DEVELOPING THE PUBLIC TRANSPORTATION SYSTEM TO SERVE URBAN TOURISM.

by

NASIM REZVANPOUR

(Under the Direction of Jack Crowley)

ABSTRACT

Transportation has always been an inseparable part of the tourism industry due to its vital role in transferring tourists from one country to another and circulating visitors within their destinations. Public transportation is an important factor in growing tourism within a destination. However, American public transit systems in most cities face the dual challenges of high operating costs and low ridership. Promisingly, however, there are destinations within touristic cities where visitors have a significant impact on the economy compared to the size of the population.

Since tourism has created a critical effect on a city's economic achievement and social dynamism, this research focuses on how well city mass transit systems serve visitors to major North American cities. We believe that tourist-friendly public transportation can increase ridership and significantly impact the success of the city's public transit system. The primary goal of this research is thus to plan tourist-friendly public transportation in United States cities. This study aims to answer one fundamental question: "What does a well-designed public transit system that specifically serves tourism in the interest of economic development look like?" The current study uses different tools, predominantly ArcGIS network analysis, to represent the spatial pattern of U.S. cities' visitor origins and destinations and the accessibility of these points via city public

transit systems. The findings, which represent major U.S. cities, demonstrate a similar spatial pattern for visitors' origins and destinations. Moreover, they represent a positive correlation between having a public transit system that is developed and one that is tourist friendly.

INDEX WORDS: Tourist-friendly, public transportation, ArcGIS Network Analysis, Origin-Destination Matrix.

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DEDICATION

This dissertation is dedicated to my beloved family, my supportive spouse Arash, whose encouragement for four years gave me the passion to keep on, my mom and dad, Nayyer and Hadi, who endorsed me emotionally in every stage of my life, and my brother and sister-in-law, Hamed and Fatima whom I will love forever.

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CHAPTER 1

INTRODUCTION

Studies have shown people living in high-density locations are more likely to use transit systems (Delbosc et al., 2019). Several studies have asserted that applying appropriate policies to reduce public transportation ticket costs, increase parking fees and increase the number and frequency of public transit vehicles lead people to use this system more often (Grimsrud & El-Geneidy, 2013; Kuhnimhof, Buehler, & Dargay, 2011). According to the U.S. National Household Travel Survey 2017, the average annual person trip per household by public transit has demonstrated an increasing trend from 2000 until 2017 (NHTS, 2018). This finding aligns with the growth of urban density and the public transit system within U.S. cities.

Several studies worldwide have argued that the younger generation's travel behaviors have shifted toward using more public transportation and fewer private cars (Brown, Blumenberg, Taylor, Ralph, & Voulgaris, 2016; Dutzik & Baxandall, 2013; Dutzik, Inglis, & Baxandall, 2014; Grimsrud & El-Geneidy, 2013; Kuhnimhof et al., 2011; Page, 2014; Polzin, Chu, & Godfrey, 2014). Urban tourists whose destinations are European cities are hesitant to use private transport to avoid the cost, effort, and difficulties that arise from driving (Albalate & Bel, 2010). One significant reason for this hesitancy is that European cities offer well-developed public transit systems that provide accessibility for visitors. As for European cities, in the United States, a new trend indicates the younger generation of visitors want to travel within cities but minimize the cost of transportation, time, and parking and driving difficulties. A well-designed public transport system offers visitors accessibility from their origin to their destinations. There is a need for well-

developed public transportation systems within high-density cities that meet the needs of both residents and urban visitors, particularly the younger generation.

Problem statement

The number of studies that analyzed the accessibility of origins and destinations for the younger generation of U.S. cities visitors is very limited. As U.S. cities become denser and younger, a new culture and trend of replacing private cars with forms of public transportation are emerging among younger residents. Moreover, the same trend can be observed among a new generation of city visitors, particularly millennials, and generation Z, for multiple reasons that will be described later. Many studies have analyzed the use of public transportation within cities for individuals traveling between work and home. However, there is a considerable gap in the literature regarding city visitors' daily commute between their origin and destination while using city public transit systems. The current study intends to fill the gap by paying special attention to these types of commutes for a younger generation of visitor whose destinations are cities. It aims to assess the extent to which tourists' circulation within cities has been examined and whether these considerations align with emerging tourist types and their needs.

Research question

The ultimate purpose of this research is to assess the connectivity of city visitors' origin and destinations in ArcGIS to explore whether city public transit systems are "tourist-friendly." The research uses a case study approach to compare various cities' public transit systems in the context of visitors' needs. The main question associated with visitor-friendly public transport is, "What are the elements of a well-designed public transit system that specifically serves city tourism?" The following sub-questions are defined to help answer the main question:

1. What are the critical factors to consider before planning visitor-friendly public transportation?
2. How does the spatial pattern analysis of origins and destinations support public transit development within U.S. major cities?
3. How well does a city's public transportation system provide accessibility from visitor origins to destinations and from visitor destinations to origins within U.S. major cities?

Research significance

Meeting city visitors' needs and developing a visitor-friendly public transit system offer several advantages for cities. One crucial benefit is attracting a younger generation of visitors to the city, leading to economic growth. The United Nations estimates that annual tourism revenue has grown by 30% since 2017 as 2 billion young generation visitors, millennials, spent $180 billion globally (Merritt, Kline, Crawford, Viren, & Dilworth, 2018). Later, we will indicate young visitors respect sustainability more and favor affordable travel.

Planning tourist-friendly public transit is a driver of urban economies because tourists support local users by providing more off-peak movements on local commuter services. According to Albalate and Bel (2010), this off-peak revenue helps planners and authorities reduce charges to residents or reduce targeted tax payments to the transportation system. Moreover, by providing accessibility to second-ranked attractions, visitor-friendly public transportation adds more value to these places, thereby improving the city's overall livability.

Tourist-friendly public transit also helps cities and the environment by reducing traffic congestion, assisting visitors in using their short trips efficiently, and assisting residents in

commuting easily, especially in city centers, without getting stuck in unnecessary traffic. Furthermore, the current research findings will provide guidelines for future mass transit planners by presenting them with accurate actual data to illustrate how making public transit attractive and efficient will increase ridership.

Research Design

To explain the main question, sub-questions are proposed, which will lead to a comprehensive solution for the study's main question. The first sub-question is general, while for answers to the second and third sub-questions, six case studies throughout the U.S. have been selected. It has been assumed that the developed public transit systems in the research's case studies range from the most accessible to the least accessible for tourists. Answering the research sub-questions will shape this spectrum and help urban planners develop the best methods for designing a tourist-friendly public transit system. Table 1 gives a schematic view of the overall structure of this research.

Table 1 Summary of Research Questions, Objectives, and Methods

<table>
<tr><th colspan="2">Main Question: What are the elements of a well-designed public transit system that specifically serves tourism?</th></tr>
<tr><td colspan="2">Sub-question 1: What are the critical factors to consider before planning visitor-friendly public transportation?</td></tr>
<tr><th>Objective</th><th>Methods</th></tr>
<tr><td>Objective 1: Identify the prerequisites of a tourist-friendly public transit system before any attempt to plan it.</td><td>Literature review: Study surveys, peer-reviewed articles, and books to assess the needs of the younger generation of city tourists.</td></tr>
<tr><td colspan="2">Sub-question 2: How does the spatial pattern analysis of origins and destinations support public transit development within U.S. major cities?</td></tr>
</table>

Objective	Methods
Objective 2: Identify the geographic location for origins and destinations and find the patterns, if any, among several case studies.	**Case studies:** using several U.S. cities as the research case studies to compare the visitors' origins and destinations and the city's public transit networks. **Spatial Data Analysis:** Use ArcGIS to identify patterns among case studies and between tourist origins and destinations and the city's public transit.
Sub-question 3: How well does a city's public transportation system provide accessibility from visitor origins to destinations and from visitor destinations to origins within U.S. major cities?	
Objective	**Methods**
Objective 3: Identify public transit networks' connectivity between visitors' origins and destinations and vice versa.	**Case studies:** Use several U.S. cities as the research case studies to compare their public transit networks. **GIS Network Analysis:** Use General Transit Feed Specification (GTFS) data to identify the accessibility between origins and destinations

Research Organization

Chapter 2 presents the literature review and explains the previous research and studies on tourism transport concepts. It posits the factors of tourist-friendly public transit as representing a need for further investigations and describes the current gap in planning tourist-friendly public transportation. Although numerous studies have emphasized the need to develop public transport for city visitors, few have focused on defining these factors and analyzing quantitative factors for use in planning. This part represents the current research and reports on the tourism-transport context and travel trends of younger generations and argues there is a gap in the literature review in quantifying emerging young generations' travel needs when their destination is cities.

Chapter 3 explains the reasoning behind the quantitative approach to this research and defines the data and analysis processes. This study uses various data related to visitors' origins and

destinations and the city's public transit network to assess 1) the patterns between visitors' origins and destinations and 2) the accessibility of each origin to destination and destination to origin using the city's public transit system.

Chapter 4 presents the findings exported from ArcGIS and visualized in map format. For each case study, three final maps have been created to answer the first sub-question and to find the spatial pattern of city visitors' origins and destinations. In addition, for each case study, eight final maps have been created as a result of the analysis for answering the second sub-question and assessing the accessibility of each origin to destination and each destination to origin using city public transit systems.

Chapter 5 represents the discussion part. This part focuses on the research questions and how they support the related findings. The study outcomes are compared to other quantitative findings to understand the younger generation's needs in using cities' public transit systems. Moreover, chapter 5 elaborates on the limitations of this study.

Chapter 6 is the final chapter representing the conclusion, introducing significant outcomes, and recommending grounds for future research.

CHAPTER 2

LITERATURE REVIEW

This literature review examines the concept of "tourist-friendly public transportation" within destinations. The chapter begins by presenting the various characteristics associated with tourism and transport concepts. It first elaborates on general ideas that exist in the tourism and transportation context. It then explains various types and generations of tourists. Based on several studies, there is a correlation between younger generations' lifestyles and their choice of public transportation.

Therefore, the current research focuses on the young generation's travel behavior, origins, and destinations. These factors help in narrowing the research to specific tourist types and generations and specific types of public transportation. Based on this foundation, this study will perform quantitative analysis to determine whether there is connectivity among visitors' origins and destinations via cities' public transit.

Urban visitors and attractive public transportation at destinations

Transportation plays a vital role in the tourism industry. Tourism and transport are inseparable, as there is always a need to drive tourists to the places they want to visit (Mandeno, 2011). Groundbreaking modes of air travel have dramatically reduced the cost of international travel, resulting in outstanding growth in the tourism industry. According to Duval (2007), five innovations in transportation have affected tourism: 1) time reduction, 2) cost reduction, 3)

comfort and safety improvements, 4) increases in connectivity of destinations, and 5) increases in the accessibility of destinations.

In general, there are three modes of transportation, ground, air, and marine, all of which have public and private uses. While all three modes provide accessibility between destinations, ground transportation is used more often to transfer people within destinations. Public transit at the destination transports masses of people and provides fixed services in space and time. It includes metro, bus, light rail, bus rapid transit, suburban and regional rail. Studies have shown that cities with developed public transit networks are more attractive to tourists (Hall, Le-Klähn, & Ram, 2017). In addition, according to some studies most public transit users are well-educated and relatively young (Thompson & Schofield, 2007). This research focuses on the use of public transportation at destinations by considering young visitors' origins and destinations. It uses ArcGIS analysis to ascertain the accessibility between these origins and destinations.

As improved transport networks affect tourism development at destinations, the public transit investors in most cities in the United States are spending to improve the quantity and quality of public transportation services to increase ridership while retaining their loyal users. Such attempts reduce traffic congestion in towns and weaken the dependency on private cars, thereby helping protect the environment (Hess & Bitterman, 2008). Developing a public transit system that serves city residents and city visitors is a new trend on which this research focuses on.

A critical point is that residents' and visitors' origins and destinations vary significantly. Tourist preferences, motivation, and behavior vary from those of residents. In general, in the process of planning and designing public transit routes, attention is paid mostly to local users (Thompson, 2004). In a typical transportation model, residential zones tend to have the highest trip

generation at certain times of the day, yet for the tourism industry, trip-generating zones tend to be highly concentrated near hotels, motels, and resorts, as well as the houses of friends and relatives (Lew & McKercher, 2006). Given this discrepancy, more research and quantitative analysis are needed to incorporate visitors' needs when developing public transportation for destinations that are popular tourist spots.

Many studies have explained various aspects of the broad concept of tourism transport. The current research narrows the wide-ranging tourism-transport concept by defining tourist type and tourist origin and destination based on the specific kind of tourist and a particular mode of transportation, which will be explained later in this chapter (Figures 1 and 2).

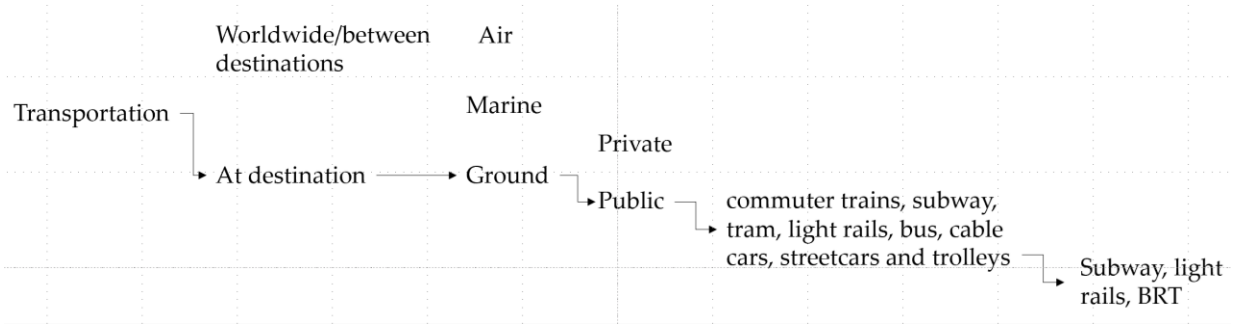

Figure 1: Selected modes of transportation.

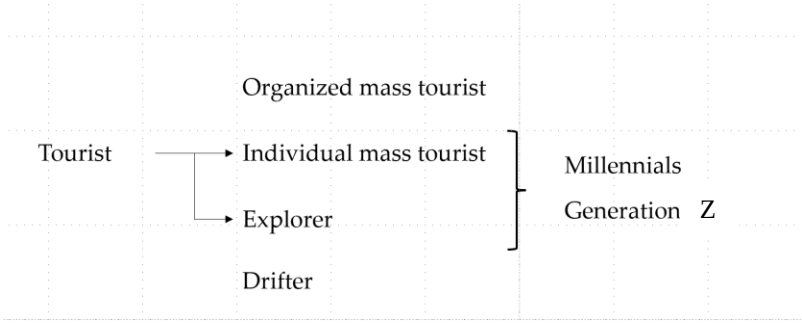

Figure2 : Selected tourist types.

As mentioned earlier, various modes of public transit systems within cities include commuter trains, subway, trams, light rails, buses, cable cars, streetcars and trolleys, and ferries for cities with rivers. Certain modes of public transport, such as - public ferries, streetcars, and subways are easier to use than others and are thus more tourist-friendly. In contrast, bus networks are often challenging for tourists who do not have sufficient information to use them (Lew & McKercher, 2006). Moreover, bus systems are usually more complex and have more stops, which can confuse visitors.

In most touristic cities, double-decker buses and private rideshare vehicles are essential in transferring tourists from their origins to destinations. However, these forms of transportation have disadvantages. For instance, open-top double-decker bus tours which are common in cities such as Edinburgh and London and have been added to those cities' bus networks obstructing city centers, and residents cannot complain about the number of buses because they belong to the private free market (Orbasli, 2000). Moreover, tourists using private rideshare companies like Uber or Lyft cannot experience an authentic city or share in the lives of locals an objective that some types of tourists such as drifters and explorers, pursue. Furthermore, double-decker buses and private rideshare vehicles are pricey, especially for younger generations (e.g., millennials) who like traveling but have limited budgets and their routes are restricted. Finally, different modes of public transportation such as BRT and light rails can alleviate the high probability of getting stuck in city traffic. However, such amelioration can only occur when the city's public transport system considers the needs of tourists as well as residents or, in other words, when public transportation is "tourist-friendly."

Bus rapid transit (BRT), one of the latest types of public transportation, has the advantage of reducing travel times, thereby, attracting new riders and promoting transit-oriented

development. One characteristic of BRT is direct routing with fewer stops which is attractive for tourists who want to visit multiple attractions within a limited time frame. Other characteristics include enhanced customer boarding, frequent service, and the ability to pay fares in advance (Hess & Bitterman, 2008). As city buses lack these features, they might not suit city tourists. Orbasli (2000) explored trams as a good tourist attraction and appropriate public transport for both residents and visitors. She noted a tram network in the touristic Istiklal Street in Istanbul, Turkey, as an authentic means of transportation that helps people commute on a pedestrian street without disturbing pedestrians.

In his book, Walker introduced seven demands that transit users expect from a public transit system: stop and stations, connectivity, frequency, fare, speed or delay, reliability, and simplicity (Walker, 2011). Overall, the ease of use is often highlighted as an essential factor influencing visitor satisfaction with public transportation (Le-Klähn & Hall, 2014; Thompson & Schofield, 2007). Connectivity between different public transit modes such as BRT stops and bicycles is another option that is attractive to visitors, as cycling has become increasingly popular in the last decade. Another factor is a multimodal ticket that enables users to transfer between different public transport routes and modes quickly. Sometimes, users receive a discount when they pay for a fare package. This policy is potentially attractive for certain groups of public transit users, especially young adults, who are more price-sensitive (Lumsdon, 2006).

As evidenced, public transit network connectivity plays a vital role in visitors' perception of a destination's overall attractiveness. However, if city authorities spend money to improve their system's connectivity without paying attention to visitors' origins and destinations, visitor heavy areas remain disconnected. Therefore, it is essential to recognize the origins and destinations of

new generation visitors to design and develop public transit services for both residents and visitors. In the following sections, we will focus on these factors.

Different types of tourists

Cohen (2004) quotes Ogilvie's social scientific definition of tourists one of the pioneers in tourism concept. In his definition, the tourist is absent from home for a short period and spends money earned from where he/she lives. The prominent definitions of "tourist" revolve around entertainment and pleasure. The Oxford English Dictionary defines a tourist as "*a person who is traveling or visiting a place for pleasure,*" and Merriam-Webster as "*one that makes a tour for pleasure or culture*." According to the U.S. Travel Association, leisure travel accounted for 80 percent of all U.S. domestic travels in 2018. Thus, this research focuses on tourists who travel to cities seeking leisure and entertainment.

Overall, tourists fit into one of the following four categories based on their role: organized mass tourist, individual mass tourist, explorer, and drifter (Cohen, 2004). As the itinerary of organized mass tourists is fixed in advance, they are unlikely to use public transit systems to commute within the city. In contrast, drifters' probability of using public transportation is high, yet their destinations are incredibly different from those of regular entertainment tourists. Therefore, this research focuses on tourists seeking "*a routine novelty*" who arrange their trip alone and have the role of individual mass tourists or explorers. In reference to millennials' travel behavior, young generations take the role of explorer or drifter (Lee, 2013), and they are great potential users of the city's public transportation.

One study revealed that while the aging groups represent most public transportation users in rural areas, younger visitors are the more significant public transportation users within cities

(Le-Klähn & Hall, 2014). In his research, Buffa (2015) concluded that nearly 70 percent of younger generation tourists consider price in their choice of accommodations and have more sensitivity to sustainability. Therefore, there is a need to develop a sustainable transportation system that meets this generation's needs.

Millennials as a different type of tourist

In terms of age classification, baby boomers are born between 1946-1964; Generation X, 1965-1976; Generation Y (millennials), 1977-2000; and Generation Z, 2000-2012. Generation Y (millennials) outnumbered baby boomers in 2019, and their population is now more than 1.8 billion. Based on their socioeconomic status, their use of products and services is more complicated than those of previous generations (Merritt et al., 2018).

The millennial generation in the U.S. has more racial diversity and includes a more significant number of minorities and different family structures. This diversity affects their characteristics in using the products (Iyer, Eastman, Monteiro, Rottier, & Zokarkar, 2016). Research shows that nearly 43% of the millennials population in the U.S. are non-white, and the difference in ethnicities leads to biculturalism among millennials (Blancero, Mouriño-Ruiz, & Padilla, 2018). In addition, large U.S. cities welcome diverse ethnic groups, and millennials are more likely to adopt different behaviors, cultures, and ideas.

Several research studies have revealed that millennials' travel behavior differs from baby boomers and Generation X. Experiencing economic stress, living with their parents longer, having late marriages, and living in cities rather than a suburb are characteristics of the millennial generation. There is a strong relationship between being financially secure, getting married, moving to the suburbs, and an individual's vehicle miles travel (VMT). There has been a noticeable

decrease in average VMT, car ownership, and the number of driving licenses among millennials (Polzin et al., 2014).

Kuhnimhof et al. (2011) investigated the travel trends among German and Britain millennials by analyzing National Travel Survey data. Their findings demonstrated that the demand for vehicle travel had declined sharply for the younger generations, while the distance traveled by public transportation doubled for this age group. Their study concluded that Generation Y's vehicle ownership status and tendency to substitute technology for travel will continue to affect the tourism industry in the future.

While part of this tendency results from declining car availability for a younger European generation, it also highlights that many European countries have highly developed modes of public transportation as their cities are developed prior to the invention of the car. Millennials have a higher tendency to use public transport than the two preceding generations. Consequently, if public transit is well developed within millennials' leisure destinations, we will see fewer private rental cars by tourists.

Generation Y represents a significant element of international travel, accounting for more than 23% of the billion trips yearly based on the 2017 United Nations World Tourism Organization (UNWTO) annual report. However, due to their economic status and their preference to travel internationally, travel is only possible if they do so on a budget, which is why generation Y are unlikely to use a private car while traveling.

Millennials and public transportation

An online survey commissioned by the KRC research group and Zipcar in 2013 showed that the availability of public transit stops exerts a considerable impact on millennials' driving

decisions. Millennials' environmental concerns are reflected by their attempts to drive private vehicles less frequently. Moreover, mobile technology and the ability to track public transportation real-time arrival and departure data make using public transit systems attractive for those who use this technology regularly (Dutzik & Baxandall, 2013).

The American Public Transportation Association (APTA) completed a research study between December 2012 and April 2013 among millennial (aged 18-34) transit riders in five urban areas (Boston, San Francisco, Austin, Boulder, and Minneapolis) to understand their decision making, with a focus on mobility. One of the findings was that millennials chose driving, taking public transit, biking, or walking, based on their trip destination. Millennials are attracted to communities with multiple transit options. Moreover, the research found that public transportation is a suitable commuting mode for millennials because it allows riders to use their phones and socialize online. Figure 3 represents their findings on millennials' top five preferred modes of transportation.

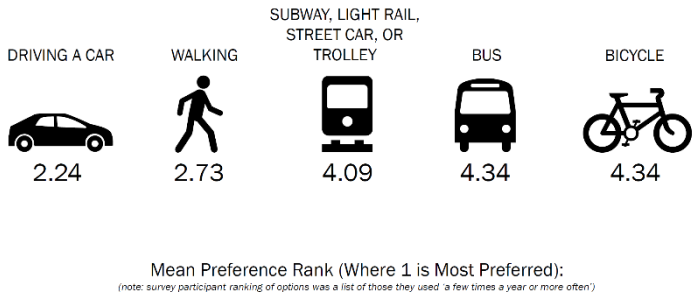

Figure 3: Millennials' top 5 most preferred modes of transportation.
Source: American Public Transportation Association report, (2013).

Furthermore, a survey by the Urban Land Institute found that 20% of millennials use a public transit mode of transportation at least once a week. In contrast, this figure is 7% for

Generation X and 10% for Baby boomers (Dutzik et al., 2014). In addition, more millennials walk and bike to their destinations than other generations (Figure 4).

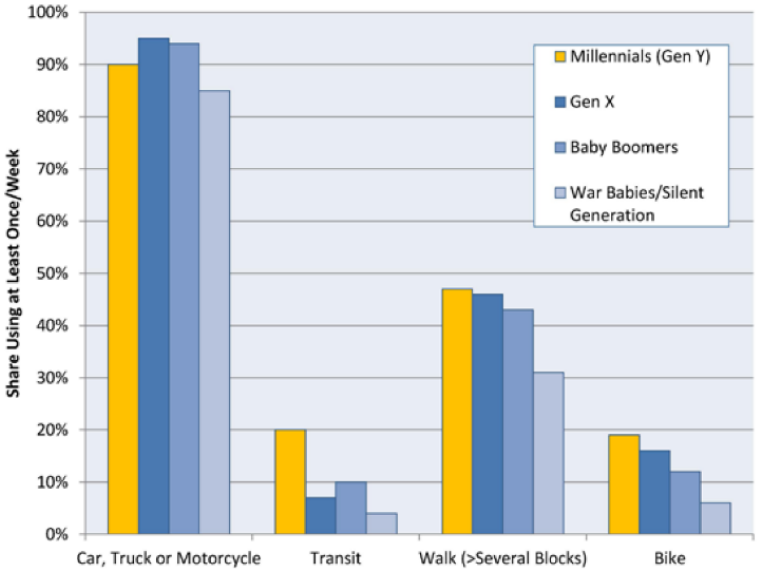

Figure 4: Different generations transit mode choices.

Source: Dutzik et al. (2014)

Millennials' origins

Leisure tourists' origins vary and include hotels and motels, Airbnb, hostels, and the houses of family or friends. Millennials' travel patterns reflect their tendency to stay in more cost-effective places. For example, hotels with reasonable prices and decent services attract younger travelers. Airbnb is also prevalent as it is in line with the younger generation's taste. Airbnb lodgings give people an opportunity to try the local culture, a factor that attracts millennials' attention, and offer the chance to rent an entire apartment or house which is affordable when traveling with friends. Airbnb was founded in 2008 to benefit from overbooked hotels, and now, its value is worth over $30 billion has exerted a considerable impact on the online accommodation industry (Wright, 2018).

However, as opposed to licensed hotels that pay taxes the factor that, to some extent, guarantees their geographic location Airbnb's geographic locations are less reliable. There has been an ongoing debate on whether to enforce regulations (and, thus, financial burden) on short-term rental units such as Airbnb, and some cities in the U.S. have authorized restrictions on short-term rentals. For example, according to the New York ordinance, people cannot rent their entire home for fewer than 30 days. They can, however, rent bedrooms of the house, although the owner should live on site. There are new tax rules for Airbnb logings in some states such az Georgia. In Las Vegas, rental property owners should get a business license. There are some slight restrictions in San Francisco, Honolulu, and New Orleans. None of these rules, however, are intended to restrict the stay of short-term leisure tourists. This research uses Hotels and Airbnb as millennials' origins in this analysis, and based on their credibility, it will give them weight in producing different outcomes.

Millennials' destinations

Tourist destinations within cities represent the places that tourists visit. According to Weidenfeld and Leask (2013, p. 554), a tourist attraction within cities refers to an "individual site" or "small-scale geographical area, based on a single key feature," which draws many visitors to travel there from their homes. Therefore, these attractions are critical components in enticing tourists to cities. Based on the tourist type defined earlier, this research elaborates on these attractions.

The decision-making involved in finding a suitable place to travel is a time-consuming process that requires several variables, including vacation length, whether to travel alone or with others and transportation mode. With the advent of the internet and online websites that host

reviews about various destinations have the same functionality as word-of-mouth and are highly effective in helping tourists choose their destination (Pantano, Priporas, & Stylos, 2017).

Several studies have shown that millennials are drawn to living in cities and urbanized metropolitan areas (Brown et al., 2016; Dutzik & Baxandall, 2013). According to research completed in 2011 for the National Association of Realtors, "47% of younger generations would prefer to live in a city or a neighborhood with a mix of houses, shops, and business" (Stewart, 2011, p. 2). Their report also revealed that 77% of younger generations believe that sidewalks are important in their communities for walking to grocery stores, pharmacies, hospitals, restaurants, medical providers, and public transportation. A survey conducted in Belgrade with 354 respondents with an average age of 24 argued that sea voyages and well-known world cities are millennials' top preferred destinations (Gajić, Brdar, Živković, & Ilić-Petrović, 2019).

Some research has explored millennials' preferred activities at destinations. One study examined features linked to destinations that create a memorable tourism experience, including experiencing local culture; engaging in various activities such as hiking, cooking, and workshops; sports; infrastructure; accessibility to multiple attractions; service quality; and the destination's physical geography (Kim, 2014). Public transportation provides visitors with the opportunity to engage with residents, circulate within the authentic city and feel the unique sense of place that private cars fail to fulfill. In their research, Merritt et al. (2018) ascertained millennials' leisure activities at their destinations. Among the 52 items for leisure activities included in the study walking/nature walking, beach activities, swimming, nature viewing, and hiking held the top rankings. Exploring millennials' activities at their destinations is necessary to create visitors' origin shapefiles and use this data in the final accessibility analysis.

Tourists and transport within destinations

Since 1985, having a satisfactory transport system has been listed as one of the ten most important aspects of cities for tourists, as such systems contribute to the destination's attractiveness and overall image (Thompson & Schofield, 2007). Although many studies have examined tourism transport in terms of aviation, cars, and cruises, there is little literature on public transport and tourism despite its importance in circulating tourists within the destination.

A study by Page (1999) explicitly focused on the tourism-transport interface and stressed the importance of analyzing tourist transport management issues. This study addressed the importance of government policy and the significance of certain demand/supply issues in understanding tourist transport systems. It also considered the human and environmental impacts of tourist transport and various quality service provision issues that can affect transportation services in tourism.

One thought-provoking idea for circulating tourists in cities was proposed by Hall and Page (1999) who described four spatially related roles for tourism-transport within the destination: connecting the source market with visitors' destinations, providing accessibility within a destination, providing accessibility within the single attraction, and easing tourists' commute along a recreational route to improve the tourist engagement with a destination.

Halsall (1992) spotlighted modern forms of tourist travel, including land-based transport and the use of trails, waterborne transport, and heritage transport for nostalgic journeys. He captured transportation as both a recreational behavior on its own and a means to travel to a recreational facility. He considered the effect of transportation such as tramways on shaping the image of a place in the visitor's mind, concluding that preserving the old railways and the

monuments and landscape adjacent to them shapes a unique memory for tourists and visitors, which helps to create a sense of place (Halsall, 2001).

Following Halsall's research, Lew, Hall, and Williams (2004) considered the period spent by tourists on transit to get to their destination as a recreational activity. Nonetheless, they noted that it is more difficult for tourists than for other riders to use transit systems, as they are not designed based on tourists' needs. Nevertheless, the invention of smartphones has made public transportation more entertaining for regular commuters.

Lumsdon also examined the concept of tourism and public transportation to investigate alternatives to enhance visitor access to the countryside through public transit network (Lumsdon, Downward, & Rhoden, 2006). Lumsdon engaged with issues impacting the design of tourism bus networks in rural and coastal destinations in the United Kingdom. He introduced seven main topics concerning bus network design for tourists: design approach, traffic management, social exclusion, market evaluation, design standards, service delivery, and partnerships (Lumsdon et al., 2006).

Lumsdon and Page elaborated on tourism public transport usage behavior in a collaborative study and addressed some significant challenges constraining tourism transport. They used a public transport quality matrix and concluded that the tourism-transport relationship had not been integrated into the overall policy of sustainable development and that the reason why visitors still use private cars is poor demand management (Lumsdon & Page, 2004).

Dickinson and Dickinson (2006) analyzed the diversity of social realities that strengthen people's attitudes towards transport, tourism, and subsequent behavior in London. Their study identified four social representatives that affect visitors' perceptions of using public transportation by reviewing several studies in tourism transport. One statement was people would use public

transit more, if the system improves, highlighting that participants viewed public transit as dirty, unreliable, and infrequent. Their recent research has focused on destination-based travel behavior. Their in-depth interviews with visitors revealed that time fluidity -i.e., whether visitors stick to a daily plan and place rhythm – and the timeframe of attractions are important factors why visitors use public transportation (Dickinson & Dickinson, 2006; Dickinson et al., 2013).

Several studies have investigated tourist satisfaction with their destinations' public transit systems. For example, one study sought to determine the factors influencing visitors' level of satisfaction in Munich. Their results indicated certain features of the Munich public transit system, including network connection, reliability, and service frequency. They also noted features about which users complained, including staff service, comfort while waiting at bus stops or train stations, and ticket price (Le-Klaehn, 2014). In another study, the same author investigated the visitors' motivations for using (and not using) public transportation in Munich and concluded that the main factors that encourage visitors to use public transport are drive-free benefits, traffic reduction, advantages of local public transport, and car unavailability (Le-Klahn, 2014).

A study by Hall et al. (2017) is an experiment in tourism and public transport within the destination. The book attempts first to define modes of transportation and different tourist types and then to explain the necessity of developing local and intra destination public transit based on recent reports. Finally, it describes several essential aspects of developing public transport for tourists, including the destinations' economic growth, reducing global emissions, and reducing city traffic.

All the above-mentioned studies have investigated and explained different concepts in the tourism-transport context. However, none of them quantified tourists' access to different destinations in the city, and only a very few used GIS to assess tourists' use of public transportation

by tourists within destinations. The following section focuses on this type of assessment, which is more aligned with the purpose of this study.

GIS-based evaluation of tourist-friendly public transit systems and tourist origins and destinations in cities

A recent study in the touristic city of Costa Daurada in Catalonia has revealed a discrepancy between tourists' origins and the city's public transportation system. Antoni and Gutierrez (2017) applied a GIS spatial analysis tool to determine the correlations between public transport stops and fixed and seasonal population distribution. Their assessment included five indicators: the ratio of public transit stops and populations, population with easy access to bus stops, population with access to multimodal stops, connectivity between transport areas, and the population within less than 500 meters from stops. They concluded that the spatial accessibility of transport networks for the dispersed houses containing lodgings was disproportionate and below the municipality's average (Antoni & Gutierrez, 2017).

Another study that aligns with the present research was the analysis of the spatial penetration of Airbnb in U.S. cities by Quattrone, Greatorex, Quercia, Capra, and Musolesi (2018). In their case studies, which included San Francisco, Oakland, New York City, New Orleans, Austin, Seattle, San Diego, and Los Angeles, they considered three explanatory variables (geographic, social, and economic) to explain the spatial penetration of Airbnb. Geographically, their results indicated a negative relationship between the distance from city centers and Airbnb locations. Socially, they found a strong positive correlation between younger individuals and Airbnb penetration. Finally, from an economic perspective, they concluded that the median household income was positively correlated with Airbnb penetration (Quattrone et al., 2018).

Most of these studies focused on defining the concept of tourism transport. Only a few recent studies, however, have attempted to recognize tourists' needs and to define influencing factors to develop a public transit system that supports tourism within destinations. Moreover, a gap exists in implementing this qualitative literature as the framework for a legitimate quantitative study. Despite its neglect in academic research, however, tourist-friendly public transit systems have considerable values, which we will discuss in the following sections.

Tourism, transport, and sustainability

The concept of sustainable development has raised the idea of tourists using public transportation for their commutes within destinations. Transport is responsible for around 75% of the CO2 emissions generated by tourism, with aviation representing the bulk (40%) (World Tourism Organization, 2008, p. 9). Tourists' larger aviation footprint and heavy reliance on rental cars and campervans also increase CO2. Climate change challenges increasingly force local authorities to adopt green urban transport policies and sustainable tourism attempts to ensure that a destination's resources are protected for the next generations (Mandeno, 2011). In New Zealand, transport is responsible for 90% of tourism emissions; Dubois, Peeters, Ceron, and Gössling (2011) discussed public transportation as an option for emission reductions in the tourism sector. If the public transit system provides reliable, affordable, and satisfactory connectedness between visitors' areas, they will have alternative opportunities to choose from rather than hold on to private cars.

The application of sustainable development to urban areas was first discussed in A review of the IPCC Fifth Assessment in 2015. In particular, this review considered the need to examine city consumers' travel behavior to plan better for their commutes and to assess the willingness of tourists to change to low-carbon transport options (Scott, Hall, & Gössling, 2015).

Following the IPCC assessment in 2015, the tourism industry's negative environmental impacts have increasingly raised concerns. One solution to alleviate these impacts is paying better attention to public transit systems (Le-Klähn & Hall, 2014). Many authors (Dickinson & Dickinson, 2006; Dickinson et al., 2013; Dubois et al., 2011) have mentioned the use of public transit to serve tourists within destinations as a solution to these negative environmental impacts.

Tourist-friendly public transport as a driver for destination' economies

The impact of travelers on the U.S. economy is significant. According to the U.S. Travel Association, both direct purchases and services and indirect benefits from travel business operators boost the economy. According to U.S. Travel and Tourism Overview (2019), travel-related industries saw a financial gain of $2.5 trillion in 2018 that supports 15.7 million U.S. jobs.

Gimeno and Vila (2007) identified that when the destination transit system makes it easier for tourists to go from one place to another, they can participate in more activities, thereby generating more revenue for the destination. Moreover, when tourists use a city's public transportation, they subsidize local users by offering more off-peak movements on local commuter services. The enhanced off-peak revenue reduces ticket fees to residents and eventually reduces budget subsidies to the transit system (Mandeno, 2011). Almost all public transport networks have prominent commuter peaks, with lower usage of the networks outside of commuting hours. Therefore, Albalate and Bel (2010) believed it would be in cities' best interest to encourage as many visitor movements as possible through public transport.

Public transport as a brand in attracting tourists

Applying the brand idea to places has expanded to tourism from the commercial world in a quest for city progress, regeneration, and quality of life. City branding is a way to implement city marketing, which depends largely on the construction, communication, and management of the city's image since tourists' communication with cities occurs through their perceptions and images of those places.

In general, tourists' perceptions of places arise through three elements: 1) planned interventions such as urban design; 2) how people use places; and 3) various representations of a place, such as in films, novels, and news reports. It is generally acknowledged that people form stable views regarding places through constructing mental images, which are the basis of our everyday interactions with the environment (Figure 5). Each individual's cognitive maps allow them to grasp complex realities; branding deals specifically with such mental images (Kavaratzis, 2005).

Kavaratzis (2004) elaborated on the relationship between people's mental processes and the shaping of place branding. In his proposed framework, three types of communication occur in the observer's mind when dealing with a new place. The first is prompted by landscaping strategies, including green spaces and the architecture of public spaces within cities.

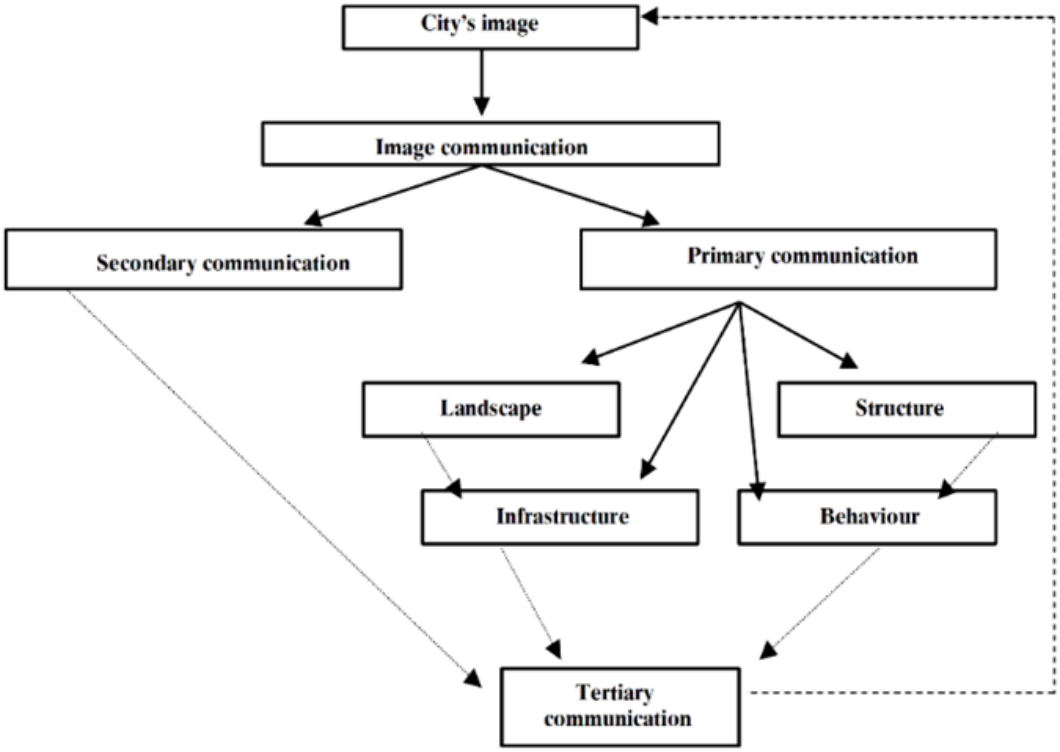

Figure 5: City image communication

Source: Kavaratzis (2005)

The infrastructure is also part of first communication and refers to the projects developed to improve the accessibility to the city's unique places, such as monuments, parks, airports, and cultural centers. The city's public transit system is thus a crucial part of the primary communication between a city and tourists, whereas marketing practices and word of mouth or social media are secondary and tertiary communications accordingly.

Modern transport operators have observed a new wave of interest in developing positive images of public transport around stronger brand identities to attract visitors (Lumsdon & Page, 2004). Cities have a variety of products with the potential to attract visitors one of which is public transport (Mandeno, 2011). Several authors who have studied the attractiveness of tourist destinations have identified transport as a key contributor to a destination's attractiveness. The

adequacy of the transport system is one of ten aspects of cities that are extremely important to tourists, highlighting that the adequacy of a city's transport system contributes to its attractiveness and overall image (Law, 2002; Thompson & Schofield, 2007).

Public transportation is an essential factor in growing tourism within the destinations (Le-Klähn, Hall, & Gerike, 2014). Nevertheless, most cities in North America are struggling with high operating costs and, at the same time, low ridership (Guerra & Cervero, 2011). Destination managers cannot impact nor shape tourist-friendly transportation. It is the role of urban planners to analyze visitors' needs within the city and incorporate those needs into planning and developing the city's public transit network. An ultimate approach is to enhance tourist destinations with commuter destinations such as offices and hospitals and to consider new tourist destinations such as theatre, museums along the future transit routes. The research applies a case study approach to analyze the degree of connectivity of U.S. cities' public transit networks.

CHAPTER 3

METHODS

Research approach

This study applied several empirical, analytical procedures to reach a reliable explanation of urban trends that predict certain impacts. The author posits that the result can be used as foundational knowledge for transit decision-making. The case study method was used to perform various analyses for this research. Its main advantage is that its results provide an in-depth analysis of events within context (Gagnon, 2010). Combining the quantitative research approach, with the case study method offers a reliable, systematic foundation for results.

The case study approach allowed this study to compare the accessibility of several cities for visitors traveling from various origins to destinations using public transit systems. To address the proposed research questions, this study conducted quantitative research by collecting data related to cities and public transit systems, including Geographical Information System (GIS) shapefiles and General Transit Feed Specification (GTFS) data, analyzing the data with the ArcGIS Network Analysis tool, and weighing the results to create a ranking spectrum for cities.

Spatial analysis was performed with GIS software as all the data used to create the final analysis are spatial. The geographical analytical techniques of point pattern analysis are used in this research to illustrate spatial patterns. Three main quantitative analytical methods were applied:

network analysis, spatial pattern analysis, and Python coding applied to illustrate final accessibility created by origin-destination (O-D) matrix.

ArcGIS Network Analysis

Esri defines GIS as "a geographic information system" that serves as "a framework for gathering, managing, and analyzing data". ArcGIS Network Analyst is used in GIS analysis to provide network-based tools to address complicated routing problems. Thanks to network analysts, organizations employ transportation network models to represent their distinctive network requirements precisely.

Network analysis is based on graph theory and topology and it is concerned with the distances that exist between nodes. The descriptive measures of the network are calculations of the numbers of edges and vertices and measurements of the associated attributes of those essentials, such as the total length of the edges. In what follows, I will explain network topology network distance measurements.

Graph theory is the study of graphs that mathematically connect objects. Graphs are composed of vertices/points/nodes that are connected by edges/links/lines. Any transportation network can be presented as a graph in a mathematical set consisting of links and nodes. Topology is how the nodes and edges are arranged within a network. Topological properties are important for GIS network analysis and can help identify relevant sub-structures within a network. Some of the most used topological properties and concepts are degree, shortest path, transitivity, and centrality.

For any two locations in a network, the distance is the length of the shortest path between these two locations within the network. Finding the shortest path is based on graph theory. The shortest path is computed based on the travel weight, such as travel distance or travel time of

network edges (Xuegang, 2009). If we imagine an abstract machine as a graph where vertices represent cities and edges represent moves, shortest path algorithms can be used to find an ideal sequence of choices to reach a certain city.

The ArcGIS Network Analysis Extensions, including the O-D matrix, are based on the famous Dijkstra algorithm to find the shortest paths. This algorithm resolves the shortest-path problem on a weighted graph. To find the shortest path from origin to destination, it a) calculates the shortest paths for multiple joints' b) holds them, c) adds another joint that has the minimum shortest path, and d) updates the overall shortest path.

The current study applied ArcGIS network analysis to evaluate the existing situation of public transit networks and whether they meet tourists' needs. GIS network analysis was used to find transit travel time and overall accessibility between the set of tourists' origins and destinations using public transit general transit feed specification -GTFS data.

Method Workflow

This section defines a quantitative process applicable for addressing the research sub-questions: obtaining quantitative data from different sources, carefully managing those data (revising the locations), and geolocating them in ArcMap to create the final network analysis O-D matrix. The final analysis is designed to provide accurate results proper to the research goal. Although each step involves many details and revisions, the below figure summarizes the general procedure for obtaining the ultimate result.

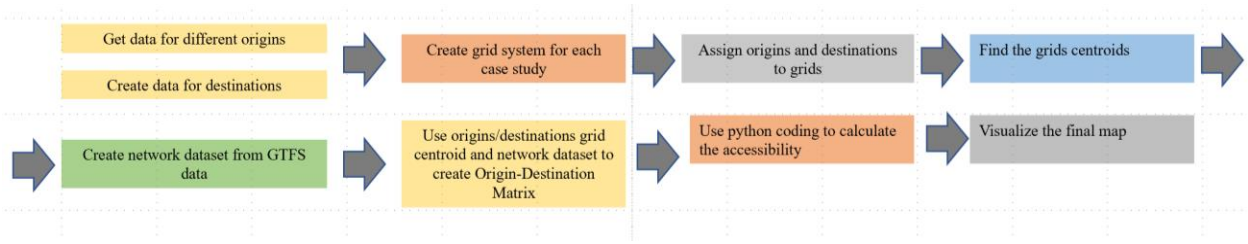

Figure 6: Method Workflow

Case Studies

The research focused on several North American cities for two reasons. First, cities have become popular destinations for the younger generation of travelers. Second, cities have high ridership of public transportation. For this research, twenty-eight cities were sorted based on the number of visitors they received in 2018 (Table 2). Then, based on their geographical locations (east, west, north, and south) and their characteristics, six cases were chosen for analysis: New York and Boston from the east, Los Angeles and San Francisco from the west, Chicago from the north, and Austin from the south. San Francisco, Boston, Austin, Chicago, and New York are among the top cities to live for young professionals in the United States. Moreover, the selected cities have provided more established public transit systems for their residents.

Table 2: The Most Visited Cities in the United States, 2018

City	Visitors	City	Visitors	City	Visitors
New York City	65.2 million	Los Angeles	50 million	Boston	21.8 million
Chicago	57.6 million	San Francisco	25.8 million	Austin	19.8 million

Origin – Destination Data

The origin data consist of hotels and Airbnb. Destination data are each city's attractions. Excel files, including the latitude and longitude of hotels, were downloaded from the data-axel

website (previously Reference USA) for each case. Excel files, including the latitude and longitude of Airbnbs, were downloaded from the InsideAirbnb website for each case.

