FLOWS FROM THE ORIGINS OF CYCLISTS TO URBAN PARKS*

Jennifer Domeneghini[1], Valéria Borges Yonegura[2],
André Luiz Lopes da Silveira[3]

Abstract: components such as bicycle infrastructure should be valued more highly in the current context of Brazilian cities dominated by motorized traffic, which is why researches in the subject are so important. Because there have been no studies linking cyclists' origins to urban parks, the current study aims to identify cyclists' origins (neighborhoods and cities) and destinations (urban parks) in three urban parks at Porto Alegre/RS, as well as the modes of transportation they use to get there, in contrast to the estimated distance from their origin. A quantitative study was undertaken for this, with data gathered from surveys about cyclists' origins in each of the three urban parks, as well as information about the locations received from Google Maps, largely using data analysis software like QGIS and Excel. This technique shows that cyclists come from all regions of the city and surrounding cities, covering an average distance of 2,977 km, and that riding one's own bicycle is the most common way of transportation, meaning that green space is important. It is also necessary for cyclists, and the closer it is to the cyclist the urban park, the more frequently it is used.
Keywords: Cyclists. Urban parks. Bicycle. Bike lane. Flows.

FLUXOS DAS ORIGENS DOS CICLISTAS AOS PARQUES URBANOS

Resumo: componentes como a infraestrutura cicloviária devem ser mais valorizados no contexto atual das cidades brasileiras dominadas pelo tráfego motorizado, por isso as pesquisas sobre o assunto são tão importantes. Como não existem estudos relacionando a origem dos ciclistas com os parques urbanos, o presente estudo tem como objetivo identificar as origens (bairros e cidades) e destinos (parques urbanos) dos ciclistas em três parques urbanos de Porto Alegre/RS, bem como todos os meios de transporte que utilizam para chegar até o local, em contraste com

a distância estimada de sua origem. Para tal, foi realizado um estudo quantitativo, com dados recolhidos a partir de questionários sobre a origem dos ciclistas em cada um dos três parques urbanos, bem como informações sobre as localizações recebidas do Google Maps, recorrendo em grande parte aos *softwares* de análise de dados como QGIS e Excel. Essa técnica mostra que os motociclistas vêm de todas as regiões da cidade e cidades vizinhas, percorrendo uma distância média de 2.977 km, e que a bicicleta é o meio de transporte mais comum. O que significa que o espaço verde é importante e necessário para os ciclistas, e quanto mais próximo o parque urbano dos ciclistas, maior é o uso.

Palavras-chave: Ciclistas. Parques urbanos. Bicicleta. Ciclovias. Fluxos.

FLUJOS DESDE LOS ORÍGENES DE LOS CICLISTAS HASTA LOS PARQUES URBANOS

Resumen: componentes como la infraestructura para bicicletas deben ser más valorados en el contexto actual de las ciudades brasileñas dominadas por el tráfico motorizado, por lo que la investigación sobre el tema es tan importante. Como no hay estudios que relacionen el origen de los ciclistas con los parques urbanos, el presente estudio tiene como objetivo identificar los orígenes (barrios y ciudades) y destinos (parques urbanos) de los ciclistas en tres parques urbanos de Porto Alegre/RS, así como todos los medio de transporte que utilizan para llegar al lugar, en contraste con la distancia estimada desde su origen. Para ello, se realizó un estudio cuantitativo, con datos recogidos de cuestionarios sobre la procedencia de los ciclistas en cada uno de los tres parques urbanos, así como información sobre las ubicaciones recibida de Google Maps, utilizando en gran medida software de análisis de datos como QGIS y Excel. Esta técnica muestra que los ciclistas provienen de todas las regiones de la ciudad y ciudades vecinas, recorriendo una distancia promedio de 2.977 km, y que la bicicleta es el medio de transporte más común. Lo que significa que el espacio verde es importante y necesario para los ciclistas, y cuanto más cerca esté el parque urbano de los ciclistas, mayor será su uso.

Palabras clave: Ciclistas. Parques urbanos. Bicicleta. Cíclovia. Flujos.

As in other parts of the world, Brazilian cities are seeing an increase in the number of vehicles and motorcycles. Because of the remarkable growth in the pace and volume of these motor vehicles' fleets (METRÓPOLES, 2019), the private car is the dominating mode of transportation. Between 2008 and 2018, the overall number of cars climbed from 37.1 million to 65.7 million, with 17 major metropolitan zones accounting for 40% of the rise (METRÓPOLES, 2019), in Porto Alegre/RS, for example, the rate of motorized vehicles has increased by 15.2 percent over the last ten years (METRÓPOLES, 2019).

A city must provides the appropriate conditions for displacement, i.e., people should be able to easily move from home to work, home to leisure, or anywhere else they choose to go, regardless of the mode of transportation they use (DE WITTE *et al.,* 2013; KARSSENBERG, 2015). To alleviate this traffic bottleneck, components such as bicycle infrastructure should be prioritized in a municipal master plan and long-term transportation strategy, with additional bike lanes being built to connect more areas to public transportation and a less fragmented bicycle network (ZUO *et al.*, 2018).

When compared to walking, bicycling increases the amount of territory that can be covered while giving more mobility and some health and social benefits (TUMLIN, 2011). In addition to not emitting pollutants, the bicycle contributes to a space free of congestion; its use also provides greater equity in the appropriation of urban space des-

tined for circulation, frees up more public space for leisure, results in a calmer traffic pattern, and has numerous health benefits for its users (AULTMAN-HALL *et al.*, 1997; BOARETO, 2007; BUEHLER; HANDY, 2008; LI *et al.*, 2020). Public spaces like urban parks, which are vital not only for the population but also for the city, are visited by cyclists too, but usually this is not regarded in researches.

Parks have always been an important component in an urban area (SAKIP *et al.*, 2015); they are important spaces in the relationship between man and nature, and they promote and provide space for physical activity, as well as reduce some diseases, such as diabetes and certain types of cancer (KACZYNSKI; HENDERSON, 2008; SAKIP *et al.*, 2015), contributing to daily psychological revitalization (ULRICH *et al.*, 1991; KAPLAN, 1995; MCCORMACK *et al.*,, 2010; THOMPSON *et al.*, 2012; NASIR *et al.*, 2013; HARTIG *et al.*, 2014). They also provide social advantages by increasing possibilities for social engagement, diversifying neighborhoods and communities, and promoting a sense of well-being (COLEY *et al.*, 1997; MAAS *et al.*, 2009; HARTIG *et al.*, 2014; PETERS; MACKENZIE, 2019).

