Utilization of GIS for the evaluation of visitor travel patterns after signage treatments at the Tallgrass Prairie National Preserve

by

Amy Cochran

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Department of Horticulture and Natural Resources
College of Agriculture

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Approved by:

Major Professor
Dr. Ryan Sharp

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Abstract

Understanding visitor travel patterns provides objective information for managers that supports efforts for sustaining the resources as well as visitor experiences through interpretation or signage. However, there is little objective evaluation of visitor travel patterns related to the effectiveness of messaging and park signage. This study was conducted to determine: 1) how does signage affect visitor concentrations; 2) how does directional signage affect visitors' time allocation; and 3) how does directional signage affect visitor travel directionality at signage locations. Visitor travel patterns after signage manipulation were investigated at the Tallgrass Prairie National Preserve (TAPR) from September 2019 to November 2019. TAPR, a National Park Service unit located in east, central Kansas offers over 11,000 acres of prairie ecosystem, hiking trails, historic buildings, visitor center, and a small bison herd for viewing. Researchers used stratified random sampling to distribute GPS data loggers to all travel parties who voluntarily participated. Researchers sampled on weekends, weekdays, events, and holidays to better understand the differences in visitor-use patterns over a variety of days. A total of 91 visitors voluntarily participated in the study resulting in a 75% response rate. Results found that signage treatments were not effective in the way researchers expected for dispersing visitors towards desired locations, increasing overall time, and directing visitors to targeted locations. The findings give valuable objective information to managers, who can then better understand their visitors' and plan where to focus messaging and interpretive efforts.

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Chapter 1 - An Introduction to Visitor Travel Patterns

Since 1916, the National Park Service has been entrusted to care for parks and protected areas. These places hold natural, historical, and/or cultural value with the intent of providing enjoyment, education, and inspiration to all who visit (NPS, 2020). Overall, U.S. National Parks have seen an upward trend in visitation over the past 10 years (NPS, 2018), and although the recent global pandemic has affected visitation to protected areas worldwide, it is expected to rebound once the pandemic is over. Overall, higher visitation has amplified challenges faced by managers as they aim to provide public use and resource protection (Eagles, 2013; Leung, Spenceley, Hvenegaard & Buckley, 2018).

As concerns rise, a growing body of literature has examined visitor travel patterns in parks and protected areas. This spatial and temporal data is considered valuable to managers by revealing resource use along with when and where visitors have experiences (D'Antonio & Monz, 2016). Visitor travel pattern information exposes highly impacted areas and helps identify where to concentrate public outreach and interpretation efforts (Beeco & Hallo, 2014; Absher et al., 2008; Sharp et al., 2019). While a high volume of interpretive research is subjective and survey based, there is a lack of objective research to understand how to best reach people (Alpert & Herrington, 1998; Bullock & Lawson, 2008; Harmon, 1992; Park et al., 2008; Roggenbuck & Berrier, 1982). By obtaining more objective research, managers can better understand their site, park visitation, and make more accurate and informed decisions.

The purpose of this study is to better understand how people interact with messaging, specifically signage, by examining visitor travel patterns at the Tallgrass Prairie National Preserve (TAPR). The primary goal of this study is to objectively assess and evaluate how signage may influence visitor travel patterns. The knowledge provided by this research can be helpful in the design of future interpretation and public outreach while also providing an objective baseline of data to the managers at TAPR and similar parks and protected areas.

The primary study objective is to assess and evaluate how signage manipulates park visitor movement at the Tallgrass Prairie National Preserve. This study was conducted to determine: RQ1) how does signage affect visitor concentrations; Hypothesis: visitors will distribute according to targeted locations provided by the signs; RQ2) how does directional signage affect visitors' time allocation; Hypothesis: time allocated to overall visit will increase in response to targeted locations provided by the signs and RQ3) how does directional signage affect visitor travel directionality at signage locations; Hypothesis: visitors will travel in the direction of targeted locations provided by the signs.

Chapter 2 - Manuscript: Utilization of GIS for the Evaluation of Visitor Travel Patterns after Signage Treatments at the Tallgrass Prairie Preserve

Introduction

Since 1916, the National Park Service has been entrusted to care for parks and protected areas. These places hold natural, historical, and or cultural value with the intent of providing enjoyment, education, and inspiration to all who visit (NPS, 2020). Overall, U.S. National Parks have seen an upward trend in visitation (NPS, 2018), with a spike in visitation in the past 10 years. Higher visitation has amplified challenges faced by managers as they aim to provide public use and resource protection (Eagles, 2013; Leung et al., 2018).

As concerns rise, a growing body of literature has examined visitor travel patterns in parks and protected areas. This spatial and temporal data is considered valuable to managers by revealing resource use along with when and where visitors have experiences (D'Antonio & Monz, 2016). Visitor travel pattern information can be used to identify high-use areas and help know where to concentrate public outreach and interpretation efforts (Beeco & Hallo, 2014; Absher et al., 2008; Sharp et al., 2019). While a high volume of research related to messaging and interpretation is subjective and survey based, there is a lack of objective research to understand how to best reach people (Alpert & Herrington, 1998; Bullock & Lawson, 2008; Harmon, 1992; Park et al., 2008; Roggenbuck & Berrier, 1982). By obtaining more objective research, managers can better understand their site, park visitation, and make more accurate and informed decisions.

