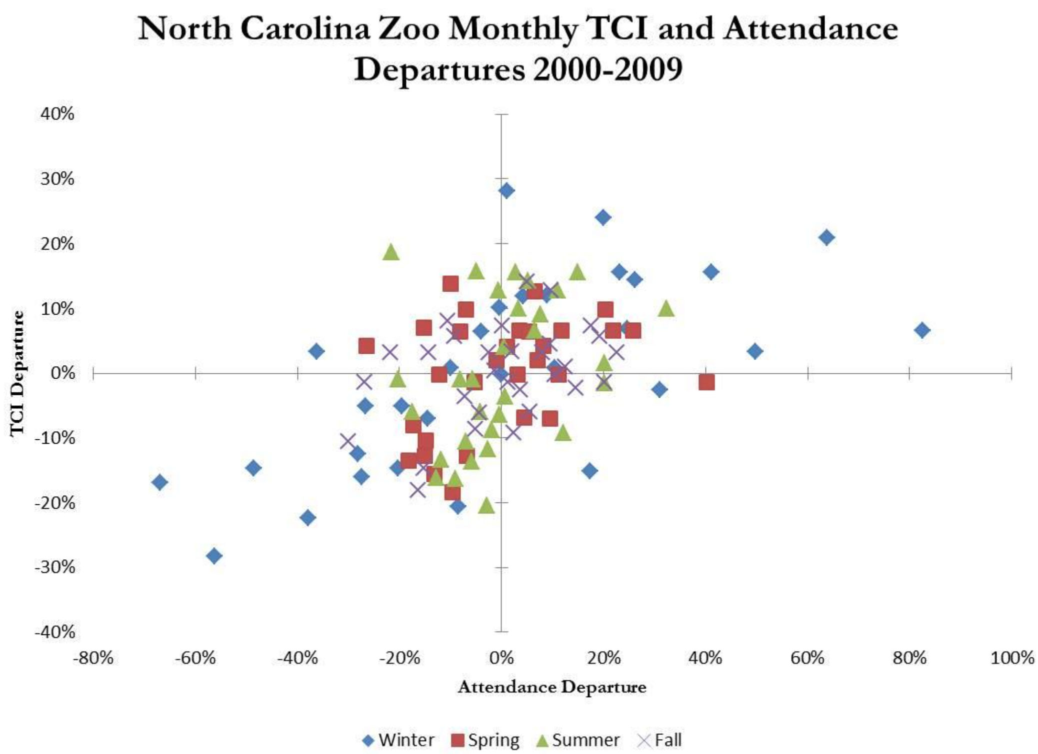


Figure 20: North Carolina Zoo Monthly TCI & Attendance Departures

Figure 21 displays the scatter diagram distribution of TCI scores for all months plotted with respective attendance departures at Zoo Atlanta. When the TCI score is above month averages, attendance is also above average 27 of 38 months or 71% of the occurrences. Conversely, if month TCI is below average there is a 24 of 34 (or 71%) probability that attendance is also below the month average. Results show that greater TCI departures in both positive and negative directions indicate greater magnitudes in attendance departures.

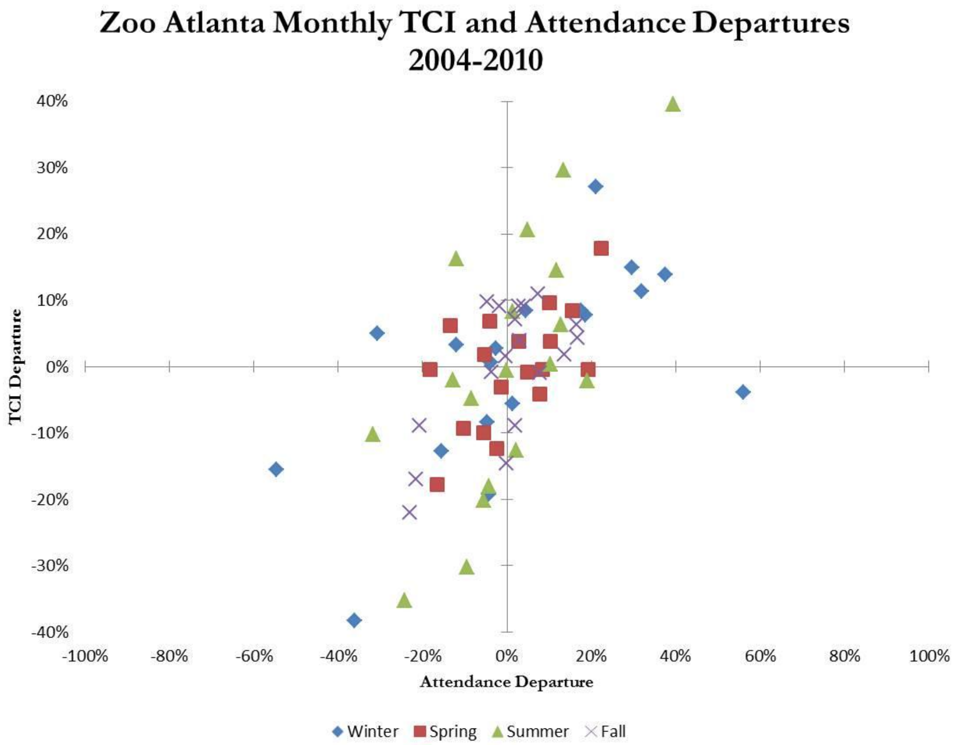


Figure 21: Zoo Atlanta Monthly TCI & Attendance Departures

Results show that at the North Carolina Zoo the magnitude of TCI departure has little influence on the magnitude of attendance departure. These are opposite the results of Zoo Atlanta. Increased TCI departures from the period average are not followed by equivalent magnitudes in attendance departures.

Chapter IV:

Discussion

This discussion section contextualizes results and findings of the study. It begins with a discussion of results that reviews points of interest arising directly from Chapter III with detailed analysis of weather variables influencing zoo attendance. Next, it discusses implications of findings through analysis and speculation of what factors may be causing the results seen in Chapter III.