The city's attractions shapefile was created by the author. The author used the TripAdvisor website to extract attractions information for each city. Based on their age classification and the advent of the internet, millennials are referred to as "the first generation of digital natives" (Skinner, Sarpong, & White, 2018). Millennials are the first generation to begin socializing through social media. Within the travel and tourism context, visitor recommendations through online websites such as TripAdvisor and Yelp are the alternative to so-called word-of-mouth suggestions. Even though there are fake reviews on online web pages, customers recognize online reviews as more reliable than official destination websites (Pantano et al., 2017).

The 2018 Future of U.S. Millennials Travel Report by Resonance Consultancy surveyed millennials' vacation activities within cities. The current study relied on the type of activities that millennials engage in rather than the percentage of each activity. These activities include dining, fun attractions, sightseeing, learning new things, shopping, engaging with nature, visiting a cultural attraction, nightlife, attending cultural events, health & fitness, watching live sports, participating in outdoor sports, participating in once-in-a-lifetime activities, volunteering, and personally participating in athletic competitions (Figure 7).

Information provided in TripAdvisor for each city's attractions align with activities millennials tend to engage in their vacations in cities that are reported in several studies. Categories include sights/landmarks, spas/wellness, nature/parks, museums, fun/games, water/amusement park, classes/workshops, zoo/aquarium, and casinos/gambling.

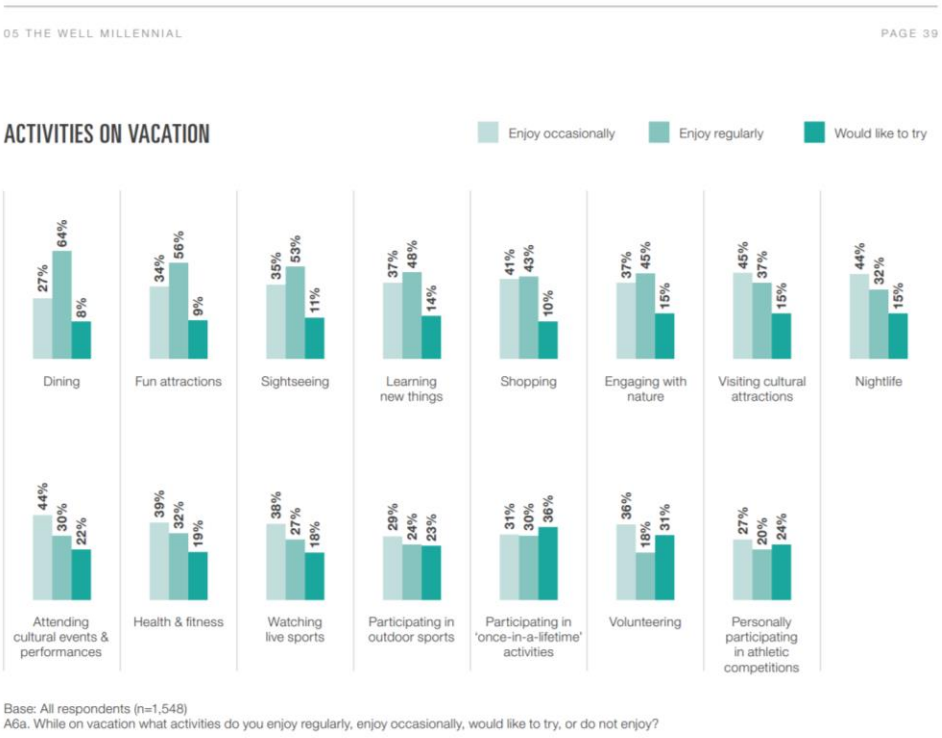

Figure 7: Millennials' activity on vacation.

Source: U.S. Millennials Travel Report (2018)

A visual web scraping tool called Scrape Storm was used to download each city's attractions in a CSV format. As the data did not contain addresses or latitude/longitude information the author used Google Maps to find and add each attraction address.

To add origin/destinations CSVs to ArcGIS, the Address Locator tool was created based on the "US Address-Dual Ranges" locator style. ArcGIS Hub's North America Detailed Street was used for reference data. Next, the addresses were geocoded. In the geocoding process, approximately 15_30% of attractions did not match the address locator. The author attempted to minimize this error by revising the addresses manually and then rematching them (Figure 8). The remaining unmatched addresses were checked several times to ensure that none were among the most highly reviewed attractions.

Grid Index Feature

To optimize the number of origins and destinations for the final O-D matrix analysis and represent the final analysis in polygon format rather than points, the points were assigned to a grid system. To estimate the width and length of each grid, the average area of one block was calculated for each city (Table 3). To ensure that all cases followed the same grid system, a second average area was calculated for cities' grid width and length of 1000 feet by 1000 feet. This number worked perfectly with point data, as each grid in each city contained a reasonable number of origins and destinations. Additionally, for the portion of the study using grid centroids in the analysis, 1000 feet is within walking distance of attractions, hotels, and Airbnbs.

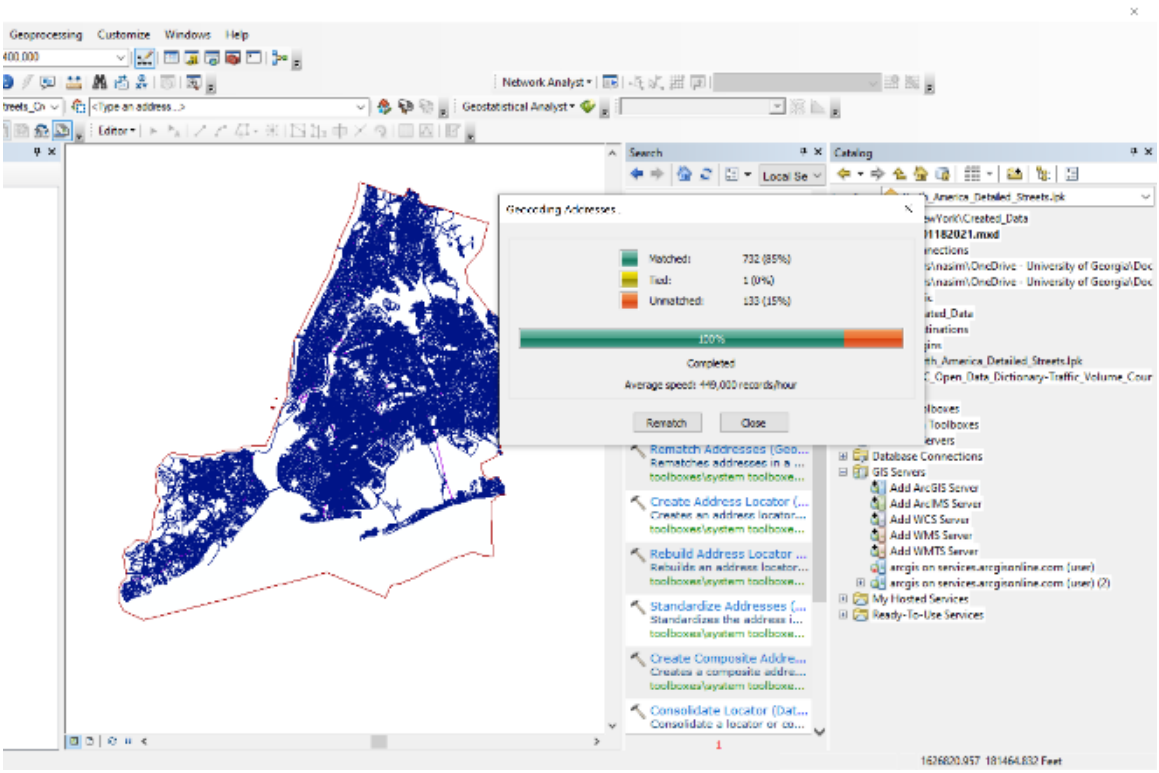

Figure 8: The unmatched addresses, NYC.

Table 3: The average grid width & length for each case study.

	New York	San Francisco	Los Angeles	Chicago	Austin	Boston
Average Block Area	2288474 ft²	2933518 ft²	410983 ft²	141224 ft²	848225 ft²	246758 ft²
Width*Length	1500*1500	1700*1700	641*641	375*375	920*920	496*496

Hotspot Analysis

As stated before, Airbnbs are not universally legalized, and their locations may change in the future. Therefore, less weight was given to Airbnbs than hotels through optimized hotspot analysis to select those hot grids containing Airbnbs (Figure 9). The optimized hotspot analysis results present the grids with Gi-bin values of -3 to 3. A high z-score and a low p-value for a feature indicate a significant hotspot (Gi-bin equals 1, 2, or 3). A low negative z-score and a small p-value indicate a significant cold spot (Gi-bin equals -1, -2, or -3). We selected those grids whose Gi-bin equaled 1, 2, or 3. The results of the optimized hotspot analysis contained several grids with no point data. Based on the number of points in each grid, those that contained more than 10 percent of the overall Airbnb points were selected.

Spatial Pattern Analysis Maps

Visitors' origin and destination point data analysis is essential for recognizing the spatial patterns across different regions of a city and possible factors contributing to this pattern. Therefore, three different maps of hotels, Airbnbs, and attractions grid patterns were created to symbolize the grids based on the number of points they contain (Figure 10). A half-mile buffer analysis was created for rapid transit stations to determine how many origins and destination grids were within the buffer polygon.

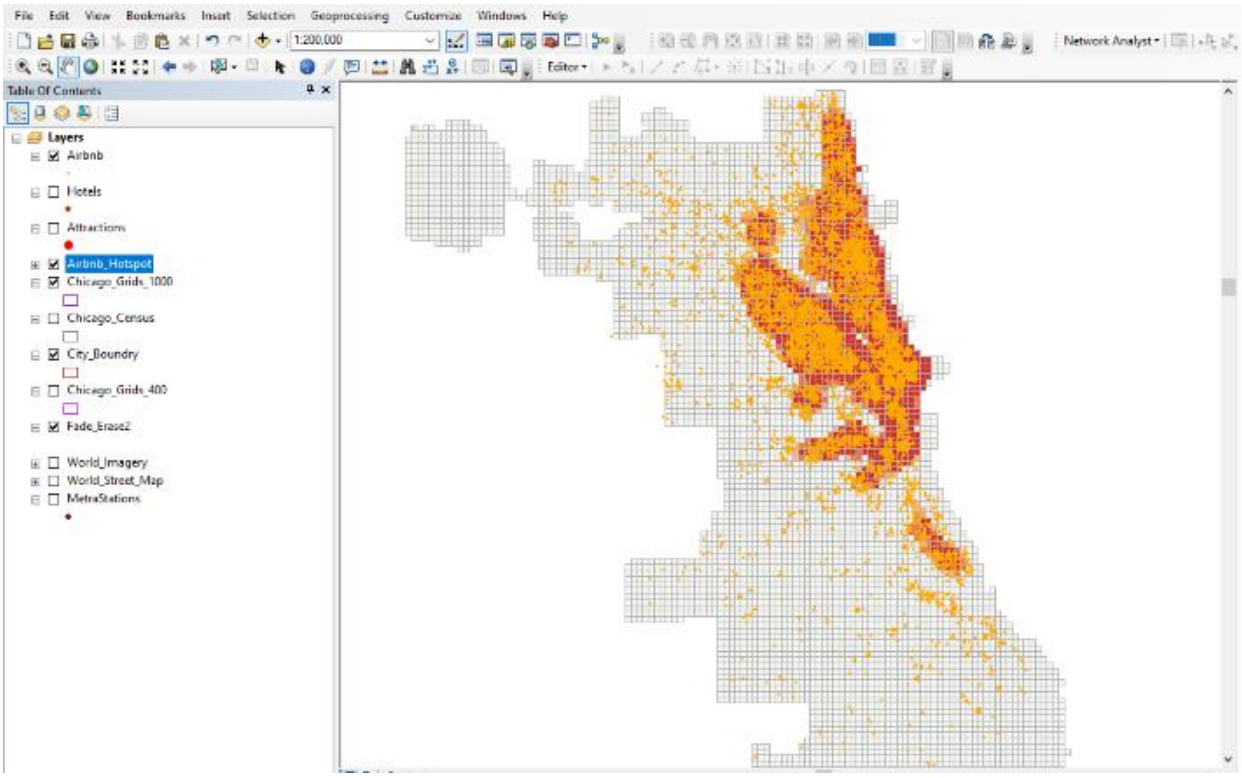

Figure 9: The Optimized Hotspot Analysis, Chicago Airbnb

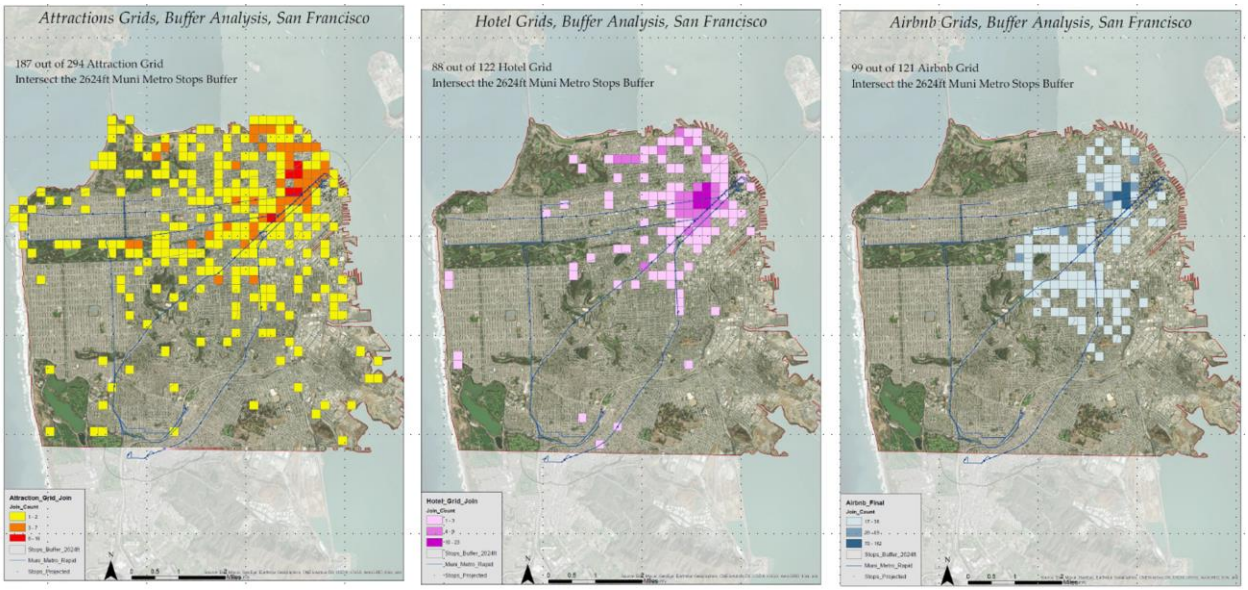

Figure 10: Spatial Pattern of Attraction, Hotel, Airbnb Grids, San Francisco.

Network Dataset

The grid centroids were added as O-D matrix origins and destinations (Figure 11). Because the final analysis aimed to assess accessibility via the city's public transit system, the network dataset used in the O-D matrix was created by using each city's GTFS data and the Add GTFS to Network Dataset tool in ArcGIS. GTFS data contain both bus and rail information. For this research, accessibility was considered transit travel time, calculated in minutes.

General Transit Feed Specification (GTFS) data

The General Transit Feed Specification (GTFS) is a data model that outlines a shared format for public transportation schedules and associated environmental information and allows public transportation agencies to publish their data in a form that can be used by various software applications. GTFS data include several text files, including routes, shapes, stops, trips, calendar, calendar dates, feed info, and stop times.

Some cities, including Los Angeles and NYC, provide separate GTFS data for the bus and subway systems. However, as this was not an option for all the case studies, we combined separate GTFS data.

Add GTFS to a Network Dataset Tool

The *Add GTFS to a Network Dataset* tool was used to create a network dataset using GTFS data in ArcGIS 10.8.1. This tool was downloaded from the arcgis.com website to the ArcGIS desktop. The tool includes three processes: 1) Generate transit lines and stops that generate point feature classes for each transit stop and line feature classes for each transit route. It is important to note that created lines do not follow actual routes but are straight lines between transit stops. 2) Generate stop-street connections to mimic the real world. In the real world, streets touch each other

and have intersections. However, two streets might cross each other and do not have connectivity, such as when one runs above the other. In this case, the transit stop might be on one street but the visitor's destination might be in on the other one, and visitors might thus not be able to travel directly between these two streets. This step of creating a network dataset generates connector lines that fill the gap between transit stops and streets (Figure 11). 3) Get network EIDs that update certain features behind the scenes to make the network dataset work.

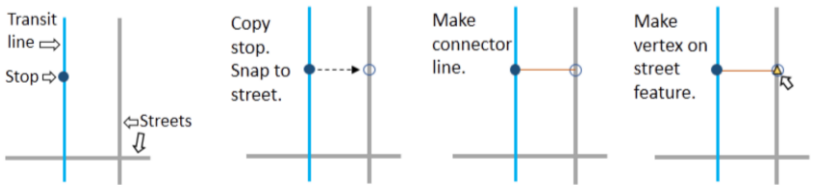

Figure 11: Generating line connector between transit stops and streets.

Source: www.esri.com

The network dataset used the five required feature classes that were created in the first and second processes of Add GTFS to Network Dataset: streets, stops, transit lines, connectors, and stopes-snapped2streets. When creating a network dataset, specifying the connectivity groups between these five feature classes is necessary as these connectivity groups indicate how pedestrians are allowed to travel between our feature classes. Group one is for streets, two is for the connectors, and three is for transit lines. The connectivity policy for transit lines and connectors is End Point, showing these features should connect only at the endpoints. The policy for streets is Any Vertex, as we use Open Street Map data, and the streets are not split at every intersection. The policy for stops is Honor, which should connect to connectors and transit lines at endpoints. Finally, the connectivity policy for stops-snapped2streets is Override, as it allows the snapped stops to connect to the streets even if the street connectivity is set to End Point. In addition, as this research aimed to find the accessibility from origins to destination based on travel time, we added

the Transit Travel Time attribute with a unit of minutes. Figure 12 represents an example of a created network dataset for Chicago.

Network Analysis, Origin-Destination Matrix

O-D matrix analysis was applied to assess accessibility and transit travel time for each origin to each destination's centroid. Four O-D matrix analyses were completed for each city:

Visitor's origin to destination

1. ***Hotel*** *grid centroids to* ***Attraction*** *grid centroids.*
2. ***Airbnb*** *grid centroids to* ***Attraction*** *grid centroids.*

Visitor's destination to origin

3. ***Attraction*** *grid centroids to* ***Hotel*** *grid centroids.*
4. ***Attraction*** *grid centroids to* ***Airbnb*** *grid centroids.*

The O-D matrix result is a line feature class with an associated attribute table containing Transit Travel Time in minutes (Figure 13).

Define the accessibility

Transit Travel Time data between origins and destinations associated with lines generated by the O-D matrix contain time data from zero minutes up to more than 506 minutes (8 hours) in some cases. Obviously, no city visitor with limited vacation time would choose a public transit mode that takes 8 hours to carry them to their desired attraction.

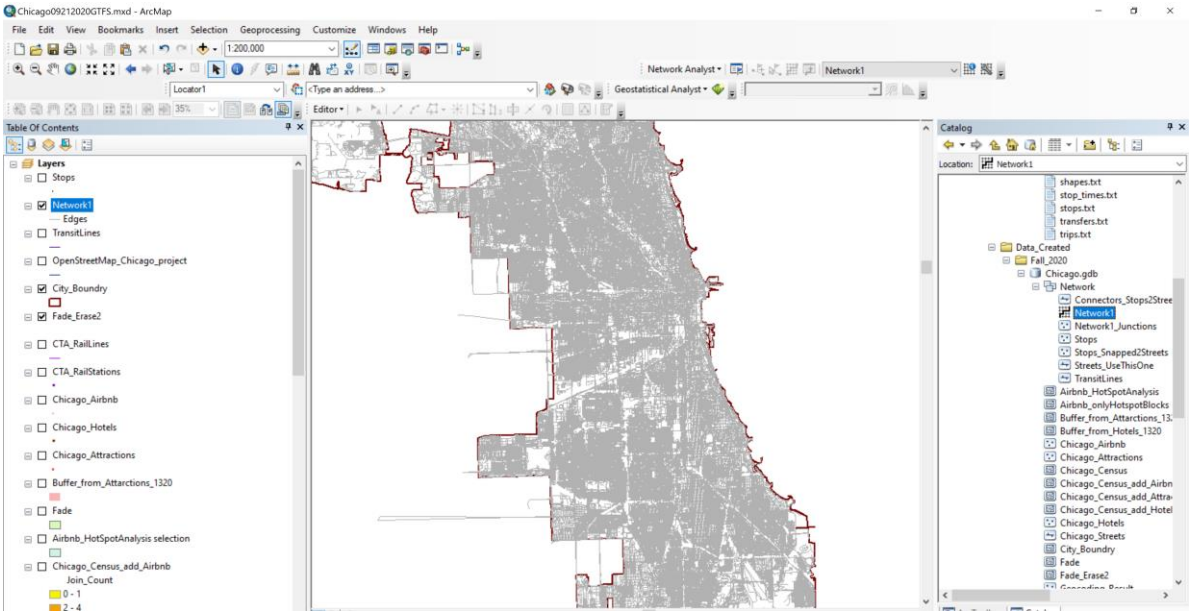

Figure 12: The Final GTFS Network Dataset, Chicago

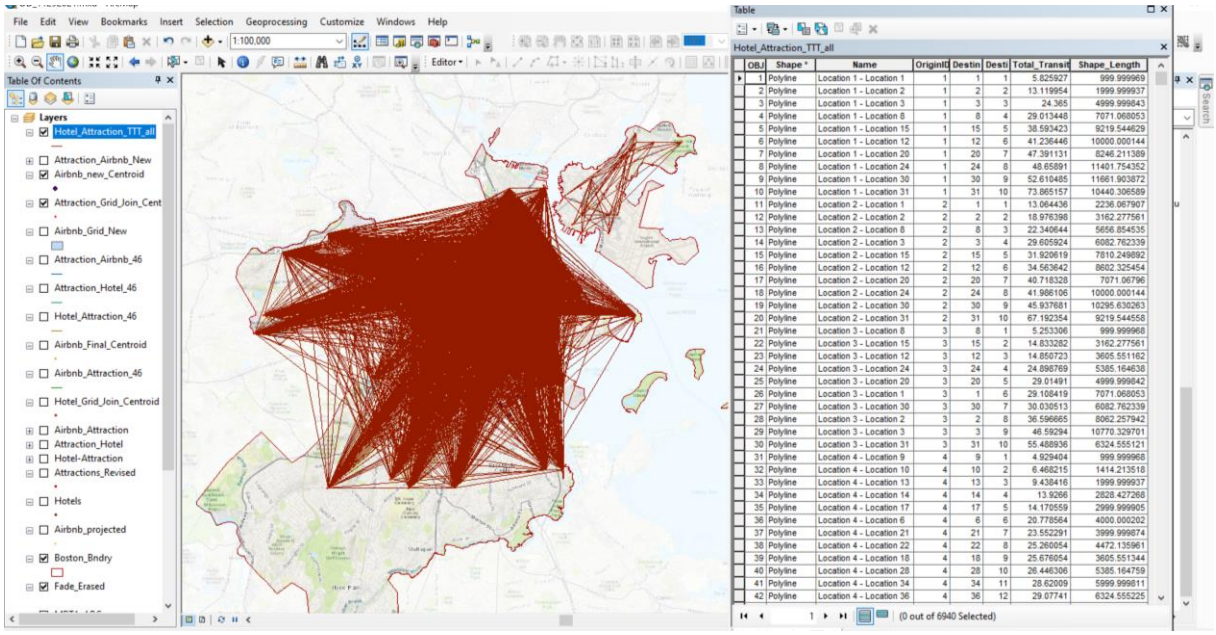

Figure 13: O-D Matrix Analysis, Hotel to Attraction, Boston

Although there is insufficient information about how much time a tourist spends using a city's public transit system every day, the author used the average time that residents in each city spend on public transportation to get to work. This timeframe is different for each case study. The Governing website provides the average commute times for metro areas using Census Bureau data for all workers age 16 and over. Considering this timeframe, the author selected only the routes that take fewer than a specific time in minutes for each city to transit from origin centroids to destination centroids. This timeframe varies among different cases: 49.5 minutes for Chicago, 49.9 for Austin, 46.9 minutes for San Francisco, 50.2 minutes for Los Angeles, 46.2 minutes for Boston, and 51.3 minutes for New York City.

Using python to visualize the O-D Matrix result on maps

To visualize the accessibility between each origin and destination grid centroid in ArcMap, the author used Anaconda, a data science platform, and developed a code using Python in JupyterLab. The code calculates the number of attraction grids that visitors can reach within a specific time frame using the city's public transit system when they stay in one of the city's hotels/Airbnb grids. It also calculates the number of hotels or Airbnb grids that are reachable from the attractions grid within a specific time frame using the city's public transit system. The same code was used to create four different analyses: Hotels to Attractions, Attractions to Hotels, Airbnb to Attractions, and Attractions to Airbnb.

After the code was run, the results were added to the attraction, hotel, and Airbnb primary grid layers which were then visualized in ArcMap. The final map represents how many origins have access to how many destinations and how many destinations have access to how many origins via the city's public transit system within a specific time. The final accessibility maps were symbolized, and the natural break was used for classification.

The distance analysis maps are also used to represent the radius of where the highly accessible origins and destinations grids are located within cities. Prior to distance analysis, the classification was reduced to three categories using a natural break. In the final accessibility analysis, eight maps were created for each case study:

1. Accessibility of hotel grids to attractions grids
2. Accessibility of Airbnb grids to attractions grids
3. Accessibility of attraction grids to hotel grids
4. Accessibility of attraction grids to Airbnb grids
5. Hotels to attractions distance analysis
6. Airbnb to attractions distance analysis
7. Attractions to hotels distance analysis
8. Attraction to Airbnb distance analysis

Summary

The analytical process began by downloading the data for hotels and Airbnbs and creating the data for attractions. Then, the grid map system was created, and origin and destination points were assigned to grids. This step reduced the number of origins and destinations and made it easy to perform the final analysis. As we needed point data for our origins and destinations, we calculated the centroid for each grid. Then the network data set was created based on GTFS data, which is real-time public transportation data. These steps were used to generate the input data for the O-D matrix. Python code was used to calculate accessibility, the results of which were visualized in ArcMap.

This research used ArcGIS 10.8.1 network analysis to assess the accessibility of city visitors' origins to their destinations and vice versa via the city's public transit system. The network

analysis O-D matrix tool calculates the travel time or distance between each origin and destination using the specified network dataset. In the final analysis, the O-D- matrix was used to explore the mutual accessibility of each origin and each attraction within a specific frame time for each city, the results of which will be discussed in Chapter 4.

CHAPTER 4

RESULTS

This chapter presents the results of the analysis of six case studies based on the steps explained in Chapter 3. The research began by identifying a quantitative gap in tourism-transport literature reviews. After identifying the problem within the context, this research developed three sub-questions related to the tourism-transport concept. Primary data was collected for selected case studies, after which the author used the methods detailed in Chapter 3 to generate results to answer the research sub-questions.

The results in this section aim to answer the last two sub-questions:

- How does the spatial pattern analysis of origins and destinations support public transit development?
- How well does a city's public transportation system provide accessibility from visitor origins to destinations and from visitor destinations to origins?

This chapter details the findings of quantitative analysis using ArcGIS spatial/network analysis and Python coding language. For each case study, analysis was completed in two different parts: 1) Maps were designed to assess the spatial patterns of visitors' origins and destinations and the city's public transit network, and 2) maps were designed to analyze the accessibility of visitors' origins and destinations via the city's public transit routes.

The Spatial Pattern Analysis of Origins and Destinations and Public Transit Systems

Three spatial pattern analysis maps were created for each case study. The outcomes of the maps represent three indicators that assess the spatial pattern of attractions, hotels, and Airbnb grids. These indicators represent how many attractions, hotels, and Airbnb points each grid contains. Finally, a buffer of 2640 feet is applied for each BRT, metro, subway, and light rail station to determine how many grids intersect with these buffers. All the attractions, hotels, and Airbnb grids are based on the 1000*1000 ft^2 grid system created earlier for each case study. The darker-colored grids indicate that these contain more origin or destination points.

Natural breaks were used to classify the grids, and the number of classes was limited to three. Natural break classification was selected because it maximizes the difference between classes, and the boundaries are applied where there are substantial differences in data values. This approach aligns with our intention to determine how many grids contain a high or low number of origins and destinations. This classification was applied to the later analysis aiming to find the most accessible origin and destination grids.

According to Federal Highway Administration statistics, people tend to walk approximately ¼ to ½ miles (~2640 feet) to reach a public transit stop. This distance is greater for heavy rail or light rail stations. Studies have shown that living within ½-mile walking distance from a transit stop leads people to change their commute from private car to public transit (Crowley, Shalaby, & Zarei, 2009).

Chicago, Illinois Spatial Pattern

The Chicago public transit system provides bus and rail services. Chicago's Rail GIS routes data, Rail L, was downloaded to ArcMap for this research. The Chicago Transit Authority (CTA)

trains currently serve the city of Chicago on 11 routes, which include red, blue, brown, green, orange, pink, purple, and yellow lines (Figure 14).

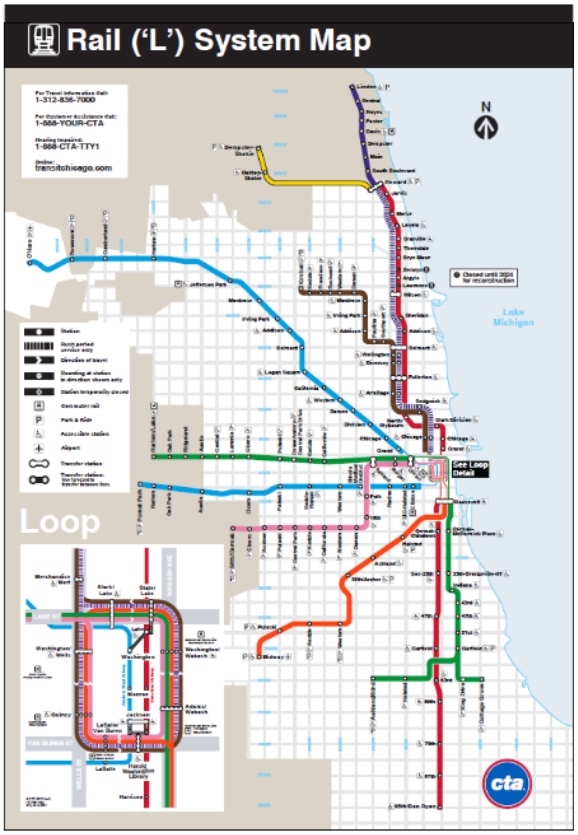

Figure 14: Chicago's Train Service.

Source: Chicago Transit Authority, July 2020.

For Chicago's attraction grids, the downtown area contains red grids with a higher number of attractions, ranging from 1 to 12. There is a cluster pattern of orange grids in the downtown area. Moving further from the city's downtown toward the city's boundaries, yellow grids that contain 1 or 2 attractions are scattered irregularly (Figure 15). Within the northern and northwestern parts of the city, the attractions are scattered around Chicago's three rail lines. Several transit lines transect red and orange grids within the downtown area. Among the 368 attraction grids, 255 grids (nearly 70%) are located within a 2640 feet buffer zone from CTA stations. This is a very high percentage and reflects that these 255 attraction grids have accessibility to CTA stops within approximately 10 minutes of walking distance.

For Chicago's hotel grids, the cluster pattern of dark pink grids is noticeable within the city's downtown area. Most grids in the downtown area contain a higher number of hotels, ranging from 1 to 12 (Figure 16). Like the attractions, the cluster pattern of hotel grids in the downtown area is scattered irregularly as it moves toward the boundaries. Based on the buffer analysis, 111 of the 154 hotel grids (nearly 72%) are located within a 2640 feet buffer zone from CTA stations.

Of the attraction and hotel grids maps, 63 grids have an overlay, meaning they contain both attractions and hotels. This number is significant for the hotel maps in particular, as it indicates that nearly 50% of the 154 total hotel grids are within walking distance of some number of attractions. These grids are located within the downtown area and spread toward the northern part of the city.

For Chicago's Airbnb grids, the cluster pattern of dark blue grids is noticeable due to its distance, spreading from the city's downtown area toward the northwest and north. The grids in darker blue contain a higher number of Airbnbs, ranging from 13 to 52 (Figure 17). Unlike the attractions and hotels, the cluster patterns of Airbnb grids within the downtown area continue toward the north and northwest as well as the southern parts of the city. Interestingly, these clusters run along the north, northwest, and south transit lines. Based on the buffer analysis, 362 of 429 Airbnb grids (nearly 84%) are located within a 2640 feet buffer zone from CTA stations, which is the highest percentage among the three layers (attractions, hotels, and Airbnbs). Geographically, hot spot analysis detected no cluster patterns in the city's southern areas. The grids toward the western and southern boundaries become lighter in color, which shows that owners whose properties are located in the northern part of the city and close to transit routes are more likely to rent out their places on Airbnb.

Comparing attraction and Airbnb grids maps, 115 grids have an overlay, meaning they contain both attractions and Airbnbs. Thus, nearly 25% of the 429 total Airbnb grids are within walking distance of some number of attractions. These grids are primarily located within the downtown area ranging toward the northern and northwestern parts of the city.

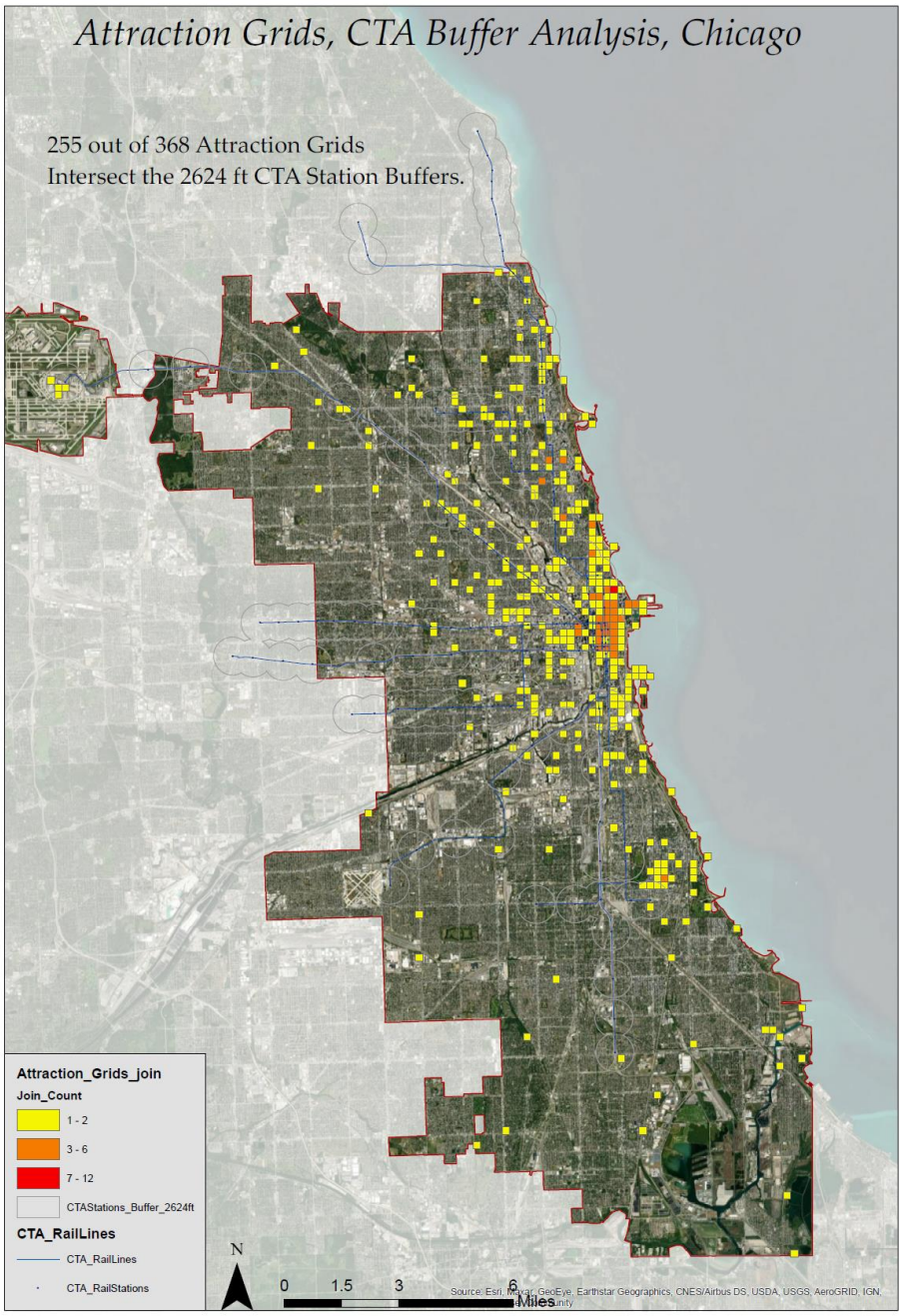

Figure 15: Attraction grids spatial pattern, Chicago

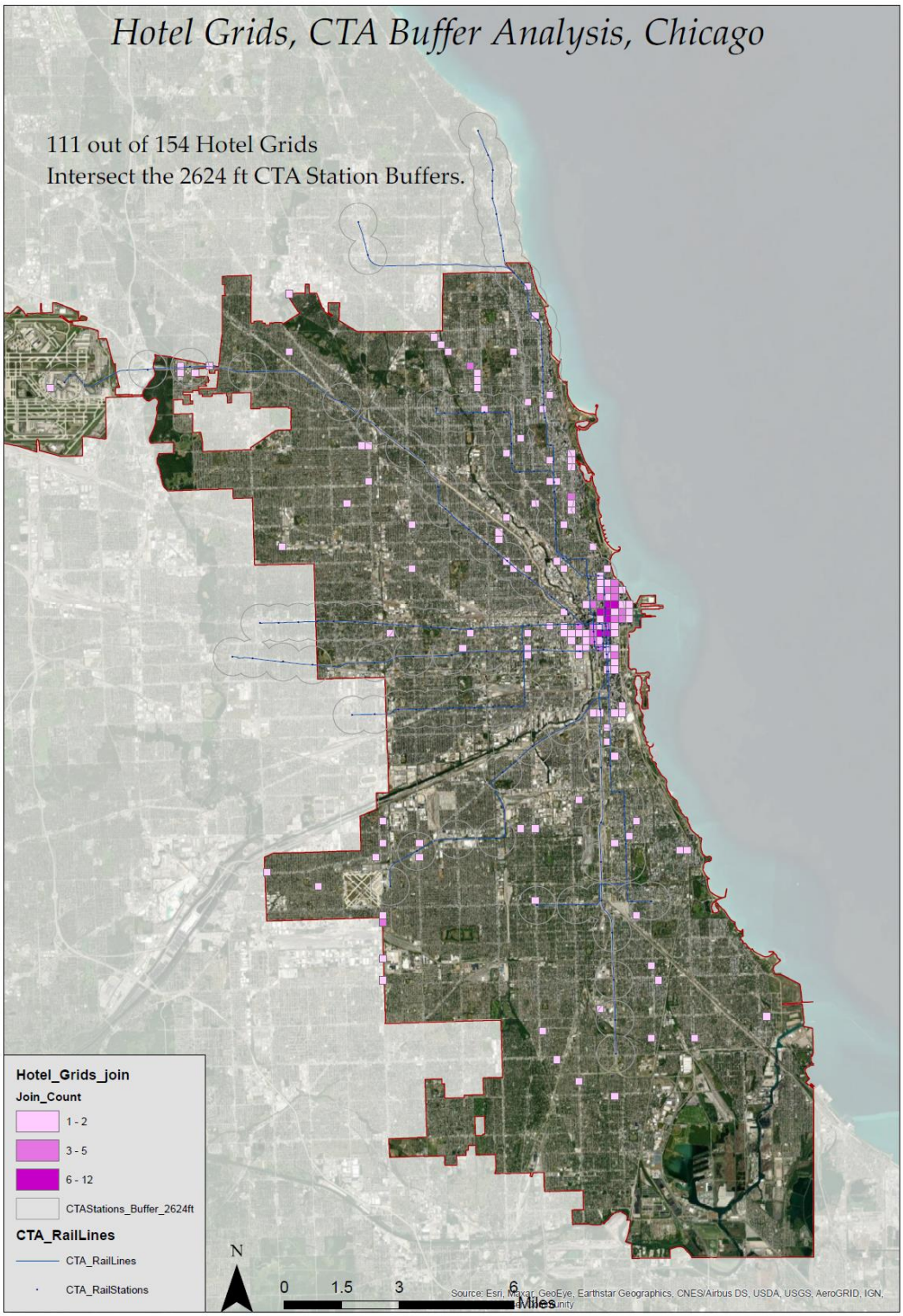

Figure 16: Hotel grid spatial pattern, Chicago

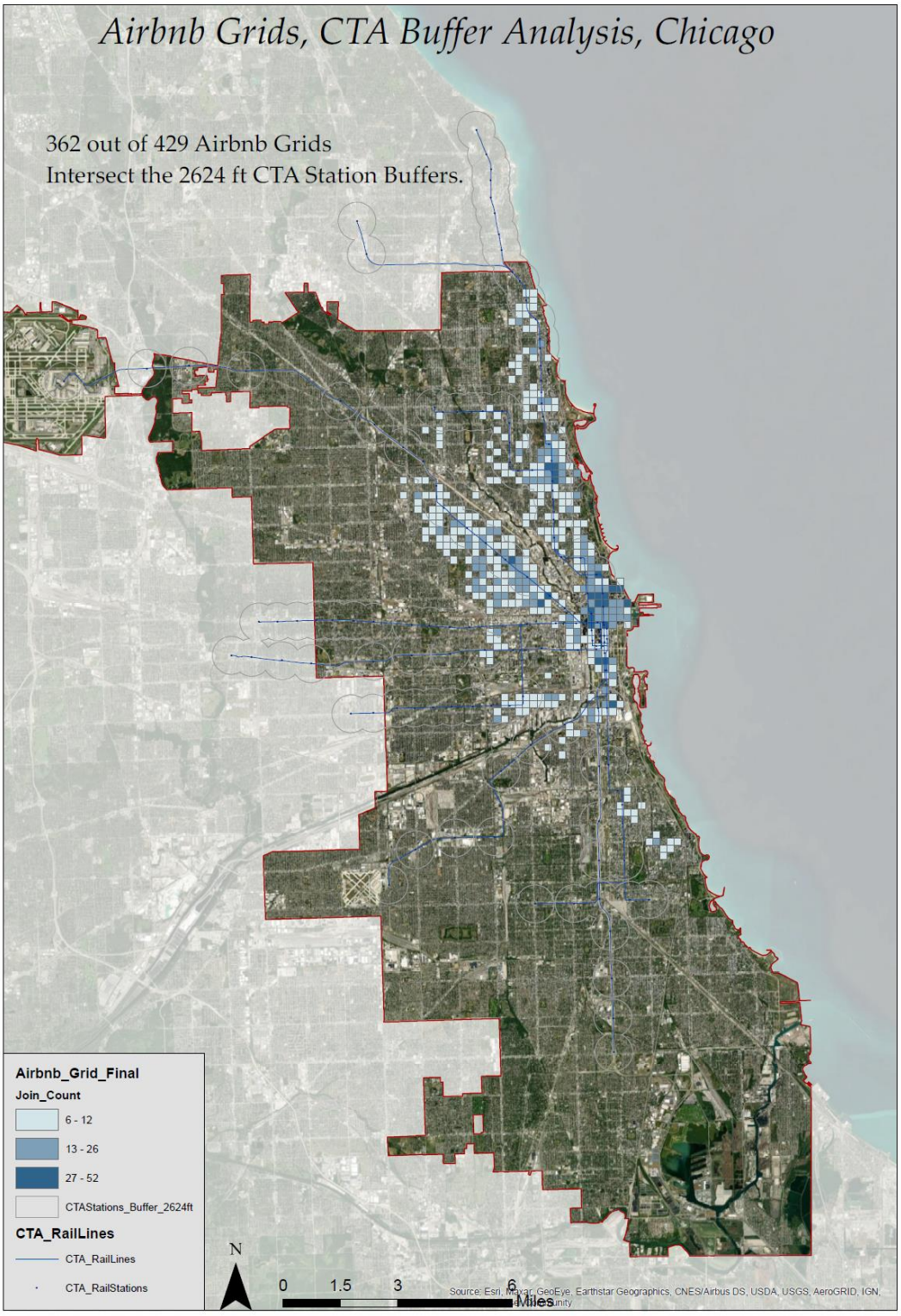

Figure 17: Airbnb grid spatial pattern, Chicago

Austin, Texas, Spatial Pattern

The Capital Metro Transportation Authority provides public transit routes in Austin. It includes bus services and a commuter rail system. GIS data for MetroRapid routes 801 and 803 and Metrorail route 550 were downloaded to ArcMap for this research. MetroRapid is a high-frequency service with a limited number of stops. Metrorail includes the red line, and Route 550 comprises commuter rail services to and from downtown (Figure 18).

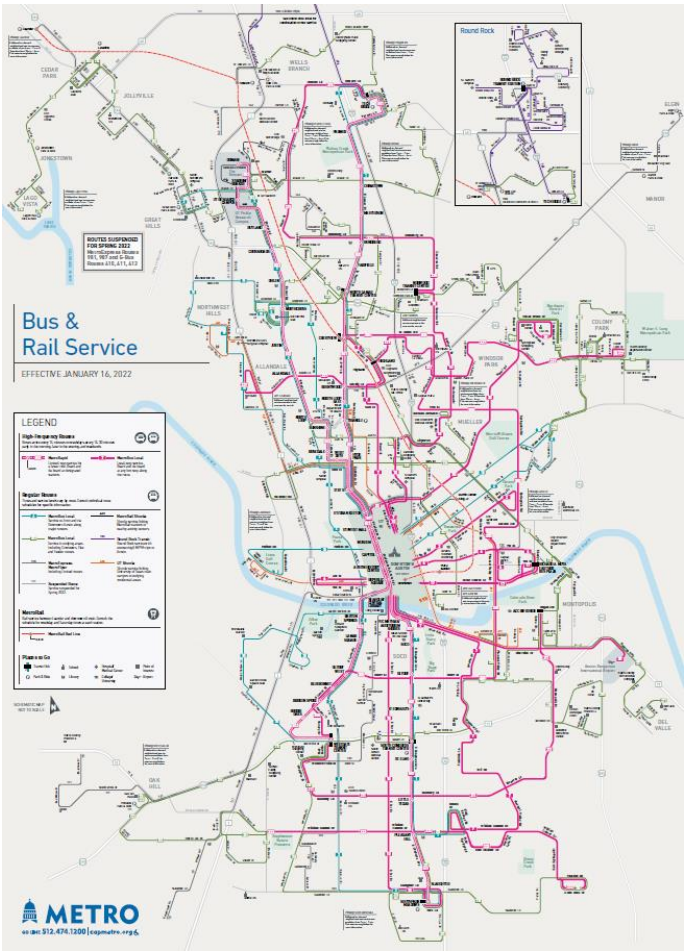

Figure 18: Austin's Transit Service Map.

Source: Austin Capital Metro, January 2022.