The purpose of this study is to better understand how people interact with messaging, in this case park signage, by examining visitor travel patterns at the Tallgrass Prairie National Preserve. This study objectively assessed and evaluated how directional signage may influence visitor travel patterns. The knowledge provided by this research can be helpful in the design of future messaging and public outreach while also providing an objective baseline of data for the managers at Tallgrass Prairie National Preserve and similar parks and protected areas. Specifically, this study examined how signage influences park visitor movement at the Tallgrass Prairie National Preserve. This study was conducted to examine how signage affects visitor concentrations; how directional signage affect visitors' time allocation; and how directional signage affects visitor travel directionality at signage locations.

Literature Review

Visitor Behaviors

Visitor behaviors may cause environmental and social impacts in PPA's (Marion, Leung, Eagleston, & Burroughs, 2016; Healy, 1994; Marion, 2016). Behaviors might include disturbance to wildlife, water pollution, and overcrowding. Evaluating these behaviors can provide data that aims to address a problem or the need to improve something (Henderson, Bialeshki, & Browne, 2017). For example, signage could promote behaviors to minimize environmental and social impacts. While many visitor use studies have been conducted, a high number rely on visitor surveys and reported behaviors, rather than actual visitor behavior (Bixler, 2014).

One study examined the behavioral intent of visitors in Rocky Mountain National Park where they administered on-site surveys to reveal the perceived effectiveness of Leave No Trace (LNT) Principles (Lawhon et al., 2013) . Results found that front-country visitors are more likely to practice LNT principles if they perceive the behaviors to be effective at reducing impacts. While this method provides valid results, it has been noted that at times, visitors response about their intent does not always lead to actual behavior (Sniehotta et al., 2014).

In 2008, a study examined how professional interpreters and educators anticipated the visitor behaviors when they were exposed to minimum impact messages presented in positive and negative terms (Winter, 2008). Results of surveys reported that positively worded messages were viewed as the most effective. Later on, researchers conducted a field study monitoring the amount of petrified wood stolen in response to signs, only to find a contrast in what interpreters and educators thought would be most effective. Because of this, more objectives data collection on visitor behavior is warranted.

Visitor Travel Patterns

Visitor behavior data can be examined through visitor travel patterns. Visitor travel patterns revolve around the way visitors move and are attached to specific places and times, referred to as spatiotemporal information (Beeco & Hallo, 2014). Spatiotemporal information allows for a more accurate view of visitor travel patterns (Hägerstrand, 1970; Aspers, 2006). By utilizing visitor travel pattern information, park and protected area (PPA) managers can identify when and where visitor's are moving, which can be helpful when planning where to concentrate messaging and interpretive efforts (D' Antonio & Monz, 2016, Sharp et al., 2019).

Tracking visitor travel patterns has been enhanced with the modern advancements in technology, such as Global Positioning System's (GPS) and Geographic Information Systems (GIS). GPS data loggers act as an important tool to record timestamped locational data. The data collected through data loggers provides actual visitor behavior information as opposed to reported visitor behavior (Sharp et al, 2019) typically collected through surveys.

Prior studies show that visitor travel pattern information can be organized into numerous variables, which produce distinct travel pattern groups and help see movement trends. An example of variables may include: total distance traveled, total duration of visit, and average speed (Beeco et al., 2018). Peterson et al. (2020) utilized a management centric-approach to decide on which spatiotemporal variables were most important to managers when understanding visitor travel patterns, which identified three temporal variables: total time spent at attraction areas, total time spent at the visitor center, and total time spent in the park. While growing academic attention has been paid to understanding the different variables of visitor travel patterns, more research is needed.

Understanding factors that influence visitor travel patterns can be helpful in the proactive management of PPA's. For example, researchers examined the individual travel patterns of tourists in Hong Kong, which resulted in the following travel pattern influencing factors: 1) travel party size 2) destination 3) first-time or repeat visitor and 4) length of stay or total duration of trip (Lau & McKercher, 2006). By better understanding actual behaviors through objective visitor travel pattern data, managers can be better informed on when, where, and how visitors are moving. These behaviors can act as a means to explore potential visitor outreach and interpretive opportunities, such as the development and implementation of interpretative signage aimed at directing visitors towards the desired targeted locations of managers.

Understanding Visitor Travel Patterns

Analyzing GPS data for visitor travel patterns in PPA's can be complex but useful to producing accurate objective information for managers (Sharp et al., 2019). Visitor concentration analyses have been used to understand visitor travel patterns in multiple ways (Peterson, Perry, Brownlee, & Sharp, 2020). Peterson et al. (2020) used spatial and temporal components to gain insight on the dynamic nature of visitor behaviors by collecting data using GPS data loggers that were distributed to day-visitors. By performing an analysis of visitor concentrations, researchers are able know which areas are more or less visited, which assists in knowing which areas might need more or less resources.

Prior studies have used time allocation analyses to understand in what sequence visitors travel through a PPA (Birenboim et al., 2013; Peterson, Brownlee, Hallo, Beeco, White, Sharp, & Cribbs, 2020). Kim et al. (2019) used temporally segmented visitor travel pattern data to better understand activity in hot spots. Knowing when visitors are traveling (e.g. 9:30 am to 10:30 am) can help managers better plan when to provided targeted educational and interpretive programs.