4.1 Discussion of results

Correlation analysis of individual weather variables, section 3.2, displays results from "assessment groups" of biometeorological indices, high temperature, low temperature, and "other weather variables" (table 3). Overall, the most influential variable grouping is the high temperature group of weather variables. This indicates it is likely that people in the southeast United States are most aware of high temperature variables when planning zoo visits.

Another factor (brought about in analysis of degree days during shoulder seasons) is that cold weather, not warm weather, is the more prominent factor affecting attendances at the zoos. There is an important distinction between this result and the previous result in that high temperature variables are most influential. During events of cold weather and warm weather, high temperature variables are equally important—in fact, more important when associating attendance than low temperature variables. Cold weather promotes a prominent behavior change in attendance decisions, but the best measure for these changes is with high temperature variables. Seen in table 9, heating degree days (a proxy for colder temperatures) is better correlated with attendance variables than cooling degree days (a proxy for warmer temperatures). It is reasonable to assume that in the southeast United States (a relatively warm climate), visitors are more sensitive to cold weather than to warm weather. As a result, when temperatures decrease, weather-attendance relationships at the zoos show more definitive associations. To further explain, a wind chill factor turns visitors away from a zoo visit more than the presence of a heat index.

On wet days, relative humidity appears to have a stronger influence on attendance than the amount of precipitation (table 9). Effects of rain on zoo attendances are nonlinear. Rain has a large effect on attendances, but also reaches an affect threshold quickly. Increasing amounts of precipitation cause attendances to drop rapidly to a point when they no longer decline. For example, a half-inch of precipitation can create "wash-out" days with low attendances; any additional precipitation does not affect attendances.

Lack of precipitation in peak visitation hours can mean that amounts of precipitation received have little or no effect on visitors at the zoo. In the summer season, heavy thunderstorm rain occurs in the afternoon and early evening. Thunderstorm rain falls quickly and usually does not affect a zoo visit for more than an hour. In the event of rain falling over a short time span, use of an average relative humidity variable helps to discount a storm that did not greatly affect zoo visitors. When light rain and lingering showers accrue precipitation throughout the day, average relative humidity is high. Average relative humidity captures the type of the precipitation event and better approximates attendances than using precipitation amounts. Sky cover can serve as a proxy variable for relative humidity and, thus, also provides benefits over using precipitation amounts when approximating attendances. High daily average sky cover, especially in the southeast United States, often indicates the presence of rainy weather. Heavy summer season rains come from cumulus clouds and occur more often in the afternoon. This is reflected in the sky cover variable as these types of rain events are discounted when using a daytime average. Day-long precipitation events, which have more damaging effects on zoo attendances, are associated in the data with high average cloud cover numbers and high relative humidity numbers.

Summer season results show a negative correlation between attendance and high temperatures. This is different from trends observed in all other seasons and scenarios. Summer seasons contain many days that are very warm and, as seen in figures 9 and 10, witness perceived temperatures that are “very hot.” In the summer season, when high temperature has a positive relationship with attendance, scenarios are wet. Wet days in the summer are usually much cooler than dry days. These cooler temperatures create a situation where the high temperature thresholds, seen on very hot days, are not reached.

Because all biometeorological index variables correlate higher with attendance than simple composite indices of heat index and wind chill, it can be guardedly confirmed that biometeorological indices are superior in this context (table 9). SET/SET(I) performs consistently and correlates higher with attendance than PMV/PMV(I) and PET/PET(I) indices in almost every instance of comparison. This is an interesting assessment as Lin (2009) has stated that PET is the biometeorological index more often and appropriately used in an outdoor setting for comfort assessment. This result may indicate SET as being a more appropriate index for thermal assessment than the other biometeorological temperature indices. More study is needed to assess these differences across the indices and their applicability in different disciplines and research contexts.

Probabilistic climate-attendance relationships (3.3) show results from direct comparisons of the TCI score with attendance. Scatter diagrams (figures 20 & 21) indicate that the TCI index is well adapted for use within zoo tourism. Seen in figures 18 and 19, TCI index values coincide well with attendance at both the North Carolina Zoo and Zoo Atlanta. The index can be tailored for zoo activity to yield the best possible results. TCI application in the southeast United States can be improved, given its current tourism classifications. In the study period, weather conditions, rarely in Atlanta and never at the North Carolina Zoo, score below a "marginal" classification. Given low attendance figures in the winter season, one assumes that the "unfavourable" classification should be applied to the weather conditions. Classifications are currently measured in equal sized groups on a linear scale. A non-linear scale with a more narrow "favorable" range, and fewer classifications in the favorably scoring months, can be useful to zoo tourism in the Southeast United States. Zoo Atlanta analysis indicates season change from summer to fall displays an immediate drop of 850 average daily visitors for equivalent TCI scores. Due to social changes in the fall season, weather no longer drives people to the zoos with as much efficiency. TCI scatter diagram analyses show more variable clustering at the North Carolina Zoo than Zoo Atlanta. This indicates Zoo Atlanta attendances may react to the magnitude of weather departures more than the North Carolina Zoo. Monthly forecasting of components within the TCI is difficult given current climate forecasting abilities. Developments of forecasting will allow the TCI to become more applied. Currently it is most useful for its addition to understanding of how weather factors affect attendances. Also, it contributes to the knowledge that zoo visitors respond to the atmospheric environment on both weather and climate time scales.

Multiple regression weather modeling results, displayed in tables 7 & 8 and observed in results section 3.1, indicate that North Carolina Zoo attendance appears to have higher correlations with weather variables than Zoo Atlanta. A scenario where attendance variance is explained in excess of 30% (r-squared is above 0.3) is used as a threshold for a “good” scenario. Zoo Atlanta displays 37.5% of its yearly observations as “good,” while the North Carolina Zoo displays 46.2% of the annual observations as “good.” Both zoos are well predicted on a basis of total days. The North Carolina Zoo, however, has a higher proportion of days with “good” attendance predictability. Counting scenarios, not days, show “good” attendance predictability at the North Carolina Zoo in 63% (10/16) of scenarios versus 50% (8/16) at Zoo Atlanta.