For Austin's attraction grids, the downtown area, located to the north of the Colorado River, contains red and orange grids with a higher number of attractions, ranging from 2 to 5. The city's downtown area hosts the strongest cluster pattern of attractions. Moving away from

downtown, grids are scattered throughout the whole city and are lighter in color, indicating that they contain only one attraction (Figure 19). Only in the downtown area do attraction grids intersect the transit lines. Based on the buffer analysis, 86 of 188 attraction grids (nearly 46%) intersect the 2640 feet buffer zone around the rapid transit stations.

For Austin's hotel grids, small cluster patterns of dark pink grids start from the downtown area and stretch out to the northern and southern part of the city in a linear pattern. Dark grids, which contain a higher number of hotels (ranging from 2 to 7), are present within every small cluster grid (Figure 20). Unlike the attraction grids, which are dispersed throughout the whole city, the hotel clusters appear closer to transit routes and main streets. Based on buffer analysis, 65 of 169 hotel grids (nearly 38%) intersect the 2640 feet buffer zone around the rapid transit stations.

Fifteen attraction and hotel grids have an overlay, meaning that they contain both attractions and hotels. Thus, 15 of 188 total attraction grids (nearly 8%) are within walking distance of some hotels. This percentage is not that high because, with the exception of the downtown area, attraction grids are scattered differently from hotel grids within the city.

For Austin's Airbnb grids, the cluster pattern of dark blue grids is noticeable within the city's downtown area toward the east and west. The darker-colored grids contain a higher number of Airbnbs, ranging from 26 to 197 (Figure 21). Unlike the attractions and hotels, the cluster patterns of Airbnb grids are highly concentrated within the downtown area, and most grids are lighter in color, containing from 11 to 25 Airbnb points. The buffer analysis revealed that 162 of 232 Airbnb grids (nearly 70%) intersect the 2640 feet buffer zone around the rapid transit stations.

Of the attraction and Airbnb grids, 35 grids have an overlay, i.e., they contain both attractions and Airbnbs. In other words, nearly 18% of the 188 total attraction grids are within walking distance of some number of Airbnbs.

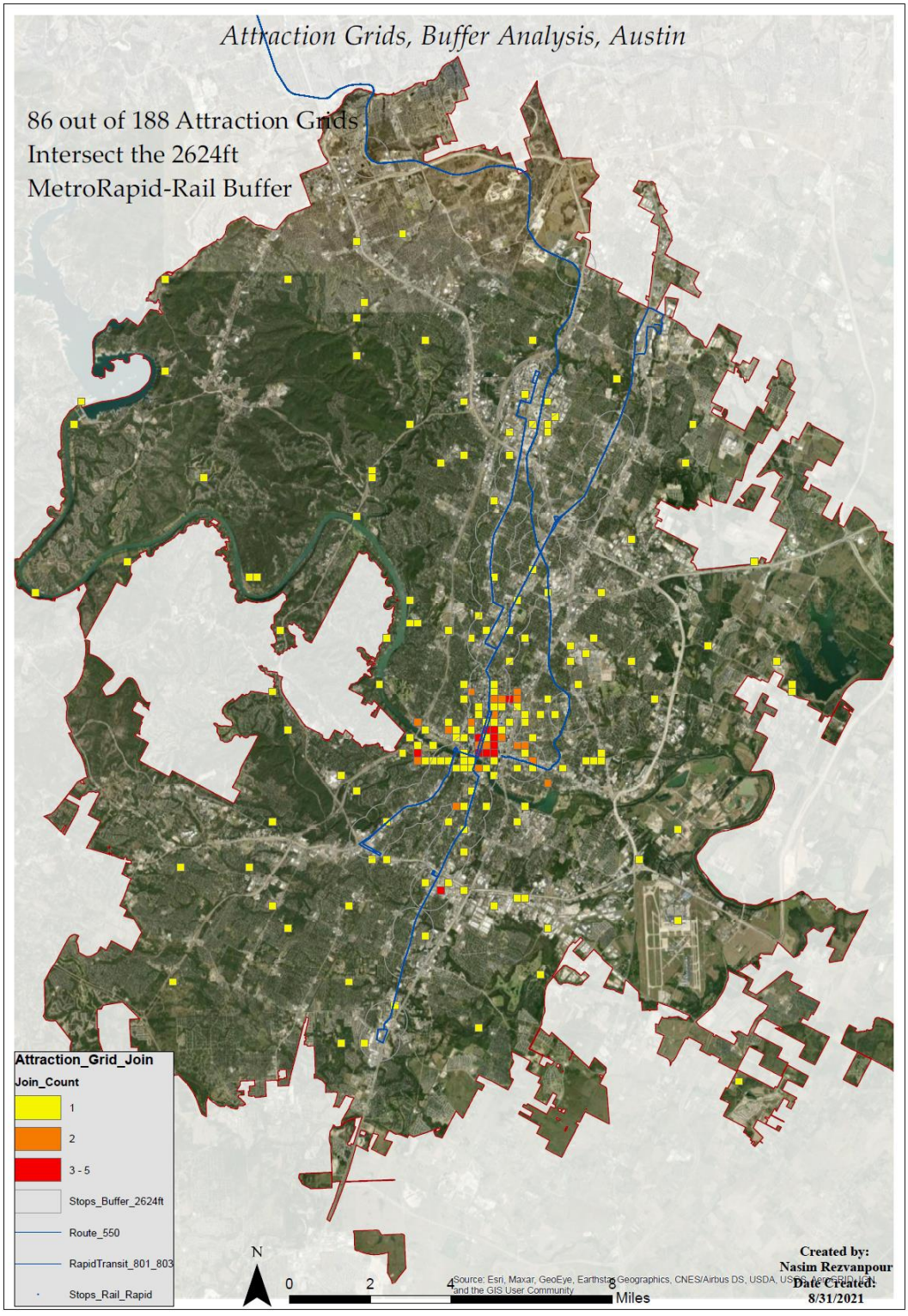

Figure 19: Attraction grid spatial pattern, Austin

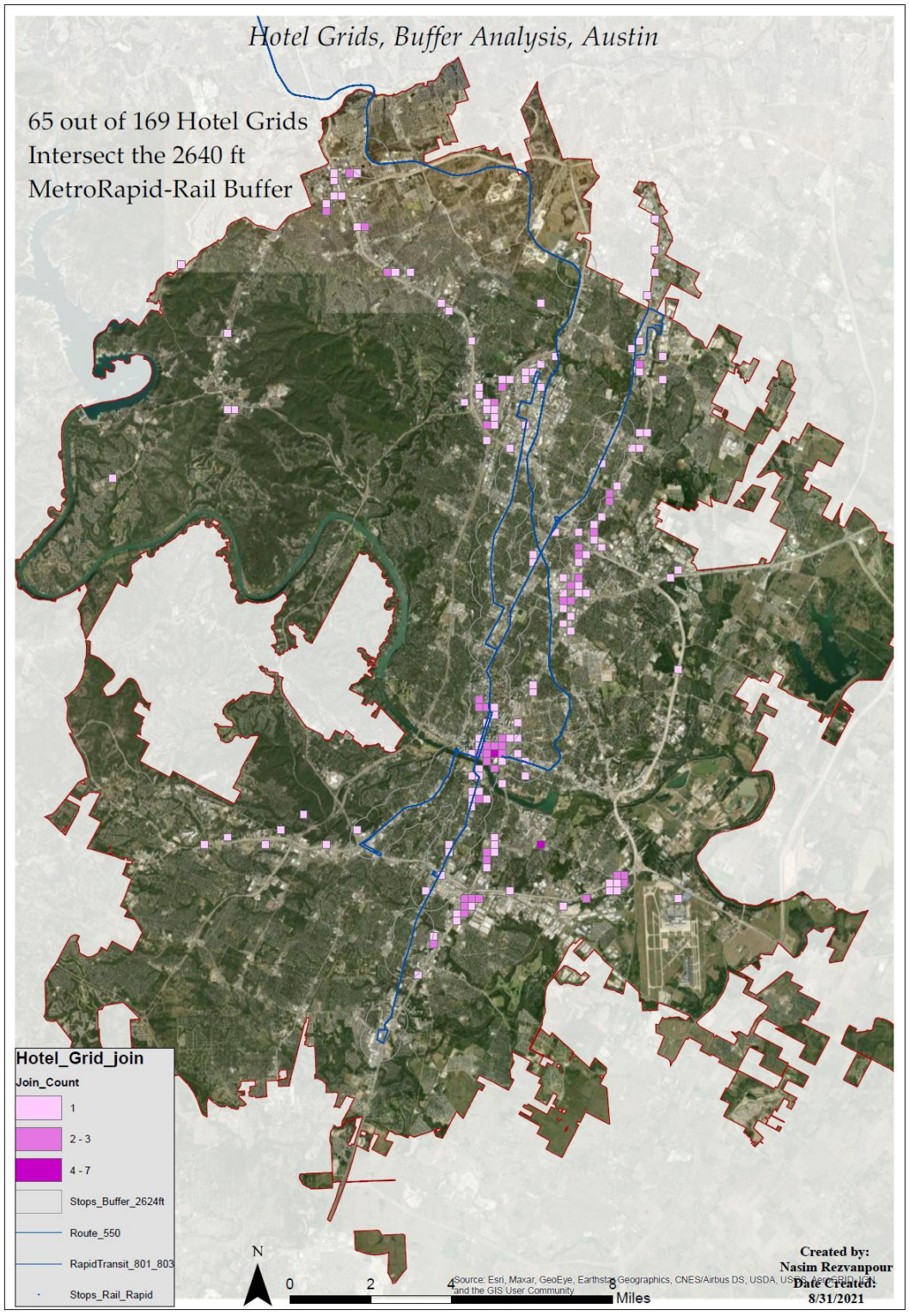

Figure 20: Hotel grid spatial pattern, Austin

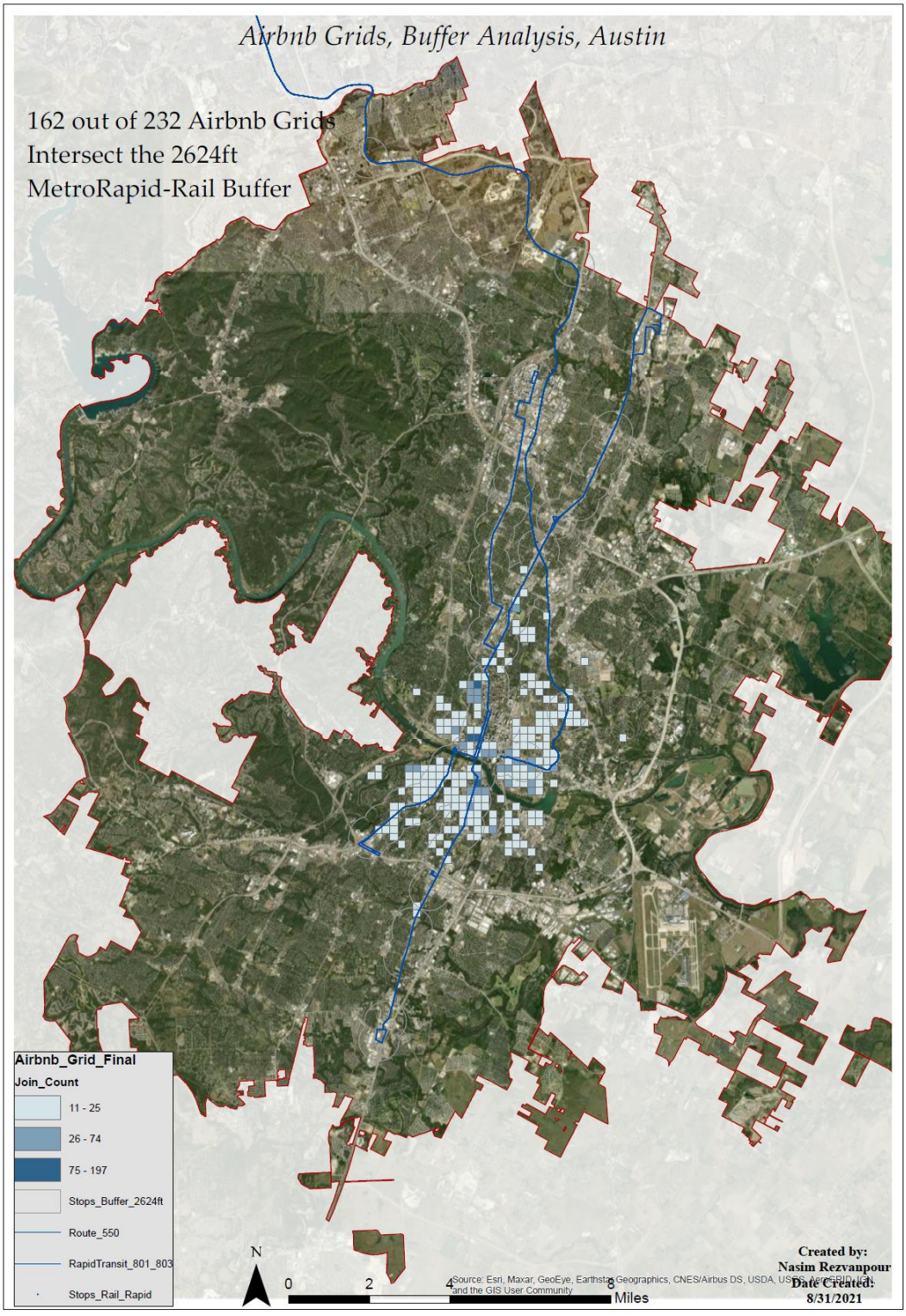

Figure 21: Airbnb grids spatial pattern, Austin

San Francisco, California, Spatial Pattern

The San Francisco Municipal Transportation Agency (SFMTA) provides all transportation services in the city. The MUNI refers to the city's bus and metro system and includes buses, light rail, Metro trains, historic streetcars, and cable cars. SF Muni Metro rail and Muni Rapid Bus GIS data were downloaded to the ArcMap for this research (Figure 22).

Figure 22: San Francisco's Transit Service Map.

Source: San Francisco Municipal Transportation Agency, February 2022.

For San Francisco's attraction grids, the city's downtown area contains a large cluster of red and orange grids with a higher number of attractions, ranging from 3 to 16. Orange grids stretch out to the northern and western parts of the city. Grids that include only 1 or 2 attractions are scattered throughout the city (Figure 23). The map shows that San Francisco's rapid transit rails serve the downtown and western and southwestern areas but does not serve the northern part of

the city. The transit lines are close by the attraction grids scattered throughout the city, except for the northern area that is not well served. The buffer analysis indicated that 187 of 294 attraction grids (nearly 63.5%) intersect the 2640 feet buffer zone around the rapid transit stations.

For San Francisco's hotel grids, the cluster pattern of dark pink grids is noticeable within the city's downtown and the neighborhoods close to downtown. These grids contain a higher number of hotels, ranging from 4 to 23 (Figure 24). However, except for these areas, hotel grids are not scattered throughout the city. The buffer analysis revealed that 88 of 122 hotel grids (nearly 72%) intersect the 2640 feet buffer zone around the rapid transit stations.

As indicated by the attraction and hotel grids map, 80 grids have an overlay, i.e., they contain both attractions and hotels. Thus, nearly 27% of the 294 total attraction grids are within walking distance of some hotels. These grids are located within the downtown area toward the north part of the city.

For San Francisco's Airbnb grids, the cluster pattern of darker grids is noticeable to the southwest of the city's downtown area, where Chinatown is located. Furthermore, these grids contain a higher number of Airbnbs, ranging from 39 to 162 (Figure 25). As with attractions and hotels, the cluster patterns of Airbnb grids are noticeable in the downtown and the middle areas of the city.

Sixty of the attraction and Airbnb grids have an overlay, meaning that they contain both attractions and Airbnbs. In other words, nearly 20% of the 294 total attraction grids are within walking distance of some number of Airbnbs. These grids are mainly located in the southwestern downtown area and range toward the middle part of the city.

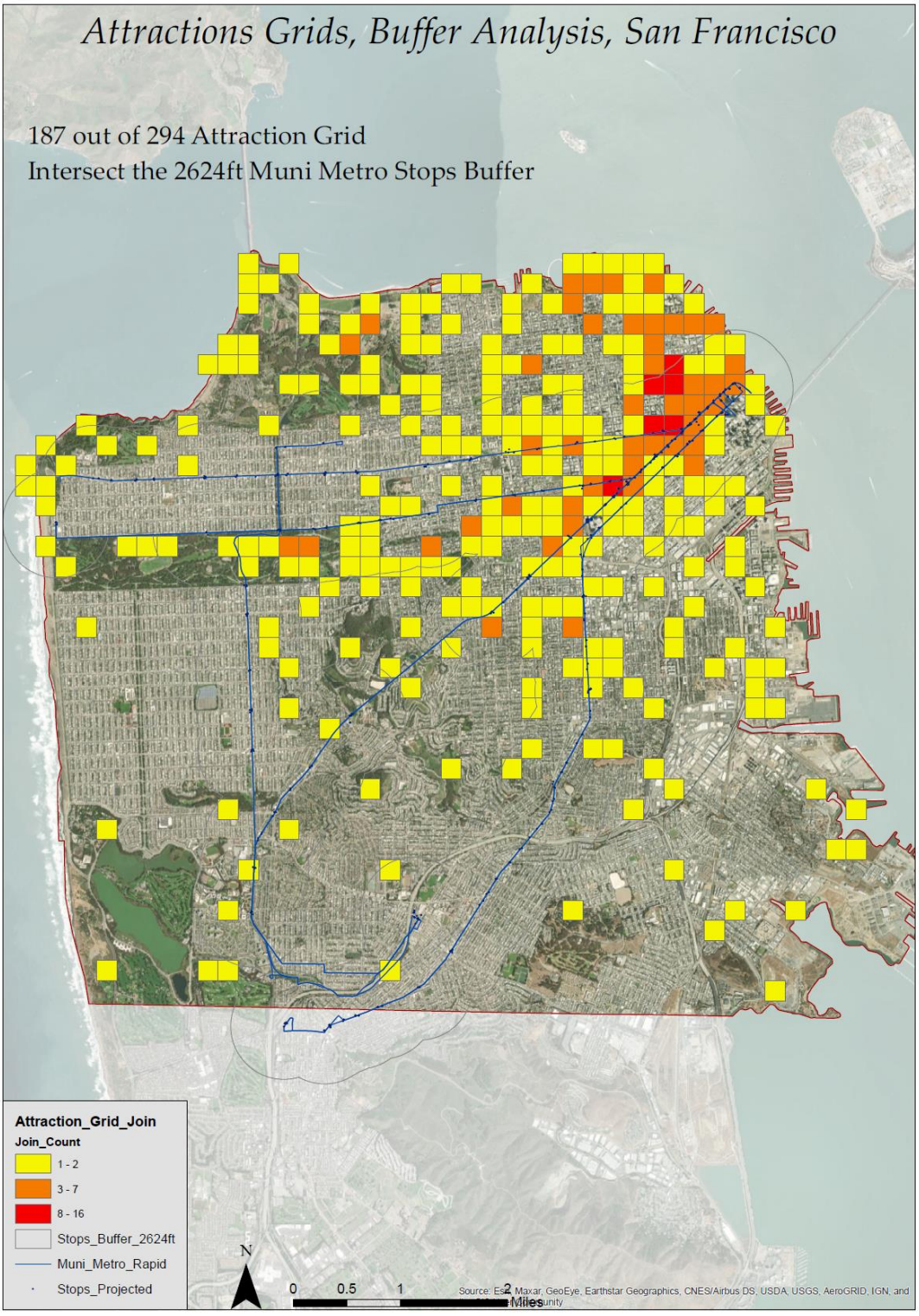

Figure 23: Attraction grids spatial pattern, San Francisco

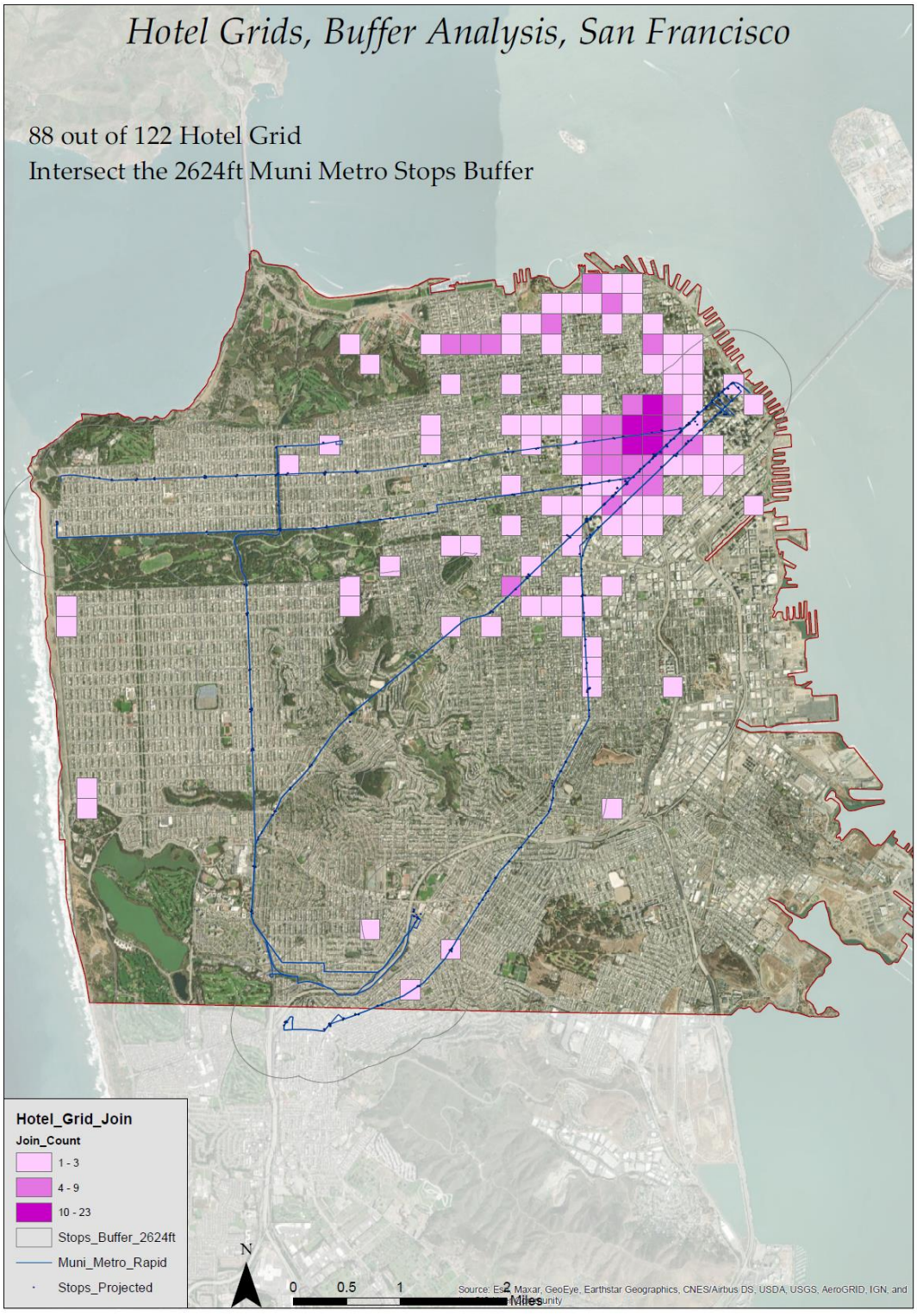

Figure 24: Hotel grids spatial pattern, San Francisco

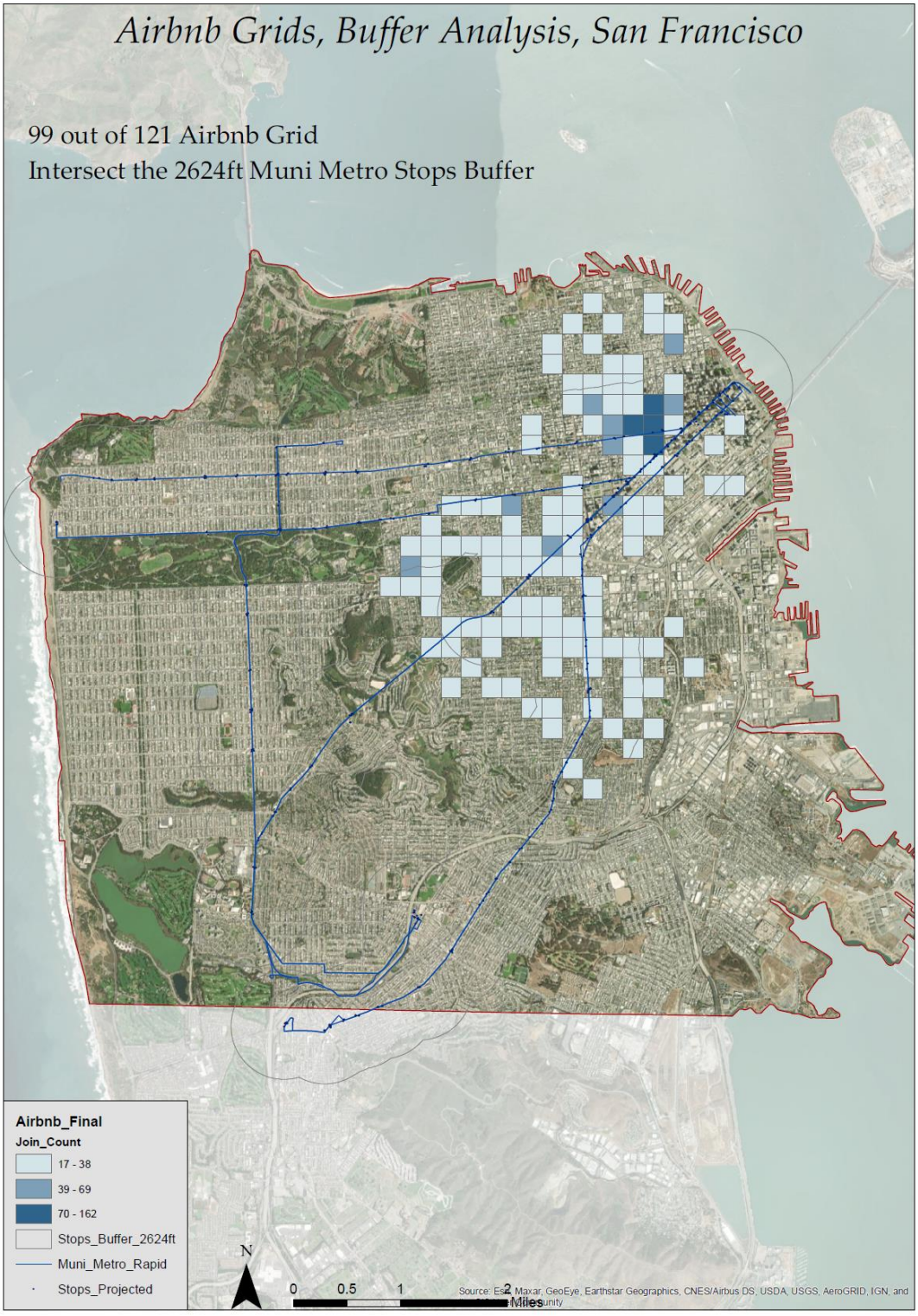

Figure 25: Airbnb grids spatial pattern, San Francisco

Los Angeles, California, Spatial Pattern

The Los Angeles County Metropolitan Transportation Authority (LACMTA), referred to as Metro or MTA, is the regional public transit system for Los Angeles and the surrounding counties. LACMTA includes the Metro Local, Metro Rapid, and Metro Express services. Metro rail lines include light and heavy rail systems and have four light rail lines (L Line, E Line, A-Line, and C Line) and one subway with two branches (B Line and D Line). GIS data for Metro rail lines and Metro Rapid transit were downloaded into ArcMap for this research (Figure 26).

Figure 26: Los Angeles's Transit Service Map.

Source: Los Angeles County Metropolitan Transportation Authority, December 2021.

Two clusters are present in Los Angeles's attraction grids: one in the LA Downtown area and another in the North Hollywood area. Grids within these two clusters contain 2 to 8 attractions. The attractions are scattered throughout the city from these locations toward the city's boundaries. The northwestern part of LA, which is separated from other city regions by several mountains, contains only one attraction, and the grids are loosely scattered (Figure 27). As illustrated in the

map, most attraction grids, even those scattered within the northwestern area are close to public transit routes. The buffer analysis showed that 274 of 360 attraction grids (nearly 76%) intersect the 2640 feet buffer zone around the rapid transit stations.

Among Los Angeles's hotel grids, similar to the pattern of attraction grids, the dark pink grids demonstrate a noticeable cluster pattern in the downtown and North Hollywood areas. These grids contain a higher number of hotels, ranging from 2 to 7 (Figure 28). Moving from the Hollywood area toward the southwest and from the downtown area toward the north and south, hotel grids are scattered irregularly. There are no hotels in the northwestern part of the city. Based on the buffer analysis, 259 of 300 hotel grids (nearly 86%) intersect the 2640 feet buffer zone around the rapid transit stations.

Among the attraction and hotel grids, 58 have an overlay, i.e., they contain both attractions and hotels. Thus, nearly 16% of the 360 total attraction grids are within walking distance of some hotels. These grids are located within the downtown area, north Hollywood, and Westwood areas.

For Los Angeles's Airbnb grids, the cluster pattern of dark blue grids is noticeable in three main areas: downtown LA, North Hollywood, and Venice. These areas contain a higher number of Airbnbs, ranging from 23 to 109 (Figure 29). As with hotels, there are no Airbnb grids in the northwestern part of the city. However, moving away from the Hollywood area toward the southwest and southeast, there are small clusters of Airbnb. Based on the buffer analysis, 415 of 462 Airbnb grids (nearly 90%) intersect the 2640 feet buffer around the rapid transit stations.

Seventy-six attraction and Airbnb grids have an overlay, meaning that they contain both attractions and Airbnbs. Therefore, nearly 21% of the 360 total attraction grids are within walking distance of some number of Airbnbs. These grids are mainly located in the downtown, North Hollywood, and Venice areas.

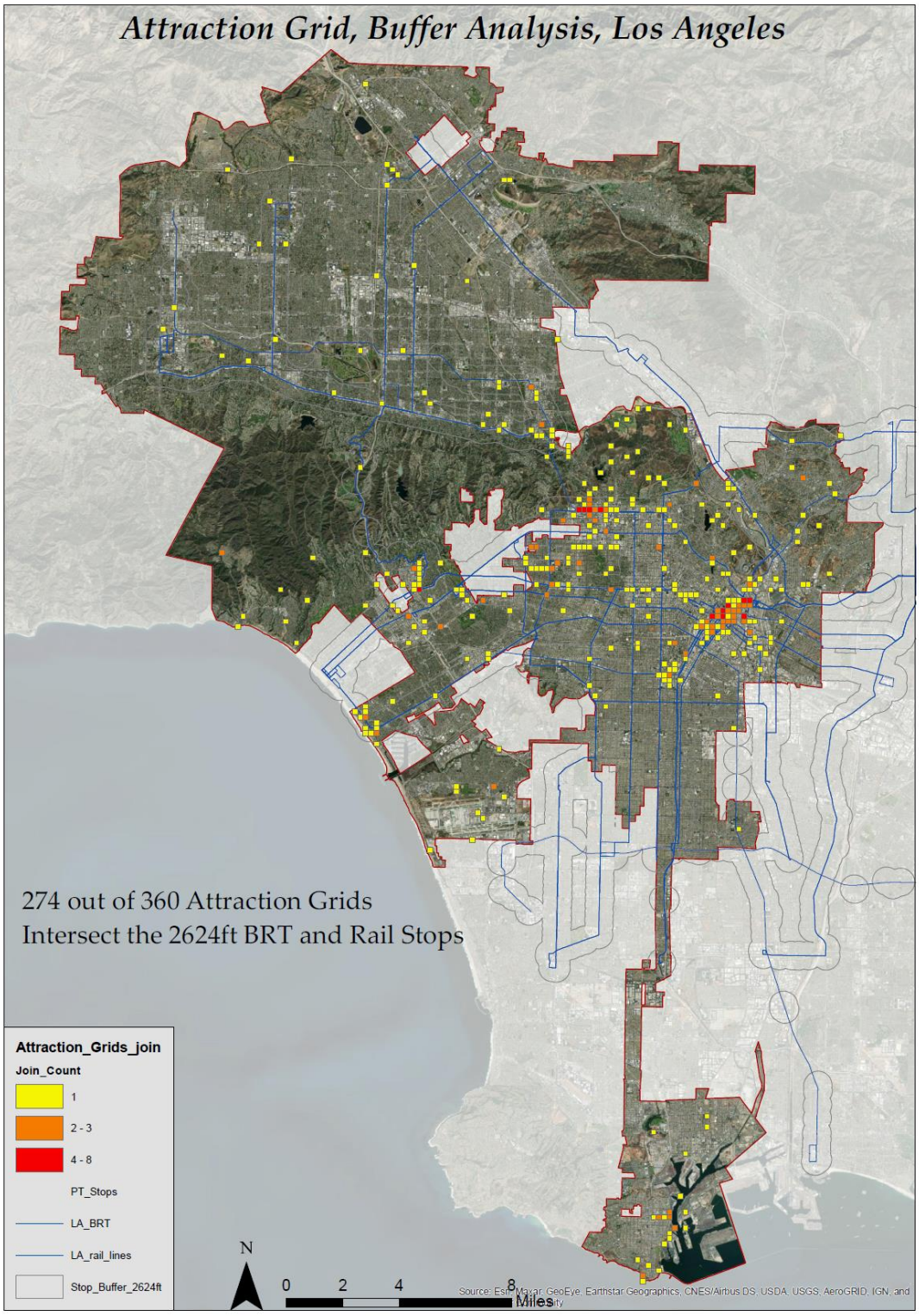

Figure 27: Attractions grids spatial pattern, Los Angeles

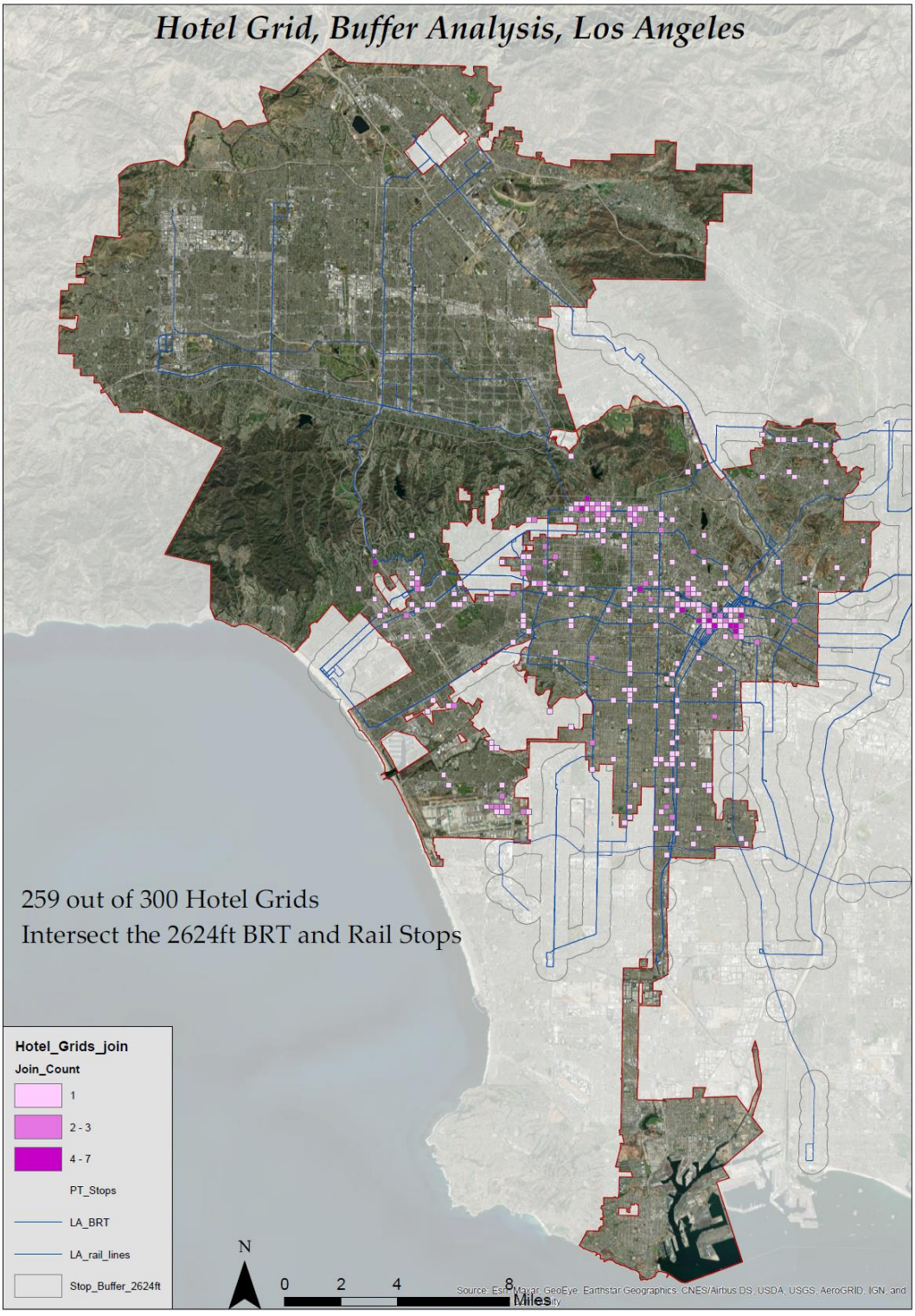

Figure 28: Hotel grids spatial pattern, Los Angeles

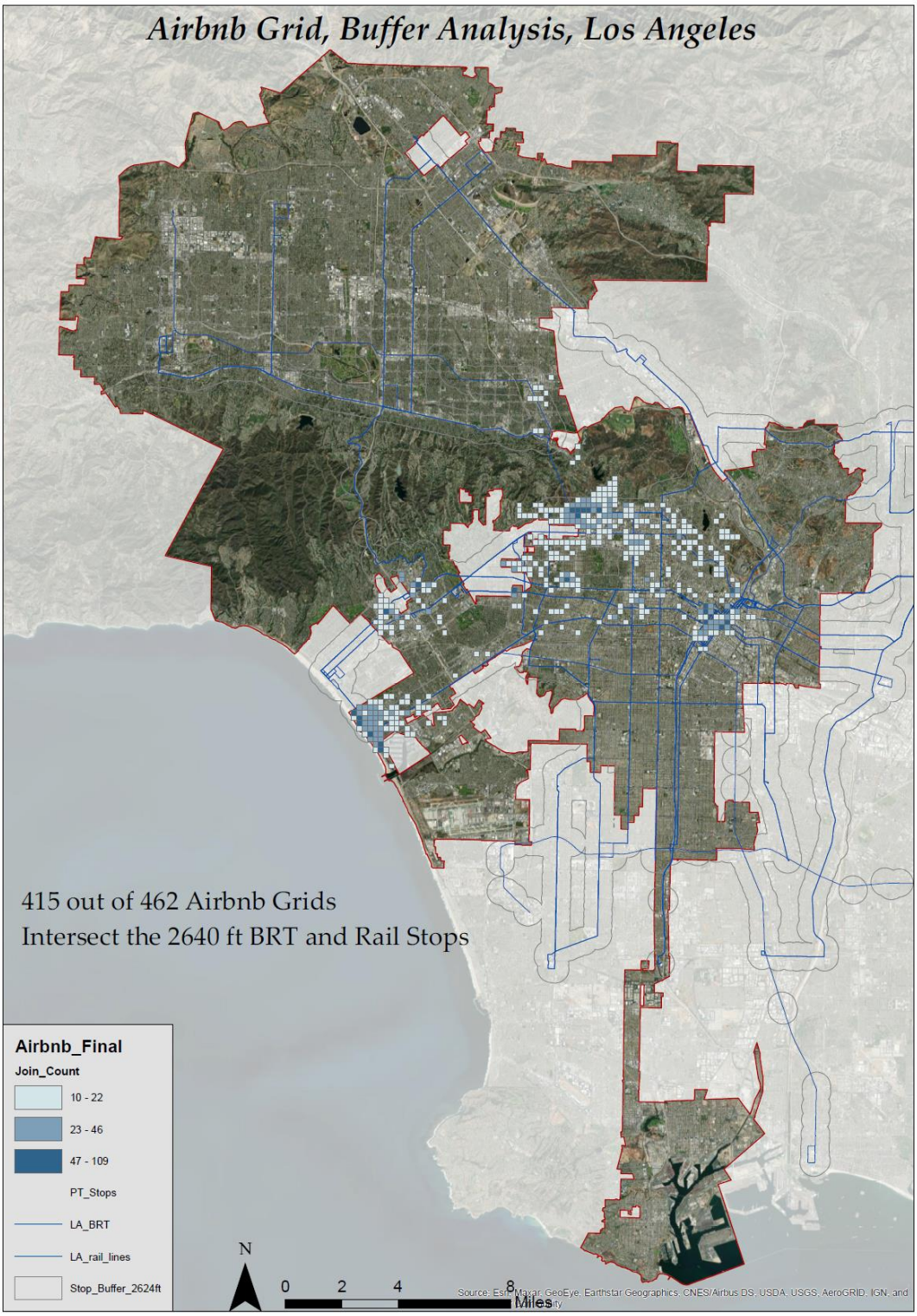

Figure 29: Airbnb grids spatial pattern, Los Angeles

Boston, Massachusetts Spatial Pattern

Boston has two main transportation networks: the Massachusetts Bay Transportation Authority (MBTA), which provides light rail/streetcar services and subway routes, and the North American Rail Network (NARN), which provides commuter rail, intercity passenger rail, and freight rail services. We downloaded MBTA light rail and subway GIS data to the ArcMap for this research (Figure 30).

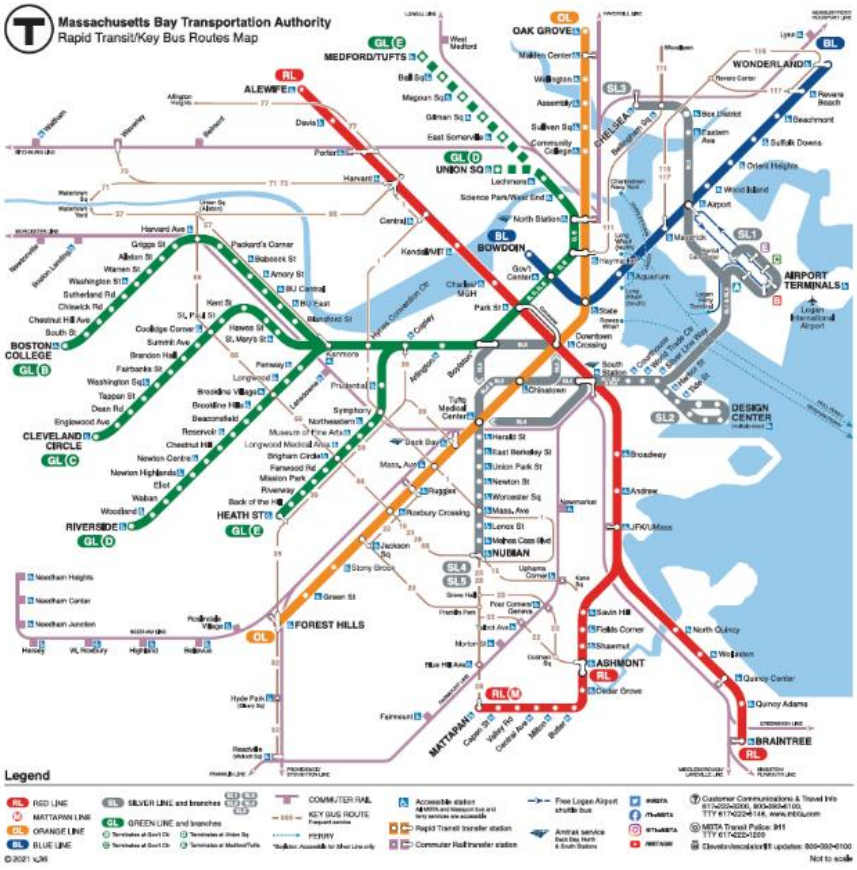

Figure 30: Boston Transit Service Map

Source: Massachusetts Bay Transportation Authority, 2021

Among Boston's attraction grids, a large cluster pattern is noticeable in the downtown and Back Bay areas, with grids containing 131 to 149 attractions. Moving from these locations toward the northeast and southwest, grids are scattered throughout the city (Figure 31). Most of the attraction grids within the downtown and northeastern areas are close to public transit routes. As

illustrated by the buffer analysis, 131 of 149 attraction grids (nearly 88%) intersect the 2640 feet buffer zone around the rapid transit stations.

Similar to the attraction grid pattern, Boston's hotel grids demonstrate a clear cluster pattern (indicated by dark pink grids) in the downtown and Back Bay areas. These grids contain a higher number of hotels, ranging from 2 to 6 (Figure 32). Moving away from these areas, hotels are scattered to the west and northeast, with few hotel grids toward the southeast. There are no grids within the southwestern part of the city. As indicated by buffer analysis, 78 of 86 hotel grids (nearly 90.5%) intersect the 2640 feet buffer zone around the rapid transit stations.

Of the attraction and hotel grids, 48 have an overlay, i.e., they contain both attractions and hotels. Thus, nearly 32% of the 149 total attraction grids are within walking distance of some hotels. These grids are located within the downtown area and Back Bay area.

Boston's Airbnb grids demonstrate a cluster pattern of dark blue grids in two main areas: downtown and Upham's Corner. These darker grids contain 20 to 138 Airbnbs (Figure 33). As with hotels, there are no Airbnb grids in the southern part of the city. Most of the Airbnb grids are close to Boston public transit routes. Buffer analysis indicated that 82 of 83 Airbnb grids (approximately 99%) intersect the 2640 feet buffer zone around the rapid transit stations.

Comparing attraction and Airbnb grids, 47 have an overlay that indicates they contain both attractions and Airbnbs. In other words, nearly 32% of the 149 total attraction grids, primarily located in the downtown area, are within walking distance of some number of Airbnbs.