Sequence analyses has been used to understand in what sequence visitors travel through a PPA (Shoval, McKercher, Birenboim, & Ng, 2015). This approach is important because sequence observations can provide insight into the complexity of visitor travel pattern behavior, allowing researchers to recognize a sequence of activities and patterns. This has been deemed a useful technique to complement existing methods of visitor travel patterns analysis (Shoval, McKercher, Birenboim, & Ng, 2015).

Visitor distribution analyses have been used to understand how much visitors disperse (Kidd, et al, 2015; D'Antonio & Monz, 2016). Kidd et al. (2015) used three visitor education strategies to measure visitor dispersion on trails of Sargent Mountain in Acadia National Park in Maine. Through spatial visitor distribution analysis, findings suggested that less dispersion happened through personal contact by a ranger, which may be the most effective way to deliver minimum impact education. Because visitor travel patterns are complex, often multiple types of analyses need to be calculated in order to gain as much information as possible, and reach the most amount of people.

Visitor Travel Patterns and Directional Signage

Communicating with visitors about their behaviors can be accomplished through a variety of management practices, often categorized as direct or indirect (Kidd et al., 2015). Direct practices may include limiting visitor use or length of stay (e.g. permits) while indirect practices may attempt to prevent undesired behaviors by impacting visitor cognitive processes (e.g. interpretation and education) (Manning, 2011). A common application of an indirect management practice is park signage. Signage is as a way for parks to communicate messages to their visitors that might influence visitor behaviors.

Some signs provide directional maps while others establish rules. Some encourage learning while others promote the protection of natural and cultural resources. Research conducted by Widner and Roggenbuch (2000) found brochures, verbal messages, and educational signage that communicate desired behaviors tend to make visitors more aware of their actions. Through observation and qualitative interviews, this awareness was shown to minimize behaviors that degrade ecological or experiential conditions.

Conducting objective experiments that examine visitor travel pattern behaviors in response to indirect management practices, such as response to directional signage, can help better understanding actual visitor behaviors as opposed to most studies that rely on reported visitor behaviors. Though there are numerous studies of how people subjectively react to signage, there is little objective research to understand how directional signage affects visitor travel patterns across a PPA (Sniehotta et al., 2014).

The primary objective of this study is to assess and evaluate how signage influences visitor travel patterns at the Tallgrass Prairie National Preserve. The research questions and hypotheses are as follows:

1. How does signage affect visitor concentrations?
    a. Hypothesis: visitors will distribute according to targeted locations provided by the signs.
2. How does directional signage affect visitors' time allocation?
    a. Hypothesis: time allocated to overall visit will increase in response to targeted locations provided by the signs.
3. How does directional signage affect visitor travel directionality at signage locations?
    a. Hypothesis: visitors will travel in the direction of targeted locations provided by the signs.

The knowledge provided by this research can be helpful in determining the effectiveness of directional signage, the design of future messaging, interpretation and public outreach opportunities, while also providing an objective baseline of data to the managers at TAPR and similar parks and protected areas.

Methods

Research Site

Tallgrass Prairie National Preserve (TAPR) is located 11 miles south of Council Grove, Kansas, in Chase County (Figure 2.1). TAPR is a popular place to visit due to the many recreational opportunities it provides and is significant to the state as being one of five National Park sites that protects nearly 11,000 acres of tallgrass prairie, or 4% that remains in North American today (National Park Service, 2020).

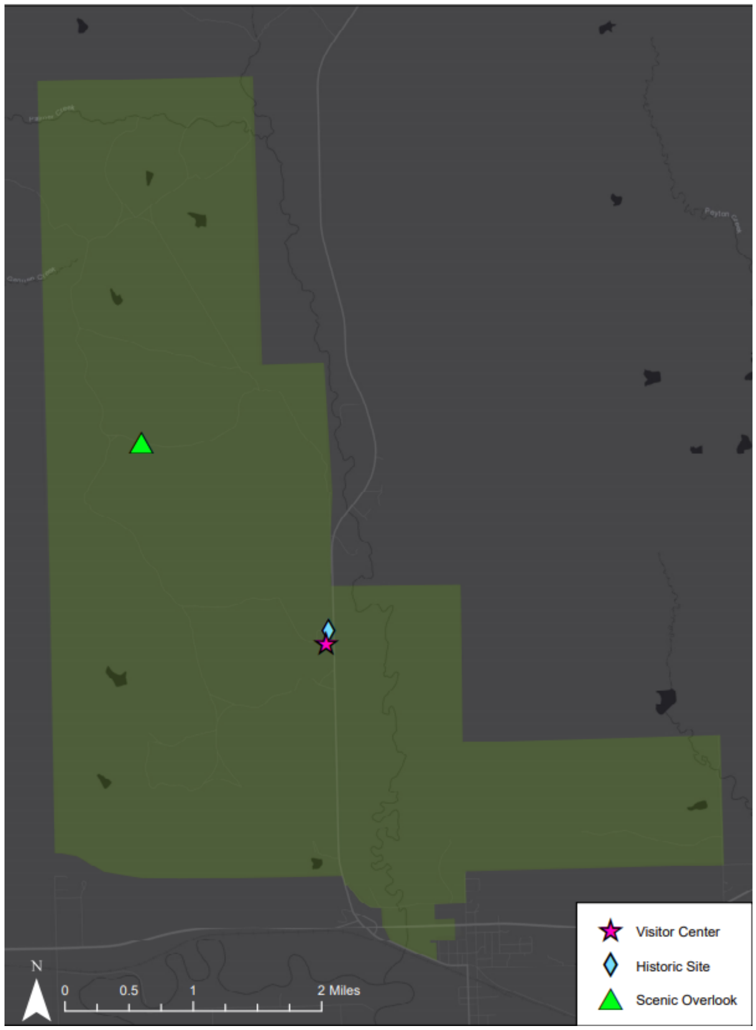
Figure 2.1.