Figure 22 ranks the r-squared of scenarios in descending order at both zoos. Scenarios are not necessarily the same in each pairing. Figure 22 shows how well each zoo predicts attendances from best to worst. The North Carolina Zoo has the highest correlated model of all tested, but the following scenarios show Zoo Atlanta correlates higher. In the least adequate scenarios, Zoo Atlanta performs poorly. Differences between rankings are not all statistically significant due to scenarios with low numbers of observations. Both zoos have several well-correlated scenarios, but the North Carolina Zoo is more consistent overall. Zoo Atlanta correlates well, but only to a point—their good models are of high quality but their bad models are very poor.

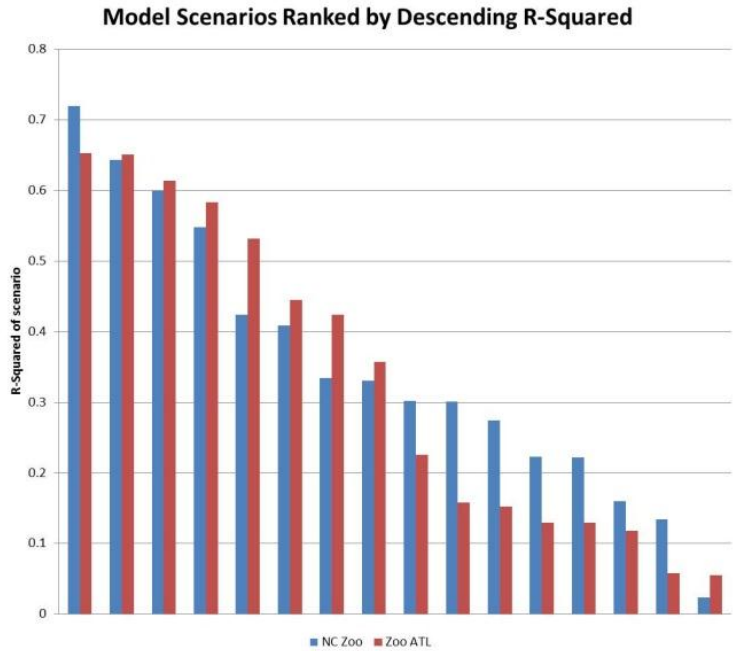


Figure 22: Model Scenario Comparison

4.2 Implications of findings

Results indicate that zoo visitors are attentive to the weather only as much as needed in order to make adequate decisions about their visit; however, while expected relationships exist, there are nuances within the results which implicate additional insights. Travel time, perceived distances, zoo layout, personal exposure and exertion influence how visitors access and interpret weather impacts on a visit to the zoo.

Figures 4 and 5 and figures 6 and 7 indicate that most visitors at the North Carolina Zoo have a one-way transit time nearly double that of Zoo Atlanta. Many visitors at Zoo Atlanta are within a 30 minute drive time, while at the North Carolina Zoo, the closest metropolitan area is in excess of 45 minutes. To encompass the equivalent number of potential visitors as in the Atlanta metropolitan area (60 minute drive time), the area surrounding the North Carolina Zoo must be expanded to 120 minutes. As a result, a maximized tourist draw at the North Carolina

Zoo requires double the travel time of Zoo Atlanta. North Carolina Zoo marketing must encompass an area four times the spatial area to satisfy the equivalent coverage of Zoo Atlanta.

Perceived distance and association with one's metropolitan area are important proximity illusions in decision making. Zoo Atlanta and the North Carolina Zoo have many variables to consider for actual transit time. Traffic around Zoo Atlanta is substantially higher than traffic along any route to the North Carolina Zoo. In addition, the availability of adequate parking is more limited at Zoo Atlanta compared with capacities at the North Carolina Zoo. Visitors familiar with these added time factors will have differing perceptions in their time calculation of a visit to the zoo; this may change behaviors and attention to any weather influence when planning a trip. Perception of proximity helps Zoo Atlanta establish short perceived travel times. Travel mode availability and place name affect perception. Travel mode availability at Zoo Atlanta is expanded through the regional mass transit authority, MARTA, which operates bus line #32, a city bus that stops near the zoo. Mode availability is comparatively limited at the North Carolina Zoo because regional mass transit is not available for tourists from the surrounding metropolitan areas. Spatial connectedness is created linguistically by the place name of the zoo. Zoo Atlanta creates an aura of city-scale and close proximity as the zoo name describes a city. On the contrary, the North Carolina Zoo creates a state/regional-scale aura as it uses the name of a state.

Difference in linear and circular zoo layouts is established in figures 1 and 3. These concepts affect weather-tourist interactions in two ways: exposure (concept adapted from Lin, 2009 and Wohlwill, 1974) and exertion. Exposure describes tourists' outdoor connectedness to the environment. Exposure at the North Carolina Zoo is higher than that of Zoo Atlanta. The linear path of the North Carolina Zoo layout provides visitors with an increasing feeling of exposure when they depart further from their origination point. Zoo Atlanta's circular design promotes a static feeling of exposure when visitors stray from their origination point in an oscillating manner. A highly tree-canopied layout and closer proximity of exhibits gives security and decreased exposure perception at Zoo Atlanta because shelter, in the event of sudden weather changes, appears closer. Knowledge of increased exposure is likely to increase a visitor's attention to the weather. High degrees of exertion will have effects on people's interpretation of weather. With knowledge of the North Carolina Zoo's long (3.85 mile) spatial layout and moderate topographic difficulty, it can be assumed that North Carolina Zoo visitors have greater awareness to weather factors compared to Zoo Atlanta visitors (1.3 miles). High temperatures and heat indices in warm months are important as zoo tourists take into consideration atmospheric variables that will have the most effect on their outdoor comfort and health. In the winter season, wind chill is a variable of interest because its effects on outdoor tourists increase their feelings of exposure when traversing zoo paths. Spatial design and layout allow Zoo Atlanta visitors to be less dependent on weather. As a result, attendances have lower correlations (tables 7 & 8) with the weather variables than the North Carolina Zoo.