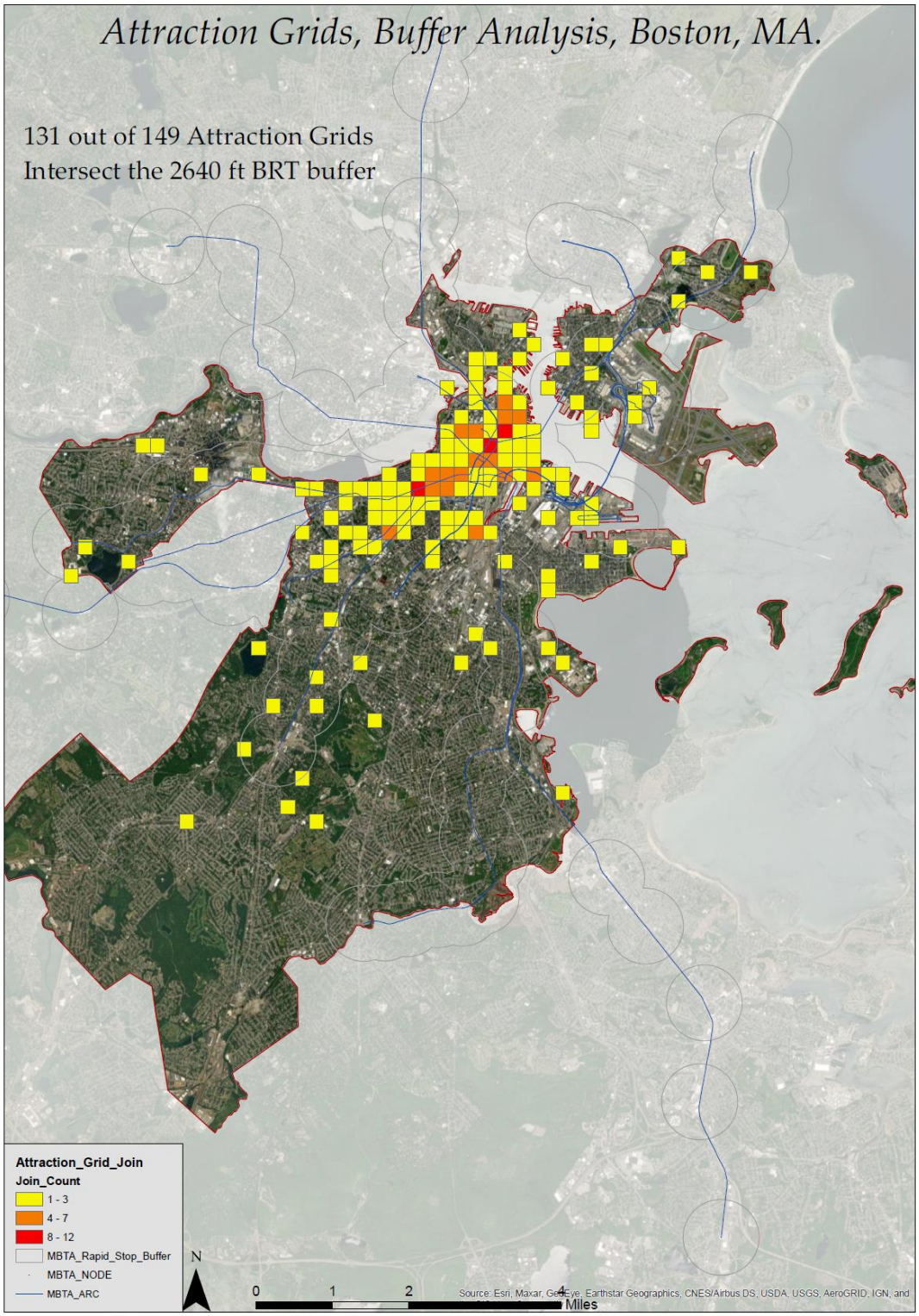

Figure 31: Attraction grids spatial pattern, Boston

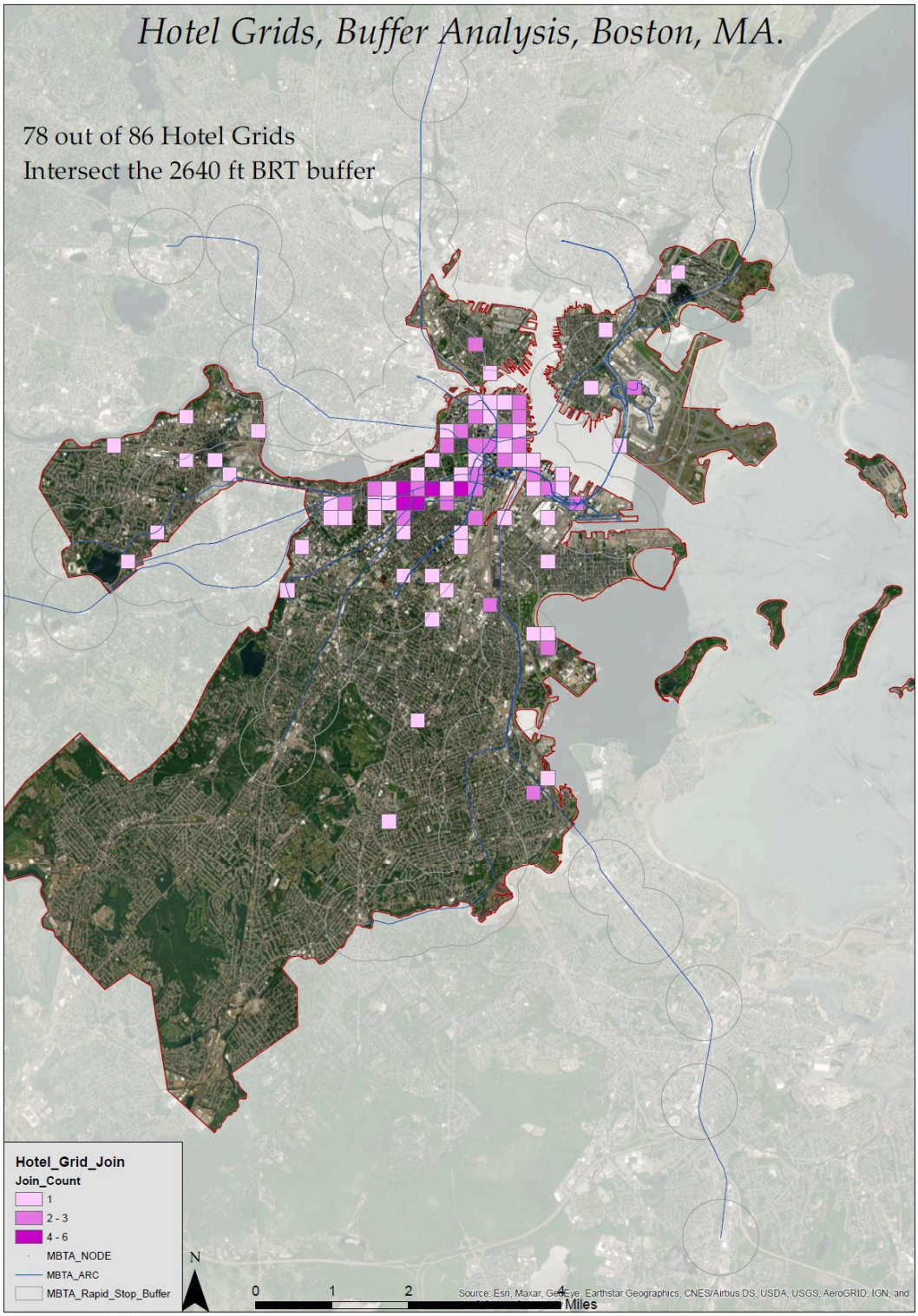

Figure 32: Hotel grids spatial pattern, Boston

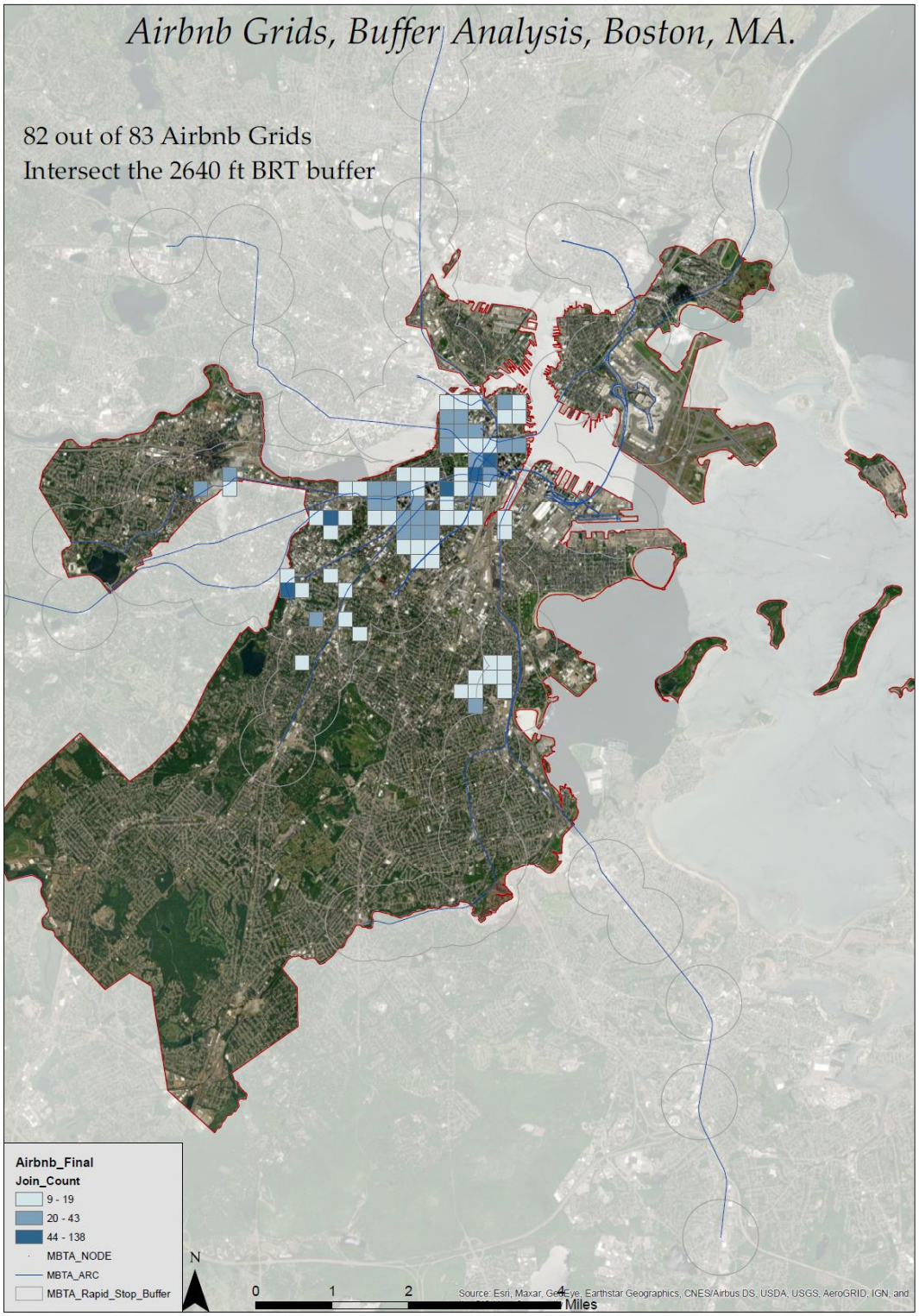

Figure 33: Airbnb grids spatial pattern, Boston

New York City, New York Spatial Pattern

The New York City rapid transit system, the Metropolitan Transportation Authority (MTA), is the eighth-largest subway system in the world as measured by ridership. The subway includes 25 routes. For this research, the GIS data for these routes were downloaded to ArcMap (Figure 34).

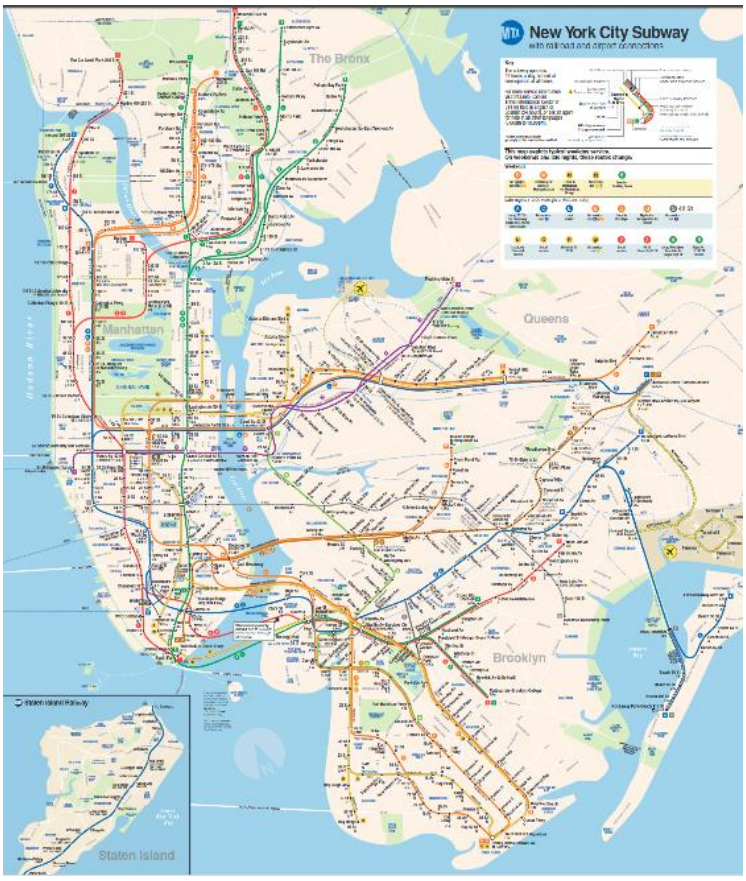

Figure 34: New York City Subway Systems.

Source: Metropolitan Transportation Authority, January 2022.

Analyzing New York City's attraction grids, a large cluster pattern of grids is noticeable in the Midtown and Lower Manhattan areas, containing up to 12 attractions. Moving north from this location toward Upper Manhattan and Harlem, there is a small cluster of grids that contain one or two attractions. Moving further toward the north and east, there are scattered grids within the Upper Manhattan and Brooklyn areas (Figure 35). Most attraction grids within the Manhattan area

are close to public transit routes. As the buffer analysis indicated, 330 of 346 attraction grids (nearly 95%) intersect the 2640 feet buffer zone around the rapid transit stations.

Similar to the patterns observed with the attraction grids, New York City's hotel grids demonstrate a noticeable cluster pattern of dark pink grids in the Midtown Manhattan area. They contain a higher number of hotels, ranging from 5 up to 20 (Figure 36). Nearer to Upper Manhattan, there are some scattered grids containing 1–3 hotels. There are no hotel grids in other boroughs. Based on the buffer analysis, 180 of 182 hotel grids (nearly 99%) intersect the 2640 feet buffer zone around the rapid transit stations.

One hundred and forty-two of the attraction and hotel grids have an overlay, meaning that they contain both attractions and hotels. Thus, nearly 41% of the 346 total attraction grids are within walking distance of some hotels.

New York City's Airbnb grids, similar to attraction and hotel maps, demonstrate a large cluster pattern within the Manhattan area. Unlike attraction and hotel grids, however, which are clustered in the Manhattan area only, there is another cluster of Airbnb grids ranging from northwestern Queens to northeastern Brooklyn (Figure 37). The dark grids, containing up to 162 Airbnbs, are in Midtown and Lower Manhattan, and northwestern Queens. Most Airbnb grids are close to public transit routes. As indicated by buffer analysis, 652 of the 655 Airbnb grids (nearly 99.5%) intersect the 2640 feet buffer zone around the rapid transit stations.

Comparing the attraction and Airbnb grids, 193 have an overlay, i.e., they contain both attractions and Airbnbs. In other words, nearly 56% of the 346 total attraction grids are within walking distance of some number of Airbnbs. These grids are located in the downtown area.

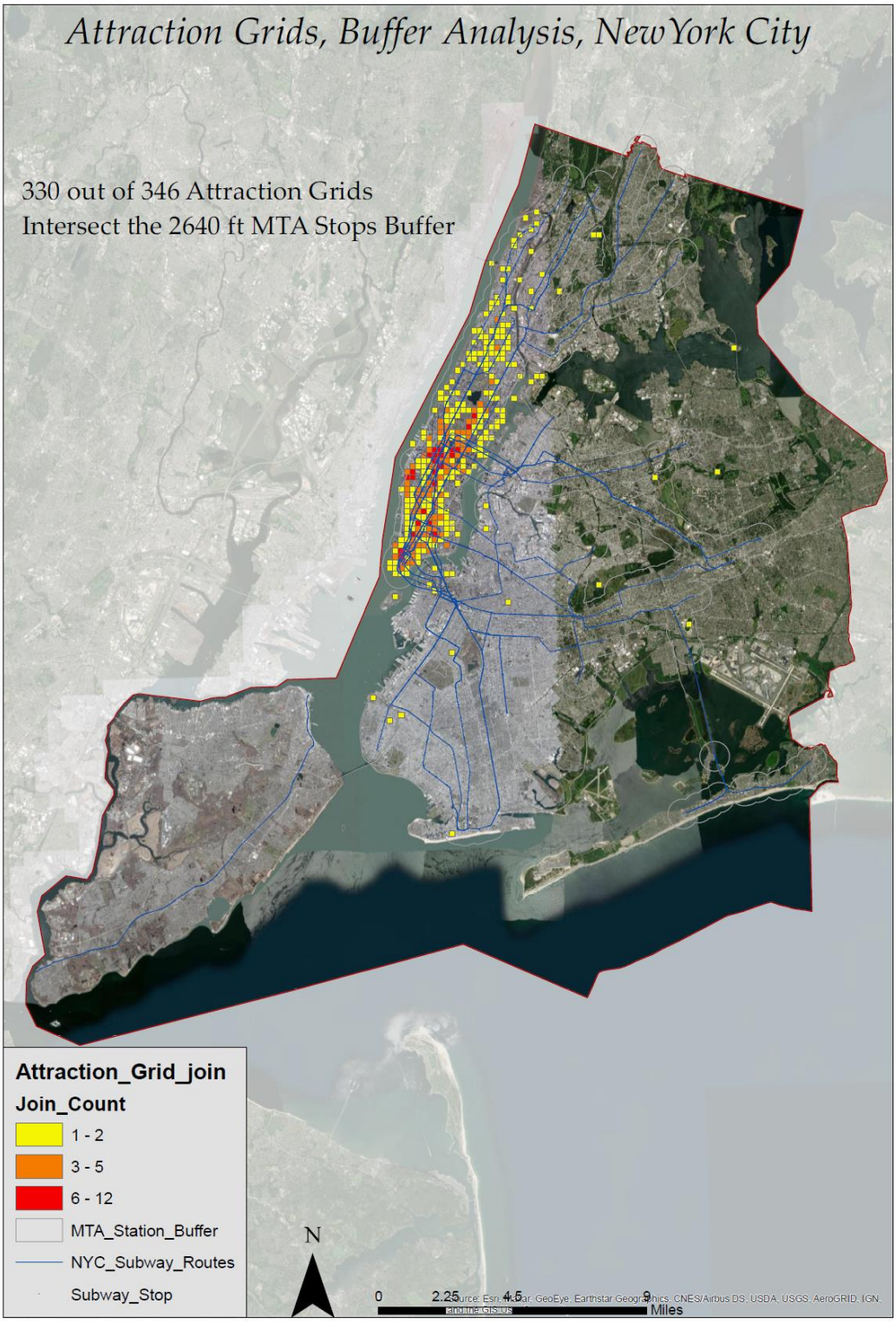

Figure 35: Attraction grids spatial pattern, New York City

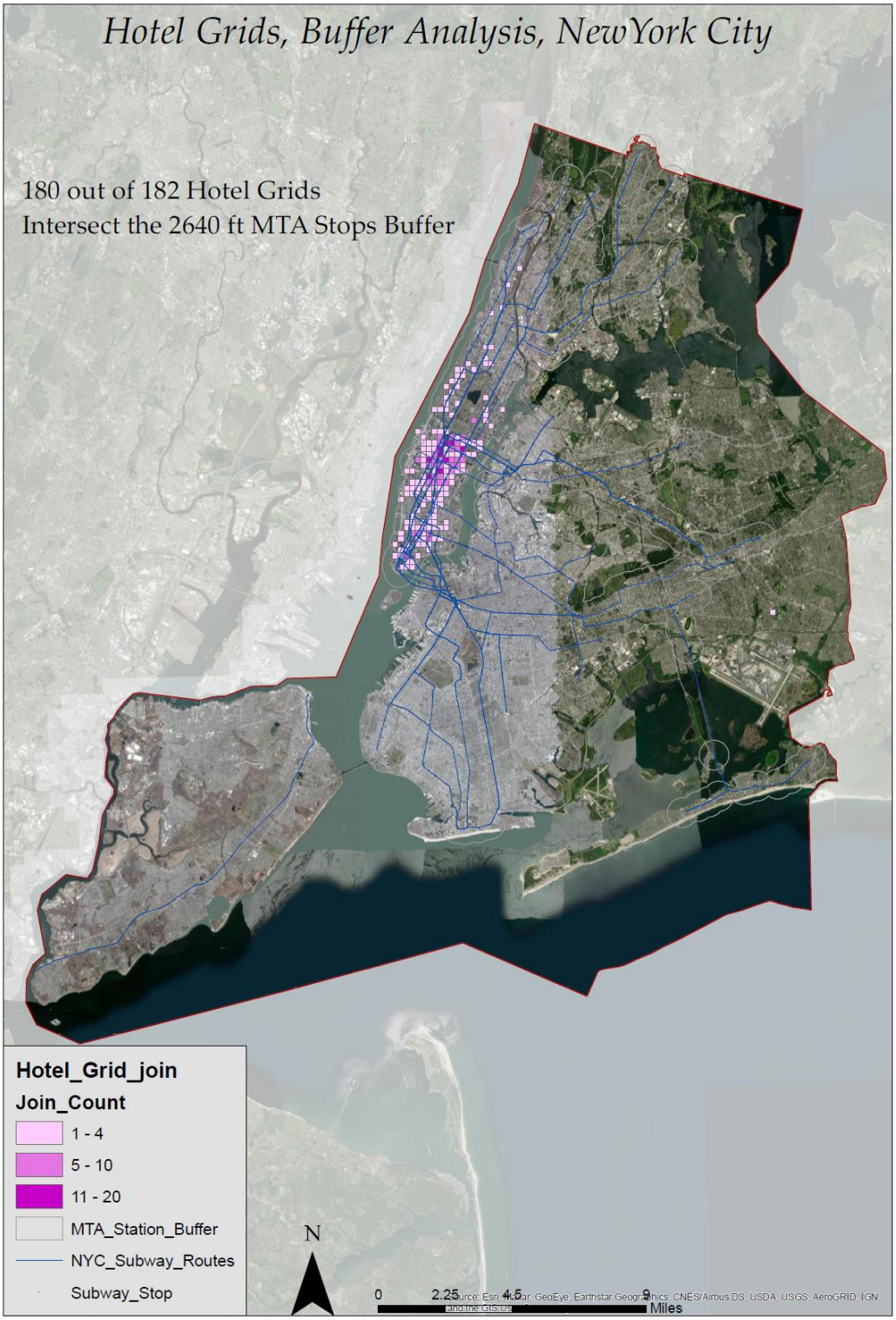

Figure 36: Hotel grids spatial pattern, New York City

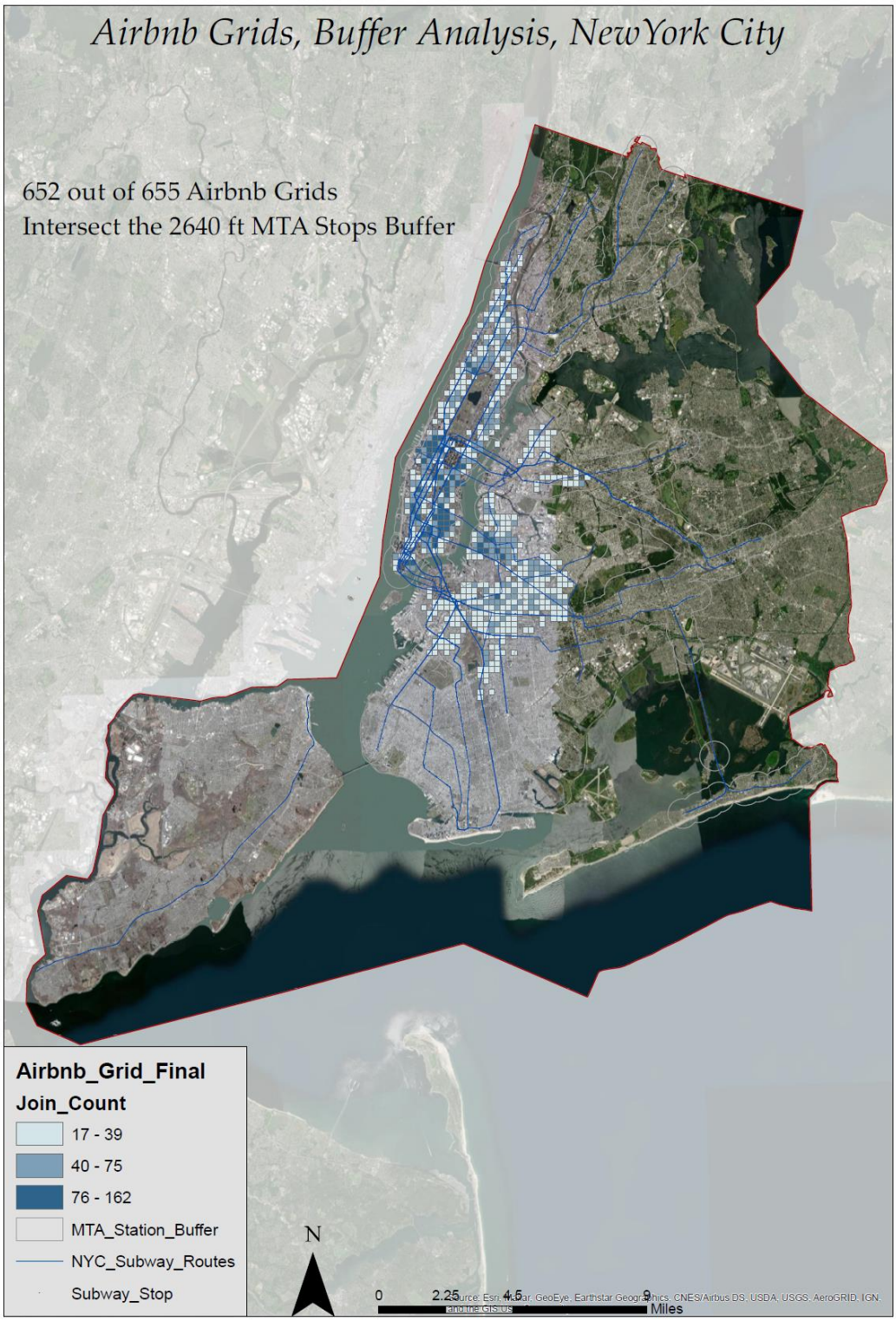

Figure 37: Airbnb grids spatial pattern, New York City

Assessing the Accessibility of Cities' Origins to Destinations (and Vice Versa) Via Public Transportation

The following maps visualize the GIS network analysis O-D matrix through Python coding. These maps visualize the number of attractions that visitors, assumed to be staying in one of the city's hotel/Airbnb grids, can reach within a specific time frame using the city's public transit system. They also visualize the number of hotels or Airbnb grids accessible from each attraction's grid within a specific time frame using the city's public transit system. This information can be used as a city tourist guide to inform visitors about how many attractions are accessible via public transit within a reasonable time frame if they choose to stay in a given hotel or Airbnb grid. In the final O-D matrix analysis, the following four maps were created using the attractions, hotels, and Airbnbs for each study:

- Hotels to Attractions
- Airbnbs to Attractions
- Attractions to Hotels
- Attraction to Airbnbs

After the O-D result maps were generated, the distance analysis maps were created to calculate the radius of the space in which grids with different colors are located. The following maps reveal information about the location of the darker colors and their status on the public transit routes:

- Hotels to Attractions Distance Analysis
- Airbnbs to Attractions Distance Analysis
- Attractions to Hotels Distance Analysis
- Attractions to Airbnbs Distance Analysis

Chicago, Illinois Accessibility

According to the Hotels–Attractions grid map, if a visitor stays in one of the darkest brown hotel grids, they can reach up to 97 of Chicago's attractions grids using the city's public transportation in less than 49.5 minutes. Among the 154 hotel grids, 14 have public transit access to approximately a quarter of the city's attractions in less than 49.5 min, and 142 have public transit access to less than a quarter of attractions grids (Figure 38).

Based on the Hotels-Attractions distance analysis map, those grids with access to the highest number of attractions (57–97) are within a radius of ~8,500 feet from Chicago's downtown area. The grids with access to a medium number of attractions (21–56) are within a radius of ~37,000 feet from the original center, and finally, the grids with access to a low number of attractions (0–20) are within a radius of ~83,000 feet from the original center (Figure 39).

According to the Airbnbs–Attractions map, if a visitor stays in one of the darkest brown grids, they can reach up to 97 of Chicago's attractions using public transportation in less than 49.5 minutes. Among the 429 Airbnb grids, 19 grids have public transit access to approximately a quarter of the city's attractions in less than 49.5 min, and the remaining grids have public transit access to less than a quarter of attraction grids (Figure 40).

As indicated by the Airbnbs–Attractions distance analysis map, those grids with access to the highest number of attractions (60–101) are within a radius of ~13,000 feet of Chicago's downtown area. Grids with access to a medium number of attractions (25–59) are within a radius of ~37,000 feet from the original center, whereas grids with access to a low number of attractions (0–24) are within a radius of ~45,000 feet from the original center (Figure 41).

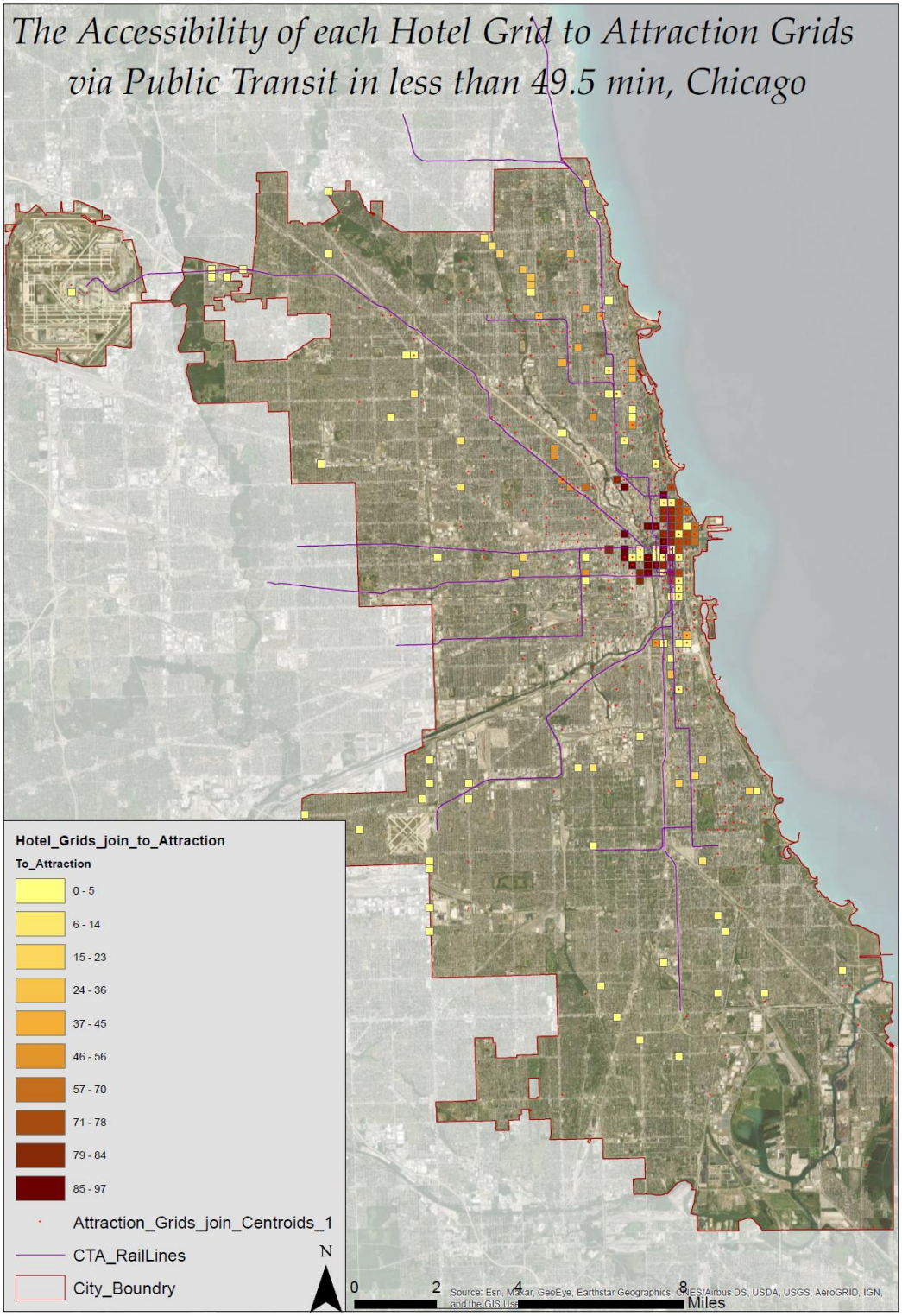

Figure 38: Hotel to attraction accessibility via public transit, Chicago

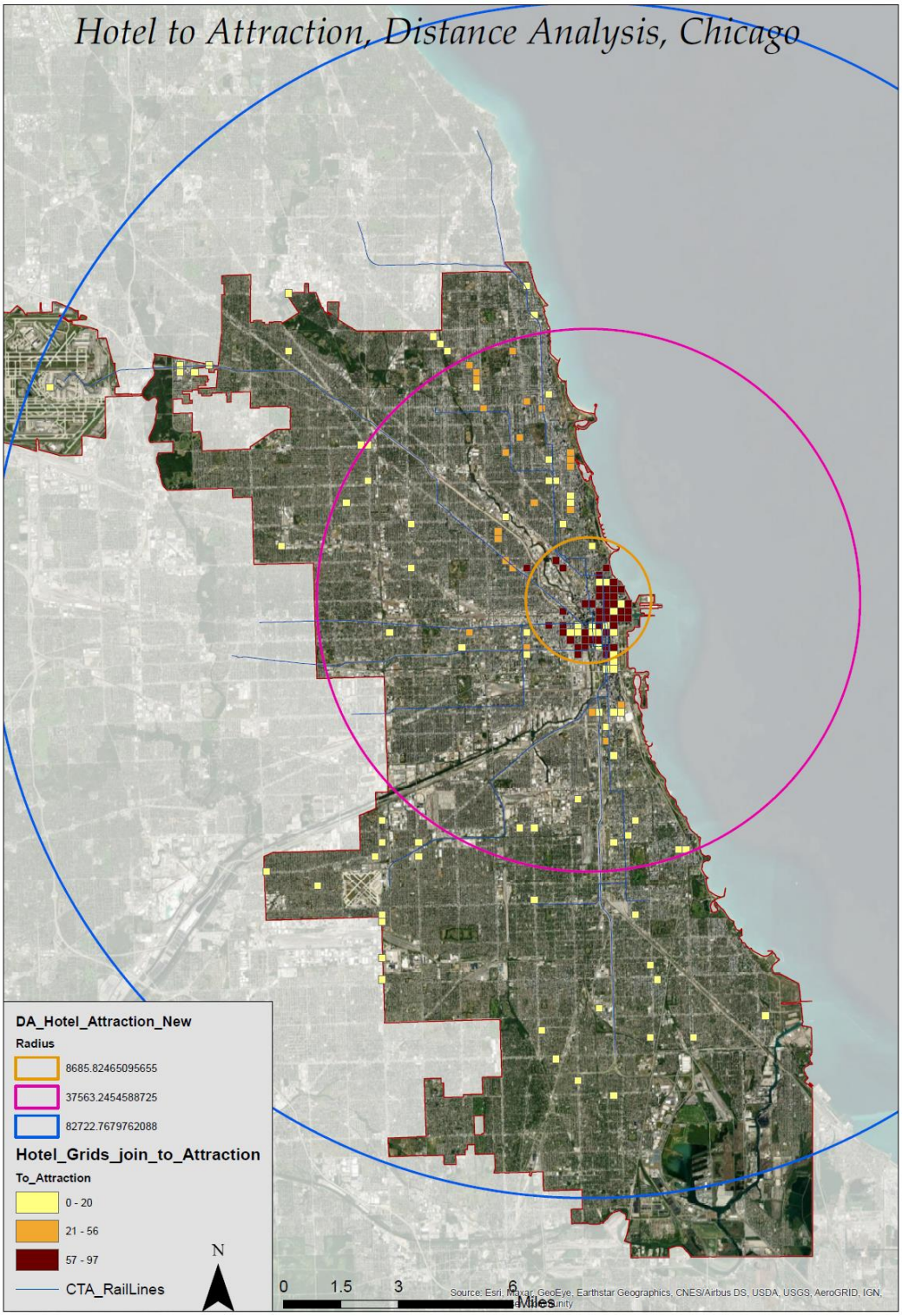

Figure 39: Hotel to attraction, distance analysis, Chicago

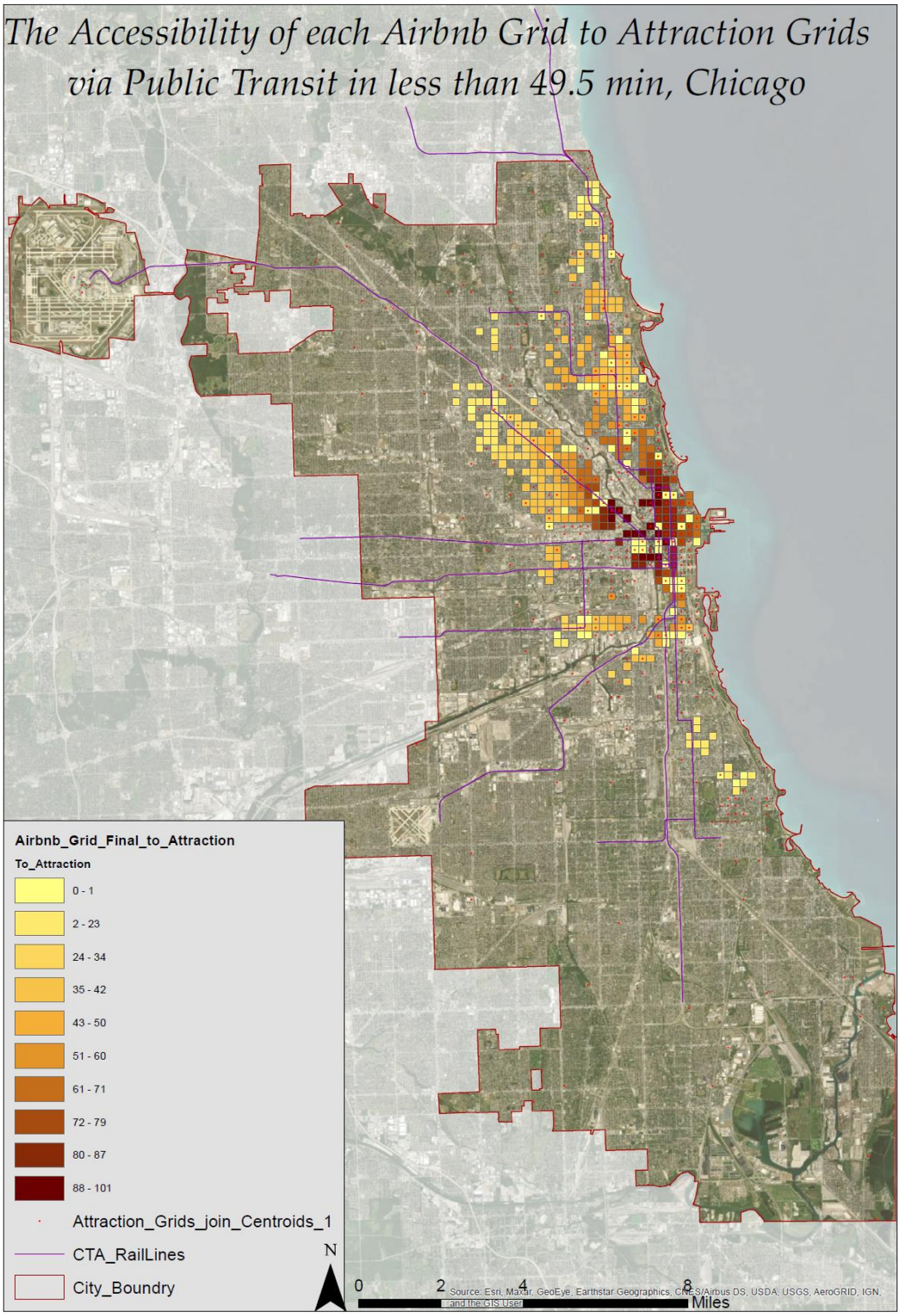

Figure 40: Airbnb to attraction accessibility via public transit, Chicago

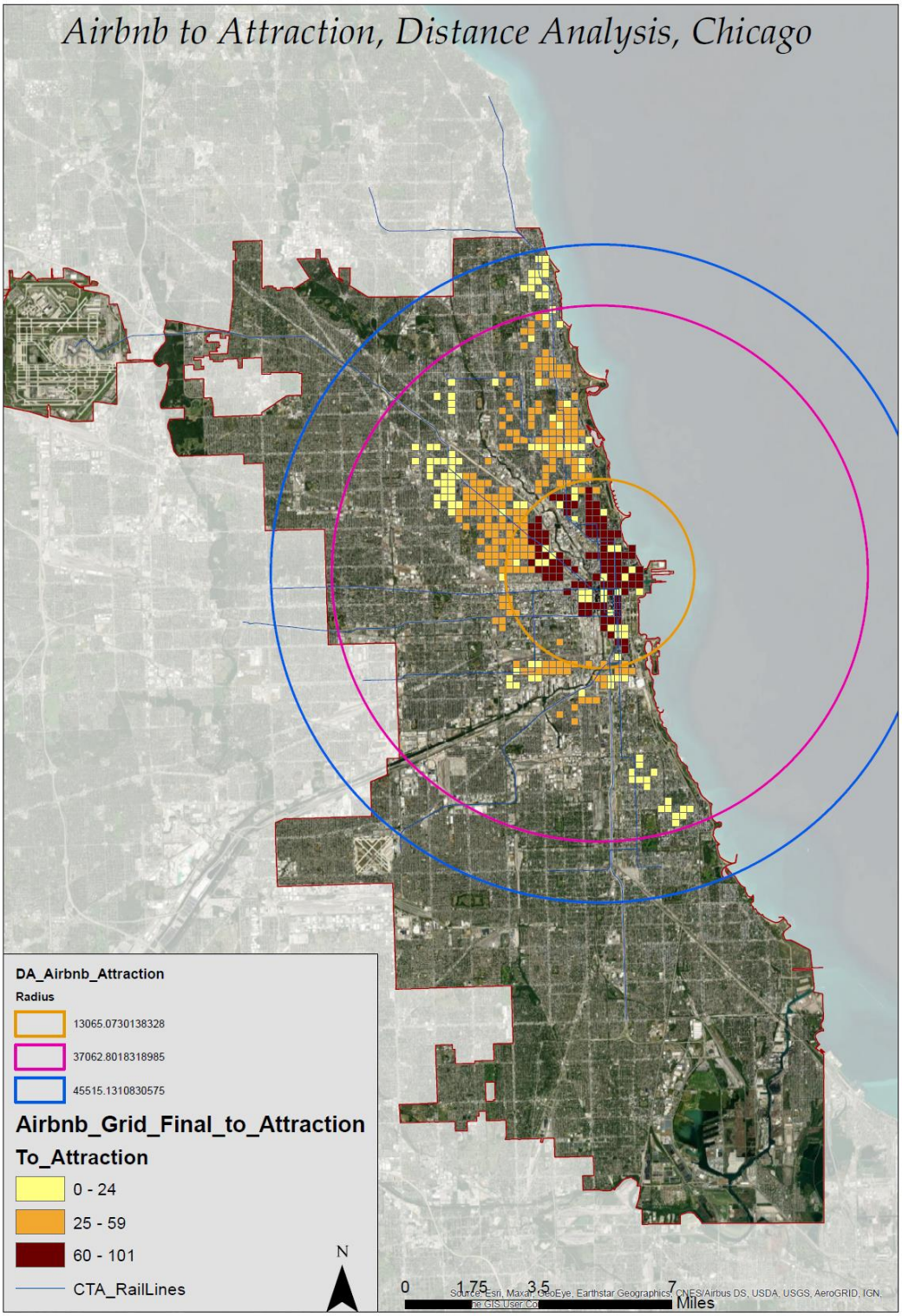

Figure 41: Airbnb to attraction distance Analysis, Chicago

As shown in the Attractions–Hotels map, among the 370 attractions grids, 50 located in the downtown area have public transit access to approximately a third of the city's hotels in less than 49.5 minutes (Figure 42).

Based on the Attractions–Hotels distance analysis map, those attraction grids with access to the highest number of hotels (28–49) are within a radius of ~9,000 feet in Chicago's downtown area. In contrast, grids with access to a medium number of hotels (8–27) are within a radius of ~36,000 feet from the original center, while grids with access to a low number of hotels (0–7) are within a radius of ~81,000 feet from the original center (Figure 43).

According to the Attractions–Airbnbs map, 38 of the 370 attractions grids, all located in the downtown area, have public transit access to approximately a third of the city's Airbnbs in less than 49.5 minutes (Figure 44).

As indicated by the Attractions–Airbnbs distance analysis map, those attraction grids with access to the highest number of Airbnbs (97–165) are within a radius of ~14,500 feet of Chicago's downtown area. Grids with access to a medium number of Airbnbs (41–96) are within a radius of ~24,900 feet from the original center. Finally, grids with access to a low number of Airbnbs (0–40) are within a radius of ~96,900 feet of the original center (Figure 45).