Studies on modal choice concentrate on various modes of transportation (DE WITTE *et al.*, 2013). In this study, it was determined that bikers would be the main players, implying that the bicycle will be the primary form of transportation. Parks were chosen as cycling destinations, drawing many people due to the benefits outlined above.

The purpose is to determine cyclists' origins (neighborhoods and cities) and destinations (urban parks) in three Porto Alegre/RS urban parks (Farroupilha, Marinha do Brasil, and Moinhos de Vento parks). In addition, to show which modes of transportation, apart from bicycle, are used by cyclists to reach urban parks (such as walking, rented bicycle, bus, urban train, private automobile, and own car), and to estimate the distance from the origin.

LITERATURE REVIEW

Bicycle Travel Distances and Factors Affecting These Distances

The bicycle is one of the most cost-effective and efficient modes of transportation accessible today, especially for short distances. A person who uses the bicycle, travels twice as fast and covers three times the distance that a person who journeys by foot does (ITDP BRASIL *et al.*,). A pedestrian route's radius of reach does not exceed, in general, 1 km or 1.5 km; this is the maximum distance that a person would be willing to walk to go to a location; longer distances can be covered by bicycle (RIETVELD, 2000; GONDIM, 2006; FLAMM; RIVASPLATA, 2014; HOCHMAIR, 2015; LEE *et al.*, 2016).

However, defining a maximum radius for ideal bicycle locomotion is difficult due to the wide range of factors that influence this determination, such as capacity, physical conditioning of each individual, and city characteristics such as topography, climate, traffic conditions, and road infrastructure (GEIPOT, 2001; DE WITTE *et al.*, 2013). However, other authors use studies to determine what these "optimal" distances would be.

Bicycles have an ideal distance of up to 3 km as a mode of transportation (GEIPOT, 1983; PORTO ALEGRE, 2008), although travel of 5 to 6 km from home to work is also regarded regular (GEIPOT, 1983). According to other studies, the acceptable theoretical limit for bicycle trips in urban areas would be 7.5 km, corresponding to a trip with a maximum duration of 30 minutes (MINISTÉRIO DAS CIDADES, 2007; LARGURA, 2012), or 20 minutes, according to the authors Tumlin (2011) and Zuo *et al.*(2018). However, according to Tumlin (2011), cycling has an average range of 5 km, considering different destinations, such as work, school, and leisure.

In a more recent study by Li *et al.* (2020), they found that 90% of trips are shorter than 5 km long and last up to 30 minutes. In addition, the trip's time varies depending on the goal. Cycling enthusiasts, for example, are more likely to pedal longer and longer for leisure activities than for activities with a defined goal (LI *et al.*, 2020). Just over 10% of trips in the study city (Porto Alegre) are less than 1 km long, roughly 50% are less than 2 km long, 70% are less than 4 km long, and 90% are less than 7 km long, but there are also trips that can be up to 13 km long (PORTO ALEGRE, 2008).

About the factors that impact this means of locomotion, cycling infrastructure is one of the most important components, in this simple and cost-effective alternative for trips of 5 to 10 km, which has been adopted in several cities throughout the world (ITDP BRASIL *et al.*,). The provision of transportation infrastructure is critical in determining intermodal connectivity and shaping traveler and transportation mode preferences (ZUO *et al.*, 2018). Bike lanes, particularly protected bike lanes, are more appealing to riders and provide more low-stress bike connectivity (FORSYTH; KRIZEK, 2011; ZUO *et al.*, 2018). Cycling is linked positively to infrastructure and safety (REYNOLDS *et al.*, 2009; TESCHKE *et al.*, 2012).

Given that travel demand derive not from the utility of travel, but from the necessity to get to regions where activities take place (KASRAIAN *et al.*, 2018), the different ranges of the bicycle, as outlined, are determined by a variety of circumstances, including the provision of adequate infrastructure (such as bicycle lanes) and the cyclist's willingness to travel longer distances. This has been proven to be a cost-effective and environmentally friendly mode of urban transportation.

The Bicycle Intermodality

Another point to consider is the bicycle's intermodality, or its ability to be connected to other modes of transportation. The bicycle's intermodality with other modes of transportation improves its utility by allowing users to travel to locations that are further away from their starting point. Bicycle and public transportation are two of the most effective ways to achieve this linkage (AASHTO, 1999; RIETVELD, 2000; ANTP, 2005; BIANCO, 2008; PORTO ALEGRE, 2008; FLAMM; RIVASPLATA, 2014; HOCHMAIR, 2015; LEE *et al.*, 2016; SIQUEIRA, 2017; ZUO *et al.*, 2018; ZUO *et al.*, 2020).

Access to public transportation at either end of a journey (starting or ending), generally referred to as the first and last kilometer, has been recognized as one of the ma-

jor challenges to enhancing transit accessibility (AASHTO, 1999; ZUO *et al.*, 2020). This could be easily integrated with the use of bicycles for this "beginning and/or end" (RIETVELD, 2000; PORTO ALEGRE, 2008; FLAMM; RIVASPLATA, 2014; HOCHMAIR, 2015; Lee *et al.*, 2016; SIQUEIRA, 2017; ZUO *et al.*, 2018), making communities more inclusive, expanding the range of accessible opportunities (BOARNET *et al.*, 2017; ZUO *et al.*, 2020).

Bicycle parking or bike-sharing systems near terminals, bus stops, or railway stations, as well as the ability for cyclists to bring their bicycles with them, can all help to achieve this integration (BIANCO, 2003; ANTP, 2005).

This intermodality is achieved in Porto Alegre with bike rack located near urban train stations, as well as the ability to take the bicycle with you at particular times during working days, weekends, and holidays, and during all hours of operation of the urban train (TRENSURB, 2019). This interconnectedness allows more people to use the bicycle with other modes of transportation, such as the bus and urban train, so it's critical that more areas, such as bus terminals, provide secure bicycle parking.

The Porto Alegre Cyclists Profile

The goal of a survey conducted by Transporte Ativo between 2017 and 2018 (2019) was to learn more about cyclists and their motivations for riding bicycles, as well as to generate subsidies for public managers, urban planners, and other stakeholders involved in formulating primarily bicycle-based mobility solutions. It should be noted that this study did not include the study areas' parks, only formal places for bicycles to circulate, such as the bike lanes that are currently being implemented on weekdays.

Some outcomes of this research (about the bike users) in Porto Alegre, which will have an impact on future research:

- The majority of people do not combine riding a bicycle with another mode of transportation;
- They are between 25 and 34 years old.

These findings highlight characteristics of the general cyclist profile in Porto Alegre, with an emphasis on the cyclist who bikes for transportation, rather than the cyclist who frequents the urban park, who was the subject of this study.