"Better weather" in a region moves decisions away from a decision threshold between "no, do not attend" and "yes, attend" (figure 23). In the southeast United States, during a dry weather scenario, temperature signals are less reliable because a change in temperature under good conditions is less influential on attendances. This change affects the strength of decision but is not likely to move a decision to the threshold of choice (movement from point A to point B). In scenarios with fewer observations, there are two components that create better predictability seen in the results. First, visitors have less experience with the weather conditions and therefore are more wary. Second, many of the low observation scenarios are "wet", indicating that people are less likely and willing to change decisions. Attendances in wet conditions are better predicted in a regression model because decisions are in close proximity to the decision threshold (point C).

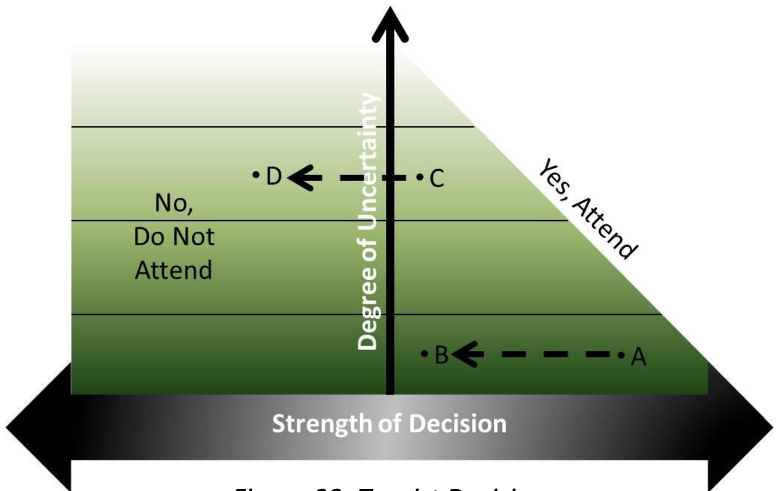


Figure 23: Tourist Decisions

Wetness promotes a higher degree of uncertainty and exposure because changes in temperature are amplified, affecting visitor comfort. For example, a clear dry day in the fall season, with temperatures around 75 degrees Fahrenheit, will likely see few threshold decisions even within a ten degree buffer (movement between points A and B). On the contrary, a wet fall day with cloud cover probably has many more attendance decisions close to the threshold. In this situation, a five degree buffer can be even more influential on patron decisions than the ten degree buffer mentioned above (movement from point C to point D).

Review of heating degree days/cooling degree days and wind chill days/heat index days shows acclimatizations and expectations that are derived regionally. The climate of the southeast United States is seasonal, and high temperatures and high humidity are more pervasive than low temperatures and winter weather events (Robinson, 2005). Because of this type of regional weather, zoo visitors gradually develop both physical and psychological acclimation to the regional weather.

Physical acclimation is thermal acclimatization. It seems reasonable to assume that people react in a stronger manner to low temperatures than high temperatures because of the regional climate. The strong reaction occurs when zoo visitors are not accustomed to low or cooler than normal temperatures and perceive them as too uncomfortable for an outdoor visit to the zoo. This theory is confirmed with the results in two manners. First, correlations between attendance and winter season low temperatures are almost unanimously improved by a wind chill index. A wind chill index can be assumed to capture a higher thermal discomfort in cold temperatures. Second, small changes in temperature, when the temperature is cold, are better modeled. This finding indicates that, in these cold conditions, decisions are closer to a threshold decision than in many warmer scenarios (figure 23).

Psychological acclimation parallels physical acclimation but is more grounded in expectations. Zoo visitors expect certain weather impacts. If expectations are realistic, then they are similar to climatology. People in the southeast United States expect, and are better prepared for, “hot and humid” conditions. “Cold” conditions are observed as aberrations to a casual visitor and are responded to in a stronger manner. Figures 8 and 9 provide an explanation of the climates at the North Carolina Zoo and Zoo Atlanta using PET frequencies. These figures indicate a seasonal and temperate climate with a variety of thermal sensations across the annum and a large amount of temperatures near a thermally neutral range. Shoulder seasons have more coloration, which is warmer than “neutral” than colder than “neutral” at both zoo locations.

Atmospheric knowledge helps provide insight into many results. Anomalous results in this study when analyzed meteorologically can be better explained. Such seemingly anomalous findings are detailed in the following questions: Why do summer season models yield poor correlations with attendance? Why does wind have a small effect, if any, on attendance? Why are TCI values less reliable in the spring season?

Summer season models in this study have low correlations due to the nature of summer season weather in the southeast United States. Summer weather in this region is generally well suited for outdoor activities. When conditions are very warm, people adjust intensity or duration rather than changing activity. Poor correlations occur because weather can be relatively homogenous, thus leaving multiple days as options for trips to the zoo. Therefore, weather is not a definitive attendance driver. Wind in the southeast United States is not an influential weather event except during severe weather. Because of its normally benign existence, wind is generally excluded from decisions of those performing most outdoor activities. Spring TCI variables are not necessarily less reliable, but appear so when the season is displayed as a whole. Figures 18 and 19 show different groupings of TCI scores witnessed during a spring season in the two study locations. Spring is the most varied atmospheric season in the southeast United States due to the presence of increasing day length (increased solar radiation and energy), colder mid-level atmospheric conditions, and often a southward depressed jet-stream. These conditions can create very good outdoor tourism days, as well as the least favorable tourism days of the year.

While many results can be assumed, further work in decision psychology and motivations of zoo tourists are needed to establish better connections between weather and zoo visitor attendance decisions. Personal knowledge of the climate in the southeast United States and anecdotes from administrators of the zoos regarding varying weather conditions assist in contextualization of results. These informational sources allow for additional authority to be given to results; however, explanations and assumptions for their occurrences are scientifically untested and cannot be used as definite justifications for results.