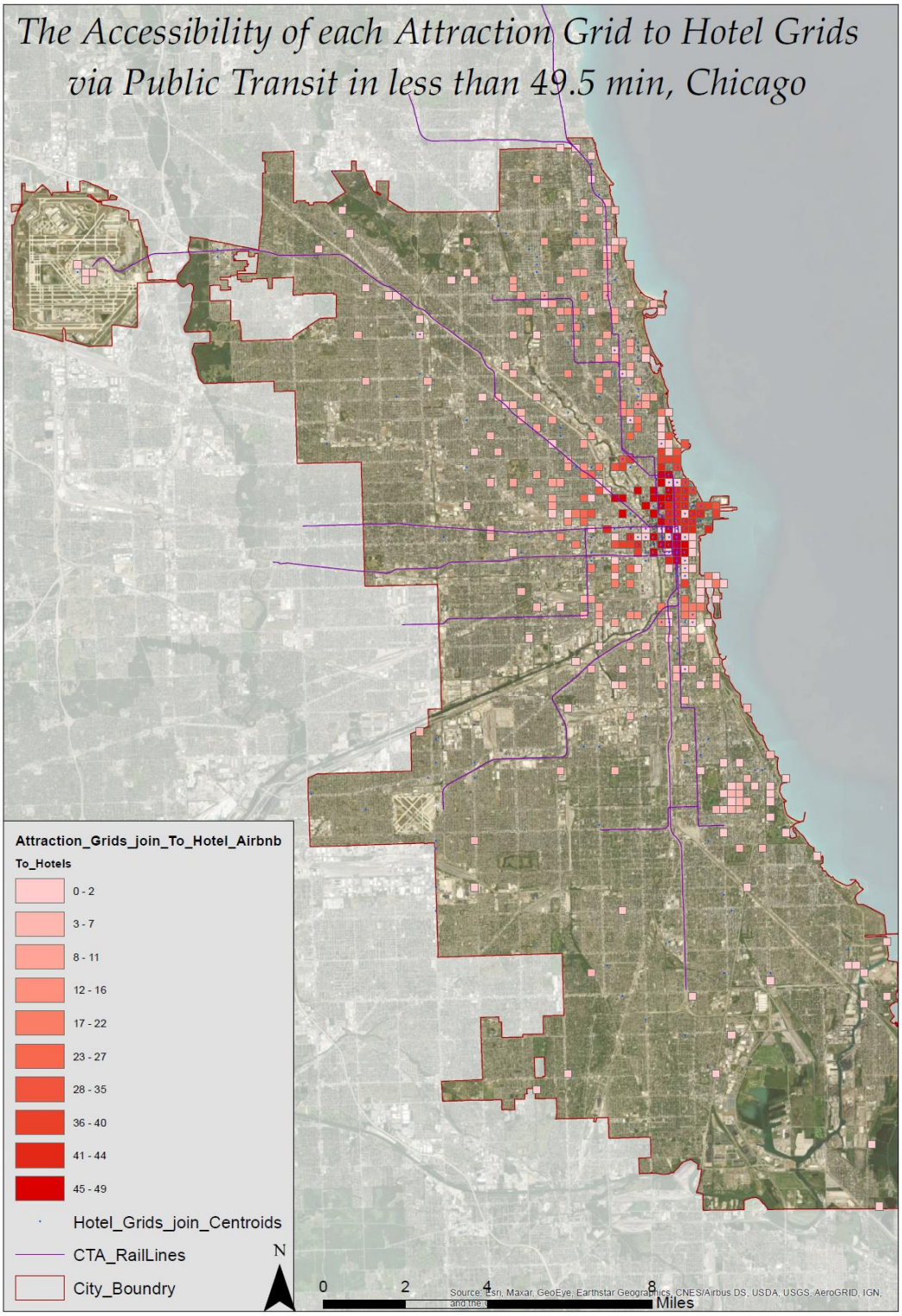

Figure 42: Attraction to hotel accessibility via public Transit, Chicago

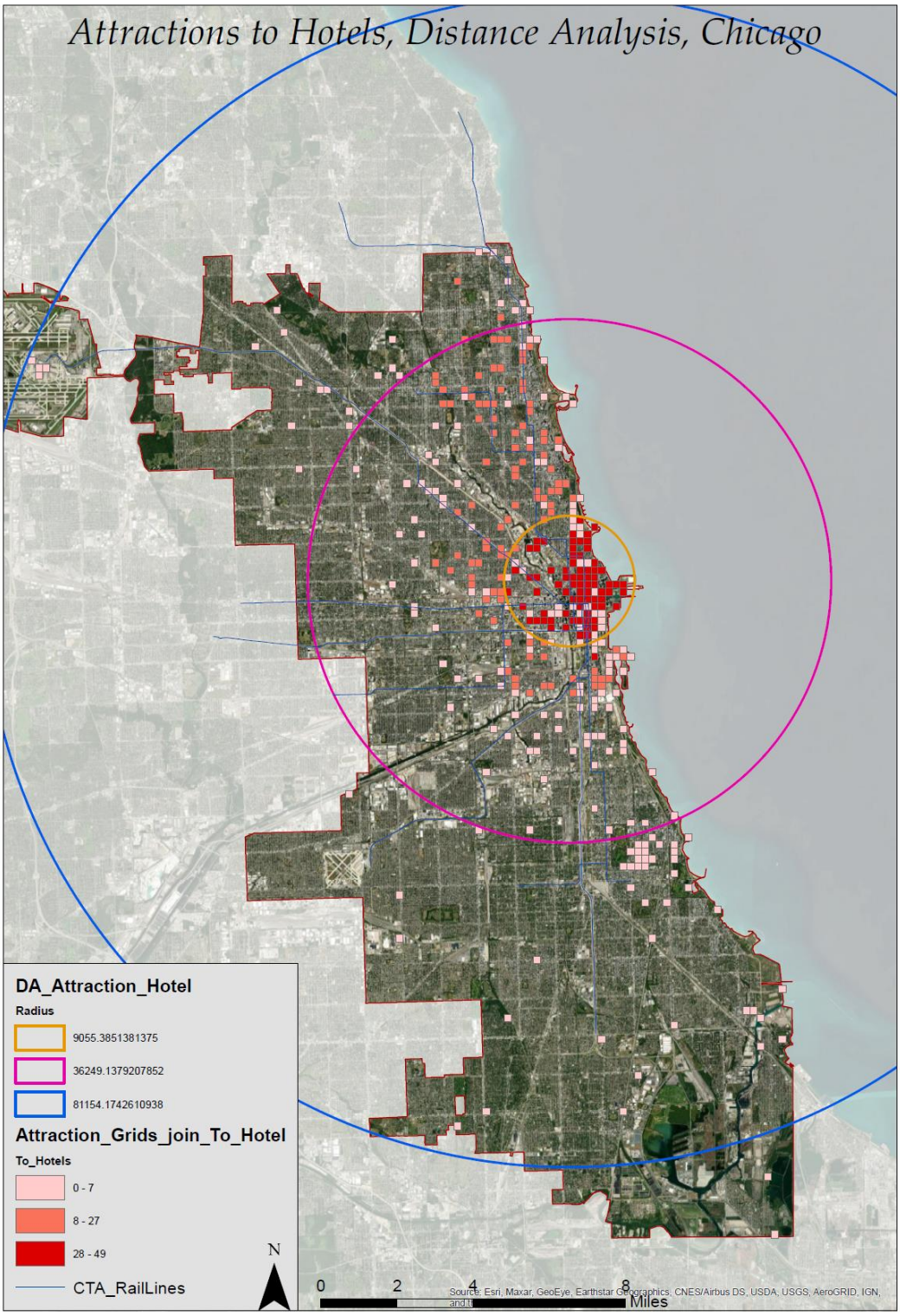

Figure 43: Attraction to hotel distance analysis, Chicago

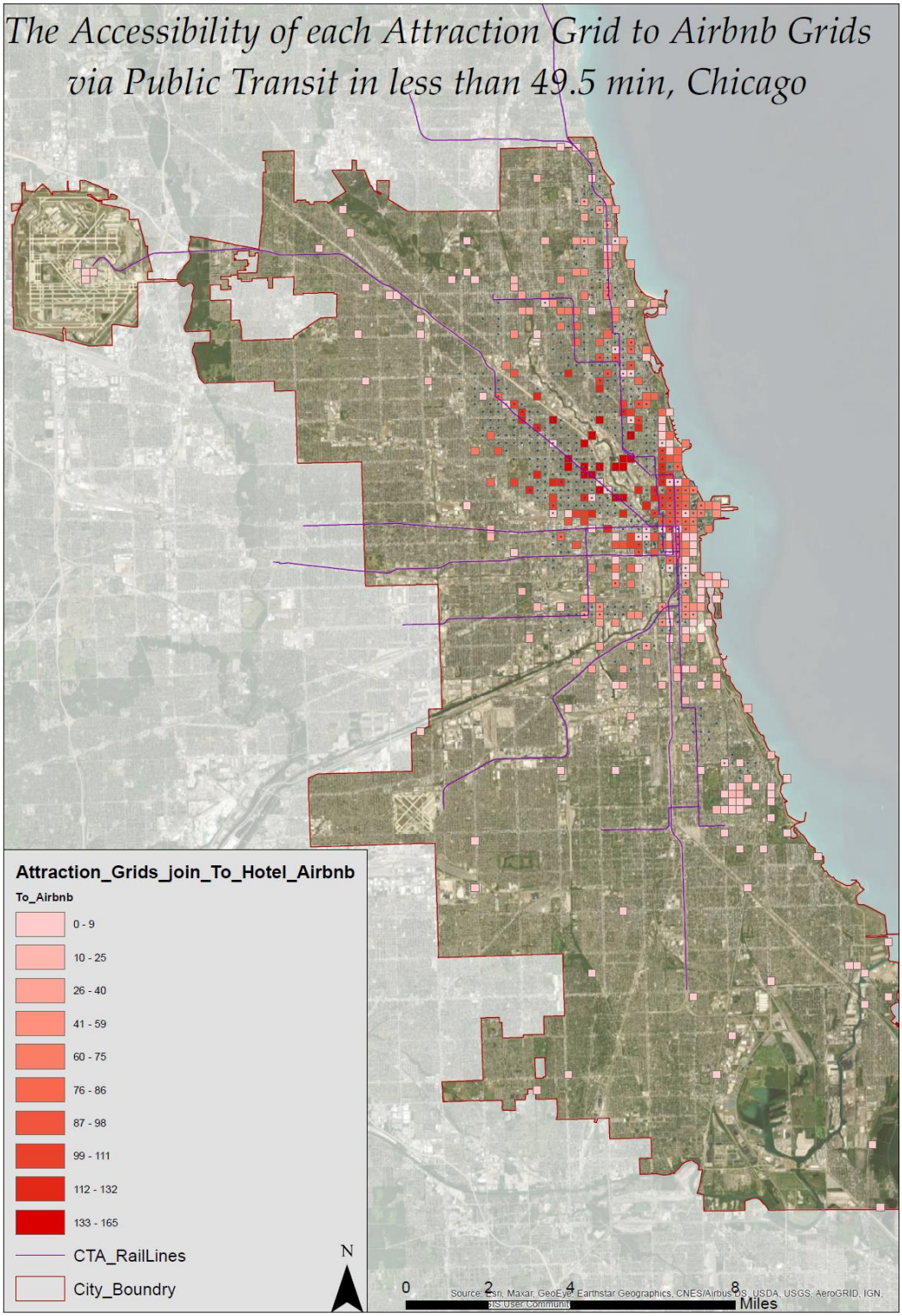

Figure 44: Attraction to Airbnb accessibility via public Transit, Chicago

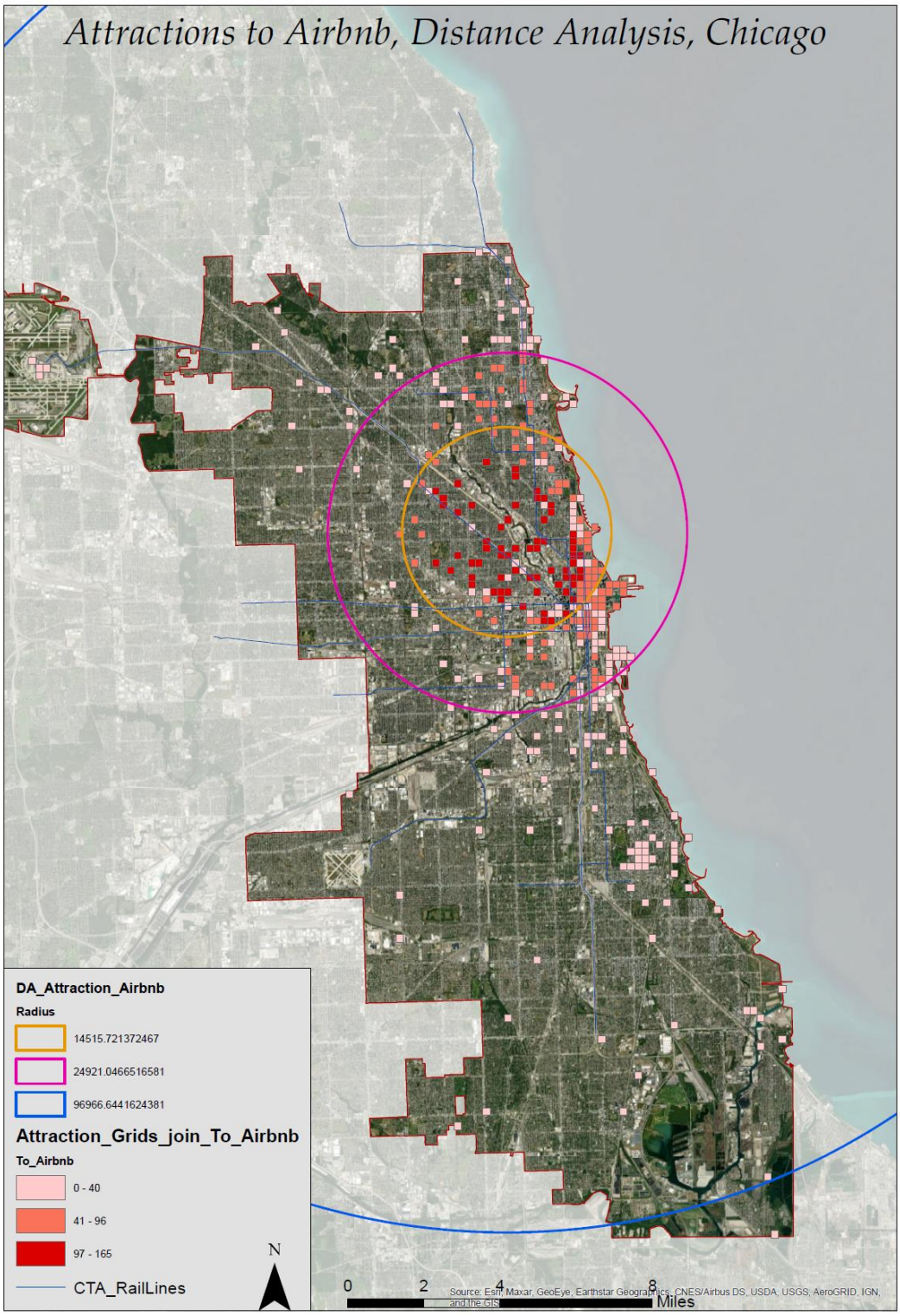

Figure 45: Attraction to Airbnb distance analysis, Chicago

Austin, Texas Accessibility

According to the Hotels–Attractions grids map, visitors staying in one of the darkest brown grids can reach up to 56 of Austin's attractions grids using the city's public transportation in less than a 39.9-minute timeframe. Seventeen of the 169 hotel grids have public transit access to approximately a quarter of the city's attractions (47) in less than 39.9 minutes (Figure 46).

As shown in the Hotels–Attractions distance analysis map, those grids with access to the highest number of attractions (40–56) are within a radius of ~5,500 feet of Austin's downtown area. In contrast, grids with access to a medium number of attractions (12–39) are within the radius of ~10,000 feet of the original center, whereas grids with access to a low number of attractions (0–11) are within a radius of ~79,000 feet from the original center (Figure 47).

According to the Airbnbs–Attractions map, if a visitor stays in one of the darkest brown grids, they can reach up to 58 of Austin's attractions using public transportation in less than 39.5 minutes. Fifty-four of the 232 Austin Airbnb grids have public transit access to approximately one-third of the city's attractions in less than 39.9 minutes (Figure 48).

The Airbnbs–Attractions distance analysis map illustrates that Airbnb grids with access to the highest number of attractions (35–58) are within a radius of ~7,900 feet of Austin's downtown area. Grids with access to a medium number of attractions (16–34) are within a radius of ~12,000 feet of the original center, and grids with access to a low number of attractions (0–15) are within a radius of ~26,400 feet of the original center (Figures 49).

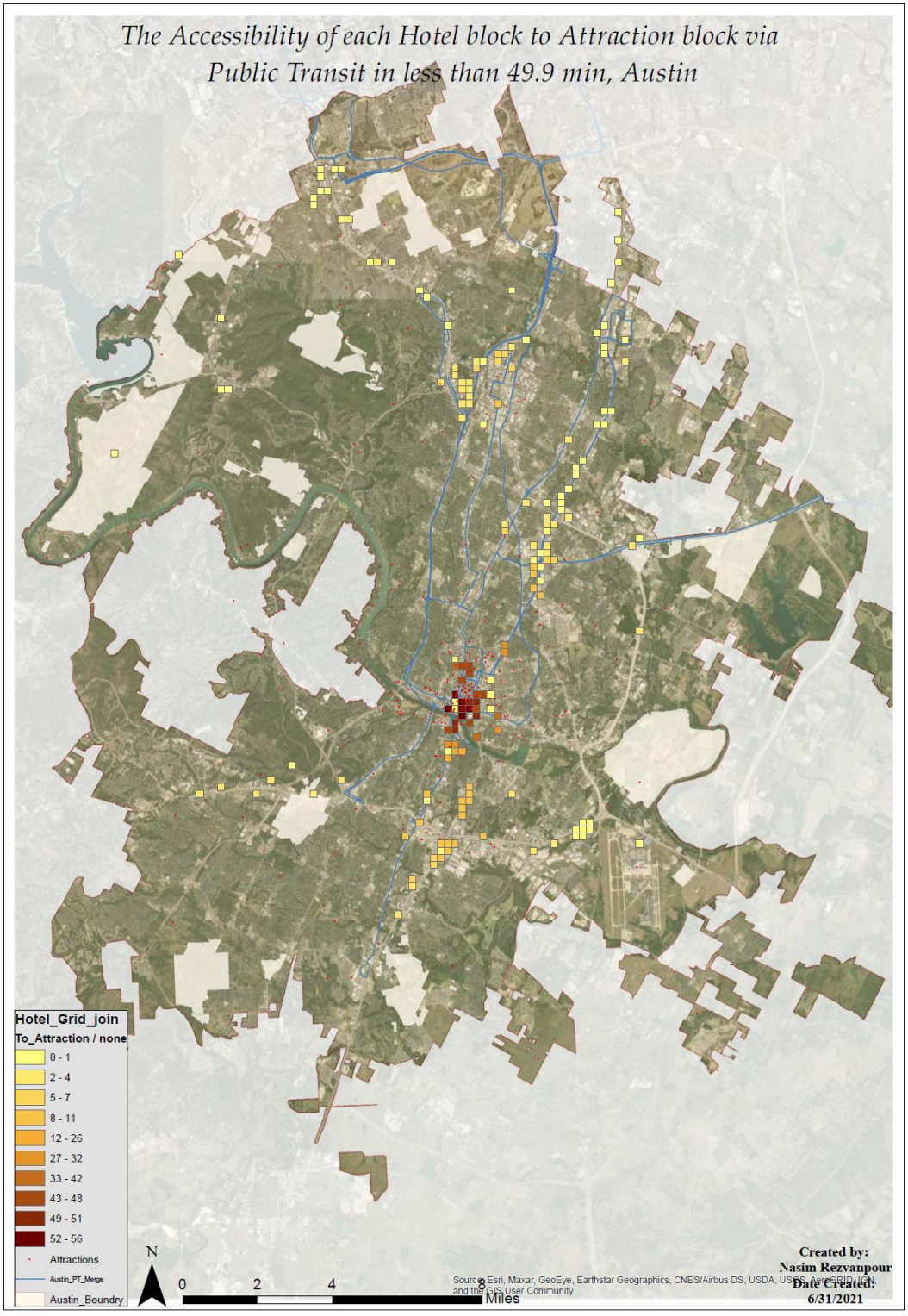

Figure 46: Hotel to attraction accessibility via public Transit, Austin

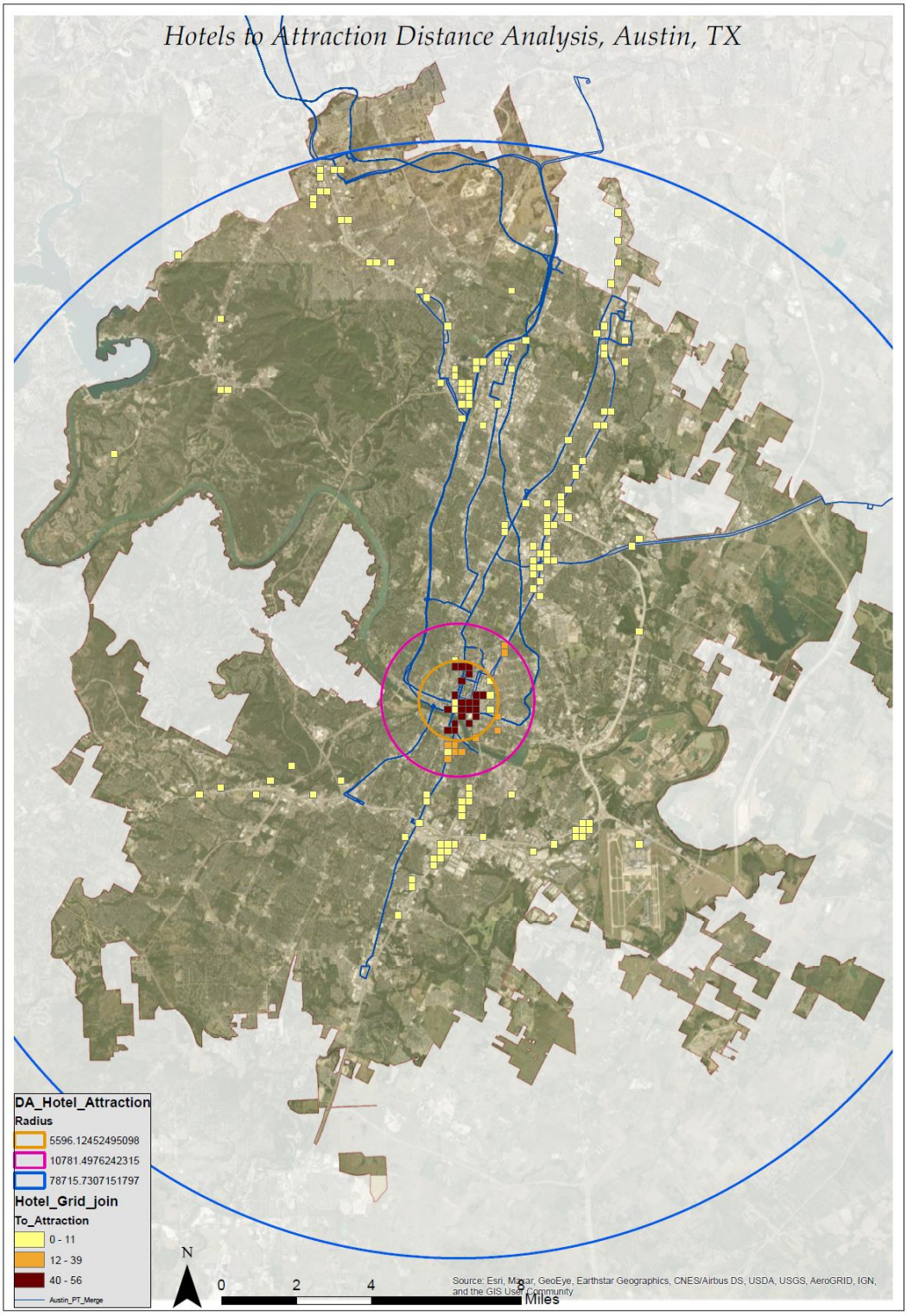

Figure 47: Hotel to attraction distance analysis, Austin

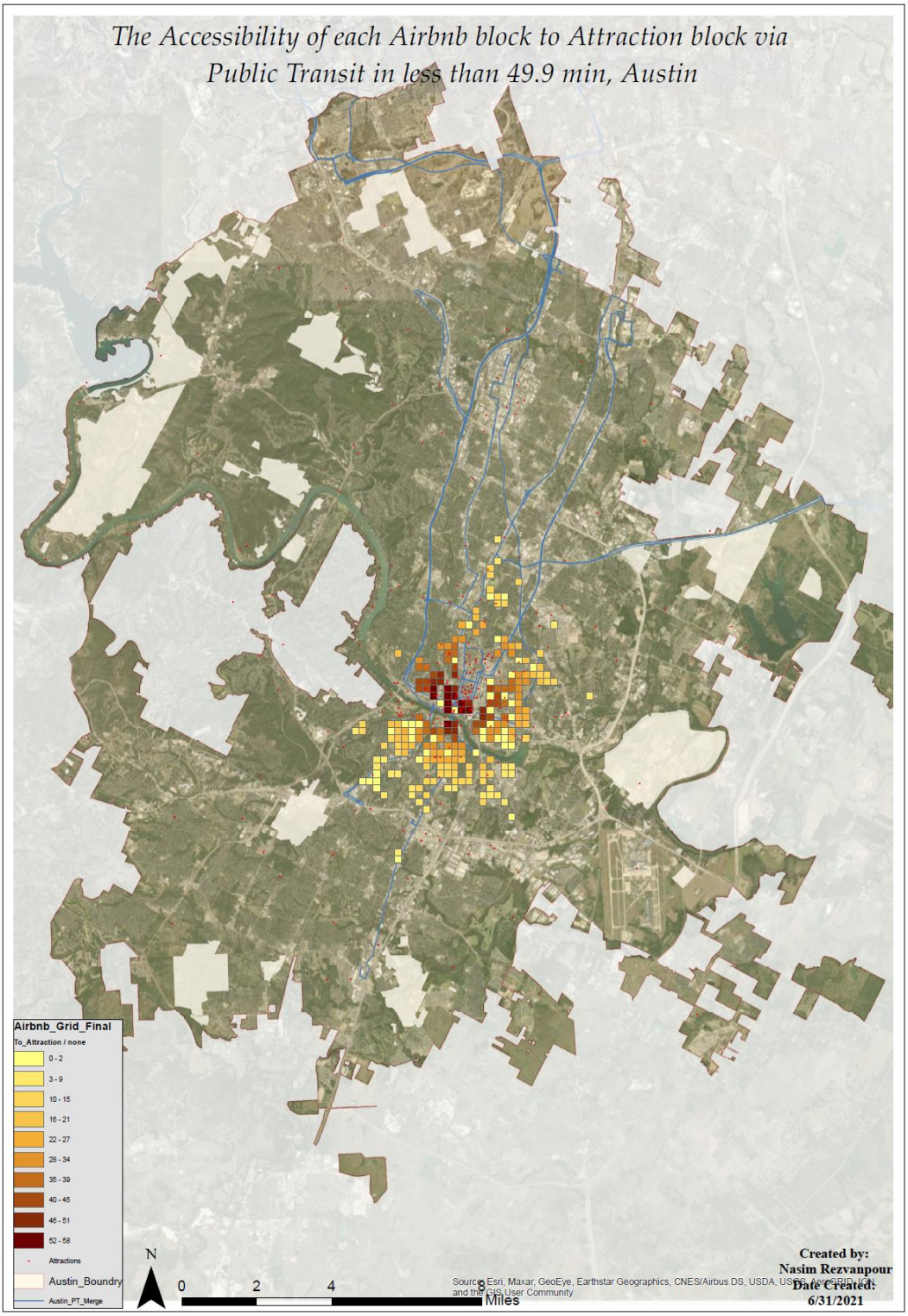

Figure 48: Airbnb to Attraction accessibility via public Transit, Austin

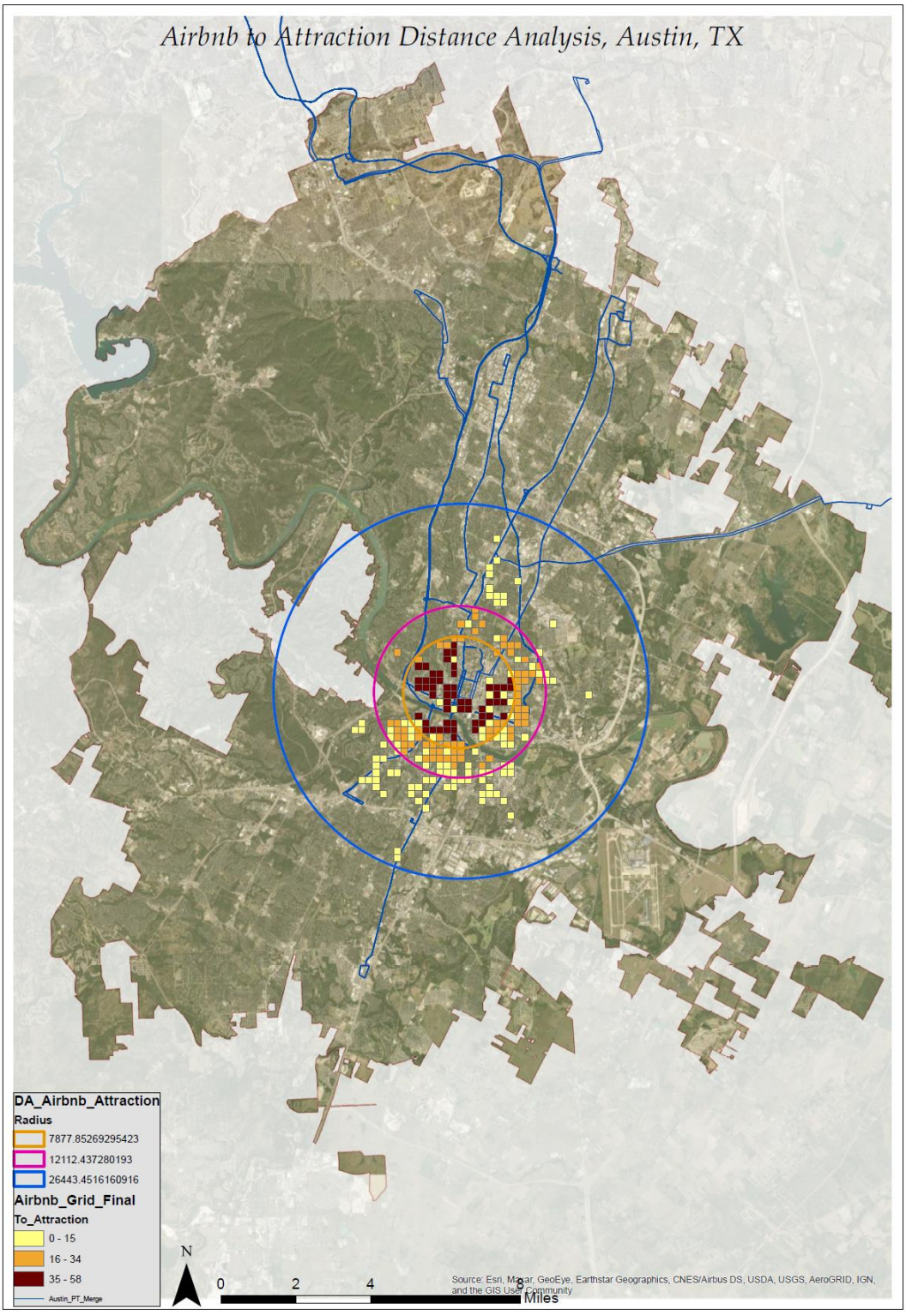

Figure 49: Airbnb to attraction distance analysis, Austin

According to the Attractions–Hotels map, among a total of 188 attractions grids, 39 located in the downtown area have public transit access to approximately 18% of Austin's hotels in less than 39.9 minutes (Figure 50).

The Attractions–Hotels distance analysis map shows that those attraction grids with access to the highest number of hotels (21–31) are within a radius of ~8,000 feet of Austin's downtown area. In contrast, grids with access to a medium number of hotels (9–20) are within a radius of ~25,500 feet from the original center, while grids with access to a low number of hotels (0–8) are within a radius of ~72,400 feet from the original center (Figure 51).

According to the Attractions–Airbnbs map, among 188 attractions grids, 38 grids located in the downtown area have public transit access to roughly half of the city's Airbnbs in less than 39.9 minutes (Figure 52).

As shown by the Attractions–Airbnbs distance analysis map, attraction grids with access to the highest number of Airbnbs (63–94) are within a radius of ~8,100 feet of Austin's downtown area. Grids with access to a medium number of Airbnbs (24–62) are within a radius of ~15,000 feet of the original center. Finally, grids with access to a low number of Airbnbs (0–23) are within a radius of ~76,200 feet of the original center (Figure 53).

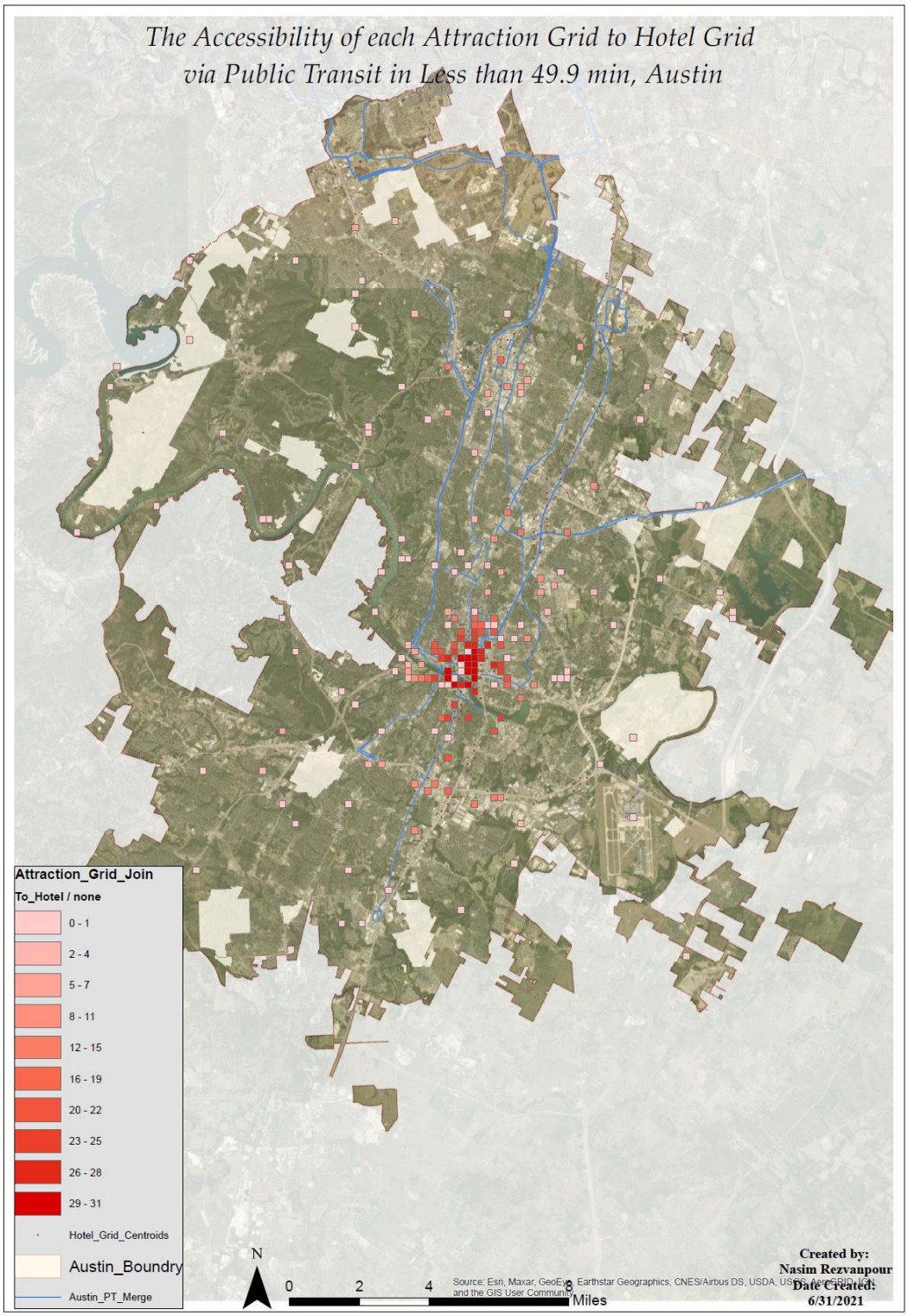

Figure 50: Attraction to hotel accessibility via public transit, Austin

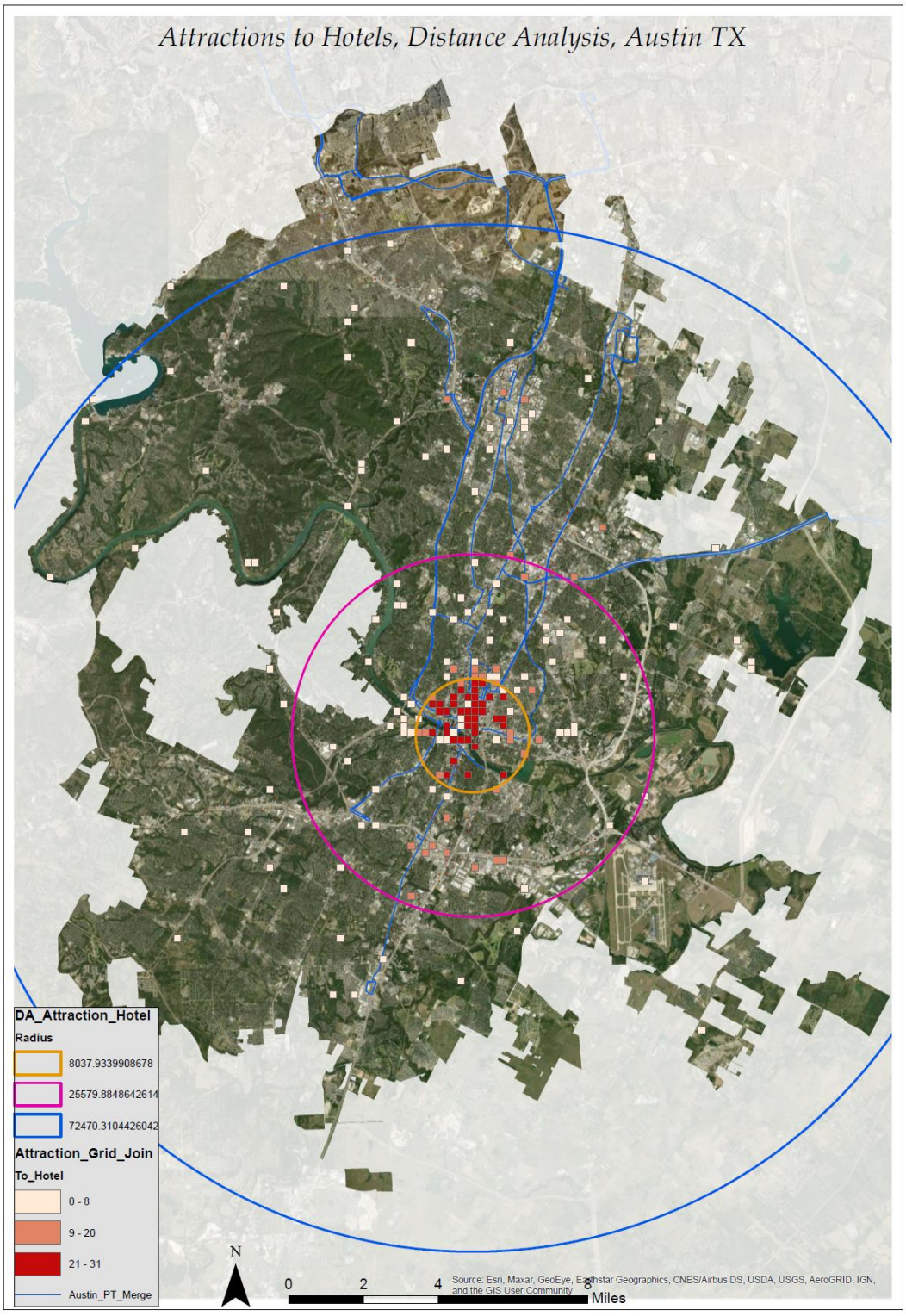

Figure 51: Attraction to hotel distance analysis, Austin

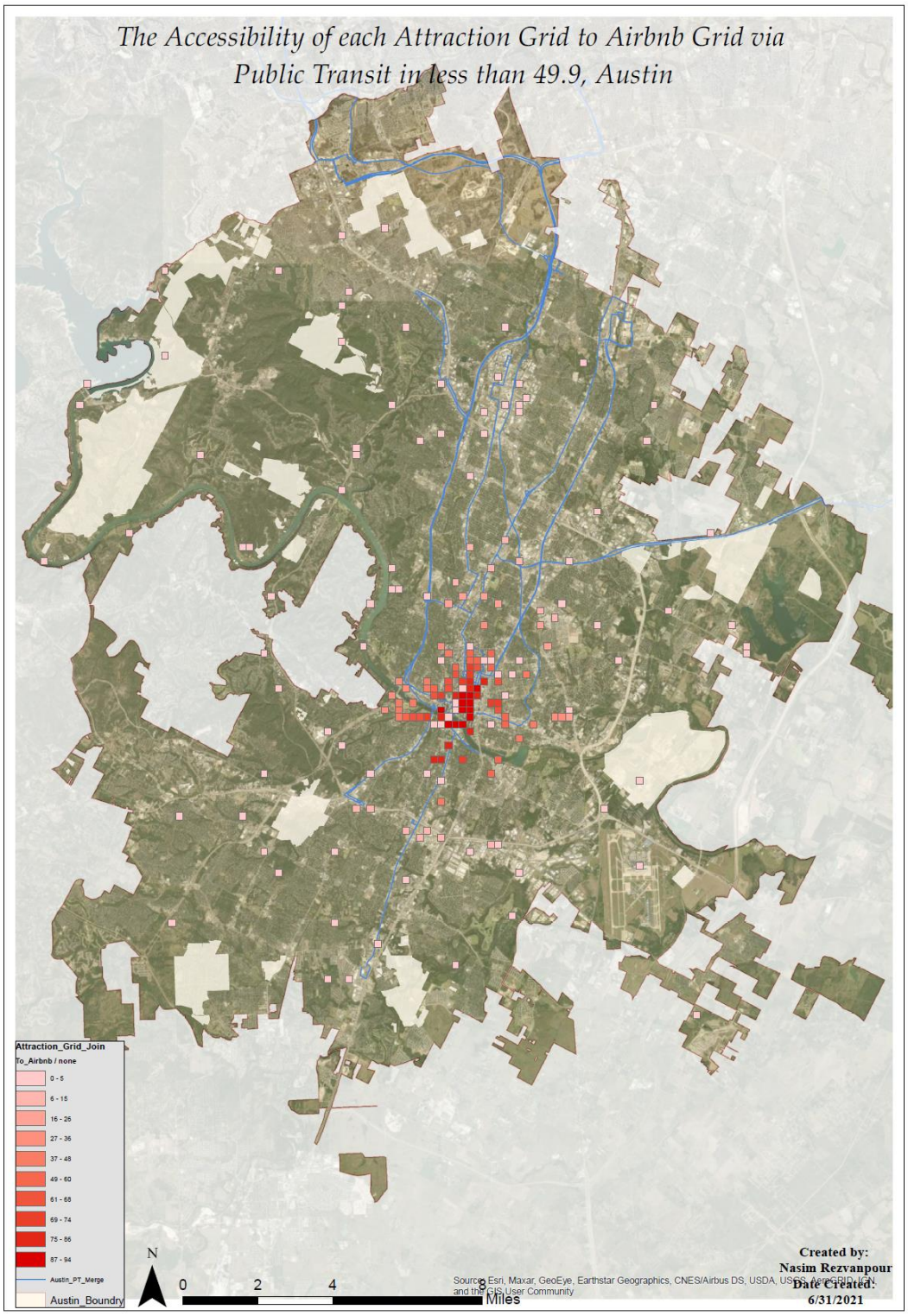

Figure 52: Attraction to Airbnb accessibility via public transit, Austin

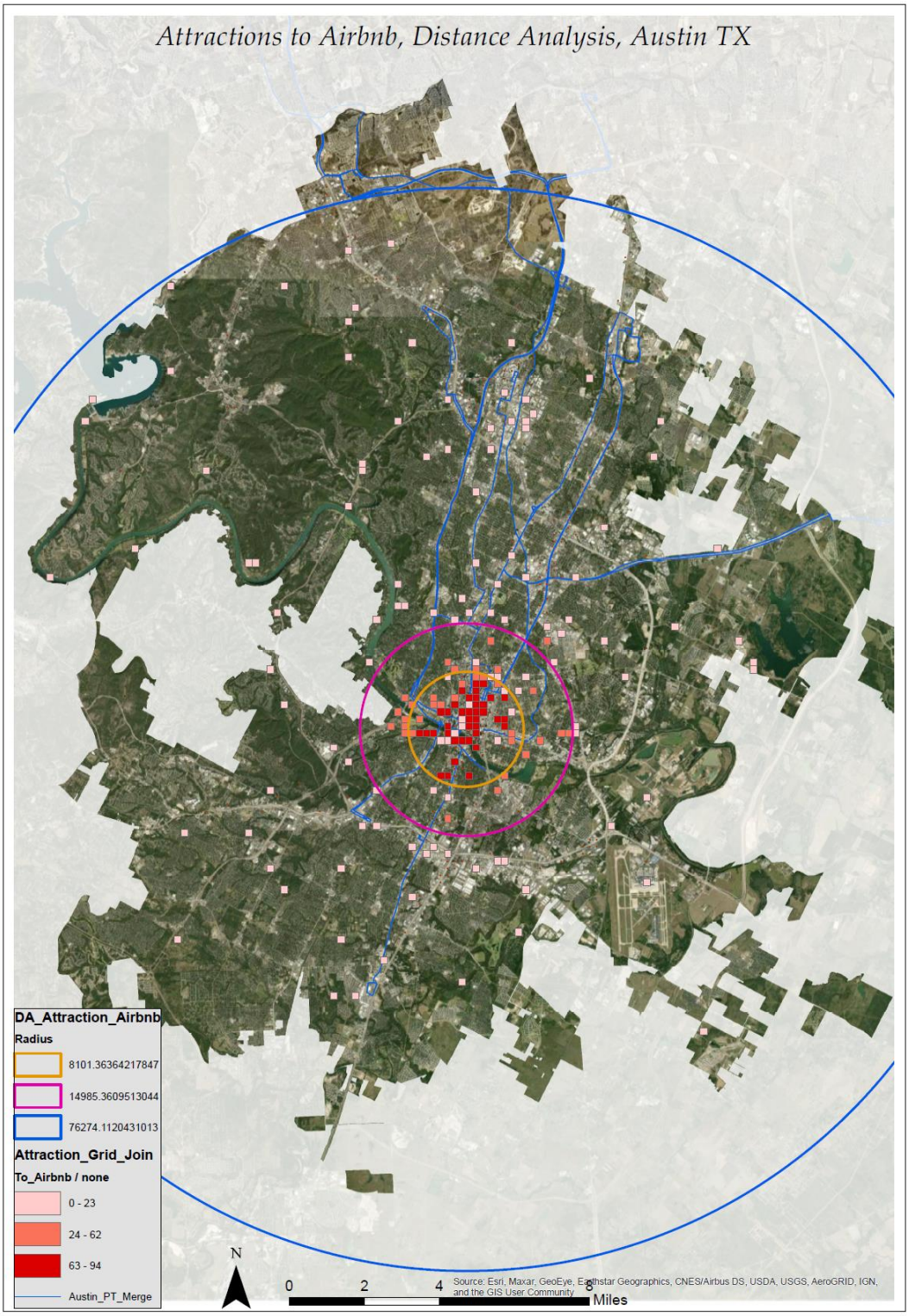

Figure 53: Attraction to Airbnb distance analysis, Austin

San Francisco, California Accessibility

As indicated by the Hotels–Attractions grid map, a visitor staying in one of the darkest brown grids can reach up to 139 of San Francisco's attractions grids using the city's public transportation in less than 46.9 min. Forty-seven of the 122 hotel grids have public transit access to approximately half of the city's attractions (150) in less than 46.9 minutes (Figure 54).

Based on the Hotels–Attractions distance analysis map, those grids with access to the highest number of attractions (124–158) are within a radius of ~7,100 feet in San Francisco's Downtown. The grids with access to a medium number of attractions (22–123) are within a radius of ~15,000 feet from the original center. Finally, the grids that have access to a low number of attractions (0–21) are within a radius of ~30,000 feet from the original center (Figure 55).

As indicated by the Airbnbs–Attractions map, visitors staying in one of the darkest brown grids can reach up to 158 of San Francisco's attractions using public transportation in less than 46.9 minutes. Forty-eight of the 121 Airbnb grids have public transit access to approximately half of the city's attractions in less than 46.9 minutes (Figure 56).

Based on the Airbnbs–Attractions distance analysis map, those Airbnb grids with access to the highest number of attractions (113–158) are within a radius of ~7,800 feet of San Francisco's downtown area. Grids with access to a medium number of attractions (47–112) are within a radius of ~13,000 feet of the original center, and grids with access to a low number of attractions (0–46) are within a radius of ~16,200 feet from the original center (Figure 57).