METHODOLOGY

The city of Porto Alegre/RS (Figure 1) has an estimated population (in 2020) of 1,488,252 people. It is located at the geographic coordinates of South latitude: -30º01'59" and West longitude: -51º13'48" and has a territorial area of 496.684 km² (Prefeitura de Porto Alegre, 2019).
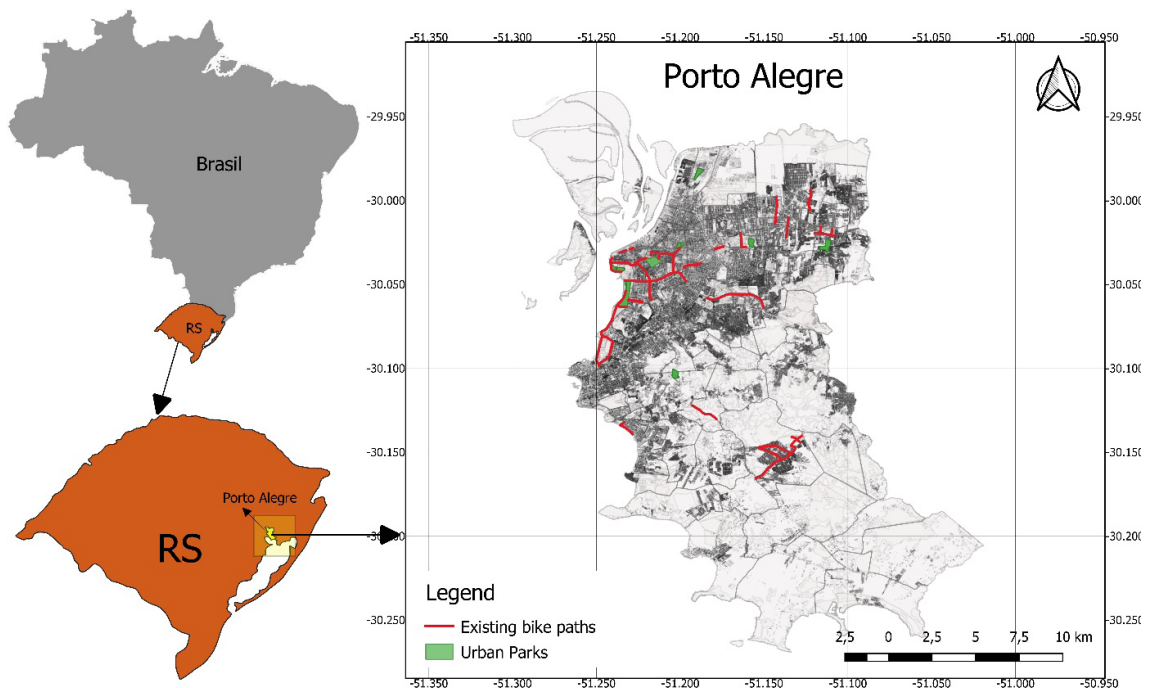
Location Map of Porto Alegre/RS

Figure 1: Location map of Porto Alegre/RS/Brazil.

Source: Authors (2022).

The research begins with a quantitative study of cyclist flows in the Farroupilha, Marinha do Brasil, and Moinhos de Vento parks in Porto Alegre/RS. Data were collected through face-to-face questionnaires (in the three urban parks) and online questionnaires (considering the choice of only one urban park to answer the questionnaire), in which each cyclist's neighborhood or city of origin was asked. There were 304 responses at the end of the collection, however only 299 were validated. The responses were initially analyzed by SPSS software, which performed a frequency count and validated the responses before being exported to Excel. "The frequencies reveal the distribution of data in relation to the categories considered in the variable," Lay and Reis (2005) write. Frequencies do not need to be accompanied by other statistical tests, according to the authors because these might be utilized to show crucial features of the interaction between users and space.

The connectivity of a bicycle network is a key component in determining cycling access to traffic (SCHLOSSBERG; BROWN, 2004; DUNCAN, 2011). These three urban parks were chosen because they have bike lanes adjacent to them, with bike lanes connecting them, as well as data gathered from Google Maps regarding the internal "trails" in the parks traversed by cyclists, which highlights cyclists mobility in these locations, as seen in Figure 2.
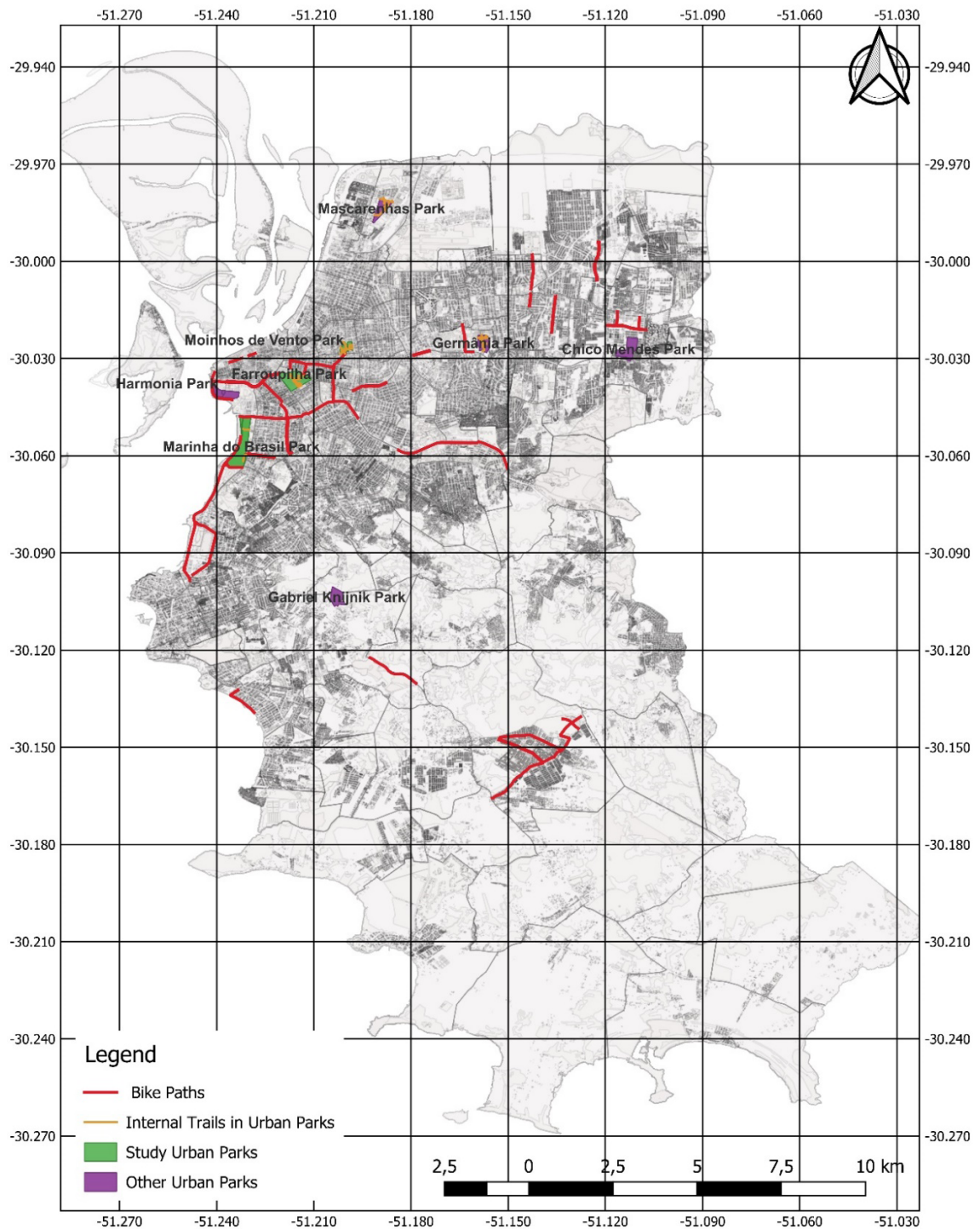
Figure 2: Map of urban parks and bike lanes in Porto Alegre/RS/Brazil.
Source: Authors (2022).

