IMPROVING BICYCLE INFRASTRUCTURE WITH THE USE OF BICYCLE SHARE TRAVEL DATA

ABSTRACT

This study examines bicycle travel demands and travel patterns in Lexington, Kentucky as generated by SPIN bicycle share users. It is hypothesized that the SPIN users emulate bicycle users on and around the University of Kentucky campus. Therefore, analyzing their travel patterns will provide a valuable understanding of bicycle demand and infrastructure needs. Locations for bicycle infrastructure improvements will be recommended as an outcome of this research. To identify such demand, travel patterns and routes were compared to the existing bicycle infrastructure in order to determine improvement needs with an ulterior goal to increase bicycling as a mode of transportation.

KEYWORDS: Bicycle Infrastructure, Bicycle Share, Bicycle Travel Demand, Geographic Information Systems, Bicycle Safety

RESEARCH QUESTIONS AND HYPOTHESIS

This study examines bicycle usage and travel patterns as generated by the users of a bicycle share program in Lexington, Kentucky called SPIN. The University of Kentucky (UK) serves as a major trip generator and is a popular destination for the bicycle trips including those generated by the SPIN bicycle share program. A similar study conducted by Noland (2019) involved evaluating trip patterns and revenue of e-scooters in Louisville, Kentucky. However, by analyzing bicycle share data, it is hypothesized that SPIN bicycle users emulate general bicycle users on and around campus. Analyzing such travel patterns will provide a valuable understanding of bicycle demand and infrastructure needs that may aid UK's mobility goals (UK 2015). To identify these needs, travel behaviors and routes were compared to the existing bicycle infrastructure to determine locations for improvement with an ulterior goal to increase bicycling as a mode of transportation.

METHODOLOGY AND DATA

Individual bicycle trip data is collected through the GPS locator that is attached to each bicycle. The methods of study include five levels of analysis: length and duration, temporal, climatic, point density, and modeling. The data used in the analysis was obtained from SPIN and consisted of information from individual bicycle trips taken from August 18, 2018 to May 3, 2019. The raw data was cleaned up to exclude trips that showed zero route distance or trip duration as well as trips with unusually high (>12 mph [19.3 kph] considered to be a speed for casual bicyclists) or low travel speeds (<5 mph [8 kph] considered slower than jogging or walking). A total of 38,505 trips were used in the analysis. For each SPIN bicycle trip, there is a start and end location represented in latitude and longitude coordinates. Route points are also collected throughout the duration of the trip. SPIN is a dockless bicycle share program meaning that a bicycle can be left anywhere that is permitted to leave a bicycle. This type of bicycle share system provides additional insight as to where bicycles have the tendency of being left without the potential consequences if the bicycle was owned, such as theft or vandalism.

FINDINGS

Literature findings have suggested that the average bicycle trip length ranges from 2.3 to 2.8 miles (3.7 to 4.5 km) with an average travel time of about 20 minutes (NHTSA 2019). The analysis showed that 95.6 percent of the SPIN bicycle trips were 2.5 miles (4.0 km) or shorter. Furthermore, 94.6 percent of the trips had a travel time of 20 minutes or less. Weekday versus weekend trips were also considered for length and duration analysis. It was found that weekday trips had an average trip length of 0.9 miles (1.4 km) with an average travel time of 7.9 minutes. Weekend trips were greater in both distance and duration at 1.2 miles (1.9 km) and 10.9 minutes.

The SPIN bicycle travel data has been further analyzed based on the time of day, day of the week, month of the year, and college semester to determine any temporal trends in ridership usage. Overall bicycle usage trends vary throughout the day. The highest hourly usage occurs at the evening rush hours around 4:00 PM and 5:00 PM. The morning peak period is from 7:00 AM to 10:00 AM with usage increasing at a steady rate during this period. It was also found that Wednesdays had the greatest number of SPIN bicycle trips taken with the weekends having the least amount of usage. Monthly patterns were also observed; it was seen that winter months had a lower number of SPIN bicycle trips than the summer months.