Chapter V

Summary and Conclusions

Research aims and questions were outlined at the end of Chapter I. They are presented here again, along with brief answers derived from the data:

1) Do weather and/or climate factors influence zoo attendances? Yes, at both locations it is seen in the results that on weather and climate scales there are substantive relationships between weather factors and attendances.

2) What weather variables or prevailing conditions are most influential on decisions of whether to visit the zoo? Several weather variables do perform better than others. For example, results show that high temperature variables usually are the best indicators of attendance in all weather conditions. Cold weather is the environmental condition that creates the most direct response seen in tourists on an annual basis.

3) Are indices established within the tourism climatology literature helpful in prediction of zoo attendances? Biometeorological variables are often better assessments than all other weather variables; however, these variables themselves are not higher correlated with attendance than the variable combinations used within the multiple regression model scenarios. The TCI, though not developed specifically for zoo tourism, is shown to work well in long-term attendance prediction.

4) What social influences coalesce with weather factors in tourist decisions to visit the zoo? This study uses a geographic perspective to determine the social influences which potentially cause differences in results between the two zoos studied. It is determined that several factors impact perception of weather and are socially derived influences on tourist decisions in spite of weather. These include zoo spatial layout and regional location, time involved in a visit (both perceived and real), exertion, and exposure.

5.1 Future work

Future work should involve additional testing of relationships between weather and zoo attendance. This would include more statistically robust and refined usage of data, geographical expansion, multi-discipline physical modeling, and use of a mixed-methods approach to quantitatively and qualitatively assess hypotheses and trends seen in preliminary studies.

Statistically more refined data is subject to the quality of the collection methods at the individual zoo. Access to gate sampling, timing of arrivals and departures, and tracking zip codes of visitors can assist with modeling weather-attendance relationships. Refining data with respect to the weather requires more advanced and specific data applications. One application could be the use of hourly weather data encompassing the time around a departure for a zoo visitor. In many circumstances, once the trip decision has been made, the weather plays a smaller role in actual attendance. Critical decision-making hours, which likely occur in the morning from 7am to 10am, may display better weather and attendance correlations. Historical forecast data days prior to a zoo visit are also useful. (Anecdotally, zoos comment how weather, forecasted days prior, affects attendance regardless of the actual weather conditions.) Trips planned several days in advance likely use weather forecasts, therefore, historical forecast data should benefit in refining data analysis.

Geographical expansion of study sites will allow different climate regimes to be tested. Results of this study are methodologically tailored for the climate of the southeastern United States based on expectations and general cultural knowledge. Extrapolating results to other locations would not yield optimal results. Also, a larger variety of zoological park layouts can be assessed. Regional acclimatization is a focus of the biometeorological community. By varying the location of zoos, research studies a common activity in differing weather conditions.

Modeling methods across disciplines might be beneficial in explaining tourist decisions and actions. Examples include attract-repel models (similar to higher and lower attendance predictabilities from tables 10 & 11) as weather elements which attract visitors are likely different than those which repel visitors to other tourism activities. Weighted population potential models (Rich, 1978) and geographic proximity can also be used to explain differences in driving times and ease of access to a zoo.

Use of mixed-methods can be achieved qualitatively through questionnaires, surveys, and interviews and quantitatively through more refined statistical modeling of historically observed attendance. These methods can be combined to assess the best combination of mathematical and sociological/psychological approaches to produce a predictive model.

5.2 Conclusions, business & policy

Decision-makers at the zoo administration level and regional tourism planning authorities at the government, state, and regional levels can use this information to maximize revenues. The location choice of a zoo, park, or other outdoor themed attraction will largely be a product of the space required for its existence. Results of this research, however, show how nuances in planning can create long-term consequences in attendance. Substantiated by an example with results of this study, it makes sense for a zoo located in a “poor weather climate” to be built in closer proximity to metropolitan areas and to be designed to minimize perceived outdoor exposure, likely through a circular, interconnected design. On the contrary, a zoo located in an area without particularly severe weather or an abundance of pleasant weather may benefit from regionalizing their location and promoting a more outdoor, linear concept in design and planning.

Zoos established and permanent in their positioning can use this information at the management level. Depending on the level of managerial and operational control, zoos can adjust their operating strategies to maximize their profits during attendance fluctuations attributable to the weather. In the event of weather factors that decrease attendance turnout, zoo managers can adjust their volunteer and temporary worker staffing and energy costs. On a longer-term plan, if conditions allow, poor weather can be a time to close exhibits for repairs and upgrades. This minimizes the number of disappointed visitors. Knowledge of marginal conditions can facilitate marketing promotions helping smooth visitor demand through competitive pricing strategies. In poor weather, discounted ticket prices can act as ways to mitigate attendance drops. Good weather days are taken into consideration. Pent-up demand over winter months can lead to explosive attendances on spring season weekends with good weather. To enhance visitor experience, zoo staffs can prepare to monitor vending stocks, custodial staffing, volunteer guides, and appropriate entrance booths to limit lines at zoological park services.

Future research and more complete visitor and climate data are needed to further unify the results and conclusions of this research effort. Results from this study begin to explain the multi-faceted interrelationships between weather and tourist decisions. Conclusions can also be applied outside the zoo industry. Pursuit of this research can increase understanding of environmentally induced responses exhibited by consumers in the tourism and recreation industry.