The bases provided by the Municipality of Porto Alegre for the limit and naming of the neighborhoods were utilized for the development of the maps of the flows, that is, origins and destinations. This base, which dated from 2016, required minor alterations in some places. The following instances were suggested by respondents to correlate to the

base provided by Prefeitura of Porto Alegre: Cohab does not exist in the base, but it is on the outskirts of the Cavalhada neighborhood; the Center was renamed Centro Histórico; Jardim Itu Sabará was renamed Jardim Sabará; and Alto Petrópolis was renamed Mario Quintana Neighborhood.

The QGIS application version 2.18 was used to process all of these data. Flow Maps plugin (Oursins) which generates flows based on origin, destination, and value (using the number of cyclists who responded who live in the neighborhood, disregarding nearby cities), was also used. The data was previously entered into an Excel spreadsheet for further processing in the plugin mentioning, considering the centroids, defined as the geometric center (MICHAELIS, 2019) of each neighborhood (origin) and urban park (destination) for its elaboration, as well as the number of cyclists residing in each mentioned neighborhood.

Only those who answered neighborhoods on the outskirts of Porto Alegre were considered for the map's creation. There were some cases from other surrounding cities, but they only accounted for 3.68 percent of all cases (both face-to-face and online), and thus they were ignored for that reason, as well as the fact that the centroid would have to be in relation to the city rather than the neighborhood (since the consideration of the city would compromise the results).

Another consideration is that the maps only provide information about the origin and destination; they lack a route identification feature or specific distances, which would necessitate data on each cyclist's particular journeys. With the QGIS 3.6 program, analysis was used to determine the average and maximum distance between neighborhoods and origins through the centroids of neighborhoods and urban parks, which generated values between each origin and destination. So, these values were exported to the Excel program and, thus, the most distant neighborhood in relation to the park was investigated. The numbers obtained in meters were also converted into kilometers in Excel, and the values calculated according to the number of individuals arriving per neighborhood, with the averages derived subsequently using the weighted average.

The data gathered before, the kilometers of each pair of origin and destination, were used to replace the names of the neighborhoods and the name of the urban park with numerical values, this one for the usage of the neighborhoods, to determine the intervals of kilometers traveled. For the cities, the km estimation was done in a straight line between the cities and the parks, using My Maps website's tool to measure distances and areas. these data were exported to Excel software and replaced by each pair of origin and destination by a numerical value, just as it was done for the neighborhoods.

After replacing the pairs, intervals in kilometers were created and later grouped according to the most common kilometers visualized. These procedures were made to (later) relate the variables subsequently, like the gender, age group, and mode of transportation utilized to get to the target park. The data crossover between gender, age group, and distance, as well as distance and mode of transportation, were calculated with 100% of the respondents in mind. Cities were included in this section since they are the means of transportation that are utilized with the bicycle to see if larger distances can be traveled by more than one mode of transportation.

RESULTS AND DISCUSSION

Cyclists cited 49 areas and seven cities near Porto Alegre/RS as their starting points (or origins). Cyclists named the neighborhoods of Porto Alegre and adjacent cities as their starting points in Figure 3. Bicyclists from 38 neighborhoods and from five cities located in the metropolitan region (Alvorada/RS, Eldorado do Sul/RS, Estância Velha/RS, Guaíba/RS, and Gravataí/RS) responded to the Farroupilha park as your destination. The Marinha do Brasil park covered 26 of the city's neighborhoods, as well as the city of Viamão/RS. Bicyclists from 28 Porto Alegre neighborhoods, as well as the cities of Alvorada/RS and Canoas/RS, were accessible by Moinhos de Vento park. It is highlighted that urban parks have a wide reach and that people are prepared to go from other cities to visit them, demonstrating the value of green spaces for cyclists.
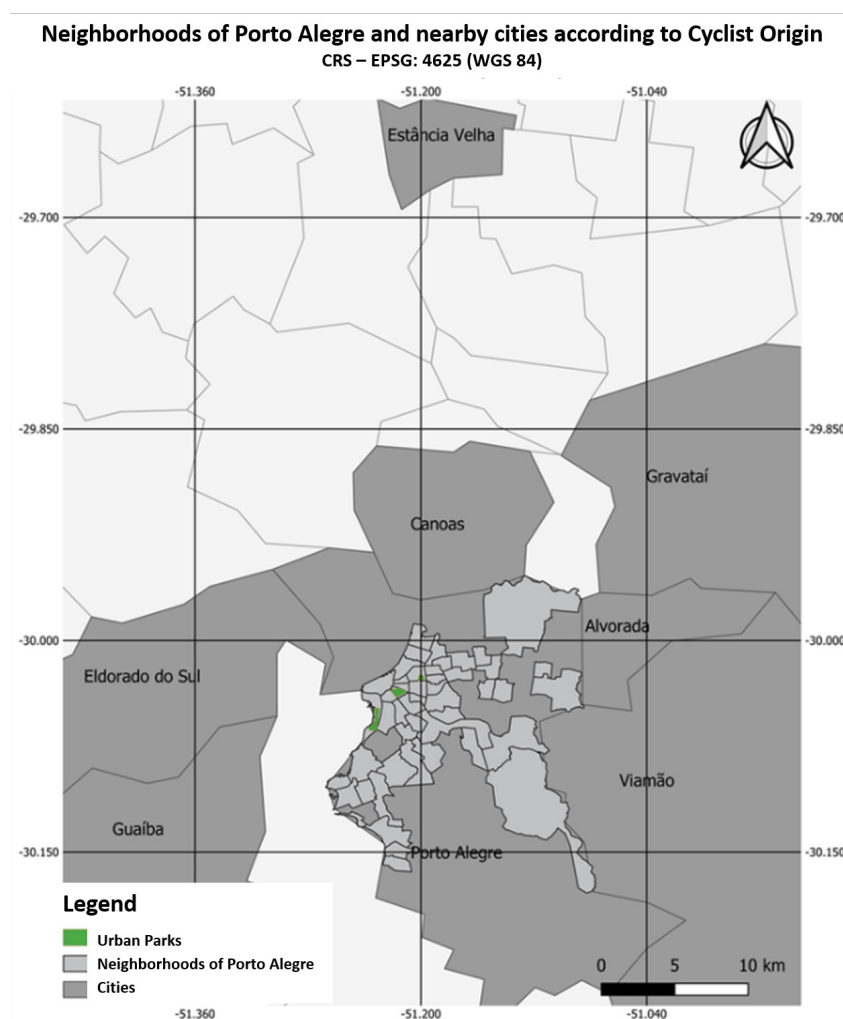