Literature findings have suggested that weather and daily bicycle trips are strongly correlated. Gebhart and Noland (2014) used statistical methods to evaluate the effect of weather on a Washington D.C. bicycle share system with results showing that cold temperatures, rain, and high humidity reduced the likelihood of using bicycle share and trip duration. Another study in Seattle, Washington identified influencing factors of bicycle travel demand and suggested that people are generally more sensitive to the presence of rain than to the intensity (Schmiedeskamp and Zhao 2016). Another unique finding was a positive linear relationship between daylight hours and count. The analysis of weather trends showed that there was a significantly higher SPIN bicycle usage during the Fall semester than in the Spring semester (Figure 1). The average temperature in the Fall semester (August 22 to December 14) was 57 ºF (14 °C) while in the Spring semester (January 9 to May 3) was 45 ºF (7 °C).

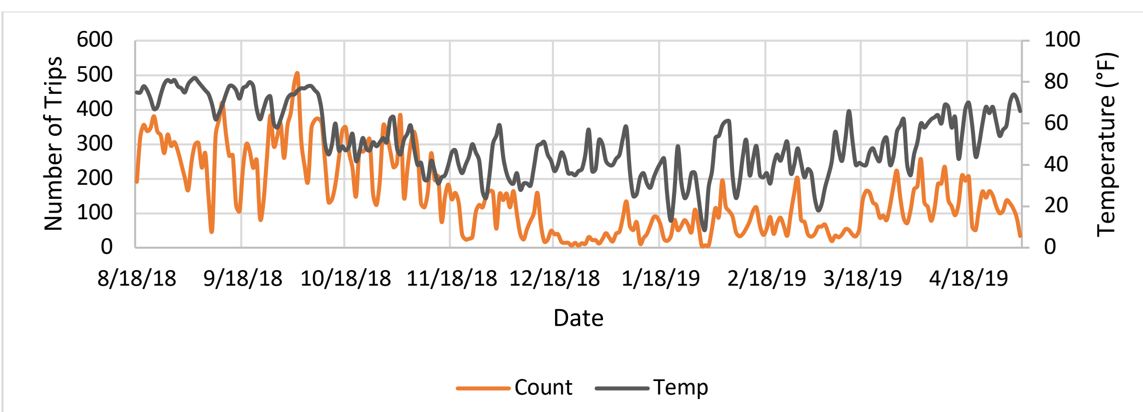

Figure 1. Daily SPIN bicycle usage trends with average daily temperature trends

To analyze the SPIN data, a generalized linear model (i.e., count model) was developed for predicting the number of SPIN bicycle trips per day. The purpose of this model is to estimate the demand for bicycling on and around campus. Several explanatory variables were considered in the analysis: average temperature (°F), weekday versus weekend (0 = weekday, 1 = weekend), average wind speed (mph), precipitation (inches), and average route distance (miles). Table 1 shows the model structure, i.e., variables in the model, their coefficients and significance (p-value) for predicting the number of trips per day. The model has an R^2 value of 0.530.

Table 1. Prediction model parameters, trips per day

	Dependent Variable Trips per Day	
Independent Variables	Coefficients	Significance (p-value)
Constant	25.954	0.269
Average Temperature (F)	4.514	0.000
Day of Week	-38.644	0.001
Average Wind Speed (mph)	-5.468	0.000
Precipitation (inches)	-31.997	0.008
Average Route Distance (miles)	-43.338	0.000

A GIS approach is taken to analyze the data and provide visual aids for understanding bicycle travel patterns. Point density maps are created to show the intensity of bicycle usage with non-existing bicycle facilities. Figure 2 shows a point density map of route points that are not along an existing bicycle facility such as sidewalks or streets without a bicycle lane. This map was used to identify four routes that should be considered for improvements based on the density of bicycle traffic on non-bicycle facility paths.

The introduction of SPIN bicycles has increased the demand for bicycle parking on UK campus, specifically around classroom buildings and resident halls. As previously mentioned, the dockless bicycle program does not require the bicycle to be docked at designated stations. Figure 3 is a point density map showing areas where SPIN bicycle trips started or ended outside a 50-foot (15.2 m) radius of an existing parking location which accounted for 79 percent of the trips. This reveals that users are finding locations that are more convenient than existing bicycle parking facilities. It was recommended that bicycle parking should be expanded or added near major classroom buildings and residence halls based on Figure 3.