Location of Tallgrass Prairie National Preserve (Google Earth, 2021)

The history found in TAPR tells a story of those who once settled in the area. A past packed with cowboys, American Indian culture, and ranching, TAPR is the study site for this research and consists of a visitor center, historic ranch site, and scenic overlook trail (Figure 2.2.). This historic site sits 150 meters (492 feet) from the visitor center. The scenic overlook is 3.2 miles (5150 meters) from the visitor center. Many visit the preserve to enhance their understanding, education, and historical knowledge of the site therefore making it a good place to better understand how visitors interact with directional signage.

Figure 2.2.

TAPR Attraction Sites (ESRI Basemap, 2020)



Research Design

To address Research Questions 1, 2, and 3, the researchers intercepted visitors at the TAPR visitor center, which most visitors pass through due to its proximity to the primary parking lot and was recommended by TAPR management. There GPS data loggers were distributed to visitors to collect spatiotemporal data while implementing four different signage treatments on four different days. Researchers used stratified random sampling procedures to ensure a representative sample (Vaske, 2008). Researchers used the Canmore GT-740FL sport because of its accuracy, precision, and ease of use, which has been validated when compared to three other data loggers (Garmin Oregon 600, GlobalSat DG-100, and GlobalSat DG-200) (White et al. 2015). Additional benefits to using the Canmore GT-740FL include its long battery life, small size, resistance to water, and hardy interface that helps participants to not accidently engage. Researchers configured GPS data loggers to record waypoints and time stamp at 15-second intervals (Peterson, Perry, et al., 2020)

GPS data loggers were distributed at the Visitor Center location from 8:30 a.m. to 2:00 p.m. each day of the study. Researchers asked one person of at least 18 years of age in each travel party to carry a data logger. Participants would return GPS data loggers to researchers when leaving TAPR or drop them off in a collection box location at the entrance to the Visitor Center. Data collection occurred during September, October, and November of 2020. Sampling occurred on one weekend, one weekday, one special event, and one holiday over the course of the three months to understand differences in visitor-use patterns over a variety of days. Four different signage treatments were implemented across the collection dates. Signage treatments were developed to be simple, easy to understand, and approved by TAPR managers (see Figure 2.3. for an example). Signage was chosen based on which areas managers would most like to distribute visitors. Signage was placed around visitor center because of the high amount of visitor traffic. The Scenic Overlook and Historic Site treatment was administered on September 21st. The no signage treatment was administered on October 14th. The Historic Site treatment was administered on November 9th. The Scenic Overlook treatment was administered on November 15th.

Figure 2.3.

Signage Treatment Example

After data collection was complete, the researchers exported data from GPS data loggers to MS Excel. Researchers then used R to configure the data for analysis and to construct point shape files projected to WGS 1984 Universal Transverse Mercator Zone 14N. The shapefiles were then uploaded, organized, and additionally cleaned in ArcMap 10.8.0 (Beeco, 2013). Five cleaning protocols were implemented: 1) raw GPS data were inspected for 15- second intervals for all consecutive waypoints, 2) mapped waypoint data were visually inspected if consecutive waypoints appeared, 3) visual confirmation that waypoints were consistent with human behavior, 4) physical feasibility was assessed by checking if humans would be at that location, 5) multipath error was visually inspected for sporadic waypoints (Peterson, Brownlee, Hallo, Beeco, White, Sharp, et al., 2020). This resulted in 86, 967 collected waypoints. The researcher's merged all point shapefiles in ArcMap to create a single shapefile for analysis.

Data Analysis

Signage was the independent variable, visitor travel patterns was the dependent variable, and no signage added was the control variable. Researchers had a sample size of 91 participants. Sample size was affected because of COVID-19 pandemic, as no data could be collected during 2020.