Figure 3: Map of the neighborhoods of Porto Alegre/RS/Brazil and nearby cities according to the origin of cyclists, where the darkest part of the map represents the cities of origin of the cyclists.

Source: Authors (2022).

Figure 4 shows a graph that depicts the gender, age group, and distance traveled by bicycles from their starting points to urban parks, based on an estimate of the distance between each pair's centroids (origin and destination). It's important noting that the male gender outnumbers the female, implying that more men frequent urban parks.

Considering the female gender, the most common age groups are 18 to 30 years old and 31 to 45 years old, with the latter having the widest range of kilometers traveled (over 15 km) but also one of the shortest (2.5 km) between 1.1 and 45 years. While the second-largest age group (between 18 and 30 years old) has intervals of 0 to 1 km and 7.6 to 10 km, indicating a contrast between women who are willing to go larger distances and those who want to travel the shortest distance to access an urban park.
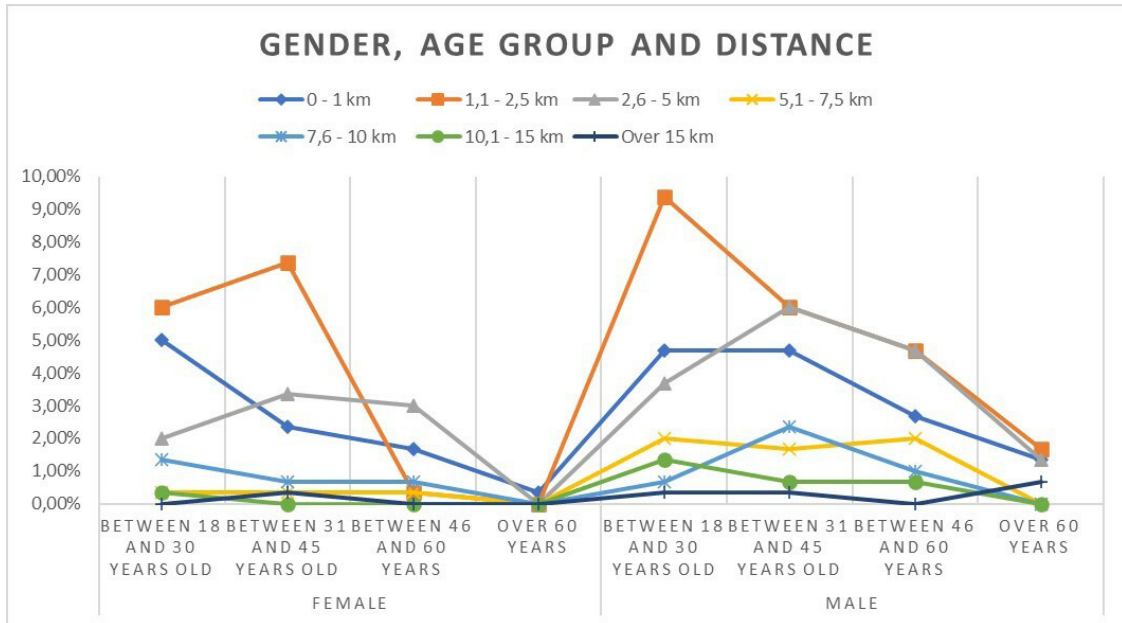

Figure 4: Graph of gender, age group and distance traveled by cyclists to urban parks.
Source: Authors (2022).

In terms of the male gender, the most common age groups are 18 to 30 years old and 31 to 45 years old. Males between the ages of 18 and 30 covered the longest distances, ranging from 10.1 to 15 km, while men between the ages of 31 and 45 covered 7.6 to 10 km. Males, in contrast to females, travel larger distances, with the most common age group being 31 to 45 years old and the most common distance being between 1.1 and 2.5 km. An interesting truth is that among the entire group, males over 60 years old are the ones who go the greatest distances, exceeding 15 km.

The most common age groups differed from the cyclists in the research, who frequent urban parks in the city, being an age group higher than that of the research presented, when compared to the profile of the general cyclist from Porto Alegre presented in the Transporte Ativo's bibliographic review (2019).

Farroupilha Park reaches neighborhoods in the North, South, East and Central zones. The most distant neighborhood in relation to the park is the Agronomia neighborhood, which is around 8,742 km away from the centroids (origin and destination); the average was in 2,558 km considering all neighborhoods. The Bom Fim neighborhood, showing more cyclists with 20 respondents residing in this neighborhood, is distant around 0.49 km, considering the park's centroid and the neighborhood's centroid.

Cyclists from all regions frequent Marinha do Brasil park. Sarandi neighborhood, in the North Zone, can be considered the most distant, with a distance of around 13,287

km from the park's centroid to the centroid of the neighborhood. In comparison to the other mentioned neighborhoods, and an average distance of 3,954 km when all distances between neighborhoods and the park were considered. The Menino Deus neighborhood received the most responses - 16 cited as the origin of cyclists - which is distant around 0.88 km (considering centroids).