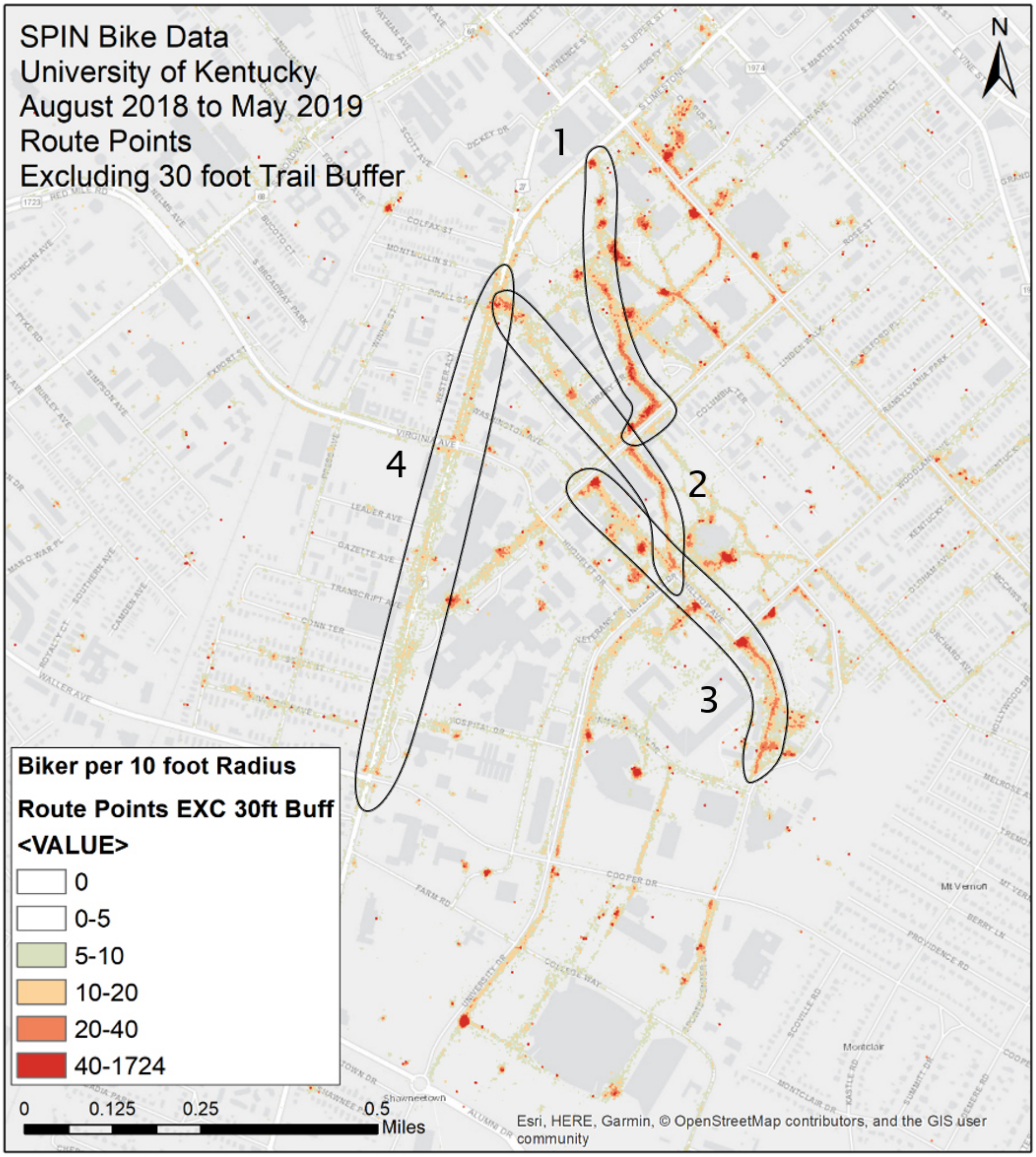

Figure 2. Route points along non-bicycle facilities

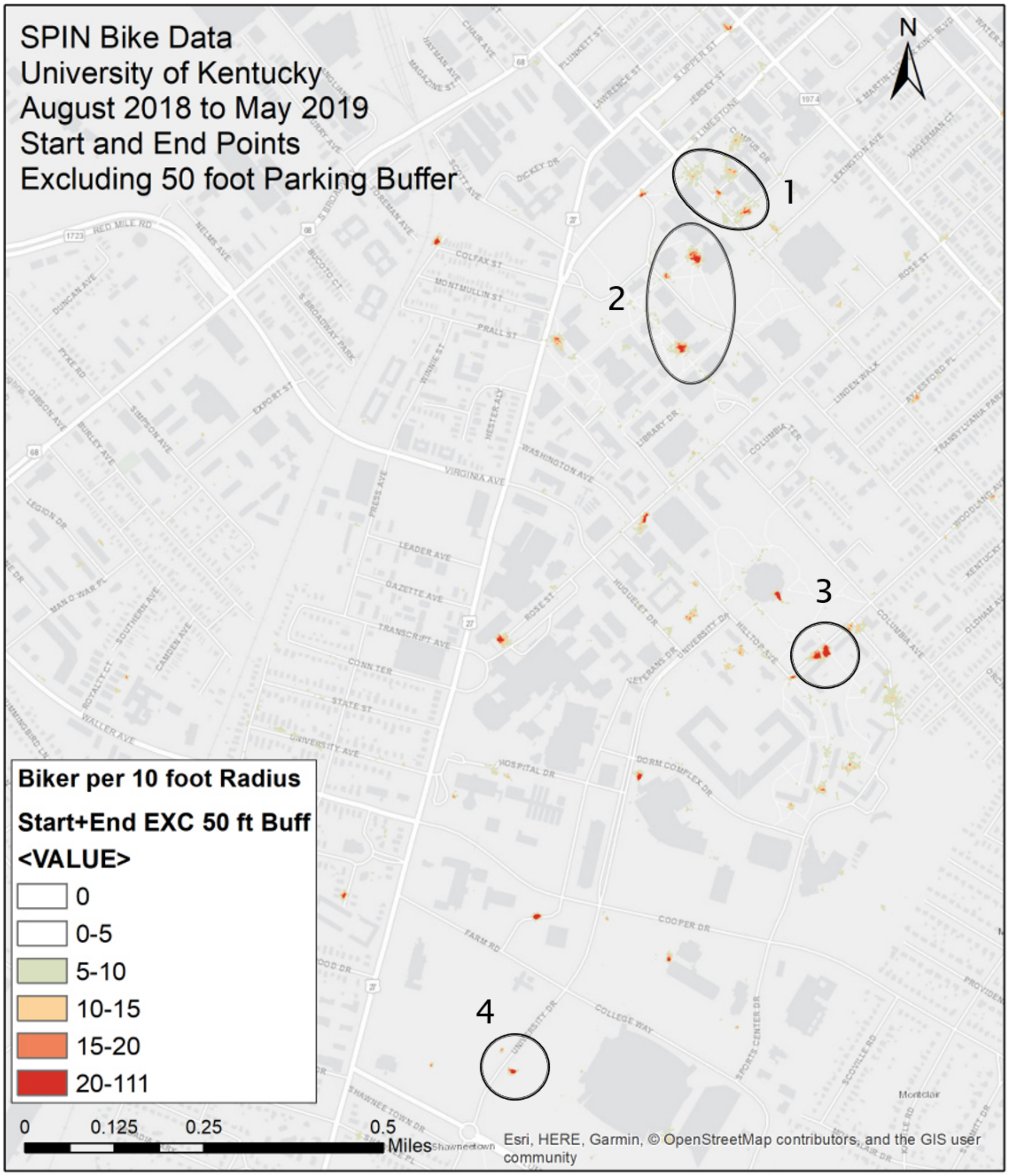

Figure 3. Start and end points outside 50-foot (15.2 m) radius of existing bicycle parking

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