Analysis of Research Question 1- Visitors' Concentration

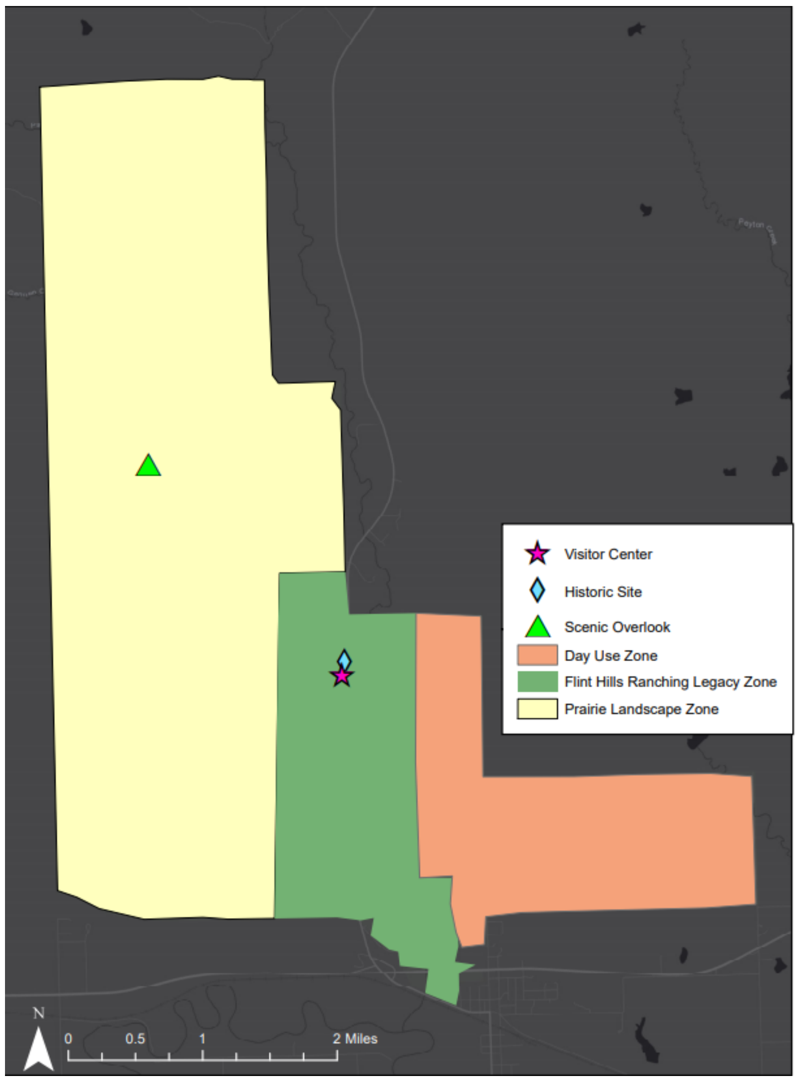
The research team conducted descriptive analysis, which consisted of using the 'mean center' tool, 'median center' tool, and 'directional distribution' tool in ArcMap to provide a basic understanding of data. The mean center point provides an average of all waypoints per treatment. The median center point provides an average that is less skewed by outliers while the directional distribution tool provides ellipses that act as a visual aid to understand trending travel direction per treatment. Researcher's used the 'kernel density' tool in ArcMap to produce a map of visitor concentration hot spots and the 'point distance' tool to understand how far every waypoint was from the visitor center. Researchers statistically compared distance distribution per signage treatment using One Way ANOVA with a Bonferoni post hoc in SPSS 26.

Analysis of Research Question 2- Visitors' Time Allocation

Researchers created a map of three TAPR management zones that were taken from the TAPR general management plan (National Park Service, 2021). Management zones consisted of the Day Use Zone, Flint Hills Ranching Legacy Zone, and the Prairie Landscape Zone (Figure 2.4.). Researchers clipped data to each zone in ArcMap then imported data to excel using the 'table to excel' tool. Researchers completed a zone analysis in excel, displaying the average time spent in each zone and percent of visitors who visited each zone. To further understand visitors' time allocation, researchers conducted a zone sequence analysis. Researchers went through each individual visitor's waypoints in ArcMap to record the sequence of zone visits per visitor per treatment.

Figure 2.4.

Management Zones (Esri Basemap, 2020)



Analysis of Research Question 3- Visitors' Travel Directionality

Researchers assessed in what direction visitors leave each signage area. Researchers conducted this analysis by looking at the first one hundred waypoints (the first 25 minutes of travel) for each visitor in ArcMap and recorded if they went in the direction of the Historic Site or Scenic Overlook.

Limitations

This study has several potential limitations. First, it's possible that not everyone within a travel party will travel the same and when people carry a GPS data logger for research purposes, it could influence their normal behavior patterns. Due to the compact nature of the location, these limitations may be mitigated. Some visitors may choose to not participate in carrying a GVT unit. To address this, researchers were diligent by asking each travel party in hopes that more visitors accept than reject and a representative sample was achieved. Due to the COVID-19 pandemic, researchers had data from only one season of use, therefore generalizability to the whole population at the park may be affected.

Results

Response Rate and Description of Sample

Response rate was 75.21% at the 95% confidence level, and 8.87% confidence interval. As part of this research, visitors were asked basic demographic questions to understand the visitor population at TAPR. This sample included 42.19% males, 53.91 % females, and 3.91% who chose to not identify their gender. Participants ranged in age from 22-86, and the average age is 53. The majority of participants self-identified as white/Caucasian (89.15%), Asian participants comprised 2.33%, 7.75% did not wish to answer, and 0.78% self-reported as other. Annual income was evenly distributed, and level of education trended towards four year college graduate (36.43%) and graduate or professional degree (42.64%).