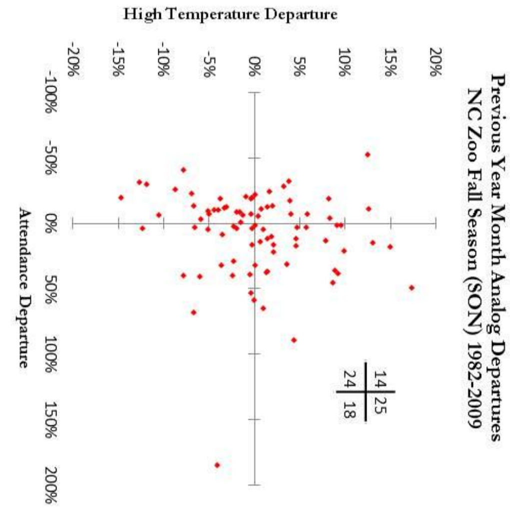
APPENDIX 1

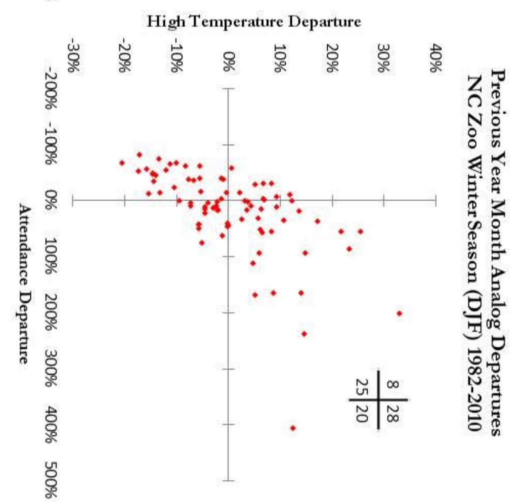
	Day of Week	Season	Wet/ Dry	Multiple Regression R^2	Number of Observations	Multiple Regression Variables Used	Best Single Weather Variable	Best Variable R^2	Best Biomet. Variable	Best Biomet. Variable R^2
North Carolina Zoo	WEEKEND	SPRING	WET	0.720	98	Daytime High Temperature, Precipitation, Average Relative Humidity	Daytime High Temperature	0.551	SET(I)	0.510
	WEEKEND	WINTER	WET	0.643	76	Daytime High, Average Relative Humidity, Daytime Precipitation, Average Wind	Daytime High Temperature	0.372	SET(I)	0.407
	WEEKEND	FALL	WET	0.599	60	Daytime High, Daytime Precipitation	Daytime High Temperature	0.399	PMV	0.329
	WEEKEND	WINTER	DRY	0.548	162	Daytime High, Daytime Precipitation, Low Temperature/Wind Chill	Daytime High Temperature	0.517	SET(I)	0.566
	WEEKEND	SPRING	DRY	0.424	163	Low Temperature/Wind Chill, Temperature Range, Average day winds	Daytime Low/Wind Chill	0.402	SET(I)	0.464
	WEEKDAY	SPRING	WET	0.409	215	Precipitation, Daytime Low/Wind Chill, Average Relative Humidity	Daytime Low/Wind Chill	0.331	SET(I)	0.404
	WEEKEND	SUMMER	WET	0.334	86	Average Relative Humidity, Average Wind	Average Relative Humidity	-0.275	SET(I)	0.198
	WEEKDAY	WINTER	DRY	0.331	421	Daytime High, Average Wind, Daytime Precipitation, Average Sky Cover	Daytime High Temperature	0.307	SET(I)	0.338
	WEEKEND	FALL	DRY	0.302	200	Low Temperature/Wind Chill	Daytime Low/Wind Chill	0.301	PMV	0.260
	WEEKDAY	WINTER	WET	0.301	171	Precipitation, Daytime High, Average Relative Humidity	Precipitation	-0.141	SET(I)	0.186
	WEEKEND	SUMMER	DRY	0.274	177	Daily High Temperature	Daily High Temperature	-0.241	SET	-0.084
	WEEKDAY	FALL	WET	0.223	198	Daytime Precipitation, Average wind, Average Relative Humidity	Daytime Precipitation	-0.147	SET(I)	0.007
	WEEKDAY	SPRING	DRY	0.222	439	Low Temp/Wind Chill, Average Daytime Winds	Daytime Low/Wind Chill	0.221	SET(I)	0.196
	WEEKDAY	SUMMER	WET	0.160	247	Average Relative Humidity, Average Sky Cover, Daytime Low, Daytime Precipitation	Average Relative Humidity	-0.122	SET(I)	0.032
	WEEKDAY	SUMMER	DRY	0.134	410	High Temperature/Heat Index, Average Relative Humidity, Daily Low Temperature	Average Temperature	-0.117	SET	-0.084
	WEEKDAY	FALL	DRY	0.024	452	Temperature Range, Sky Cover, Daily Low Temperature	Average Sky Cover	-0.021	PET(I)	-0.014