Bicyclists visit Moinhos de Vento park from all over the city (North, South, East, and Central), with a concentration in the neighborhoods nearest to the park. The most distant neighborhood in relation to the park - around 8,808 km - considering the centroids, is the Sarandi neighborhood; the average was 3,144 km. The Rio Branco neighborhood, was the one that stood out with more cyclists (with 6 cyclists), with a distance of 0.68 km considering centroids.

Farroupilha Park, as the city's most central and popular park, was the one that extended out to more communities and adjacent cities. While Marinha do Brasil Park drew bicycles from a further away neighborhood (Sarandi), this demonstrates that riders are prepared to go greater distances to access the park, even though others are closer. The flows in the neighborhoods of Porto Alegre/RS can be shown in Figure 5. In this scenario, nearby cities were not considered because the cyclists did not mention the neighborhood in which they live, making the presentation of the city's centroid as origin incoherent.
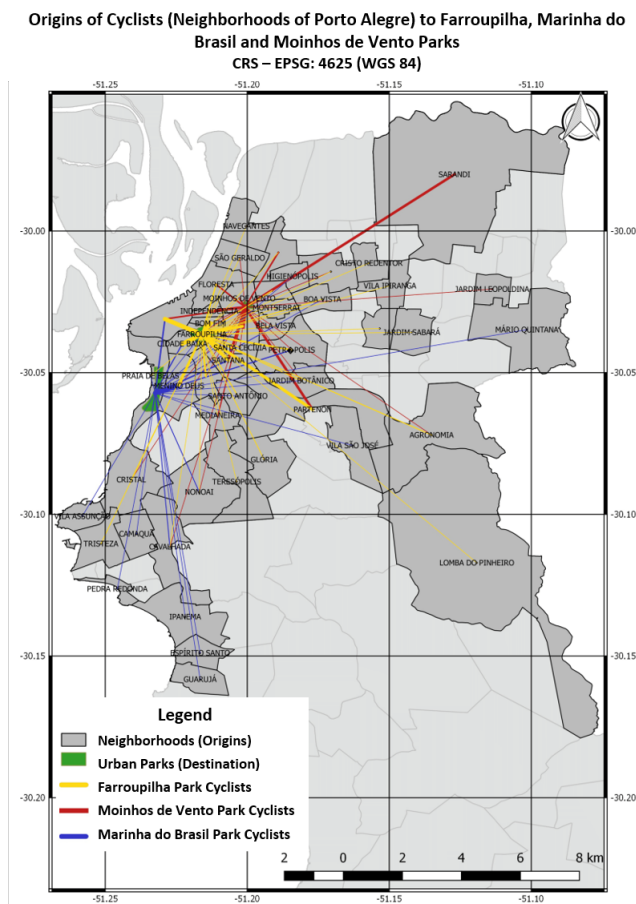

Figure 5: Map of the origin of cyclists from the neighborhoods of Porto Alegre/RS to the destination urban parks of the study in each color represents the flow of each of the three urban parks and their respective destinations, the thicker the line, the greater the number of cyclists

Source: Authors (2022).

Cyclists come from a variety of neighborhoods and localities, but the Central Region of Porto Alegre stands out as having the highest number of responders and being the closest to the three urban parks studied. From Marinha do Brasil park to Sarandi neighborhood, the maximum distance found using only Porto Alegre neighborhoods was 13.287 km. The Marinha do Brasil park was found to have the highest average distance traveled by cyclists (3,954 km), indicating that cyclists go higher distances to access this urban park.

According to De Witte *et al.* (2013) and Geipot (2001), there is no way to determine an ideal radius for cycling because it varies depending on numerous parameters (these have already been presented in the literature review). The weighted average of all urban parks was 2,977 km, which was lower than the literature's average, indicating that more cyclists come from areas closer to urban parks (considering only Porto Alegre neighborhoods).

Figure 6 depicts the modes of transportation utilized by cyclists to get to the urban park, as well as the distance traveled. Even over larger distances, the primary mode of transportation to the park is one's own bicycle (for example, over 15 km). The second most common mode of transportation was walking plus personal bicycle, which was cited in greater numbers in lengths of 0 to 1 km and 1.1 km to 2.5 km, whereas other modes of transportation were mentioned in fewer numbers in other distances.

These findings show that cyclists are prepared to travel large distances only by bicycle, despite the lack of specific infrastructure for cyclists (because cycle routes are concentrated in the city's core region). This supports the findings of authors Li *et al.* (2020), who found that cyclists are more willing to pedal longer distances according to the objective. This finding is consistent with a study conducted by Transporte Ativo (2019), whose goal was to meet cyclists that do not combine cycling with other modes of transportation. It's important noting that this study excluded parks in favor of organized areas for bicycles to circulate, such as bike routes that operate on weekdays.
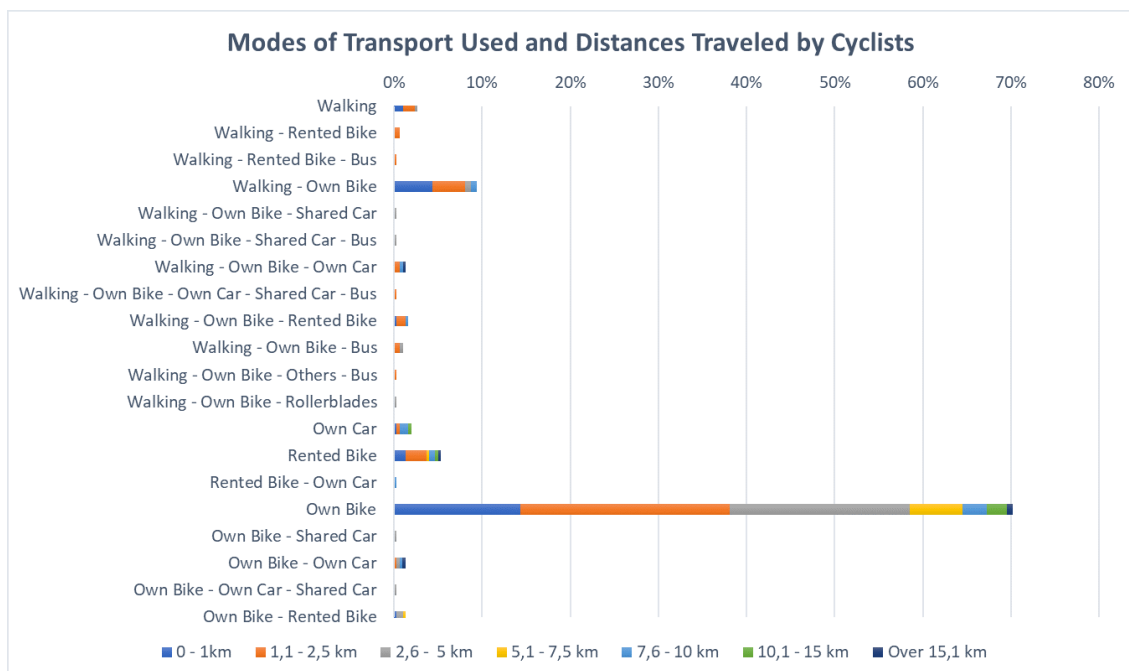

Figure 6: Graph that relates the modes of transport used by cyclists to travel to the urban park together with the distance traveled.