Results of Research Question 1- Visitors' Concentration

The mean center point results provide an average point per treatment, out of all visitor travel waypoints from the visitor center. The furthest mean center point from the visitor center is the historic site treatment (1,323.90 meters) while the closest is the scenic overlook/historic site treatment (648.06 meters) (Figure 2.5.). This reveals the historic site treatment distributed visitors the farthest from the visitor center while the overlook/historic site treatment distributed visitors the least. The median center point provides us with a point per treatment, out of all visitor travel waypoints, that is less skewed by data outliers. This helps support and give a more accurate view of signage treatment distribution from the visitor center. The median center point results found the same results as the mean center point for each treatment. The directional distribution ellipses results show the historic site treatment had the widest distribution while the scenic overlook/historic site treatment had the smallest distribution. The scenic overlook/historic site treatment, no sign treatment, and historic site treatment moved visitors towards the scenic overlook, while the scenic overlook treatment moved visitors away from the scenic overlook (Figure 2.5.).

Figure 2.5.

Mean Center Points, Median Center Points, and Directional Distribution (Esri basemap, 2020).

The Kernel Density uses a color gradient to indicate areas of higher concentration. Results show visitor concentration mainly at the visitor center (38.4323, -96.5583 decimal degrees). Results show the scenic overlook/historic site treatment distributing visitors the least from the visitor center. This is displayed with the treatment having the smallest hot spot, hot spot being an area of high concentration, out of all four treatments. Results show the historic site treatment distributing visitors the furthest from the visitor center. This is displayed with the treatment having the largest hot spot and tail leading towards the scenic overlook (Figure 2.6.).

Figure 2.6.

Kernel Density Across Treatments (Esri Basemap, 2020)

The distance distribution results display the average distance nearest and furthest from the visitor center. The historic site treatment has the highest average distribution of visitor travel waypoints from the visitor center at 1,323.90 meters. The results show the scenic overlook/historic site treatment as having the lowest average distribution of waypoints from the visitor center being 648.06 meters (Table 2.1). This aligns with the findings of Figure 5.1. Results show all treatments have statically different distributions, which tells us that the treatments are moving people in different ways, just not in the ways expected and stated in the hypothesis. The waypoints map for each signage treatment visually show the path and way visitors are navigating the area (Figure 2.7).

Table 2.1.

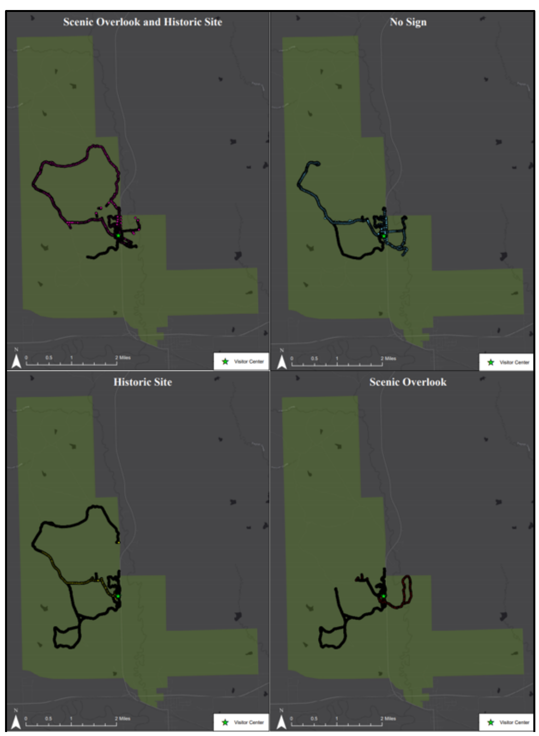
Distance Distribution Analysis

Sep21 Scenic Overlook and Historic Site (*n*=32,478) *M*(SD)	Oct14 No Sign (*n*=22,625) *M*(SD)	Nov9 Historic Site (*n*=19,527) *M*(SD)	Nov15 Scenic Overlook (*n*=12,337) *M*(SD)	*F* *p*-value
648.06(1026.74)	1,025.94(1179.83)	1,323.90(1133.45)	787.49(793.08)	1,781.31 *p*<.001

Note. Units reported in meters.

Figure 2.7.

Waypoints for each Signage Treatment (Esri Basemap, 2020)



Results of Research Question 2- Visitors' Time Allocation

Zone analysis results show the percent of zone visitation per signage treatment. Results show 100% of visitors went to the Flint Hills Zone while the least amount of visitors went to the Day Use Zone. Zone analysis results show the average time spent in each zone per signage treatment. The highest average of time spent at 112.73 minutes was in the Flint Hills Zone on the Scenic Overlook/Historic Site treatment day. The lowest average of time spent at zero minutes was in the Day Use Zone on the No Sign and Historic Site treatment day. Results also show the Scenic Overlook signage treatment day distributed the least amount of people to the Prairie Zone (Table 2.2).

Table 2.2.