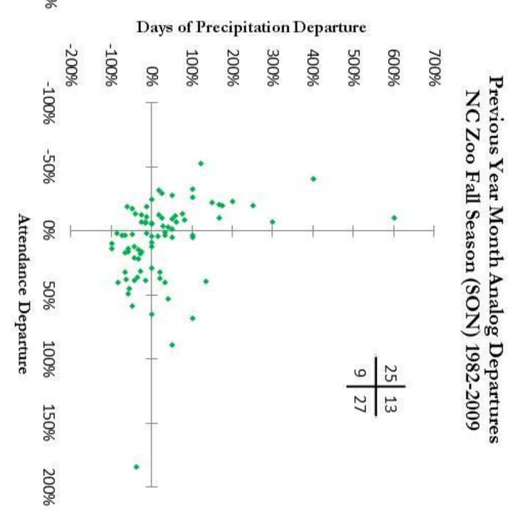
APPENDIX 2

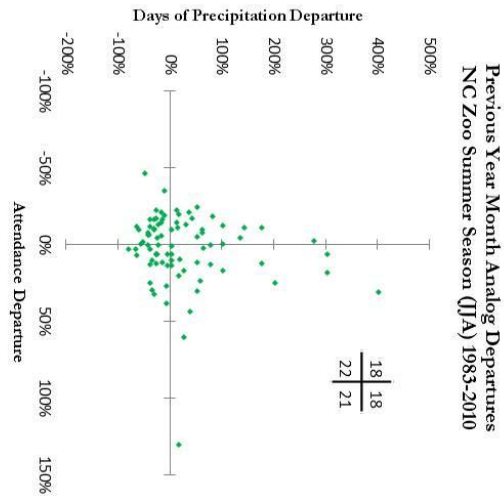
	Day of Week	Season	Wet/ Dry	Multiple Regression R^2	Number of Observations	Multiple Regression Variables Used	Best Single Weather Variable	Best Variable R^2	Best Biomet. Variable	Best Biomet. Variable R^2
Zoo Atlanta	WEEKEND	WINTER	WET	0.653	60	Low Temperature/Wind Chill, Precipitation, Average Sky Cover	Daytime Low/Wind Chill	0.235	SET(I)	0.407
	WEEKEND	SPRING	WET	0.651	59	Daily High Temperature, Average Sky Cover, Precipitation	Daily High Temperature	0.506	SET(I)	0.510
	WEEKEND	FALL	WET	0.614	22	Daytime High Temperature, Minimum Temperature	Daytime High Temperature	0.438	PMV	0.329
	WEEKEND	WINTER	DRY	0.583	104	Daytime High Temperature, Average Daytime Winds	Daytime High Temperature	0.581	SET(I)	0.566
	WEEKDAY	SPRING	WET	0.532	116	Daytime High Temperature/Heat Index, Precipitation, Average Daytime Winds, Average Sky Cover	Daytime High/Heat Index	0.433	SET(I)	0.404
	WEEKDAY	FALL	WET	0.445	94	Daytime High Temperature/Heat Index, Precipitation	Precipitation	-0.329	SET(I)	0.007
	WEEKDAY	WINTER	WET	0.424	129	Daytime High Temperature/Heat Index, Precipitation, Average Sky Cover	Daytime High Temperature	0.213	SET(I)	0.186
	WEEKDAY	WINTER	DRY	0.357	290	Daytime High Temperature	Daytime High Temperature	0.350	SET(I)	0.338
	WEEKEND	SPRING	DRY	0.226	125	Daytime High temperature, Average Daytime Winds	Average Daytime Winds	-0.209	SET(I)	0.464
	WEEKDAY	SUMMER	WET	0.158	144	Daily High Temperature, Precipitation, Average Sky cover, Daily Low Temperature	Average Sky Cover	-0.053	SET(I)	0.032
	WEEKEND	FALL	DRY	0.152	134	Daily High Temperature	Daily High Temperature	0.152	PMV	0.260
	WEEKDAY	SUMMER	DRY	0.129	260	Daily High Temperature, Daily Low Temperature	Daily Low Temperature	-0.127	SET	-0.084
	WEEKEND	SUMMER	WET	0.129	56	Average Daytime Sky Cover, Precipitation	Average Sky Cover	-0.084	SET(I)	0.198
	WEEKEND	SUMMER	DRY	0.118	105	Daily High Temperature, Daily Low Temperature	Daytime High/Heat Index	-0.143	SET	-0.220
	WEEKDAY	SPRING	DRY	0.058	343	Daytime High Temperature, Average Daytime Sky Cover, Average Daytime Winds	Daytime High Temperature	0.048	SET(I)	0.196
	WEEKDAY	FALL	DRY	0.055	287	Daily High Temperature	Daily High Temperature	0.055	PET(I)	-0.014

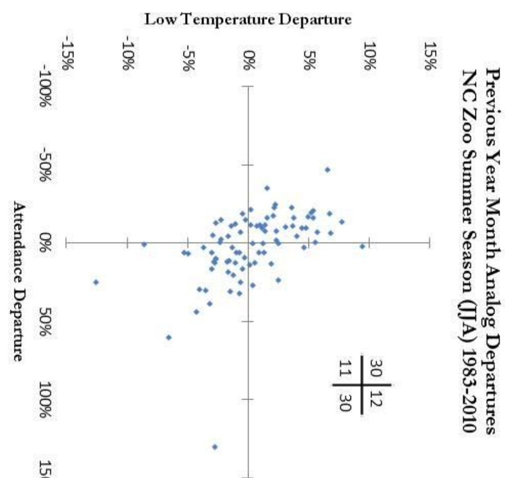
APPENDIX 3

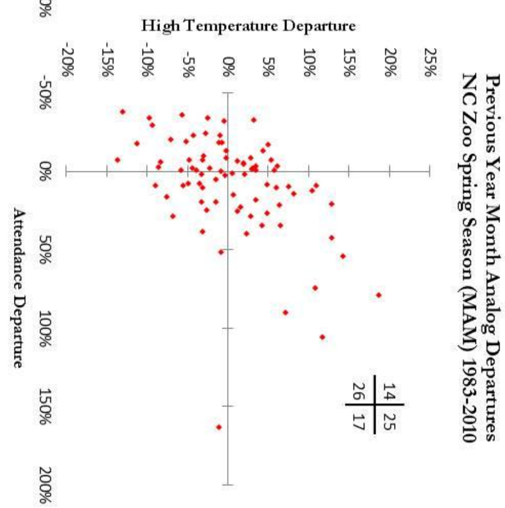

Previous Year Month Analog Departures
NC Zoo Fall Season (SON) 1982-2009
High Temperature Departure
Attendance Departure
14 | 25
24 | 18


Previous Year Month Analog Departures
NC Zoo Winter Season (DJF) 1982-2010
High Temperature Departure
Attendance Departure
8 | 28
25 | 20

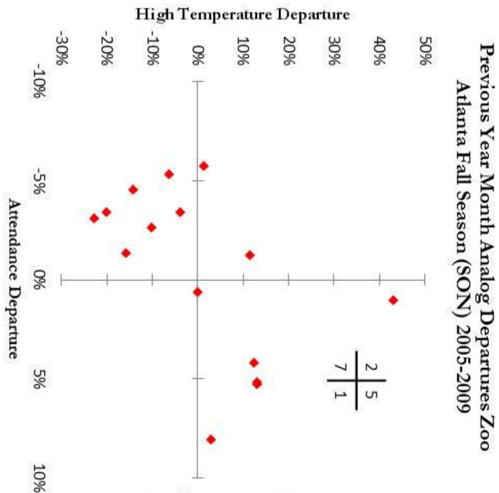

Previous Year Month Analog Departures
NC Zoo Fall Season (SON) 1982-2009
Days of Precipitation Departure
Attendance Departure
25 | 13
9 | 27