Source: Authors (2022).

The verification of origins and destinations was important to understand where these cyclists who frequent urban parks come from, which are spread across all regions and nearby cities. As a result, there was a predominance of men and an age group between 31 and 45 years old, using own bicycle to reach your goals when reaching the urban park, even over shorter distances (up to 1 km which are easily reached on foot) to longer distances (over 10 km).

CONCLUSION

The information gathered revealed the origin and destination sites for the urban parks studied. It has been proven that urban parks attract cyclists from all parts of Porto Alegre, as well as from neighboring cities. It was also found that the closer the park to the origin of cyclists, the more it is used (according to the survey of origins and destinations, the neighborhoods closest to the parks reach more cyclists). These findings demonstrate how important it is to provide green space for cyclists, how urban parks attract this public (which has been overlooked in previous studies of these spaces), and how the bicycle is inclusive when it comes to reaching different age groups, attracting both the young and the elderly.

Cycling for transportation appears to be a sensible concept in a world confronting resource depletion and global warming, as well as in cultures dealing with obesity and traffic congestion (Cooper, 2017). As a result, another point to consider is bicycle intermodality, or allowing the bicycle to be interconnected with other modes of transportation because, as we've seen, there are already some cyclists who use it (even though it is a small percentage). This intermodality allows for more cyclists to enjoy these places, as it allows users who live further away to reach them, primarily through interconnection with public transportation.

One limitation in this study was the lack of data on cyclists' itineraries, which would have allowed for a more thorough examination and precise distance measurements; this would involve the use of GPS. Because there is no open data that contains this information, it became impractical to consider the routes, and hence this other method was utilized, resulting in a large sample size.

REFERENCES

AASHTO EXECUTIVE COMMITTEE et al. *Guide for the development of bicycle facilities*. American Association of State Highway Transportation Officials: Washington, DC, USA, 1999.

ANTP – Associação Nacional de Transportes Públicos. Inserção da bicicleta na circulação urbana. *Revista dos Transportes Públicos* – ANTP. São Paulo, 2005.

AULTMAN-HALL, Lisa; HALL, Fred L.; BAETZ, Brian B. Analysis of bicycle commuter routes using geographic information systems: implications for bicycle planning. *Transportation research record*, v. 1578, n. 1, p. 102-110, 1997. https://doi.org/10.3141/1578-13.

BIANCO, S. L. O papel da bicicleta para a mobilidade urbana e a inclusão social. *Revista dos Transportes Públicos – ANTP*. São Paulo: ano 25, 3º trim., 2003

BOARETO, R. *Caderno de referência para elaboração de plano de mobilidade por bicicleta nas cidades*. Brasília: Secretaria Nacional de Transporte e da Mobilidade Urbana, 2007.

BOARNET, Marlon G. et al. First/last mile transit access as an equity planning issue. *Transportation Research Part A: Policy and Practice*, v. 103, p. 296-310, 2017.https://doi.org/10.1016/j.tra.2017.06.011

BUEHLER, Ted; HANDY, Susan. Fifty years of bicycle policy in Davis, California. *Transportation Research Record*, v. 2074, n. 1, p. 52-57, 2008. https://doi.org/10.3141/2074-07

COLEY, Rebekah Levine; SULLIVAN, William C.; KUO, Frances E. Where does community grow? The social context created by nature in urban public housing. *Environment and behavior*, v. 29, n. 4, p. 468-494, 1997.

COOPER, Crispin HV. Using spatial network analysis to model pedal cycle flows, risk and mode choice. *Journal of transport geography*, v. 58, p. 157-165, 2017. https://doi.org/10.1016/j.jtrangeo.2016.12.003

DE WITTE, Astrid et al. Linking modal choice to motility: A comprehensive review. *Transportation Research Part A: Policy and Practice*, v. 49, p. 329-341, 2013. https://doi.org/10.1016/j.tra.2013.01.009

DUNCAN, Michael. The impact of transit-oriented development on housing prices in San Diego, CA. *Urban studies*, v. 48, n. 1, p. 101-127, 2011. https://doi.org/10.1177/0042098009359958

FLAMM, Bradley; RIVASPLATA, Charles. Perceptions of Bicycle-Friendly Policy Impacts on Accessibility to Transit Services: The First and Last Mile Bridge, *MTI Report* 12-10. 2014.

FORSYTH, Ann; KRIZEK, Kevin. Urban design: is there a distinctive view from the bicycle?. *Journal of urban design*, v. 16, n. 4, p. 531-549, 2011. http://dx.doi.org/10.1080/13574809.2011.586239.

GEIPOT. *Estudos de Transporte Cicloviário*. Vol. I. Tratamento de Interseções. Brasília, 1983.

GEIPOT. *Manual de Planejamento Cicloviário.* Empresa Brasileira de Planejamento de Transportes. Brasília: Ministério dos Transportes, 2001.

GONDIM, Monica Fiuza. *Cadernos de desenho ciclovias*. Expressão Gráfica e Editora Ltda, 2006.

HARTIG, Terry et al. Nature and health. *Annual review of public health*, v. 35, p. 207-228, 2014.

HOCHMAIR, Hartwig H. Assessment of bicycle service areas around transit stations. *International journal of sustainable transportation*, v. 9, n. 1, p. 15-29, 2015. https://doi.org/10.1080/15568318.2012.719998.

ITDP Brasil, Studio-X Rio, Transporte Ativo. CicloRotas - Centro. Rio de Janeiro.

KACZYNSKI, Andrew T.; HENDERSON, Karla A. Parks and recreation settings and active living: a review of associations with physical activity function and intensity. *Journal of physical activity & health*, v. 5, n. 4, 2008. https://doi.org/10.1123/jpah.5.4.619

KAPLAN, Stephen. The restorative benefits of nature: Toward an integrative framework. *Journal of environmental psychology*, v. 15, n. 3, p. 169-182, 1995.

KARSSENBERG, Hans et al. *A cidade ao nível dos olhos: lições para os plinths*. Porto Alegre: EdiPUCRS, 2015.