Zone analysis displaying average time spent (minutes) in each zone and percent of visitors who visited each zone

	Scenic Overlook and Historic Site (*n*=36) *M*(SD)	No Signs (*n*=22) *M*(SD)	Historic Site (*n*=18) *M*(SD)	Scenic Overlook (*n*=15) *M*(SD)
Prairie Zone	47.07 (41.72) 50.00%	68.25 (72.39) 45.45%	80.55 (52.37) 61.11%	40.67 (55.34) 53.33%
Flint Hills Zone	112.73 (51.69) 100%	107.39 (73.54) 100%	105.02 (52.30) 100%	82.93 (52.36) 100%
Day Use Zone	0.17 2.80%	0.00 (00.00) 0.00%	0.00 (00.00) 0.00%	21.02 6.67%

Note. Units reported in minutes.

Zone sequence analysis results show the sequence in which visitors are traveling between zones. The Flint Hills and Flints Hills Zone/Prairie Zone/Flint Hills Zone sequence occur most often (Table 2.3). Results show the most amount of travel in the Flint Hills Zone.

Table 2.3.

Zone Sequence Analysis

Scenic Overlook and Historic Site (*n*=36)		No Signs (*n=22)*		Historic Site (*n*=18)		Scenic Overlook (*n*=15)	
Sequence	Frequency	Sequence	Frequency	Sequence	Frequency	Sequence	Frequency
FPF	50.00%	F	63.64%	FPF	61.11%	F	46.67%
F	50.00%	FPF	31.82%	F	38.89%	FPF	40.00 %
		FPFPF	4.55%			FDF	6.67 %
						FPFPF	6.67 %

Note. F = Flint Hills Zone; P = Prairie Zone; D = Day Use Zone

Results of Research Question 3- Visitors' Travel Directionality

Results of the directional analysis at signage location show the direction visitors take from the visitor center, per signage treatment. The highest percent of visitors (77.27%) traveled in the direction of the historic site on the no signage treatment day. The lowest percent of visitors (22.73%) traveled in the direction of the scenic overlook on the no signage treatment day (Table 2.4). During the historic site treatment, 44.44% of visitors traveled towards the historic site. During this scenic overlook treatment, 53.33% of visitors traveled towards the scenic overlook.

Table 2.4.

Directional Analysis at Signage Location

	Scenic Overlook and Historic Site (*n*=36)	No Signs (*n*=22)	Historic Site (*n*=18)	Scenic Overlook (*n*=15)
Direction towards Historic Site	58.33%	77.27%	44.44%	46.67%
Direction towards Scenic Overlook	41.67%	22.73%	55.56%	53.33%

Discussion

This study was conducted to determine: 1) if visitors will disperse according to the directions provided by signs; 2) if specific signage will increase time allocated to overall visit; and 3) if visitors travel towards the direction state by the sign. The overall results show visitors' did not disperse according to the directions provided by sign, signage did not increase time allocated to overall visit, and signage did not reliably point visitors in the desired direction.

Discussion of Research Question 1- Visitors' Concentration

Signage treatments did not appear to affect visitor concentration. Visitors are seen to be mostly concentrated at the visitor center on each signage treatment day. Explanation for this could be that the entrance to TAPR and the visitor parking lot is in front of the visitor center, the visitor center is the location where visitors receive GPS data loggers, the visitor center has amenities, or there isn't enough messaging and interpretive information directing visitors from the visitor center. One important finding was that signage treatments do disperse visitors from the visitor center but not to the desired locations. This was seen with the directional ellipses and kernel density map. Explanation for this could be that signage wasn't placed in the best location, more signage could be needed, or when visitor's were planning their trip to TAPR, they already knew where they wanted to go, which connects to research showing that visitors to museums and other interpretive sites will spend less time reading signs the longer they have been exposed to the signage (Falk & Dierking, 2013). Researchers note that though there wasn't a large enough sample size to effectively run analysis, 64% of visitors were repeat, which may, in part, be contributing to these results.

Discussion of Research Question 2- Visitors' Time Allocation

Signage did not appear to affect visitors' time allocation in each zone. The Flint Hills Zone received 100% of visitors and had the highest average time spent on each treatment day. This shows managers where 100% of the traffic is visiting and staying. Results also shows that certain zones are less visited. If managers desire more visitors to spend more time in less visited zones, more outreach in the Flint Hills Zone would be recommended to highlight these areas. When looking at time allocated to the Prairie Zone per treatment, the Scenic Overlook treatment directing visitors to that zone had the smallest average of time allocated to that zone (Table 2.2). Perhaps this tells us that people may have known which zone areas they wanted to visit before they arrived at TAPR or that the Scenic Overlook was farther away than people wanted to travel. The zone sequence analysis shows that there are a variety of ways visitors are moving throughout zones at TAPR. Implications of this finding may be that visitors are confused on where to go and need more interpretive and public outreach. A subfinding within this research question found that the Flint Hills Zone had a large amount of visitation, which brings researchers to recommend that managers consider creating smaller zones for management purposes. Having smaller zones could help by allowing managers to better place and allocate resources (Rotich, 2012).

Discussion of Research Question 3- Visitors' Travel Directionality

Signage did not appear to affect visitor travel directionality at signage locations. It is possible that visitors didn't look or pay attention to signage treatments. It's possible the signage placement or signs themselves could be improved with specific messages or added information for better clarity (Wandersee & Clary, 2007). It is also possible that visitors had an idea of which direction they wanted to go before their arrival at TAPR, which influenced their travel patterns more than the signage treatment.