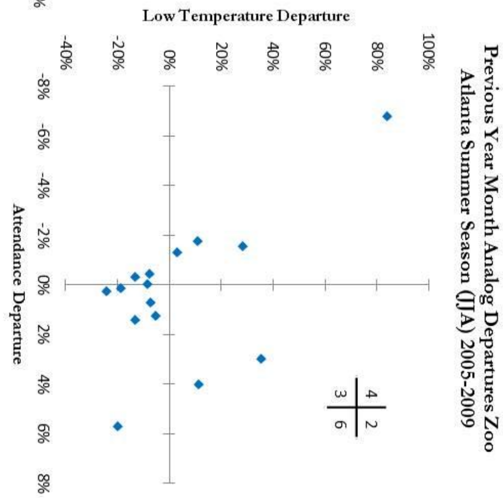

Previous Year Month Analog Departures
NC Zoo Summer Season (JJA) 1983-2010
Days of Precipitation Departure
Attendance Departure
18 | 18
22 | 21

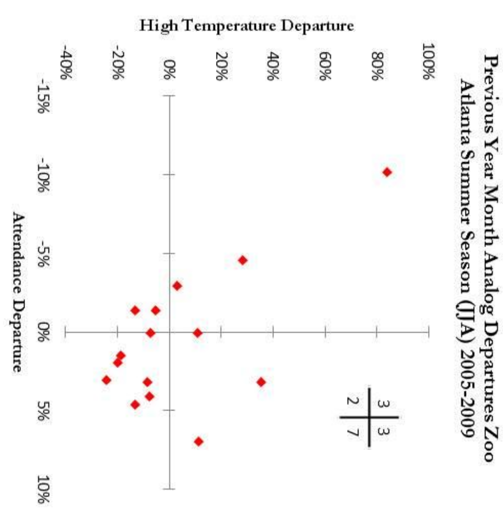

Previous Year Month Analog Departures
NC Zoo Summer Season (JJA) 1983-2010
Low Temperature Departure
Attendance Departure
30 | 12
11 | 30

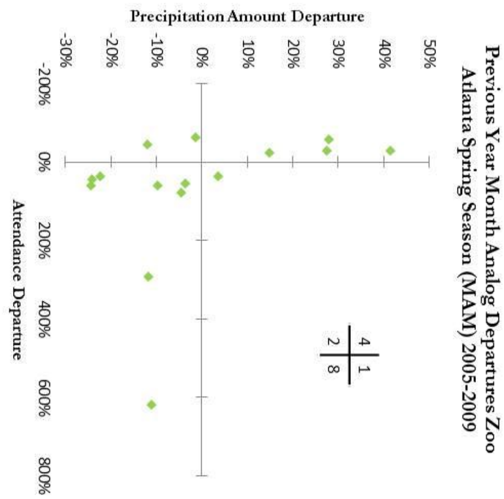

Previous Year Month Analog Departures
NC Zoo Spring Season (MAM) 1983-2010
High Temperature Departure
Attendance Departure
14 | 25
26 | 17

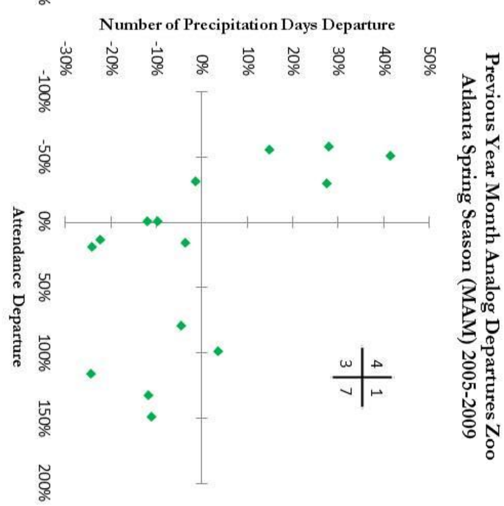
APPENDIX 4

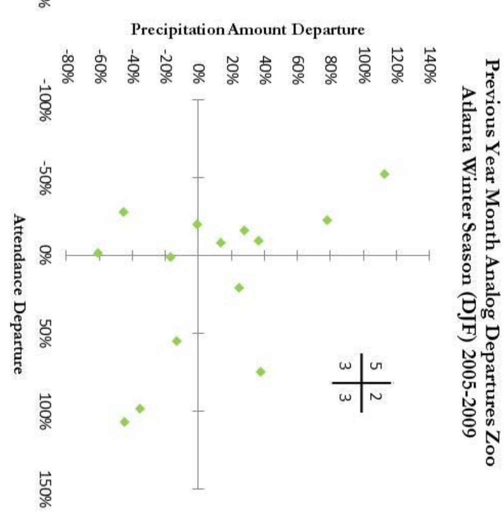

Previous Year Month Analog Departures Zoo
Atlanta Fall Season (SON) 2005-2009
High Temperature Departure
Attendance Departure


Previous Year Month Analog Departures Zoo
Atlanta Summer Season (JJA) 2005-2009
Low Temperature Departure
Attendance Departure


Previous Year Month Analog Departures Zoo
Atlanta Summer Season (JJA) 2005-2009
High Temperature Departure
Attendance Departure


Previous Year Month Analog Departures Zoo
Atlanta Spring Season (MAM) 2005-2009
Precipitation Amount Departure
Attendance Departure


Previous Year Month Analog Departures Zoo
Atlanta Spring Season (MAM) 2005-2009
Number of Precipitation Days Departure
Attendance Departure


Previous Year Month Analog Departures Zoo
Atlanta Winter Season (DJF) 2005-2009
Precipitation Amount Departure
Attendance Departure

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