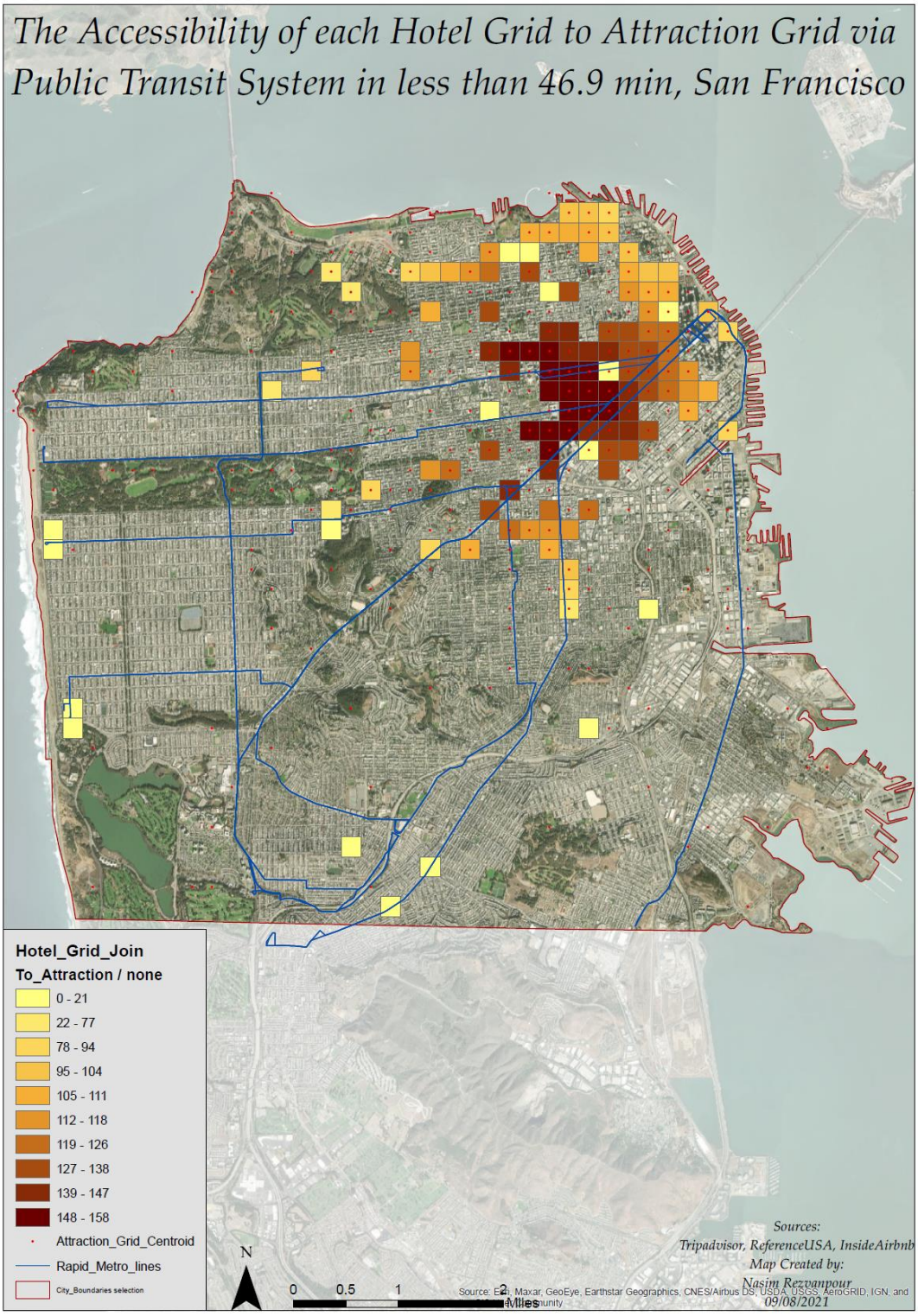

Figure 54: Hotel to attraction accessibility via public transit, San Francisco

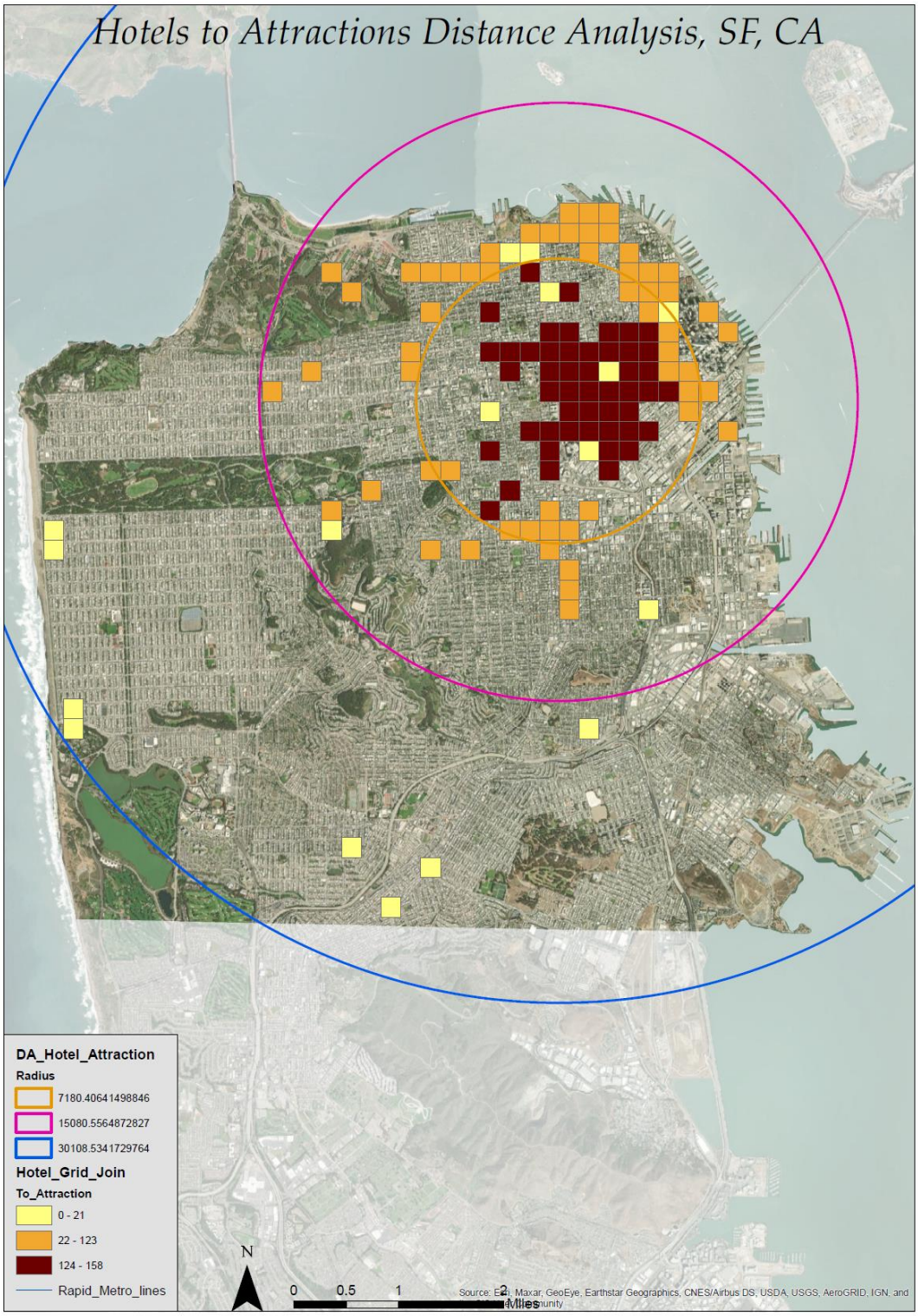

Figure 55: Hotel to attraction distance analysis, San Francisco

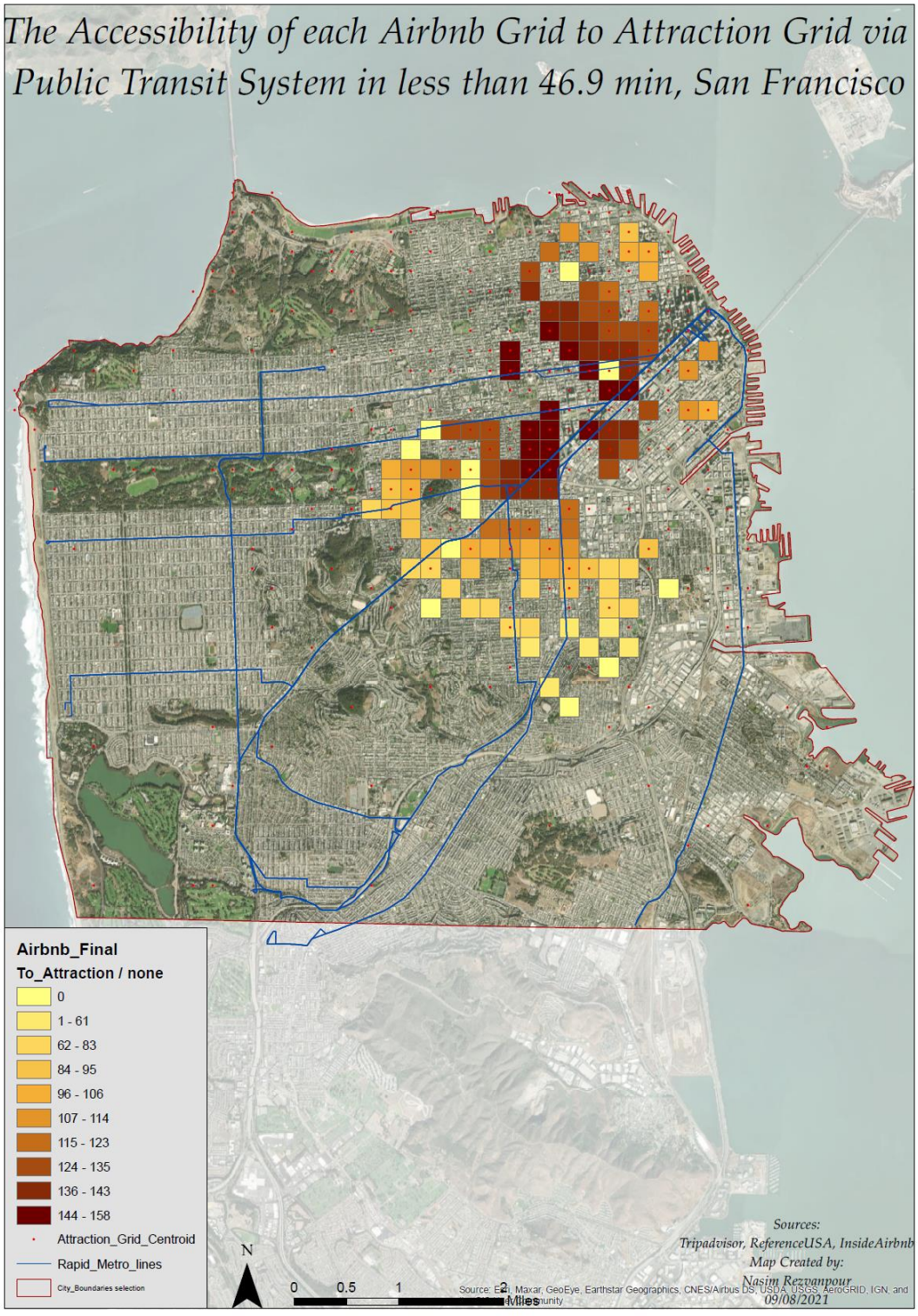

Figure 56: Airbnb to attraction accessibility via public transit, San Francisco

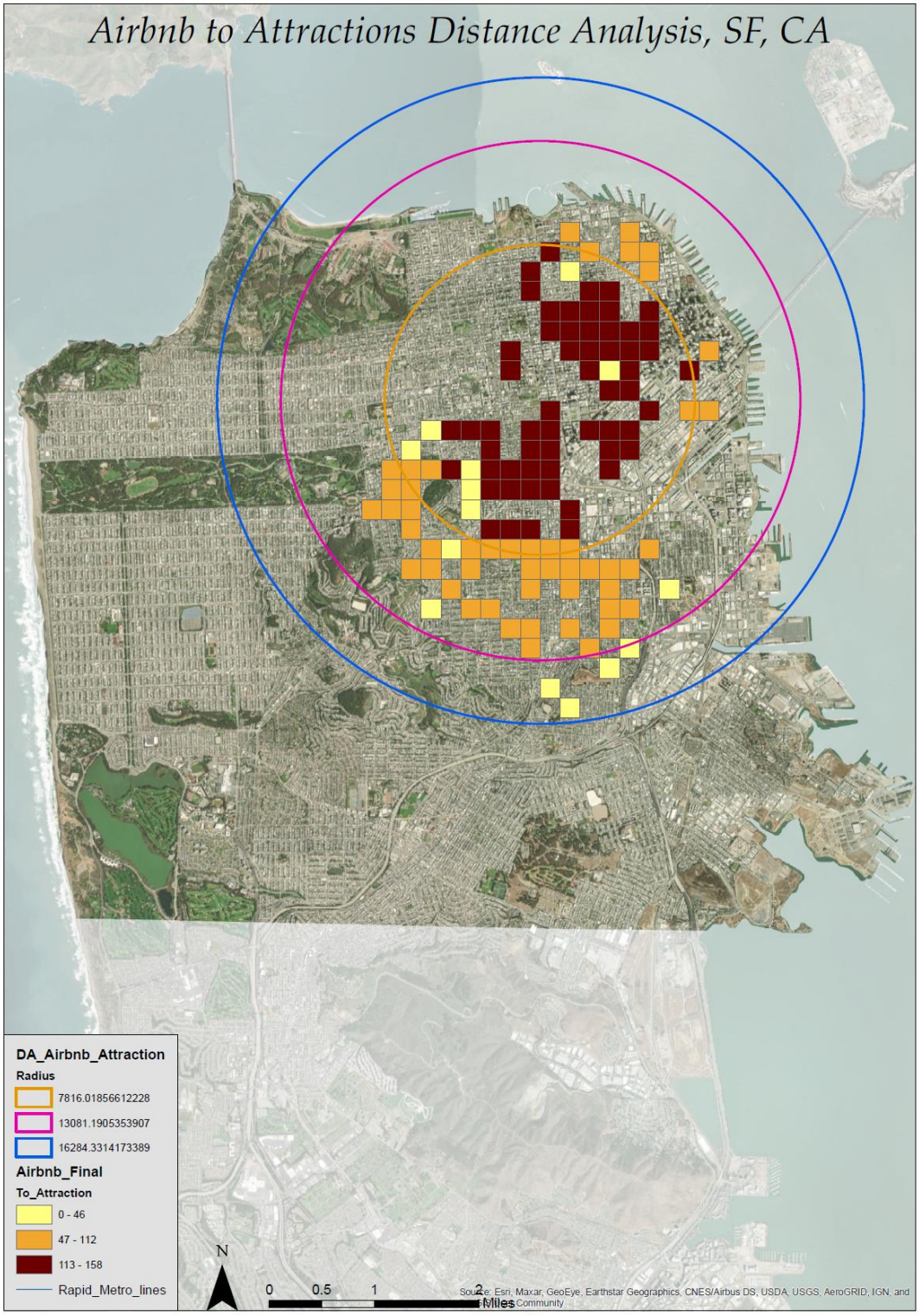

Figure 57: Airbnb to attraction distance analysis, San Francisco

As shown by the Attractions–Hotels map, of the 294 attractions grids, 53 have public transit access to approximately half of the city's hotels in less than 46.9 minutes (Figure 58).

The Attractions–Hotels distance analysis map shows that those attraction grids with access to the highest number of hotels (62–97) are within a radius of ~8,600 feet of San Francisco's downtown area. Grids with access to a medium number of hotels (27–61) are within a radius of ~13,100 feet of the original center, whereas grids with access to a low number of hotels (0–26) are within a radius of ~36,500 feet of the original center (Figure 59).

Eighty-nine of the 294 attractions grids on the Attractions–Airbnbs map grids have public transit access to approximately all the city's Airbnbs in less than 46.9 minutes (Figure 60).

Based on the Attractions–Airbnbs distance analysis map, those attraction grids with access to the highest number of Airbnbs (66–106) are within a radius of ~8,300 feet of San Francisco's downtown area. Those grids with access to a medium number of Airbnbs (26 – 65) are within a radius of ~13,900 feet of the original center. Finally, grids with access to a low number of Airbnbs (0–25) are within a radius of ~33,000 feet of the original center (Figure 61).

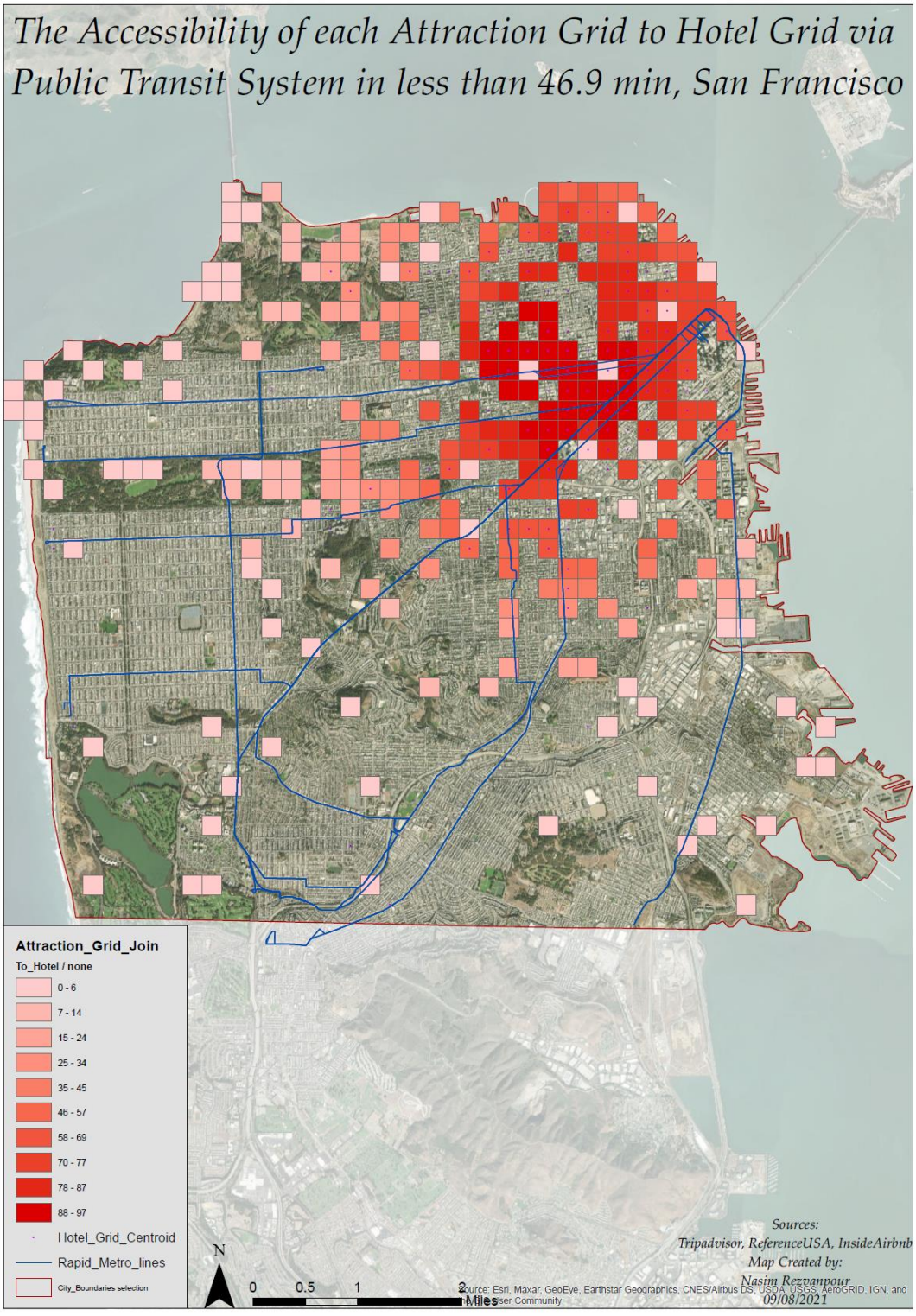

Figure 58: Attraction to hotel accessibility via public transit, San Francisco

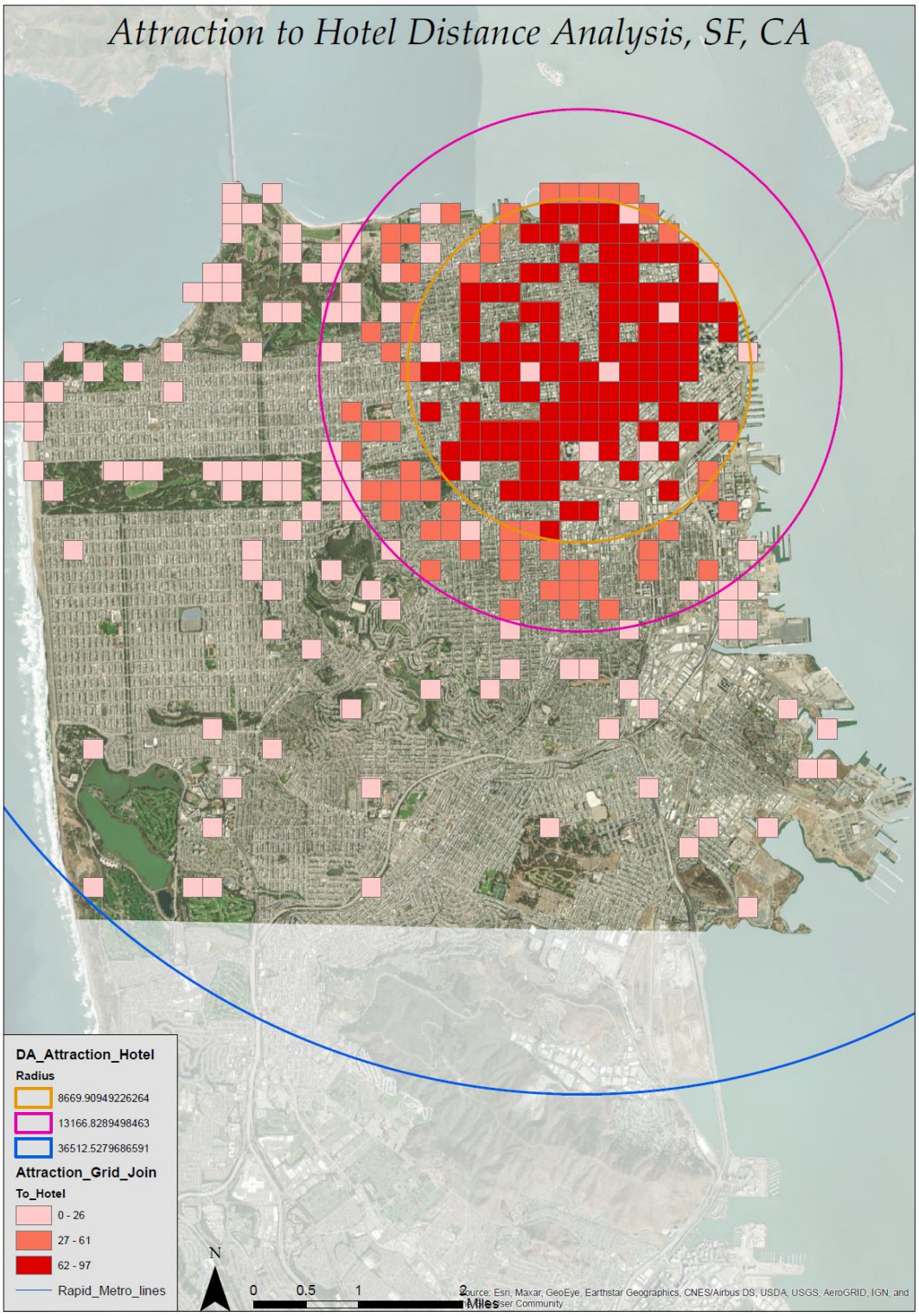

Figure 59: Attraction to hotel distance analysis, San Francisco

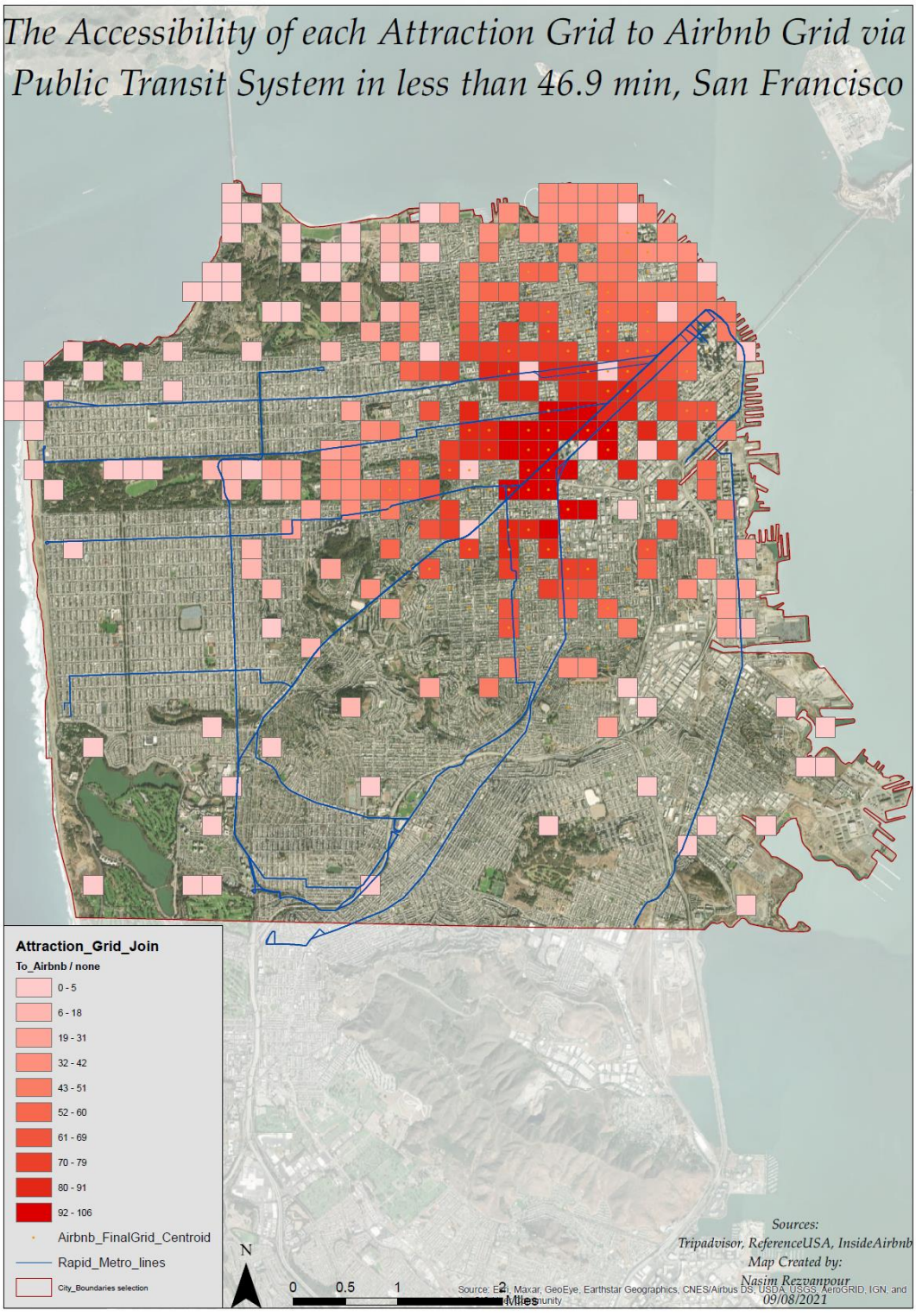

Figure 60: Attraction to Airbnb accessibility via public transit, San Francisco

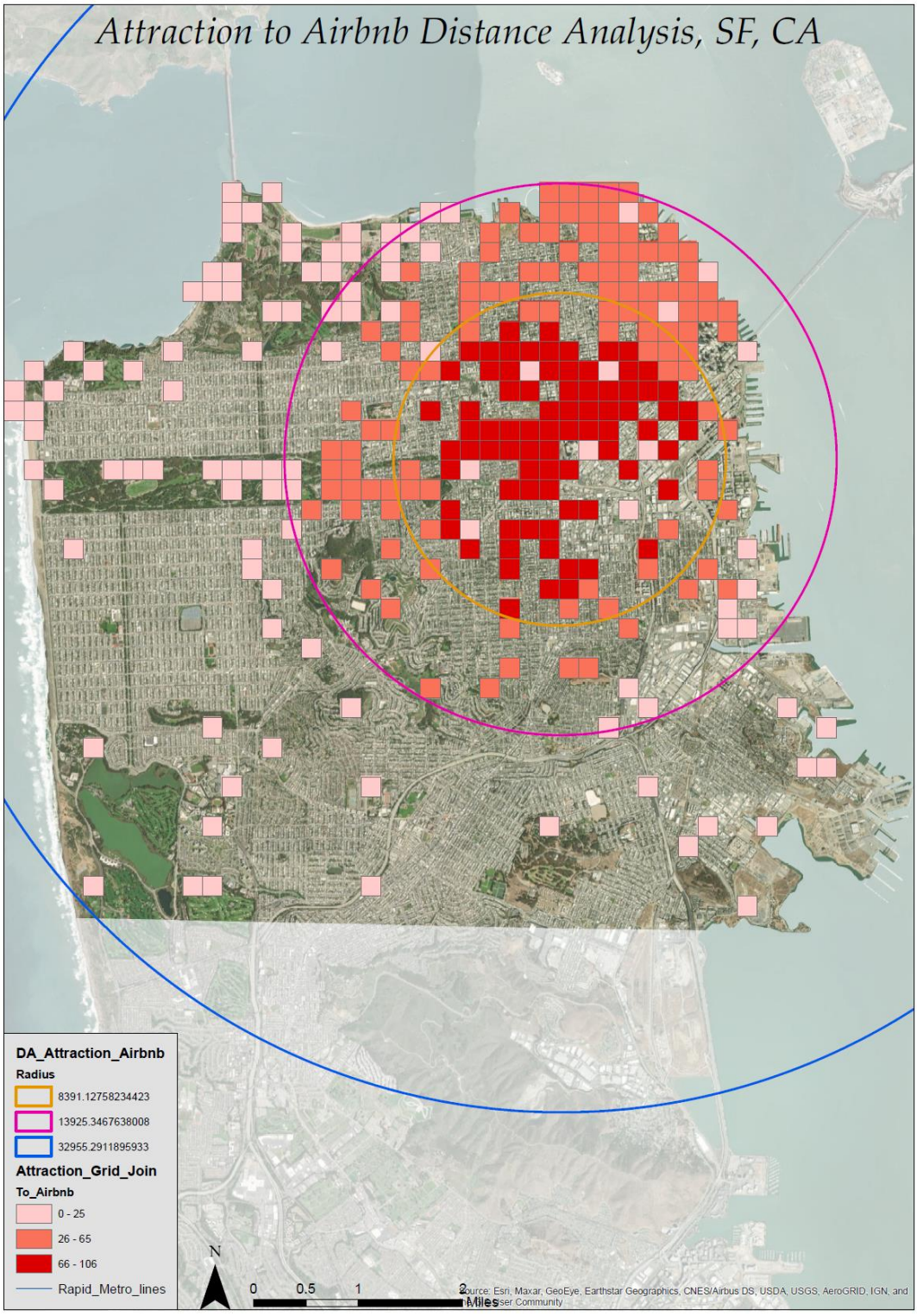

Figure 61: Attraction to Airbnb distance analysis, San Francisco

Los Angeles, California Accessibility

According to the Hotels–Attractions grid map, a visitor staying in one of the darkest brown grids within downtown and Hollywood can reach up to 23 of Los Angeles's attractions grids using the city's public transportation in less than 50.2 minutes. Eighteen of the 300 hotel grids have public transit access to approximately 1/15 of the city's attractions (23) in less than 50.2 minutes (Figure 62).

As shown by the Hotels–Attractions distance analysis map, grids with access to the highest number of attractions (15–23) are within a radius of ~20,000 feet of the downtown and Hollywood areas. In contrast, grids with access to both a medium (6–14) and low (0–5) number of attraction grids are within a radius of ~55,000 feet from the original center (Figure 63).

According to the Airbnbs–Attractions map, visitors staying in one of the darkest brown grids can reach up to 23 Los Angeles attractions using public transportation in less than 50.2 min. Thirty-three of the 462 Airbnb grids have public transit access to approximately 1/15 of the city's attractions in less than 50.2 minutes (Figure 64).

Based on the Airbnbs–Attractions distance analysis map, the grids with access to the highest number of attractions (11–23) are within a radius of ~22,500 feet of the downtown and Hollywood areas, whereas grids with access to a medium (4–10) or low (0–3) number of attraction grids are within a radius of ~ 61,000 feet from the original center (Figure 65).

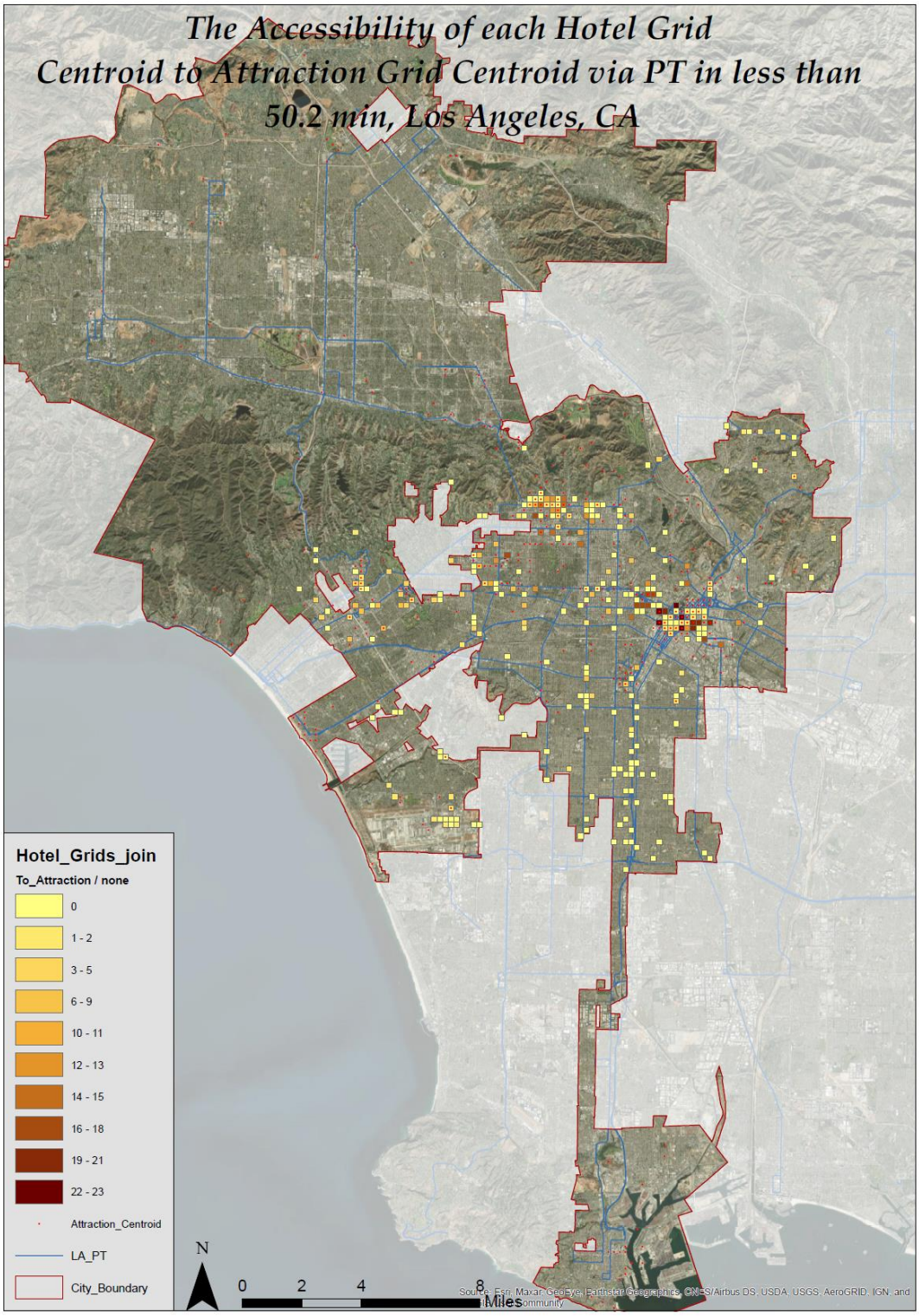

Figure 62: Hotel to Attraction accessibility via public transit, Los Angeles

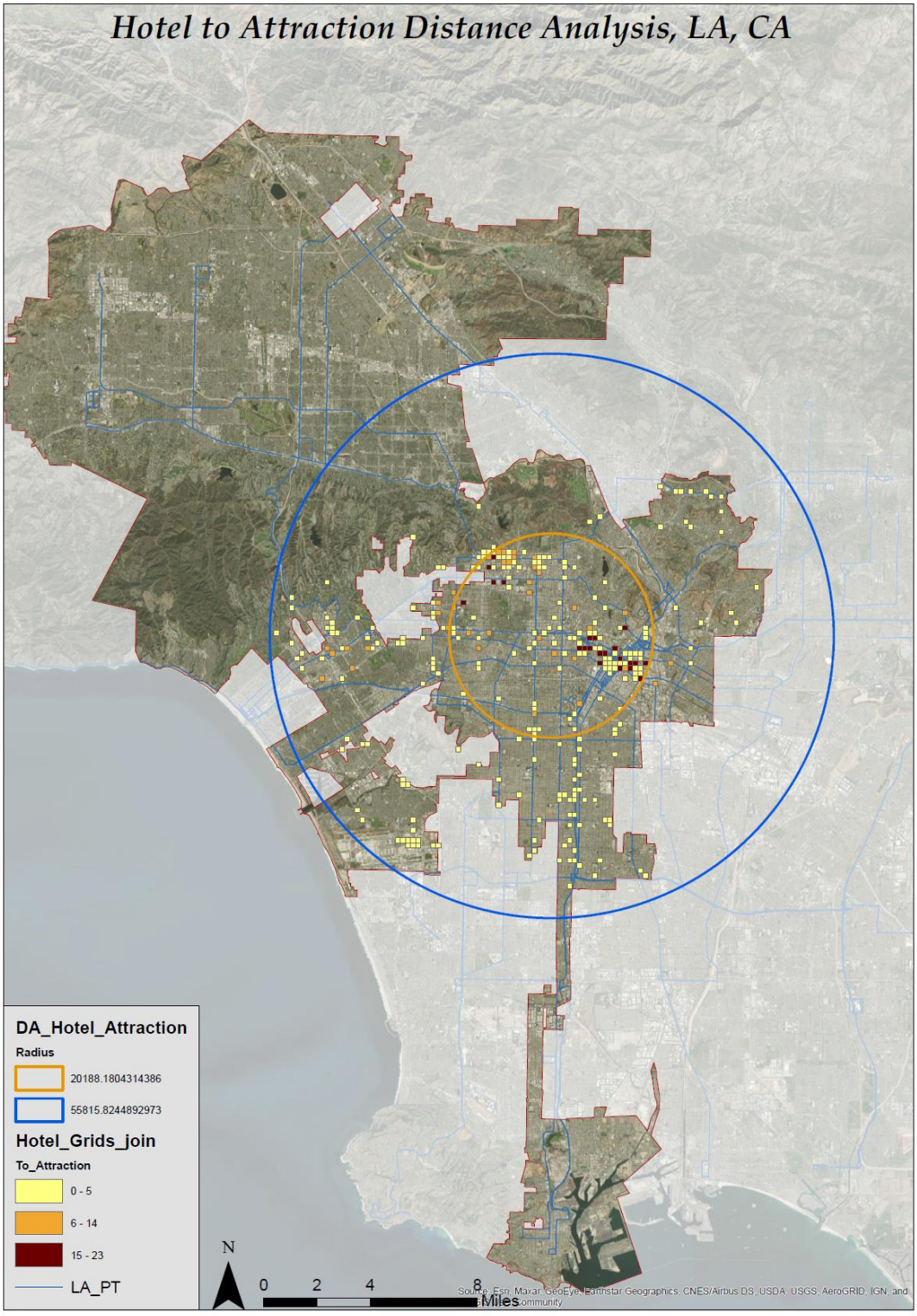

Figure 63: Hotel to attraction distance analysis, Los Angeles

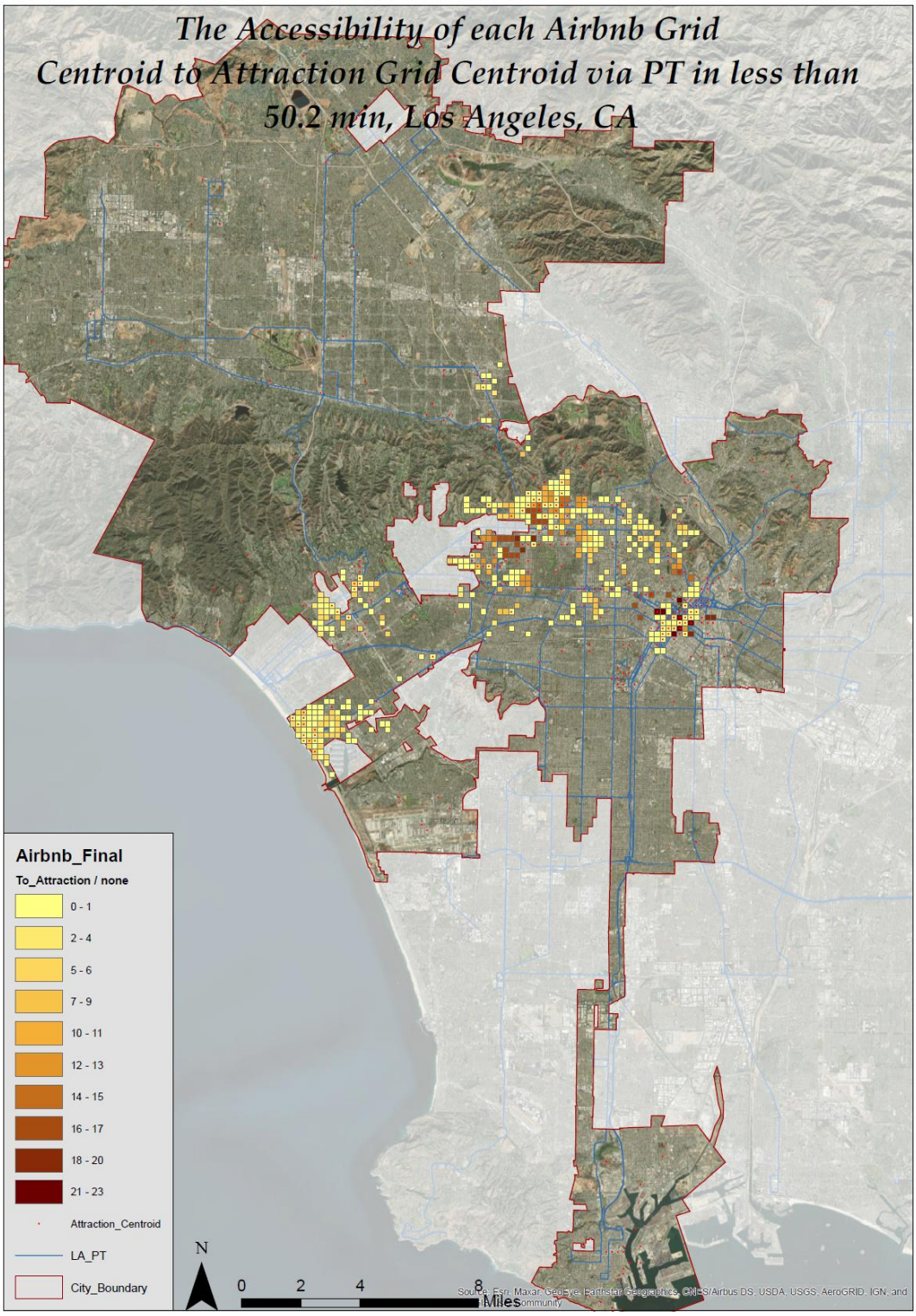

Figure 64: Airbnb to attraction accessibility via public transit, Los Angeles

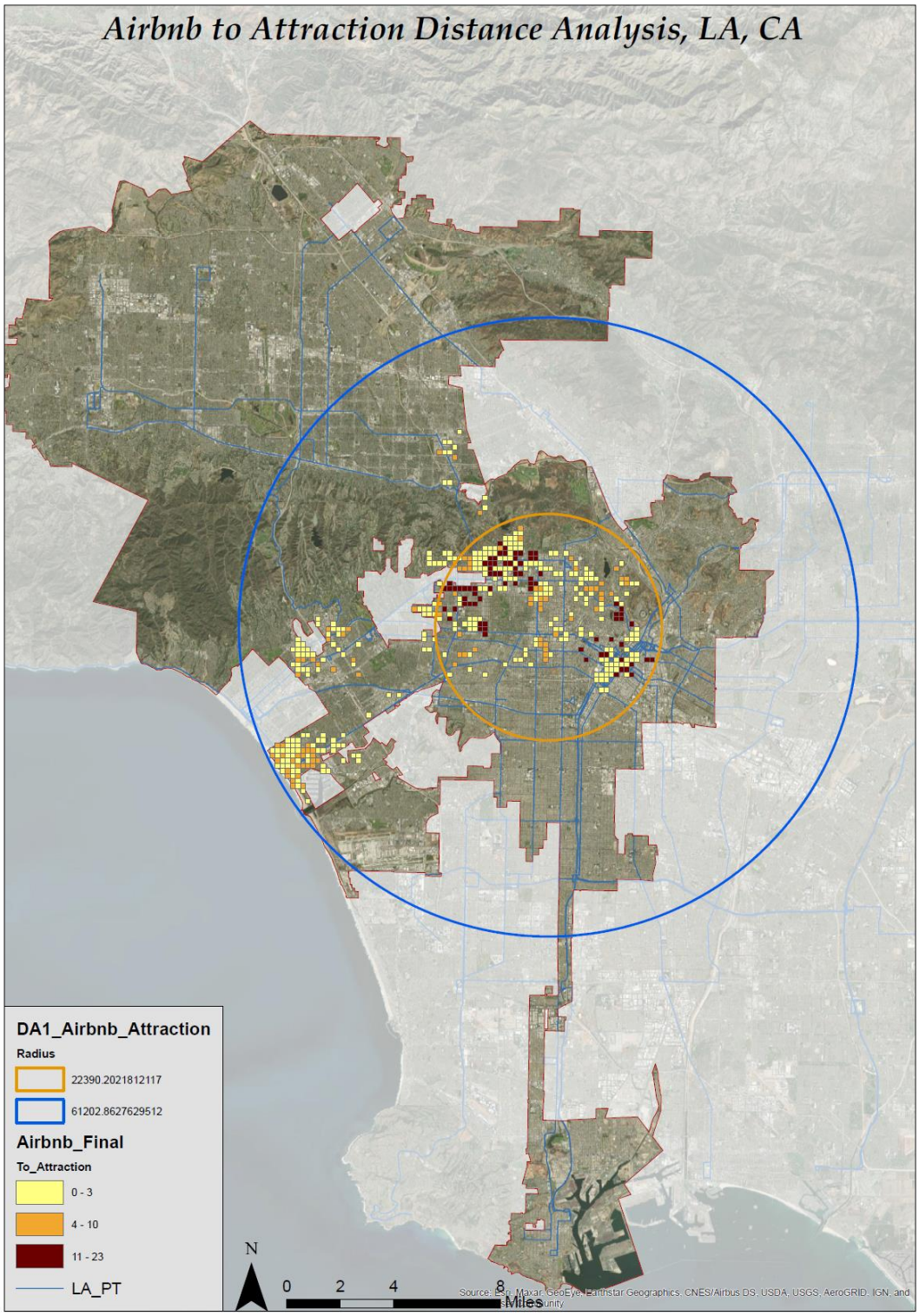

Figure 65: Airbnb to attraction distance analysis, Los Angeles

Just 20 of the 360 attractions grids shown on the Attractions–Hotels map, all located in the downtown and Hollywood areas, have public transit access to approximately 1/8 of the city's Airbnb in less than 50.2 minutes (Figure 66).