Conclusion

This study displays how GPS data loggers can be used to objectively view visitor use and act as a tool to understand where visitors go and how long they spend in certain areas. GPS data loggers can be used to understand visitor concentrations, time allocations, and directionality when interacting with directional signage. This objective information can inform managers about visitors spatial and temporal behaviors, which is important to measure as non-intrusively as possible (Bixler, 2014). It can reveal areas that may need more or less interpretation and public outreach, or that may require more of less maintenance of the resource, which allows managers to better allocate limited resources to reach the largest number of visitors.

While signage can be used to deliver interpretation and connect people to their surroundings, it is important to know if the particular signage is effective or ineffective. In this study, the signage treatments were not as effective as researchers would have expected and desired. Researchers believe there could be many reasons as to why the signage weren't reliably effective. As mentioned previously, 64% of visitors were repeat visitors, so it could very well be that visitors had an idea of where they wanted to go before their arrival, therefore, the signage didn't influence their decisions on where to go and how much time to spend in that area. Though

TAPR is a cultural site with roughly 11,000 acres, researchers may not expect to see the same results in a bigger park due to different types of visitation and demographics.

TAPR and similar PPAs can use this information to better reach visitors through an objective understanding of where most people are concentrated, and how effective messaging (or education and interpretation) can be in moving visitors to desired locations. According to results, visitors aren't venturing too far outside of the Flint Hills Zones that houses the visitor center. Knowing where to reach visitors is the first step. The second step is deciding what's the best way to reach them? Though we intentionally tried to guide visitors to more parts of the park, people didn't move as expected. Would personal services such as a roving ranger better direct visitors to targeted locations rather than directional signage? Past subjective research supports this idea, however, future objective studies can lend more clarity to this question (Kim et al., 2019).

Future Research

Future research could focus on directional signage, specifically signage placement and aesthetics. For example, additional information on each sign might make visitors more interested and curious about each targeted location. This may help better understand visitor travel directionality, time allocation, and concentration. Due to COVID-19 and the study's low sample size, future research could be conducted to gain a larger sample and make results more generalizable to the overall population. Additionally, future research comparing subjective surveys with objective GPS data could provide more insight into how visitors interact and interpret signage to help manager's know where to focus outreach efforts. Researchers recommend this study be replicated in different kinds of parks, for example a wilderness or urban park, to further understand the research questions proposed in this study. Researchers also recommend this study be replicated in parks, or areas of parks with more first time visitors, as they may be more influenced by signage.

Chapter 3 - Reflection

A lot can happen in two years. It all started with a move from Oklahoma to Kansas in pursuit of a master's degree. Little did I know that during that time, I'd learn something completely new (GIS), meet and marry someone, live through a pandemic, and lose the closest person in the world to me. I'd like to reflect on and share my graduate school experience.

Finding out about the Park Management and Conservation (PMC) program was pure luck. I met Ted Cable, former PMC professor, at one conference and Karl Noren, a former PMC instructor, at another. The luck continued to grow as a friend forwarded me a PMC graduate announcement posted by PMC professor, Ryan Sharp, completely out of the blue. Feeling God leading me towards Kansas State University, I said yes to each door that opened.

The first few months in Kansas were great. Having little furniture, no tv, and no internet, I lived in a way that required meeting new people to help comfort any feelings of homesickness. By joining community clubs, getting involved in a local church, and interacting with my new collogues, things were off to a good start.

As classes and my research project at the Tallgrass Prairie National Preserve (TAPR) started to take off, my focus shifted towards academics. I started to learn the ins and outs of research, which was one of the main reasons for joining the program. I loved the first few months of data collection at TAPR and piling in a van with willing students, eager to volunteer. I've worked in park settings in the past ,and as we interacted with park visitors and staff, I felt like I was back in my element.

The first semester came and went. As the second semester of school was underway, life took a turn no one saw coming. COVID-19 came barreling in and completely turned work, life, and anything else you can think of, upside down. At first, things were scary and unpredictable, to say the least. The university and professors worked hard so the semester could continue and finish virtually. This took some adjustment but worked. As I was deciding whether to go back to Oklahoma to be with family until things leveled out again, I unexpectedly got engaged. This made my decision clear as I pushed through the pandemic in Manhattan.

Moving into the summer semester, the university postponed research until further notice. It wasn't until Fall 2020, when we decided to start analyzing the data collected at TAPR in Fall 2019. The start of data analysis was pretty intimidating. Thankfully, I had great help and learned a ton. Who knew you could use GIS to analyze data in so many ways! As I finished up data analysis in November 2020, I was excited to celebrate with a wedding over Christmas break, when we found out my father needed open heart surgery. We quickly canceled our original plans and put a small ceremony together on the fly so he could attend. The ceremony was small, special and a success.

Married during Christmas break and excited to finish up the last semester, my father took a turn for the worse due to covid related complications and passed on February 10, 2021. Since then, I think of him daily. He was the most encouraging and supportive person I've ever met which, is why I'd like to dedicate my research to him. My hope is that every person has someone like him, someone who can cheer them on in life.

As I reflect on my time in this program, these happy and sad memories surface. I've learned countless things through the people I've work with, parks I've gotten the chance to work in, and major life changes. I'm thankful for this time and will never forget it.

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