KASRAIAN, Dena; MAAT, Kees; VAN WEE, Bert. Urban developments and daily travel distances: Fixed, random and hybrid effects models using a Dutch pseudo-panel over three decades. *Journal of Transport Geography*, v. 72, p. 228-236, 2018.

LARGURA, Aline Estela et al. Fatores que influenciam o uso de bicicleta em cidades de médio porte: estudo de caso em Balneário Camboriú/SC. 2012.

LAY, Maria Cristina Dias; DA LUZ REIS, Antônio Tarcísio. Análise quantitativa na área de estudos ambiente-comportamento. *Ambiente Construído,* v. 5, n. 2, p. 21-36, 2005.

LEE, Jaeyeong; CHOI, Keechoo; LEEM, Yountaik. Bicycle-based transit-oriented development as an alternative to overcome the criticisms of the conventional transit-oriented development. *International Journal of Sustainable Transportation*, v. 10, n. 10, p. 975-984, 2016.https:// doi.org/10.1080/15568318.2014.923547

LI, Aoyong; HUANG, Yizhe; AXHAUSEN, Kay W. An approach to imputing destination activities for inclusion in measures of bicycle accessibility. *Journal of transport geography*, v. 82, p. 102566, 2020. https://doi.org/10.1016/j.jtrangeo.2019.102566

MAAS, Jolanda et al. Social contacts as a possible mechanism behind the relation between green space and health. *Health & place*, v. 15, n. 2, p. 586-595, 2009. https://doi.org/10.1016/j.healthplace.2008.09.006

MCCORMACK, Gavin R. et al. Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. *Health & place*, v. 16, n. 4, p. 712-726, 2010. https://doi.org 10.1016/j.healthplace.2010.03.003

METRÓPOLES, Observatório Das. *Mapa da Motorização Individual no Brasil 2019*. Rio de Janeiro, 2019.

MICHAELIS. Moderno Dicionário da Língua Portuguesa. Available: http://michaelis.uol.com.br/moderno/portugues/index.php. Accessed data: 10 September 2019.

MINISTÉRIO DAS CIDADES. *Coleção Bicicleta Brasil*. Plano de Mobilidade por Bicicleta nas Cidades. Brasília – DF, 2007.

PETERS, Luke; MACKENZIE, Don. The death and rebirth of bikesharing in Seattle: Implications for policy and system design. *Transportation Research Part A: Policy and Practice*, v. 130, p. 208-226, 2019. https://doi.org/10.1016/j.tra.2019.09.012

PORTO ALEGRE. Plano Diretor Cicloviário Integrado de Porto Alegre, 2008.

NASIR, Rabiatul Adawiyah; AHMAD, Sabarinah Sh; AHMED, Azni Zain. Physical activity and human comfort correlation in an urban park in hot and humid conditions. *Procedia-Social and Behavioral Sciences*, v. 105, p. 598-609, 2013. https://doi.org/10.1016/j.sbspro.2013.11.063

REYNOLDS, Conor CO et al. The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. *Environmental health*, v. 8, n. 1, p. 1-19, 2009. https://doi.org/10.1186/1476-069X-8-47

RIETVELD, Piet. The accessibility of railway stations: the role of the bicycle in The Netherlands. *Transportation Research Part D: Transport and Environment,* v. 5, n. 1, p. 71-75, 2000. https://doi.org/10.1016/S1361-9209(99)00019-X

SAKIP, Siti Rasidah Md; AKHIR, Norizan Mt; OMAR, Siti Syamimi. Determinant factors of successful public parks in Malaysia. *Procedia-Social and Behavioral Sciences*, v. 170, p. 422-432, 2015. https://doi.org/10.1016/j.sbspro.2015.01.003

SCHLOSSBERG, Marc; BROWN, Nathaniel. Comparing transit-oriented development sites by walkability indicators. *Transportation research record*, v. 1887, n. 1, p. 34-42, 2004. https://doi.org/10.3141/1887-05

SIQUEIRA, Rafael. *Planejamento Cicloinclusivo Fundamentos para a criação de redes seguras e confortáveis*. ITDP Brasil, 2017.

TESCHKE, Kay et al. Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. *American journal of public health*, v. 102, n. 12, p. 2336-2343, 2012. https://doi.org/10.2105/AJPH.2012.300762

THOMPSON, Catharine Ward et al. More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and urban planning*, v. 105, n. 3, p. 221-229, 2012.

TRANSPORTE ATIVO. Perfil do Ciclista Brasileiro. Brasil, 2019.

TRENSURB. Projeto Cicloatividade Instala Paraciclos junto a Estações da Trensurb em Porto Alegre. Available: http://www.trensurb.gov.br/paginas/paginas_noticias_detalhes.php?codigo_sitemap=5340&codigo_sitemap_pai=96&fbclid=IwAR3Wf8oL0FQ213Hk8-1FsuXwor2ze-Dx9qWF4G1gIchhTnfmmmrQSH_FLy4. Accessed data: 30 May 2019.

TUMLIN, Jeffrey. *Sustainable transportation planning: tools for creating vibrant, healthy, and resilient communities*. John Wiley & Sons, 2011.

ULRICH, Roger S. et al. Stress recovery during exposure to natural and urban environments. *Journal of environmental psychology*, v. 11, n. 3, p. 201-230, 1991.

ZUO, Ting; WEI, Heng; ROHNE, Andrew. Determining transit service coverage by non-motorized accessibility to transit: Case study of applying GPS data in Cincinnati metropolitan area. *Journal of Transport Geography*, v. 67, p. 1-11, 2018. https://doi.org/10.1016/J

ZUO, Ting et al. First-and-last mile solution via bicycling to improving transit accessibility and advancing transportation equity. *Cities*, v. 99, p. 102614, 2020. https://doi.org/10.1016/j.cities.2020.10261

JENNIFER DOMENEGHINI

Arquiteta e Urbanista. Mestra em Planejamento Urbano e Regional pela UFRGS. Doutoranda em Planejamento Urbano e Regional na UFRGS. http://orcid.org/0000-0001-9466-0322. *E-mail*: jennidomeneghini@gmail.com

VALÉRIA BORGES YONEGURA

Doutoranda em Planejamento Urbano e Regional na UFRGS. http://orcid.org/0000-0003-3892-0825. *E-mail*: projetobyvaleria@gmail.com

ANDRÉ LUIZ LOPES DA SILVEIRA

Professor no IPH e PROPUR da UFRGS. http://orcid.org/0000-0001-9875-879X. *E-mail*: andre@iph.ufrgs.br