As shown by the Attractions–Hotels distance analysis map, those attraction grids with access to the highest number of hotels (15–23) are within a radius of ~19,500 feet from the Los Angeles downtown and Hollywood areas. In contrast, grids with access to a medium number of hotels (6–14) are within a radius of ~48,000 feet from the original center, while grids with access to a low number of hotels (0–5) are within a radius of ~133,000 feet from the original center (Figure 67).

As indicated on the Attractions–Airbnbs map, among the 360 attractions grids, 20 located in the downtown and Hollywood areas have public transportation access to approximately 1/8 of the city's hotels in less than 50.2 minutes (Figure 68).

The Attractions–Airbnbs distance analysis map illustrates that those attraction grids with access to the highest number of Airbnbs (37–62) are within a radius of ~9,100 feet from the Hollywood area. In contrast, grids with access to a medium number of Airbnbs (13–36) are within a radius of ~38,000 feet from the previous center. Finally, grids with access to a low number of Airbnbs (0–12) are within a radius of ~141,000 feet from the original center in the Hollywood area (Figure 69).

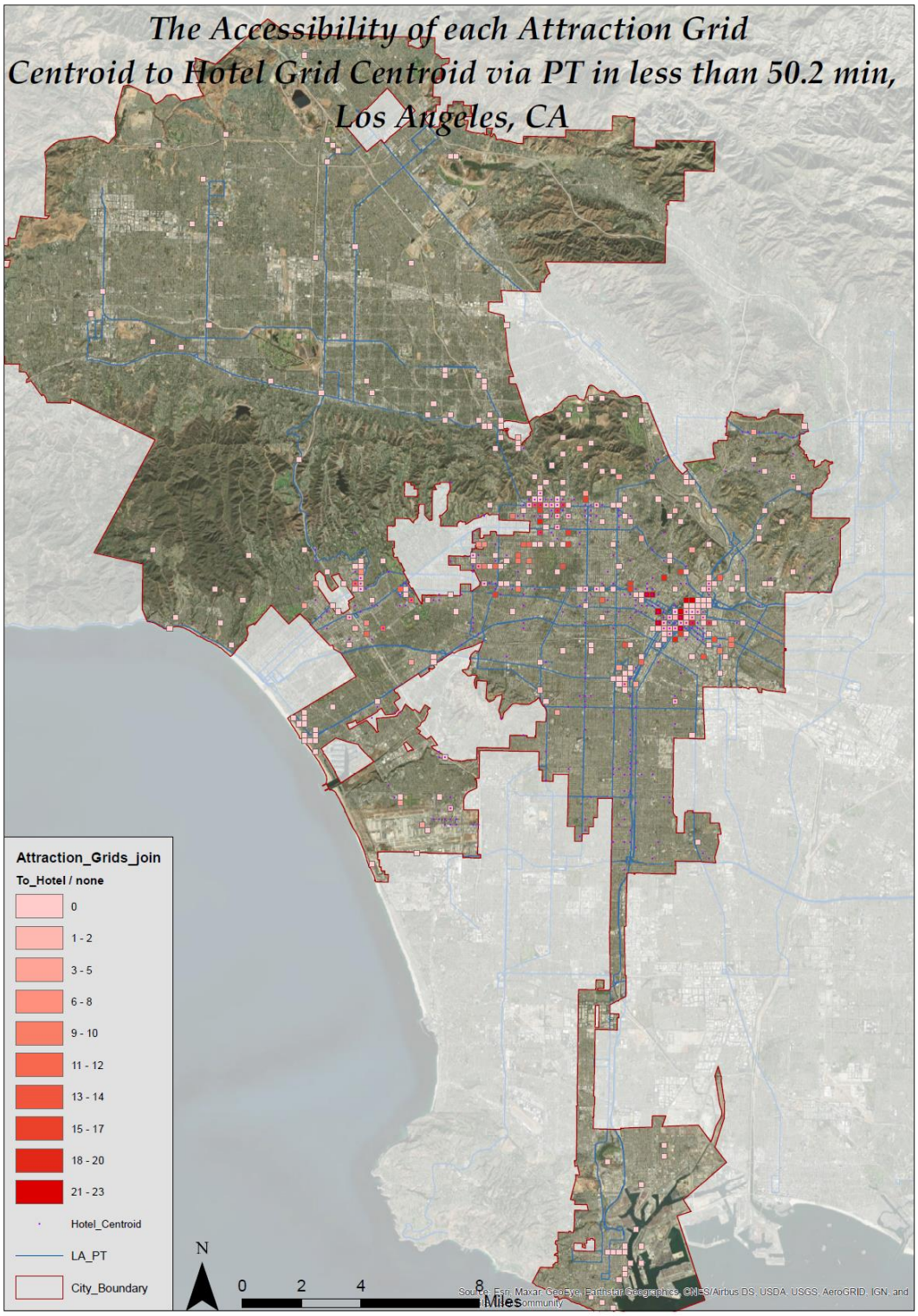

Figure 66: Attraction to hotel accessibility via public transit, Los Angeles

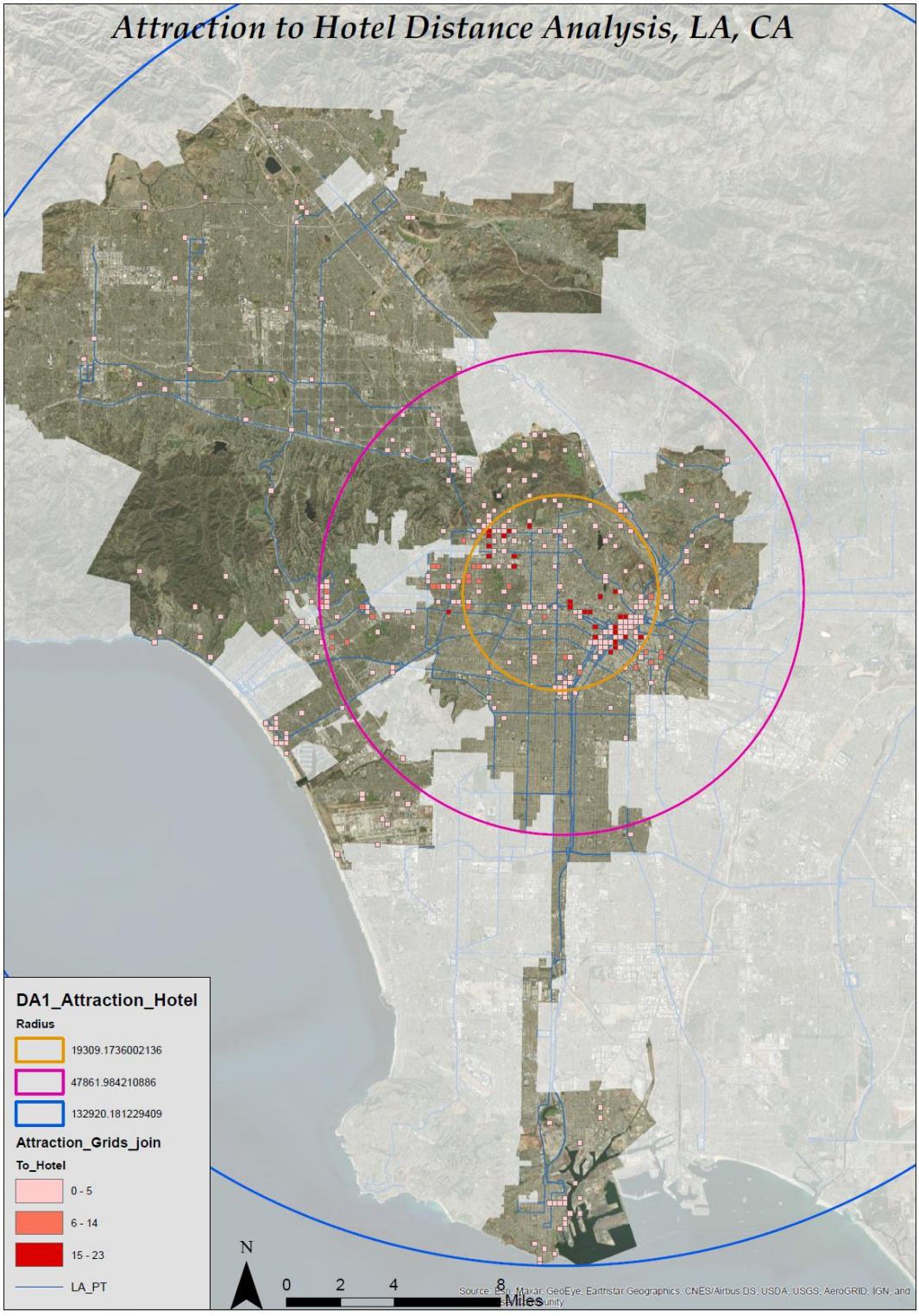

Figure 67: Attraction to hotel distance analysis, Los Angeles

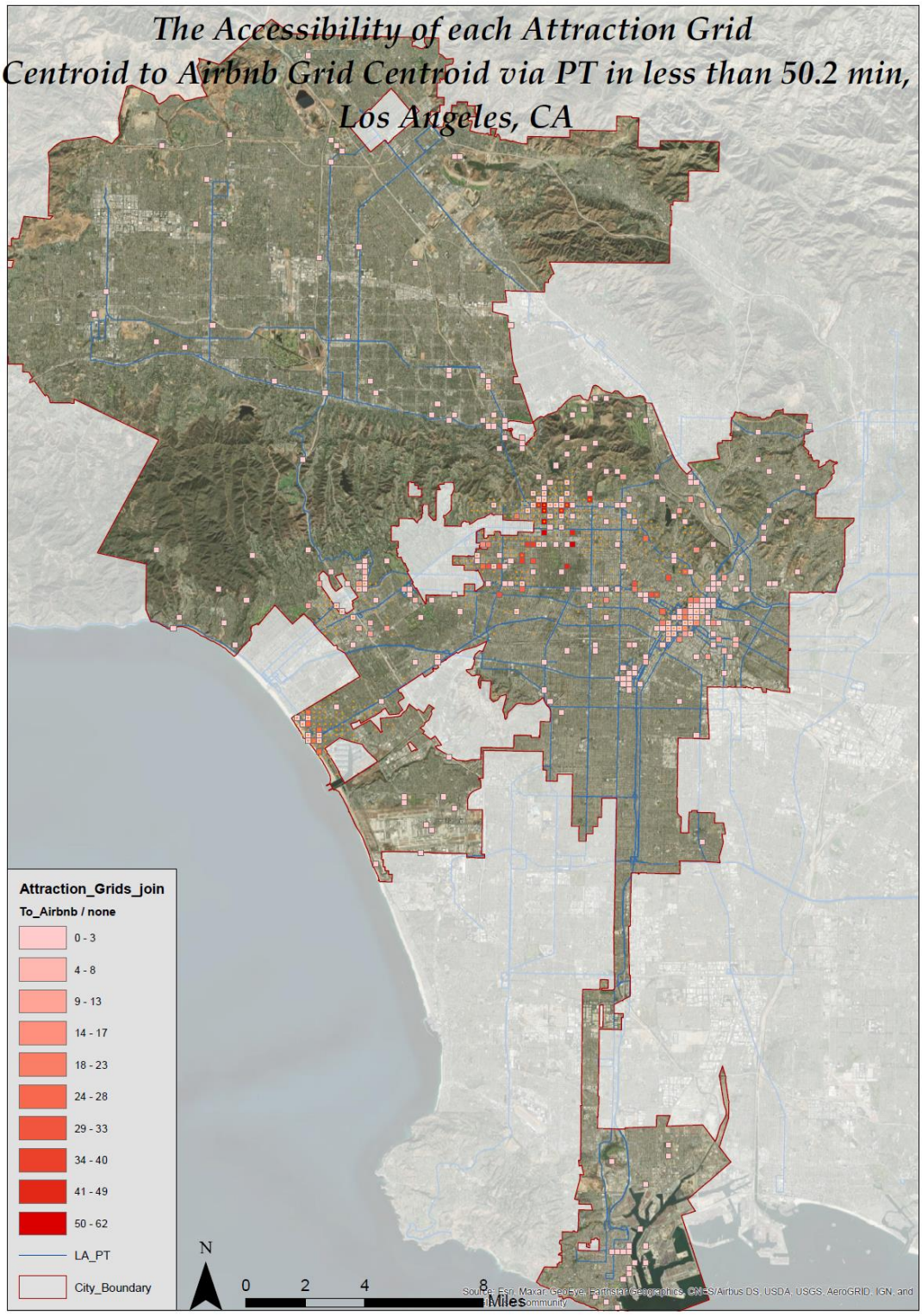

Figure 68: Attraction to Airbnb accessibility via public transit, Los Angeles

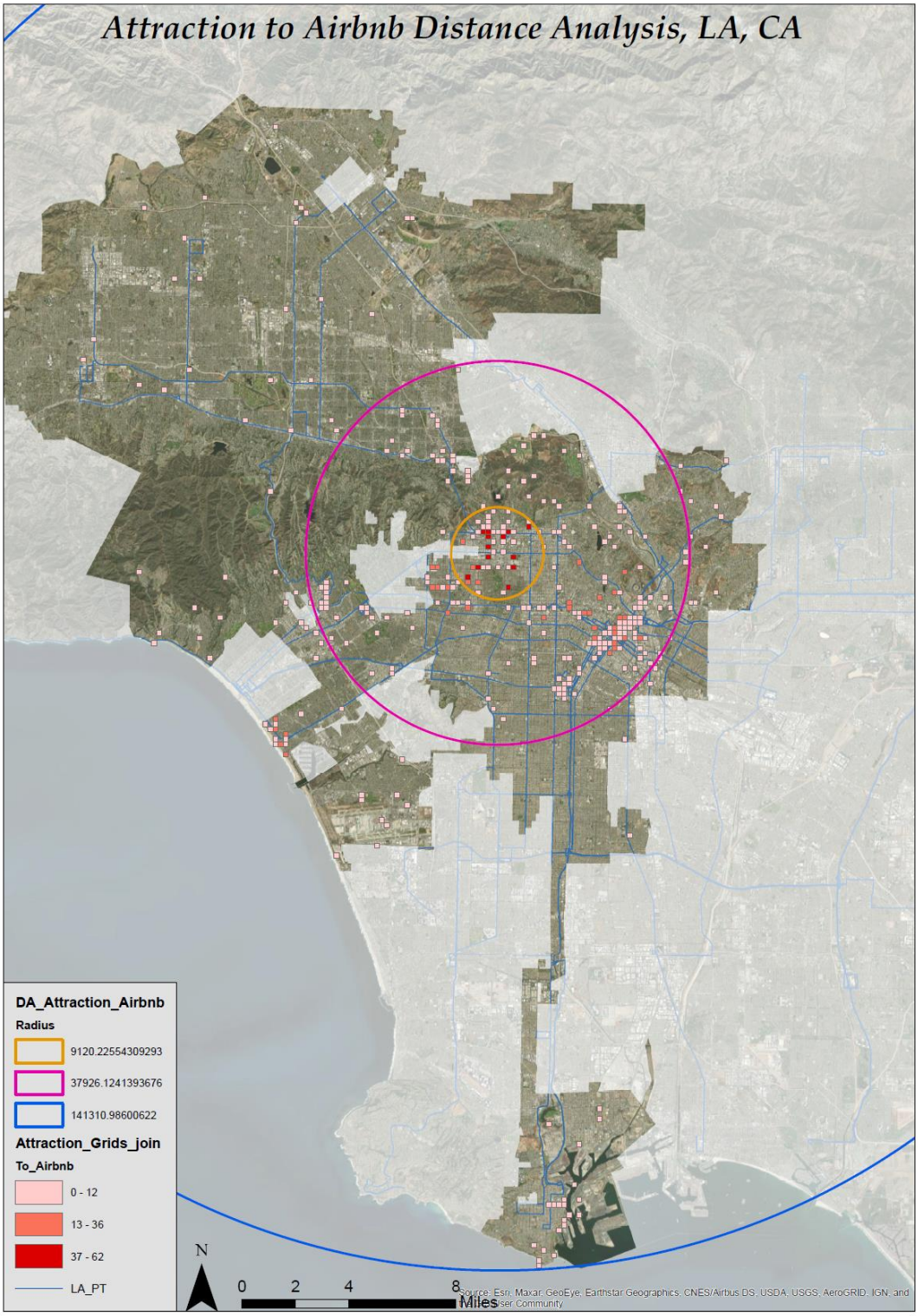

Figure 69: Attraction to Airbnb distance analysis, Los Angeles

Boston, Massachusetts Accessibility

The Hotels–Attractions grid map for Boston shows that visitors staying in one of the darkest brown grids within the downtown area can reach up to 81 of Boston's attractions grids using the city's public transportation in less than 46.2 minutes. Eight of the 86 hotel grids have public transit access to approximately 1/2 of the city's attractions (81) in less than 46.2 minutes (Figure 70).

Based on the Hotels–Attractions distance analysis map, grids with access to the highest number of attractions (58–81) are within a radius of ~2,200 feet from the downtown area. Grids with access to a medium number of attractions (22–57) are within a radius of ~3,300 feet from the downtown area, and those with access to a low number of attractions (0–21) are within a radius of ~7,400 feet from the downtown area (Figure 71).

As illustrated by the Airbnbs–Attractions map, if a visitor stays in one of the darkest brown grids, they can reach up to 82 Boston attractions using public transportation in less than 46.2 min. However, only 6 of the 83 Airbnb grid have public transit access to approximately 1/2 of the city's attractions in less than 46.2 minutes (Figure 72).

Based on the Airbnbs–Attractions distance analysis map, those grids with access to the highest number of attractions (58–82) are within a radius of ~7,000 feet from the downtown area. In contrast, grids with access to a medium number of attractions (25–57) are within a radius of ~13,700 feet, and grids with access to a low number of attractions (0–24) are within a radius of ~18,000 feet from the downtown area (Figure 73).

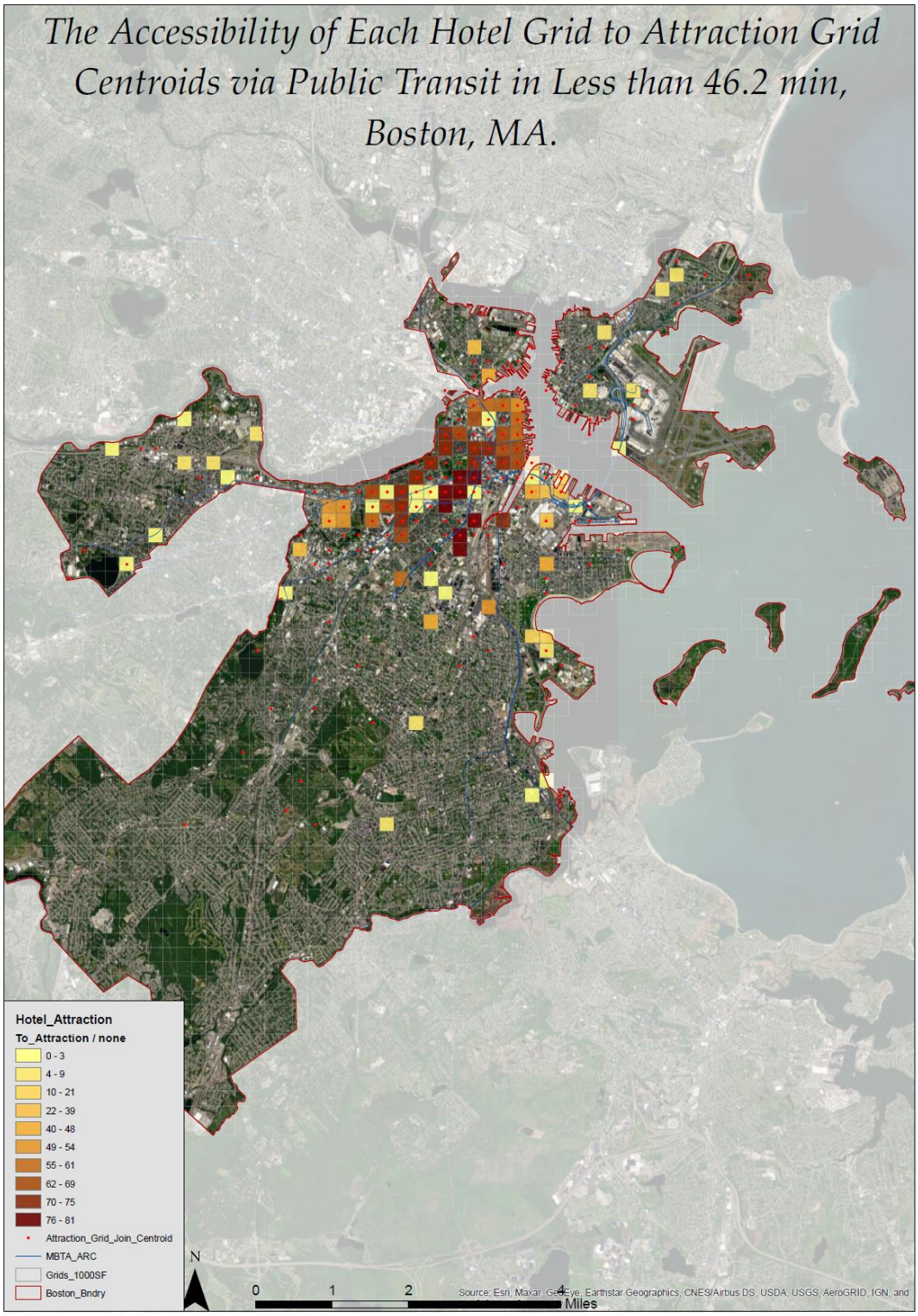

Figure 70: Hotel to Attraction accessibility via public transit, Boston

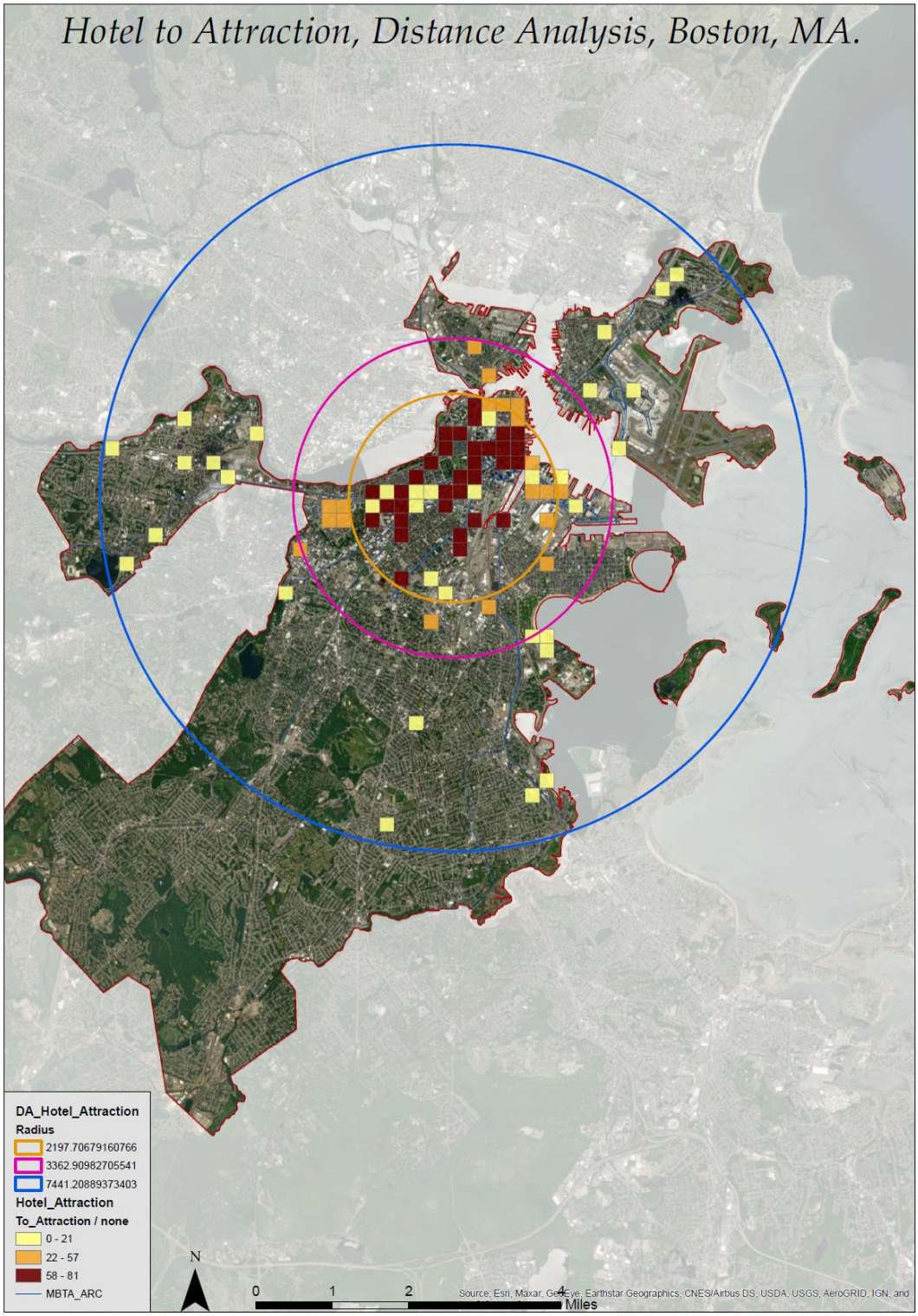

Figure 71: Hotel to attraction distance analysis, Boston

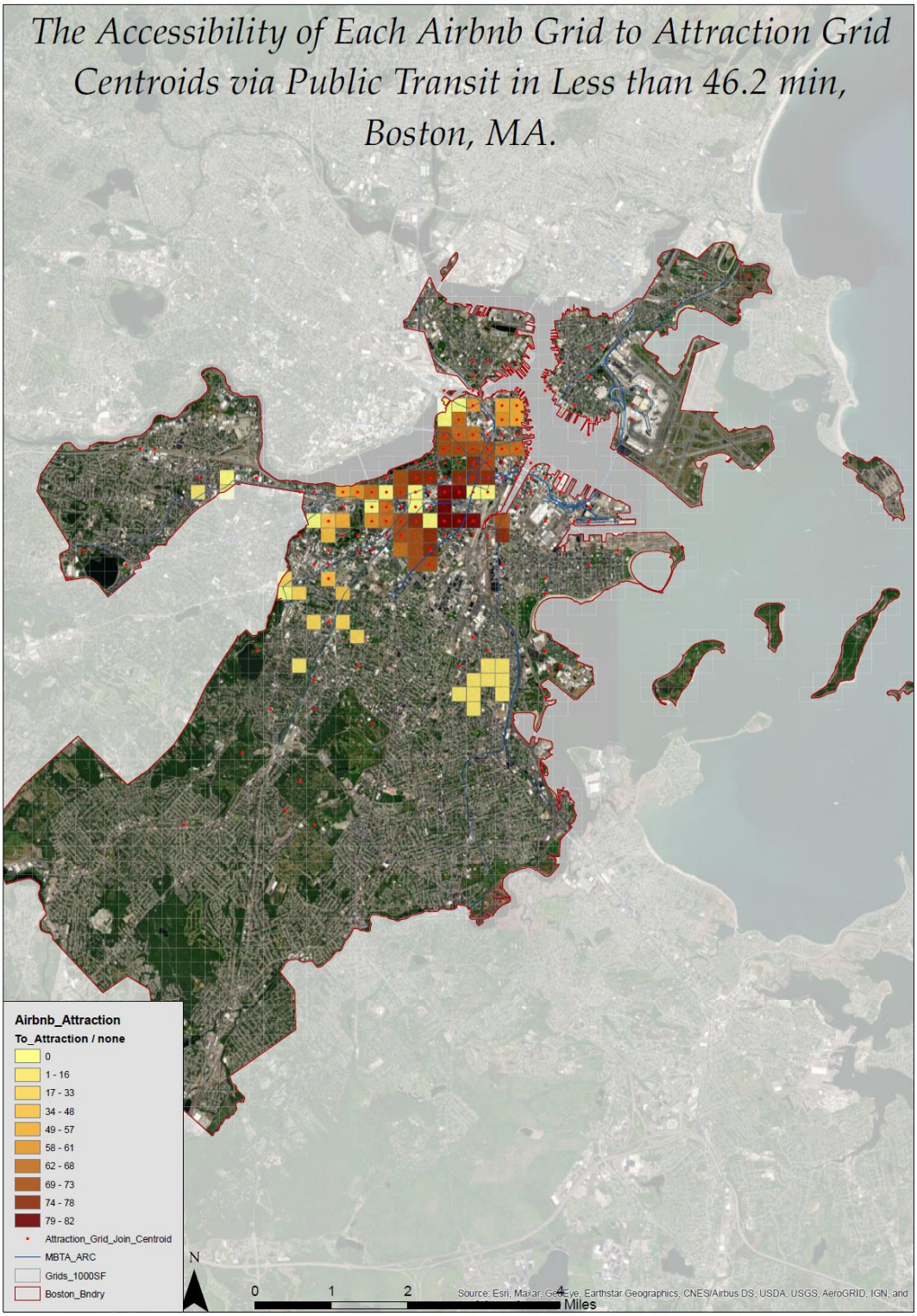

Figure 72: Airbnb to attraction accessibility via public transit, Boston

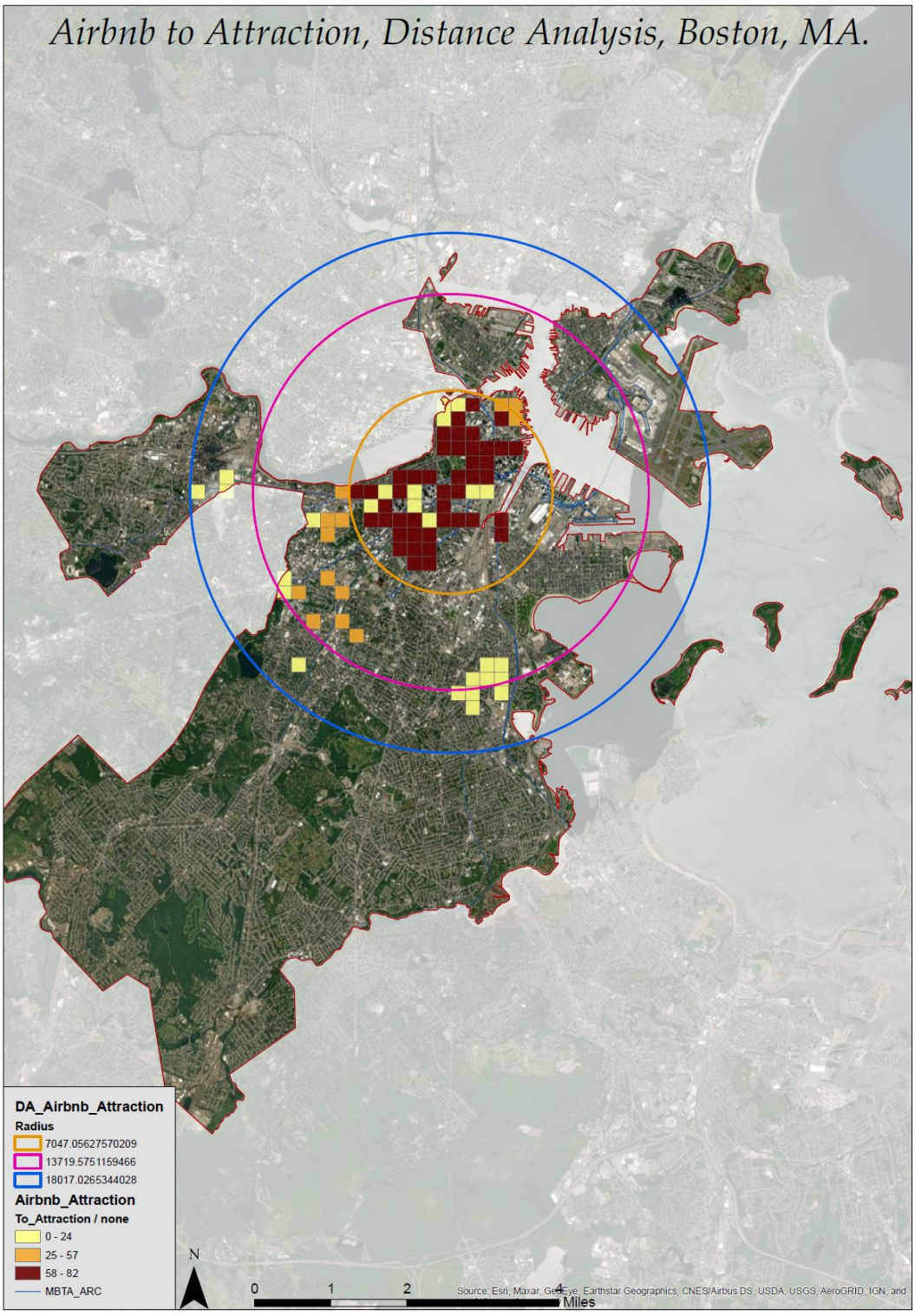

Figure 73: Airbnb to attraction distance analysis, Boston

The Attractions–Hotels map shows that, among the 149 attractions grids, 15 grids located in the downtown area have public transit access to approximately 60 percent of the city's hotels in less than 46.2 minutes (Figures 74).

The Attractions–Hotels distance analysis map shows that attraction grids with access to the highest number of hotels (34–53) are within a radius of ~7,600 feet from the downtown area. Grids with access to a medium number of hotels (13–33) are within a radius of ~13,800 feet from the original center. Finally, grids with access to a low number of hotels (0–12) are within a radius of ~30,500 feet from the original center (Figure 75).

According to the Attractions–Airbnbs map, among the 149 attractions grids, 16 located in the downtown area have public transit access to approximately 1/3 of the city's Airbnbs in less than 46.2 minutes (Figure 76).

As illustrated by the Attractions–Airbnbs distance analysis map, attraction grids with access to the highest number of Airbnbs (52–61) are within a radius of 4,642 feet from the downtown area, whereas grids with access to a medium number of Airbnbs (27–51) are within a radius of 12,704 feet of the original center. Those grids with access to a low number of Airbnbs (0–26) are within a radius of 27,600 feet from the downtown area (Figure 77).

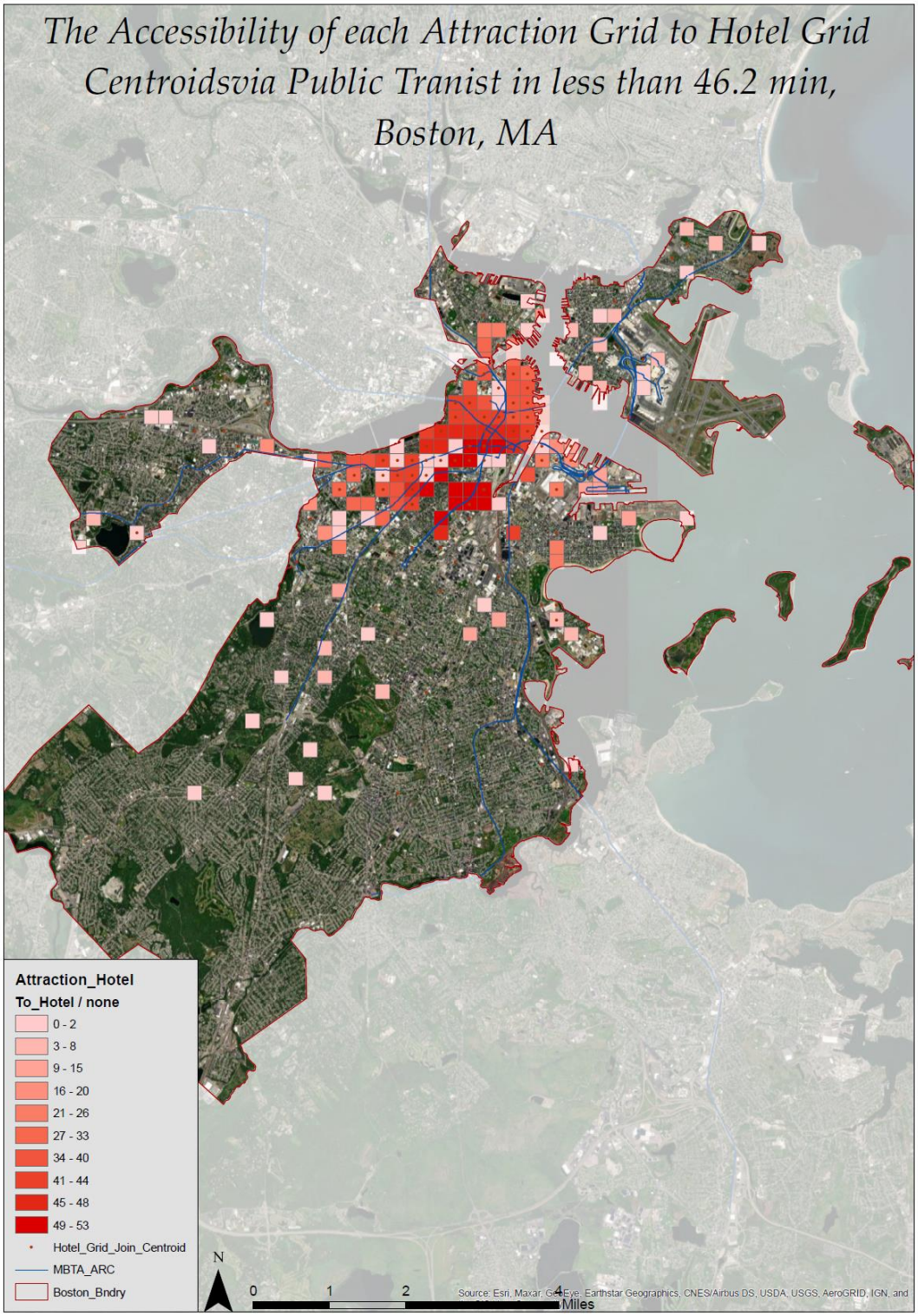

Figure 74: Attraction to hotel accessibility via public transit, Boston

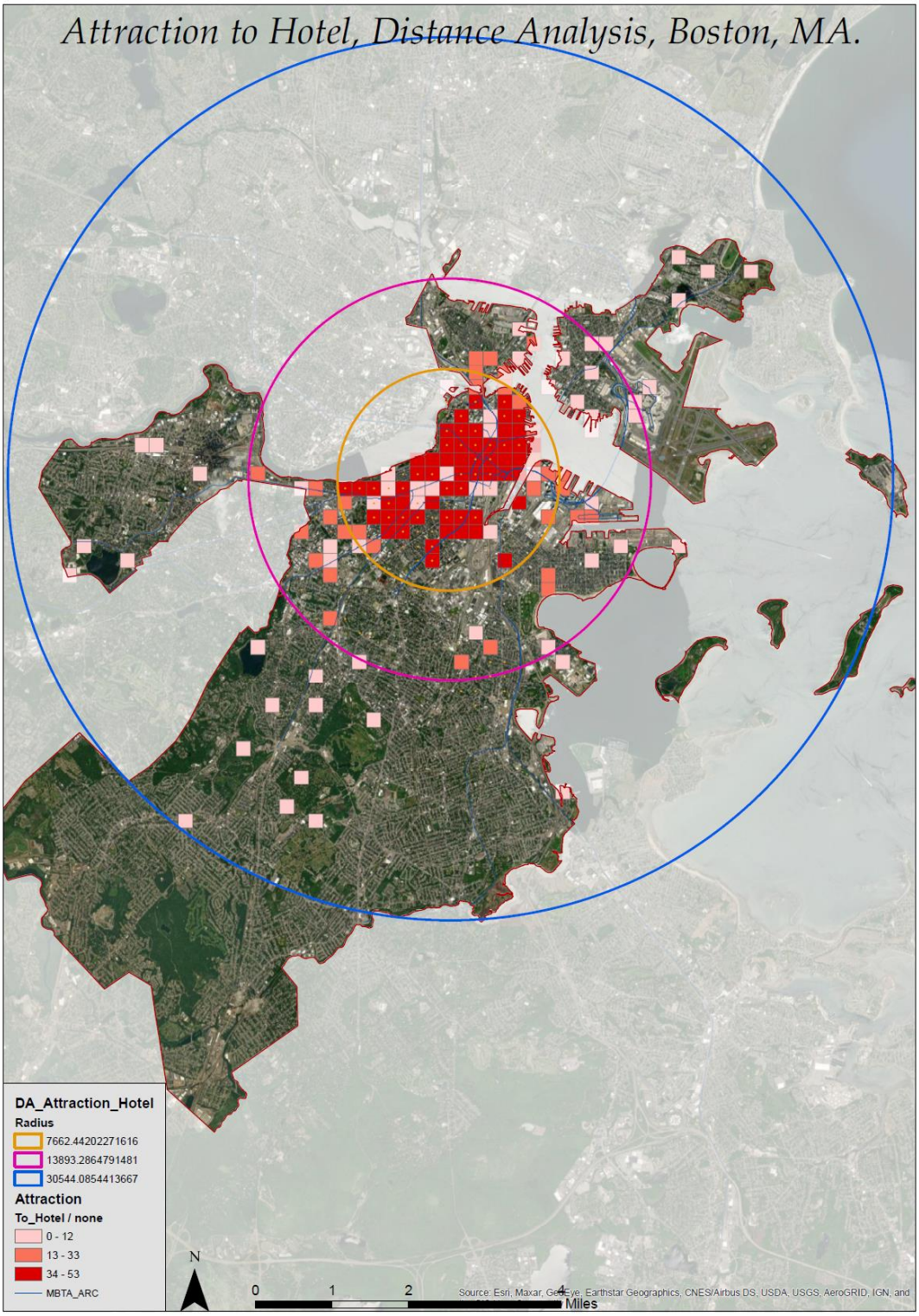

Figure 75: Attraction to hotel distance analysis, Boston

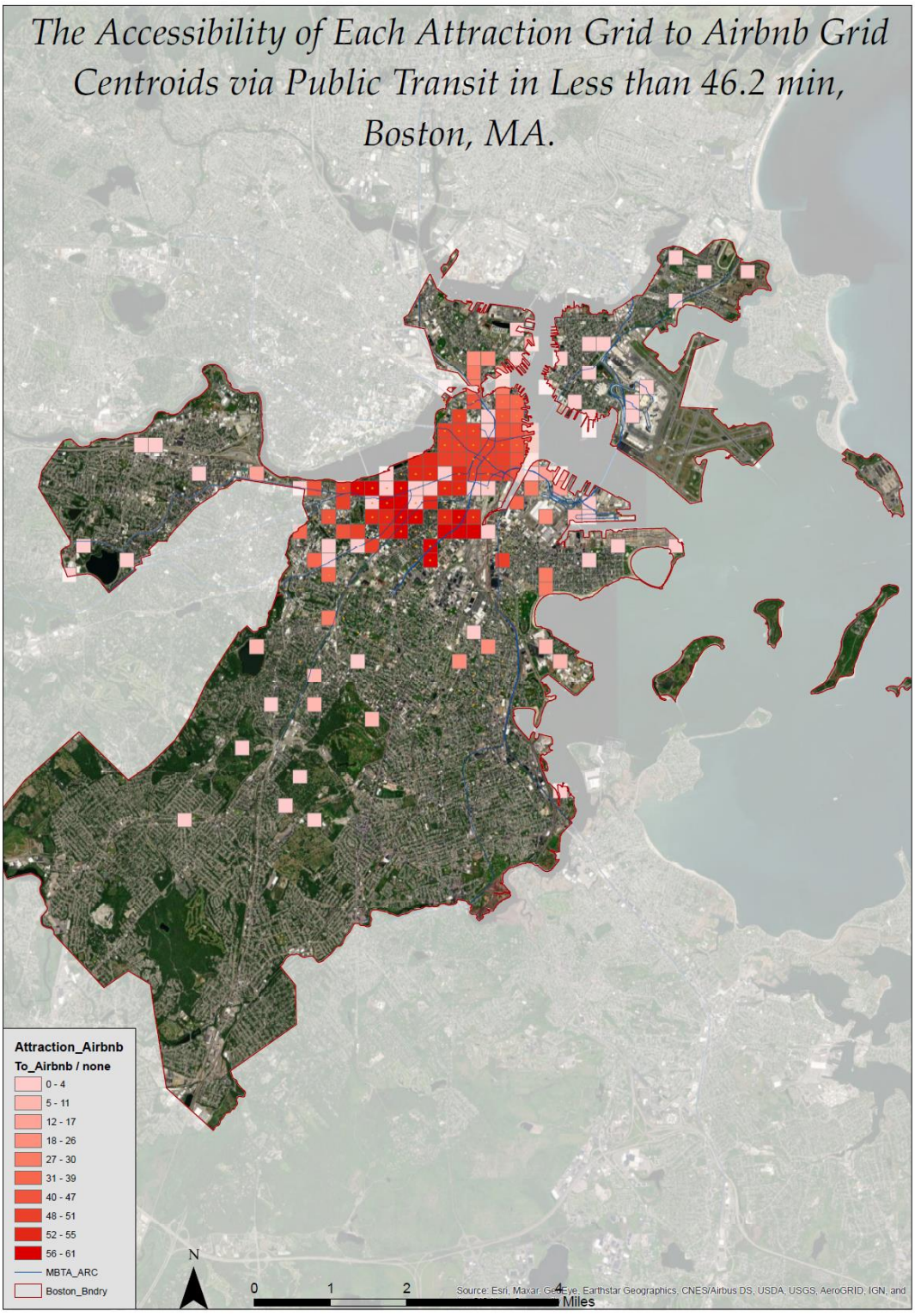

Figure 76: Attraction to Airbnb accessibility via public transit, Boston

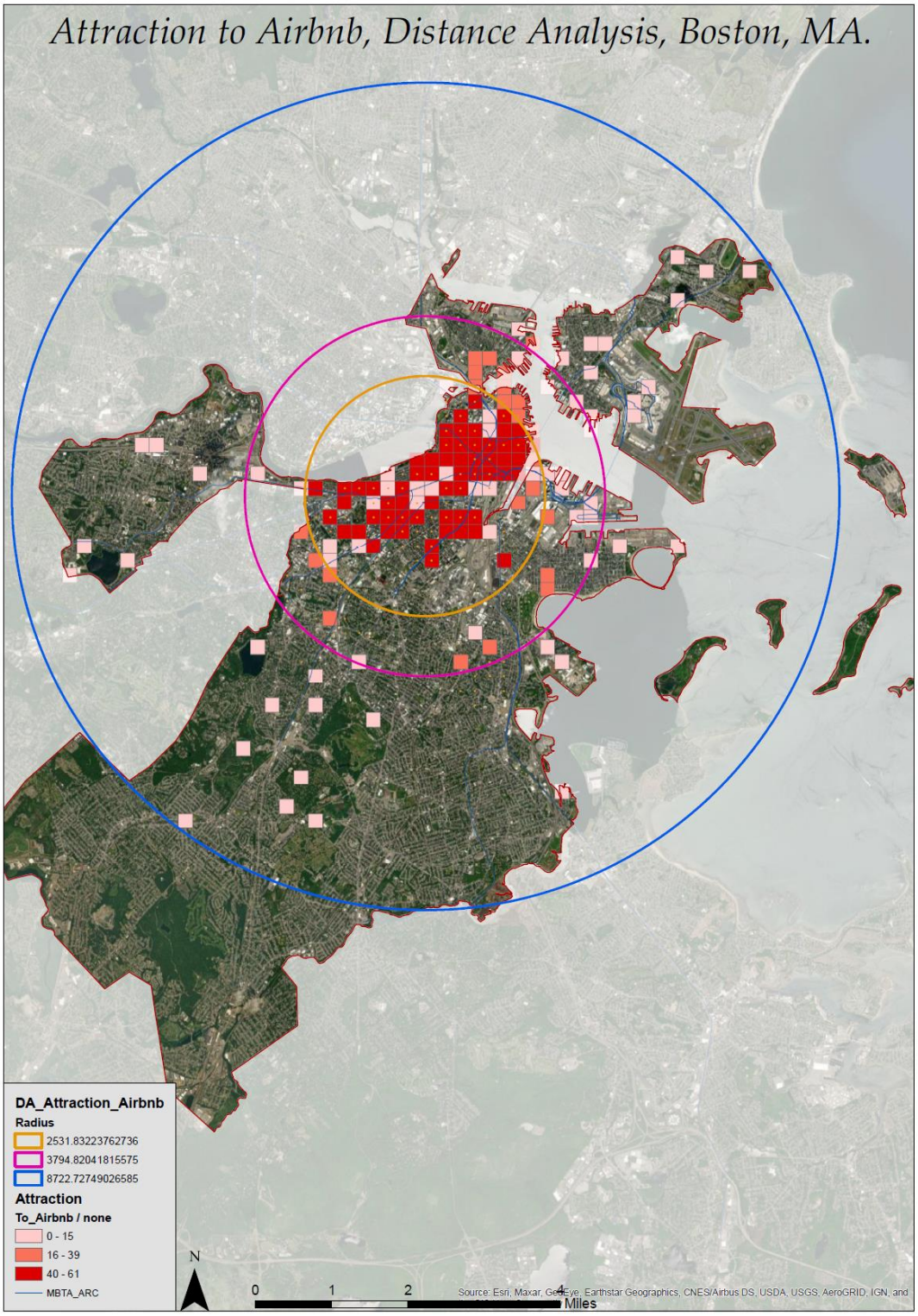

Figure 77: Attraction to Airbnb distance analysis, Boston

New York City, New York Accessibility

As shown by the Hotels–Attractions grid map, visitors staying in one of the darkest brown grids within the Midtown Manhattan area can reach up to 164 of New York City's attraction grids using public transportation in less than 51.3 minutes. Ninety-eight of the 182 hotel grids have public transit access to approximately 1/2 of the city's attractions in less than 46.2 minutes (Figure 78).

Based on the Hotels–Attractions distance analysis map, those grids with access to the highest number of attractions (124–164) are within a radius of 12,000 feet from the Midtown Manhattan area. Grids with access to a medium number of attractions (44–123) are within the radius of 29,500 feet from the original center. Finally, the grids with access to a low number of attractions (0–43) are within a radius of 49,000 feet from the original center (Figure 79).

The Airbnbs–Attractions map demonstrates that visitors staying in one of the darkest brown grids can reach up to 164 New York City attractions using public transportation in less than 51.3 minutes. Among the 655 Airbnb grids, 156 grids have public transit access to approximately 1/2 of the city's attractions in less than 46.2 minutes (Figure 80).

Based on the Airbnbs–Attractions distance analysis map, grids with access to the highest number of attractions (108–164) are within a radius of 15,000 feet from the Midtown Manhattan area. In contrast, grids with access to a medium number of attractions (43–107) are within a radius of 33,000 feet from the original center. Finally, grids with access to a low number of attractions (0–42) are within a radius of 42,000 feet from the original center (Figures 81).

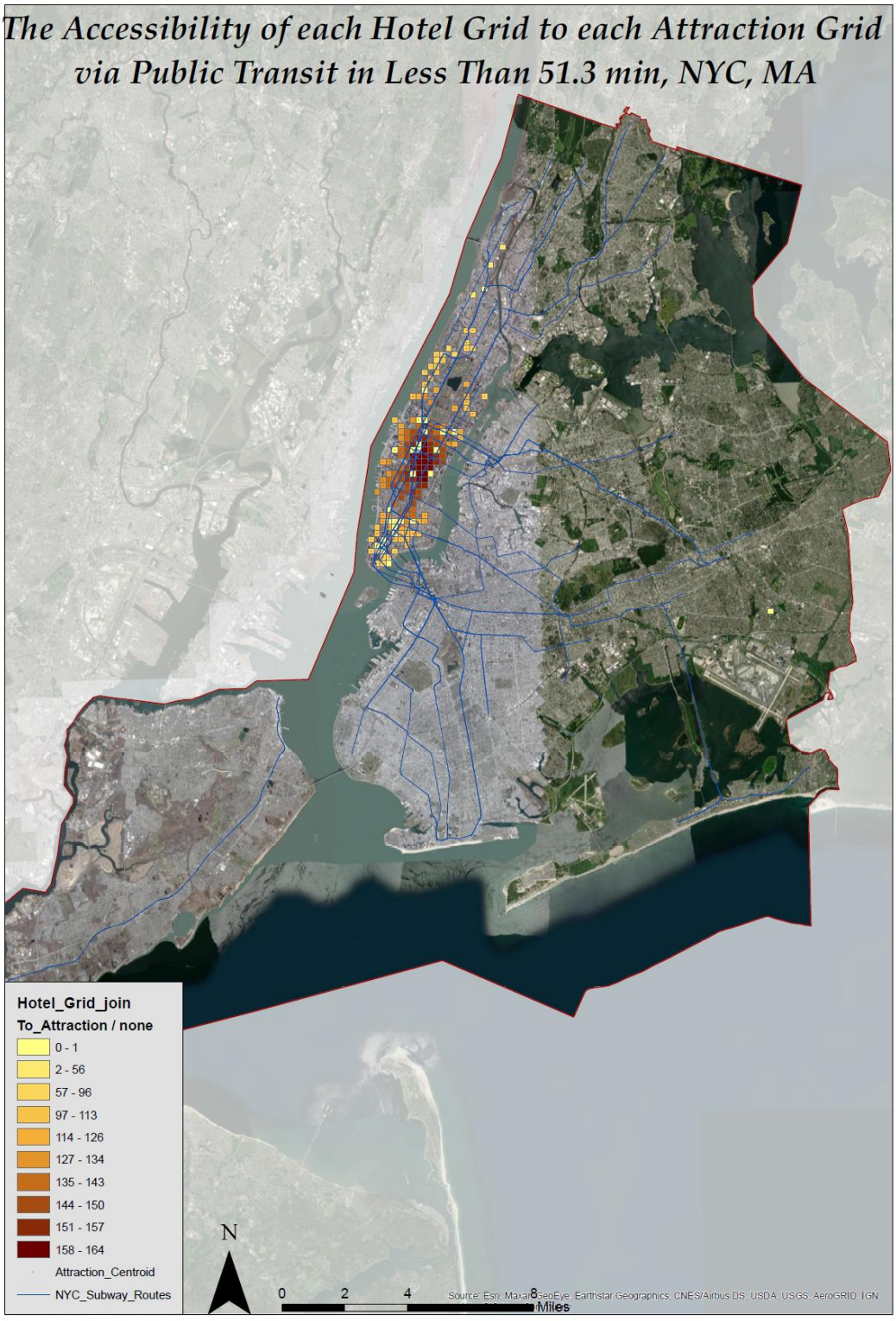

Figure 78: Hotel to attraction accessibility via public transit, New York City

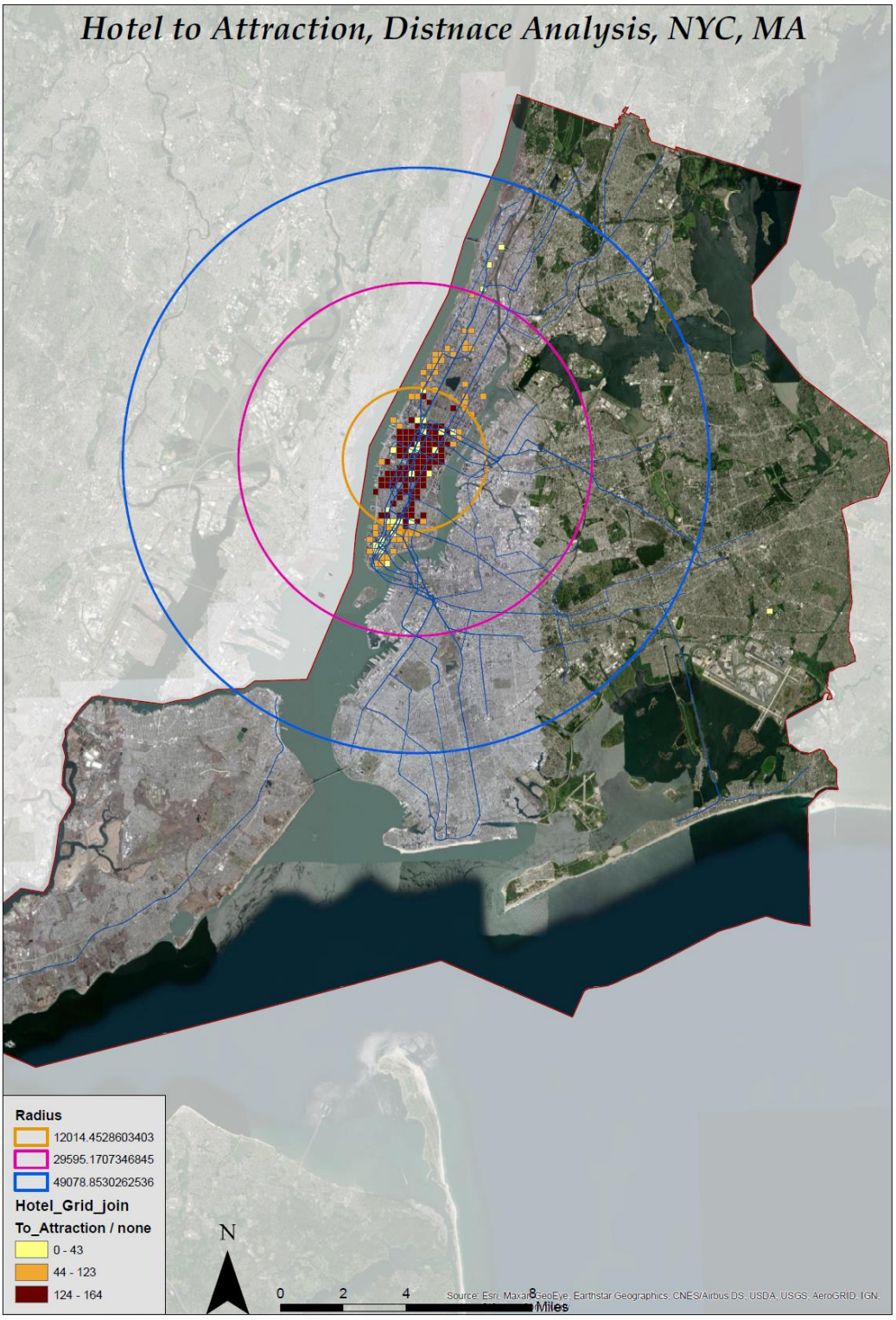

Figure 79: Hotel to attraction distance analysis, New York City

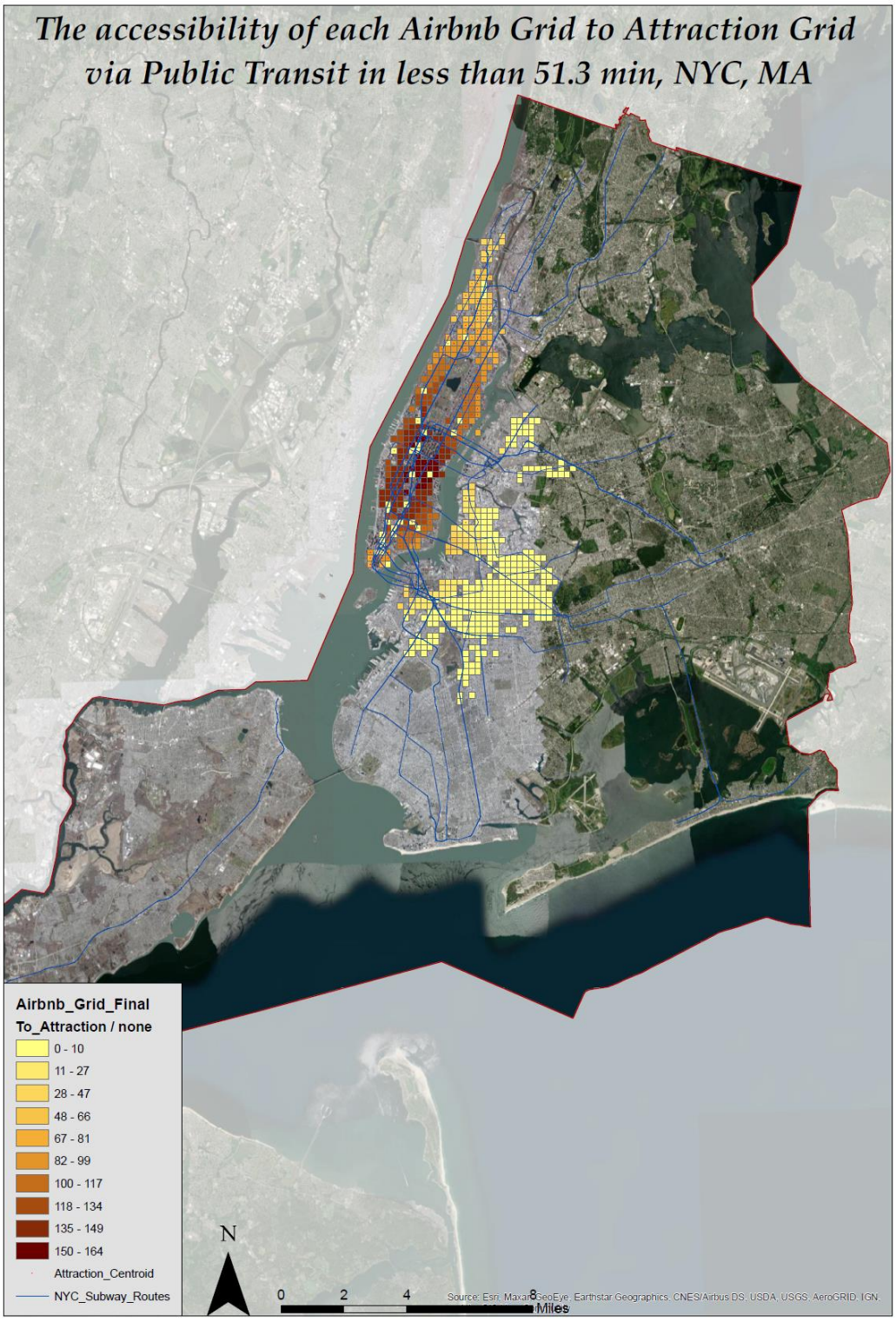

Figure 80: Airbnb to attraction accessibility via public transit, New York City

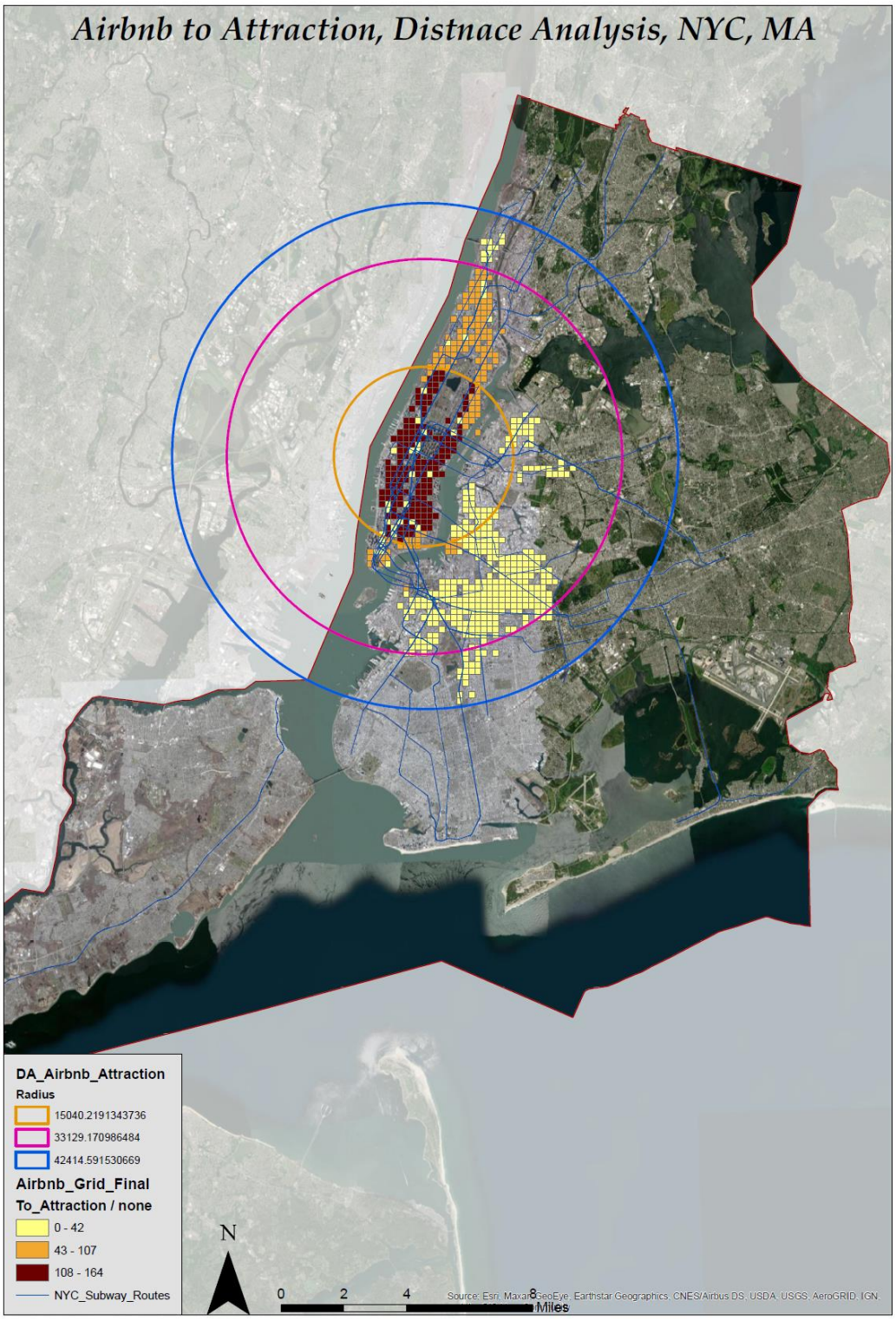

Figure 81: Airbnb to attraction distance analysis, New York City

As illustrated in the Attractions–Hotels map, among the 346 attractions grids, 136 located in Midtown Manhattan have public transit access to approximately 64 percent of the city's hotels in less than 46.2 minutes (Figure 82).

Based on the Attractions–Hotels distance analysis map, those attraction grids with access to the highest number of hotels (80–116) are within a radius of 11,000 feet from the Midtown Manhattan area. Grids with access to a medium number of hotels (34–79) are within a radius of 20,000 feet from the original center, and those with access to a low number of hotels (0–33) are within a radius of 57,000 feet from the original center (Figure 83).

As illustrated by the Attractions–Airbnbs map, among 346 attractions grids, 188 located in the Midtown Manhattan area have public transit access to approximately 1/3 of the city's Airbnb in less than 46.2 minutes (Figure 84).

The Attractions–Airbnbs distance analysis map shows that attraction grids with access to the highest number of Airbnbs (110–230) are within a radius of 21,500 feet from the Midtown Manhattan area. In contrast, grids with access to a medium number of Airbnbs (49–109) are within a radius of 35,000 feet of the original center. Finally, grids with access to a low number of Airbnbs (0–48) are within a radius of 58,000 feet from the original center (Figure 85).

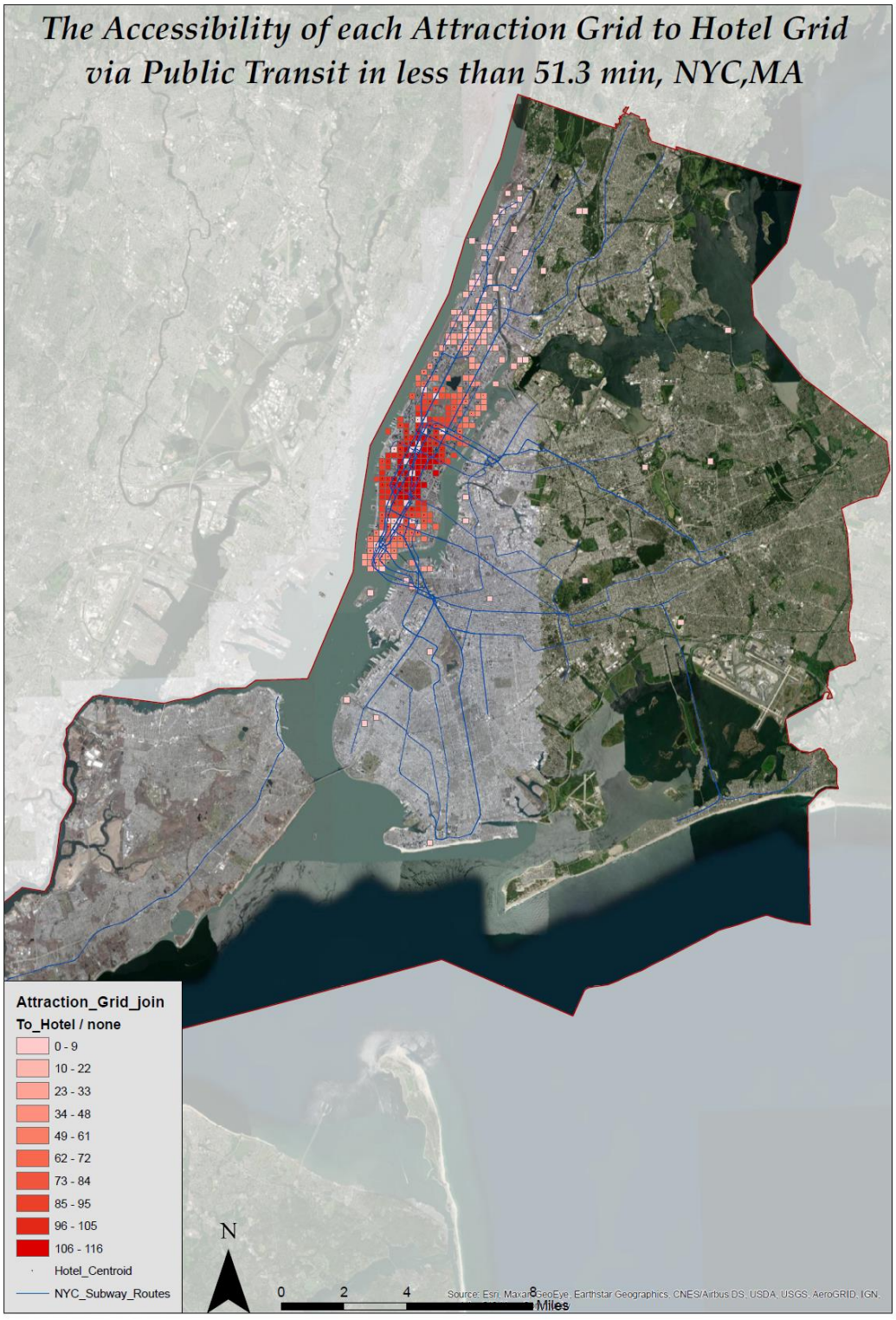

Figure 82: Attraction to hotel accessibility via public transit, New York City

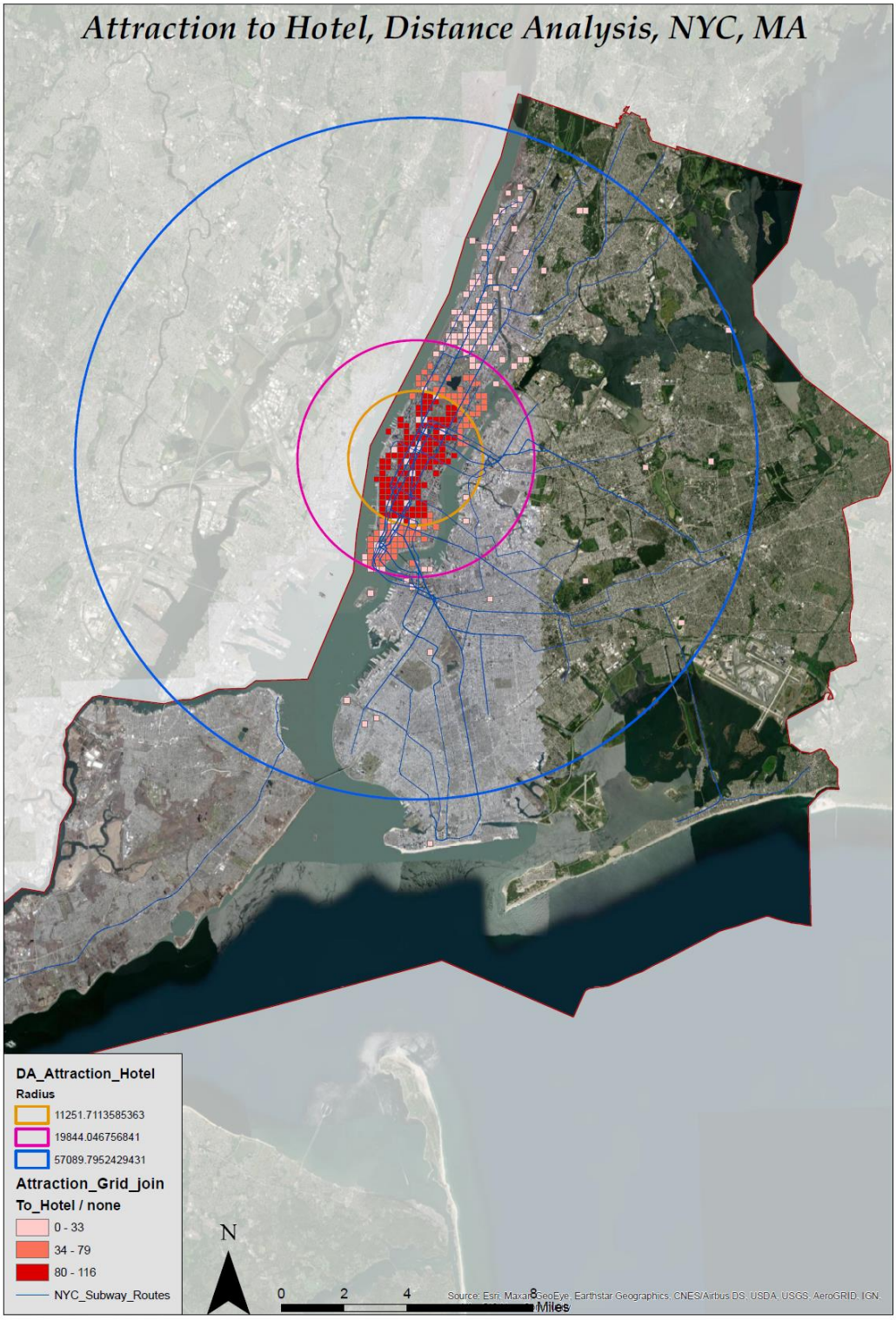

Figure 83: Attraction to hotel distance analysis, New York City

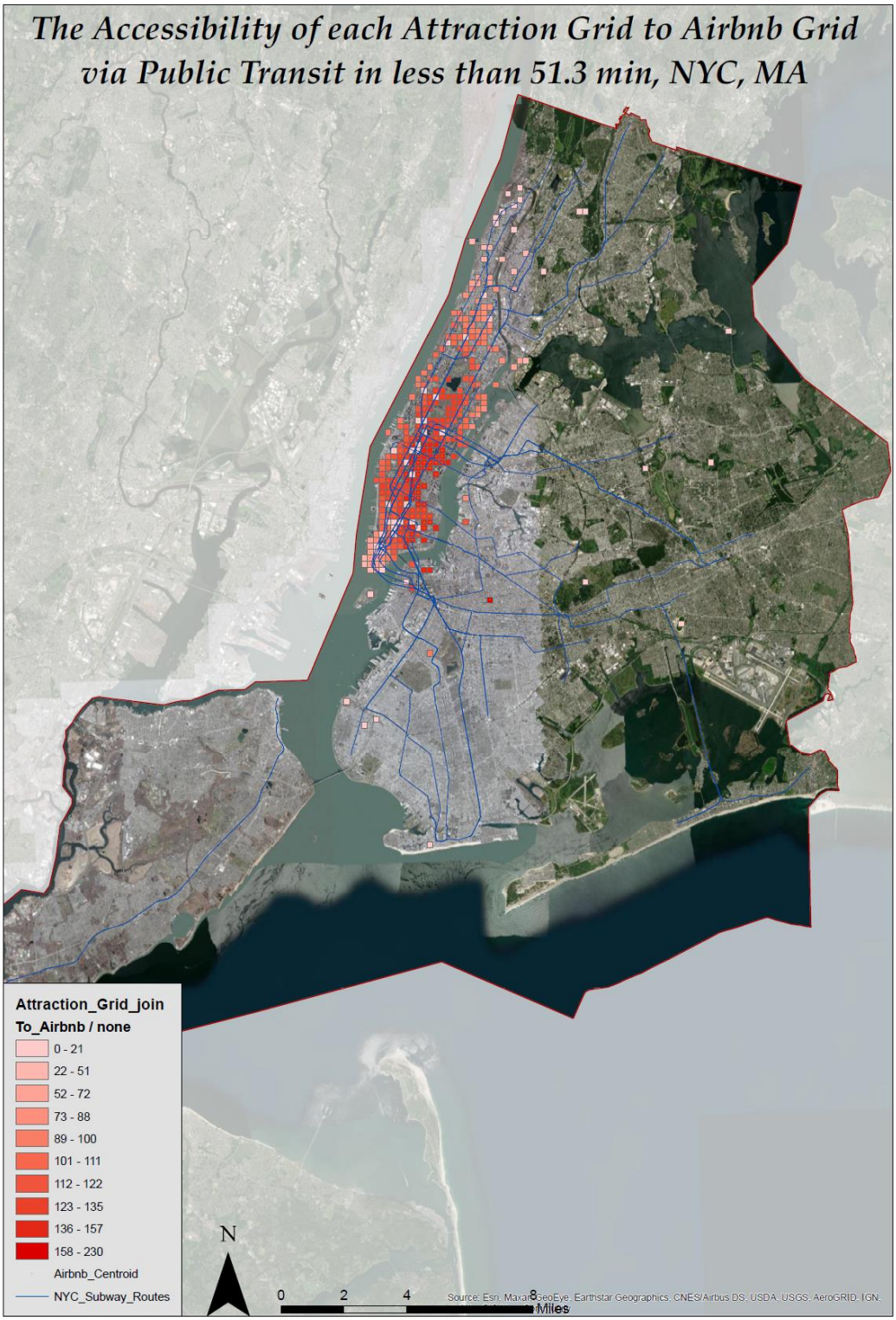

Figure 84: Attraction to Airbnb accessibility via public transit, New York City

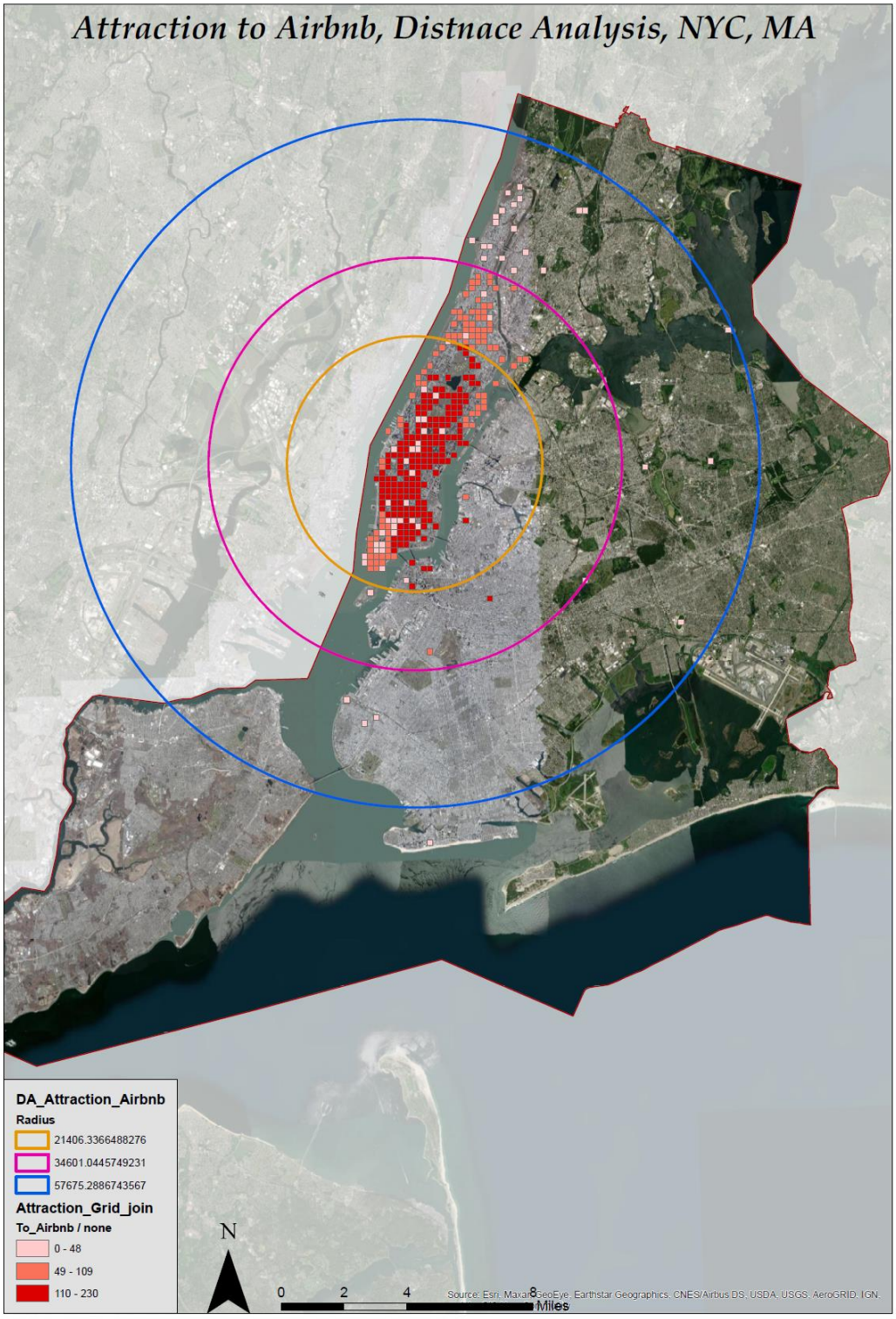

Figure 85: Attraction to Airbnb distance analysis, New York City

Outcomes

Part 1: Spatial Patterns

The previous sections described the spatial patterns of attractions, hotels, and Airbnbs, as well as their spatial relationships with public transit routes, for each case. A buffer of ½-mile walking distance from the selected rapid transit stops was created, and the attraction, hotel, and Airbnb grids intersecting this buffer were counted. The table below represents the percentages of these grids.

Table 4: Attraction, hotel, and Airbnb grids intersecting the ½ mile transit stop buffers.

	Attraction number	Intersect buffer	Percentage	Hotel Number	Intersect buffer	Percentage	Airbnb Number	Intersect buffer	Percentage
Chicago	368	255	69.293478	154	111	72.077922	429	362	84.382284
Austin	188	86	45.744681	169	65	38.461538	232	162	69.827586
SF	294	187	63.605442	122	88	72.131148	121	99	81.818182
LA	360	274	76.111111	300	259	86.333333	462	415	89.82684
Boston	149	131	87.919463	86	78	90.697674	83	82	98.795181
NYC	346	330	95.375723	182	180	98.901099	655	652	99.541985

Each case study was ranked by obtaining the average of selected attractions, hotels, and Airbnb percentages that intersect the buffer zone (Table 5). The rank represents which cities have origins and destinations within approximately ½ mile (2640 feet) from the selected rapid transit stops.

As shown in Table 5, New York City occupies the first rank, Boston second, Los Angeles third, Chicago fourth, San Francisco fifth, and Austin holds the lowest rank.

Table 5: The average of attraction, hotel, and Airbnb grids intersecting the ½ mile transit stop buffers.

City	Average
Chicago	75.25122824
Austin	51.34460184
SF	72.51825718
LA	84.09042809
Boston	92.47077274
NYC	97.93960206

Part 2: Accessibility Between Origins and Destinations

To evaluate the accessibility of hotels and Airbnbs to visitor attractions and vice versa in each city, all grids were divided into three different categories indicating high, medium, and low accessibility. As illustrated in Figure 86, the number of grids in the low accessibility category is usually significantly higher than the number of grids within high or medium categories, although category ranking is less significant in enhancing the overall accessibility of public transportation for visitors (Figure 86).

According to Figure 86, for instance, in Chicago, 45 of the 154 hotel grids are among the highest-accessibility grids, i.e., those accessible to the highest number of attractions (57–97) via public transportation within a specific timeframe. Twenty-three of the 154 grids represent medium accessibility (21–56 attractions), and 86 of the 154 grids have low accessibility (0–20 attractions) via public transportation in a specific timeframe.

Since the importance of each category in evaluating the accessibility of transportation is different, **weighting factors** were used to assign lower or higher priority to each category. The following weighting function was defined to assess the accessibility, via public transportation, of hotels and Airbnbs to visitor attractions and vice versa in each city:

$$\text{accessibility of transportation} = \sum_{i=1}^{n} w_i \, x_i$$

Boston	New York	Los Angeles	San Francisco	Austin	Chicago	
149	346	360	294	188	368	Attraction Grid Number
86	182	300	122	169	154	Hotel Grid Number
83	655	462	121	232	429	Airbnb Grid Number
58 - 81	124 - 164	15 - 23	124 - 158	40 - 56	57- 97	Hotel to Attraction-Attraction High Range
33	98	22	49	21	45	Hotel Grid Number that have access to High Range of Attraction
22 - 57	44 - 123	6 - 14	22 - 123	12 - 39	21 - 56	Hotel to Attraction-Attraction Medium Range
19	54	37	56	10	23	Hotel Grid Number that have access to Medium Range of Attraction
0 - 21	0 - 43	0 - 5	0 - 21	0 - 11	0 - 20	Hotel to Attraction- Attraction Low Range
34	30	241	17	138	86	Hotel Grid Number that have access to Low Range of Attraction
58 - 82	108 - 164	11 - 23	113 - 158	35 - 58	60 - 101	Airbnb to Attraction- Attraction High Range
44	156	78	58	54	102	Airbnb Grid Number that have access to High Range of Attraction
25 - 57	43 - 107	4 - 10	47 - 112	16 - 34	25 - 59	Airbnb to Attraction- Attraction Medium Range
13	125	89	49	71	199	Airbnb Grid Number that have access to Medium Range of Attraction
0 - 24	0 - 42	0 - 3	0 - 46	0 - 15	0 - 24	Airbnb to Attraction- Attraction Low Range
26	374	295	14	107	128	Airbnb Grid Number that have access to Low Range of Attraction
34 - 53	80 - 116	15 - 23	62 - 97	21 - 31	28 - 49	Attraction to Hotel- Hotel High Range
57	136	27	117	39	75	Attraction Grid Number that have access to High Range of Hotel
13 - 33	34 - 79	6 - 14	27 - 61	9 - 20	8 – 27	Attraction to Hotel- Hotel Medium Range
32	83	30	57	33	102	Attraction Grid Number that have access to Medium Range of Hotel
0 - 12	0 - 33	0 - 5	0 - 26	0 - 8	0 - 7	Attraction to Hotel- Hotel Low Range
60	127	303	120	116	193	Attraction Grid Number that have access to Low Range of Hotel
40 - 61	110 - 230	37 - 62	66 - 106	63 -94	97 - 165	Attraction to Airbnb- Airbnb High Range
60	188	13	93	38	65	Attraction Grid Number that have access to High Range of Airbnb
16 - 39	49 - 109	13 - 36	26 - 65	24 - 62	41 - 96	Attraction to Airbnb- Airbnb Medium Range
23	96	37	96	33	167	Attraction Grid Number that have access to Medium Range of Airbnb
0 - 15	0 - 48	0 - 12	0 - 26	0 - 23	0 – 40	Attraction to Airbnb-Airbnb Low Range
66	62	310	105	117	197	Attraction Grid Number that have access to Low Range of Airbnb

Figure 86: Different ranges of accessibility for hotel to attraction, Airbnb to attraction, attraction to hotel, and attraction to Airbnb via public transit within a specific timeframe.

where n is the number of categories (i.e., n = 3), w_i is the weighting factor of each category, and x_i is the ratio of the number of grids in each category to the total number of grids in the city. **Weighting factors in this analysis were selected as** $w_1 = 0.5,\ w_2 = 0.35, w_2 = 0.15$ to give the highest importance to the category with the highest accessibility of public transportation and less importance to those with medium and low accessibility.

The weighting factors were applied to the information in Table 6. The final ranking results are illustrated in Table 6: San Francisco is ranked first, followed by New York City, Boston, Chicago, Austin, and, finally, Los Angeles.

Table 6: cities rank based on the visitor's origin-destination accessibility

Cities	Overall Rate
Chicago	0.291275099
Austin	0.252890422
San Francisco	0.358804753
Los Angeles	0.206015873
New York	0.350135697
Boston	0.33600339

In addition to calculating the range of accessibility for origins - destinations and destinations - origins, a distance analysis map was applied to each accessibility map (Figure 88). Distance analysis calculated the location of high, medium, and low accessibility origins or destinations for each map in each case study. For example, Figure 88 shows that in Boston, those attractions that are accessible to a high number of Airbnbs (40 – 61) are located within a radius of 2,500 feet centered on the downtown area.

Boston	New York	Los Angeles	San Francisco	Austin	Chicago	
149	346	360	294	188	368	Attraction Grid Number
86	182	300	122	169	154	Hotel Grid Number
83	655	462	121	232	429	Airbnb Grid Number
58 - 81	124 - 164	15 - 23	124 - 158	40 - 56	57- 97	Hotel to Attraction-High Number
2,000	12,000	20,000	7,000	5,500	8600	Hotel to Attraction-High Number-DA-Radius
22 - 57	44 - 123	6 - 14	22 - 123	12 - 39	21 - 56	Hotel to Attraction-Medium Number
3,500	30,000	55,000	15,000	10,500	37,500	Hotel to Attraction-Medium Number-DA-Radius
0 - 21	0 - 43	0 - 13	0 - 21	0 - 11	0 - 20	Hotel to Attraction-Low Number
7,500	50,000	55,000	30,000	8,000	83,000	Hotel to Attraction-Low Number-DA-Radius
58 - 82	108 - 164	11 - 23	113 - 158	35 - 58	60 - 101	Airbnb to Attraction-High Number
7,000	15,000	22,500	8,000	8,000	13,000	Airbnb to Attraction-High Number-DA-Radius
25 - 57	43 - 107	4 - 10	47 - 112	16 - 34	25 - 59	Airbnb to Attraction-Medium Number
14,000	33,000	61,000	13,000	12,000	37,000	Airbnb to Attraction-Medium Number-DA-Radius
0 - 24	0 - 42	0 - 9	0 - 46	0 - 15	0 - 24	Airbnb to Attraction-Low Number
18,000	40,000	61,000	16,000	26,500	45,500	Airbnb to Attraction-Low Number-DA-Radius
34 - 53	80 - 116	15 - 23	62 - 97	21 - 31	28 - 49	Attraction to Hotel-High Number
7,500	11,000	19,500	8,500	8,000	9,000	Attraction to Hotel-High Number-DA-Radius
13 - 33	34 - 79	6 - 14	27 - 61	9 - 20	8 – 27	Attraction to Hotel-Medium Number
14,000	20,000	48,000	13,000	25,500	36,000	Attraction to Hotel-Medium Number-DA-Radius
0 - 12	0 - 33	0 - 5	0 - 26	0 - 8	0 - 7	Attraction to Hotel-Low Number
30,500	57,000	133,000	35,000	70,000	81,000	Attraction to Hotel-Low Number-DA-Radius
40 - 61	110 - 230	37 - 62	66 - 106	63 -94	97 - 165	Attraction to Airbnb-High Number
2,500	21,500	9,000	8,000	8,000	14,500	Attraction to Airbnb-High Number-DA-Radius
16 - 39	49 - 109	13 - 36	26 - 65	24 - 62	41 - 96	Attraction to Airbnb-Medium Number
4,000	34,500	38,000	14,000	15,000	25,000	Attraction to Airbnb-Medium Number-DA-Radius
0 - 15	0 - 48	0 - 12	0 - 25	0 - 23	0 – 40	Attraction to Airbnb-Low Number
8,500	55,000	141,000	35,000	75,000	97,000	Attraction to Airbnb-Low Number-DA-Radius

Figure 87: Distance of different range of accessibility for hotel to attraction, Airbnb to attraction, attraction to hotel, and attraction to Airbnb via public transportation within a specific timeframe.

CHAPTER FIVE

DISCUSSION

Interpretation of Findings

There are significant studies in the tourism transport context that take varying points of view, particularly economic, marketing, and social approaches. Many studies have emphasized improving public transit routes within cities worldwide. However, few analyses in the tourism transport context have examined the improvement of public transit through considering visitors' needs. The main novelty of the present work is its investigation of well-developed public transit systems that serve visitors in urban areas, focusing on six U.S. cities that receive a large number of tourists. This study first attempted to find a spatial pattern for visitors' origins and destinations in cities, then analyzed the accessibility of these origins and destinations.

Finding a spatial pattern between visitors' origins and destinations helps identify a need to add new routes and stations in the city. In addition, these outcomes can provide beneficial information about the need for additional stops that may result in ridership support along a transit route. Spatial pattern analysis generated map-based visualizations in this study for attractions, hotels, and Airbnb data, which were used in all six case studies. As illustrated by the spatial results, all six cities—New York City, Boston, Chicago, Austin, San Francisco, and Los Angeles—demonstrated clear cluster patterns of attraction, hotels, and Airbnb grids in their downtown areas. Remarkably, in all cases, grids within the downtown areas contain a higher number of attractions, hotels, and Airbnbs.

These findings align with a study published in 2017 about the spatial patterns of Airbnbs in U.S. cities, which discovered a negative relationship between the distance from city centers and Airbnb locations (Giovanni, Andrew, Daniele, Licia, & Mirco, 2018). It also found a positive correlation between the penetration of Airbnbs and the locations of tourist sites in five of eight cases. The current research analyzed the number of attractions and Airbnb grids with overlays to determine how many attractions grids are within walking distance from at least one Airbnb. The findings showed that this number did not surpass 25% for four of the six case studies (Chicago, Austin, San Francisco, and Los Angeles). However, the overlay percentages for Boston and New York City were, respectively, 32% and 56%.

When cities' public transit routes were incorporated in these findings, in all cases, public transit routes were found to have the highest number of routes and intersections in the downtown areas. Such concentration affects nearby grids, influencing them to host a higher number of attractions, hotels, and Airbnbs. This finding is consistent with a recent study that reported a positive correlation between public transit development and population size, urban compactness, and governmental financial capacity (Zhao, Lou, Fonseca, Feiock, & Shen, 2020).

Buffer analysis was used to represent the positive relationship between attractions, hotels, and Airbnb grids and a ½-mile walking distance from rapid transit stations. In five cases (all except Austin), more than 60% of attractions, hotels, and Airbnb grids are located within a ½-mile walking distance from a rapid transit station. **New York City** and **Boston**, two eastern cities, have the most rapid transit stations nearby visitors' origins and destinations and were ranked first and second, respectively. They were followed by Los Angeles, Chicago, San Francisco, and, finally, Austin.

The overall accessibility analysis of visitors' origins to destinations and destinations to origins awarded the highest rank to **San Francisco** and **New York**, with an extremely small difference, followed by Boston, Chicago, Austin, and Los Angeles. In 2019, the U.S. News & World Report website published a report on the top 10 best U.S. cities for public transportation based on three indicators: jobs accessible within a 30-minute trip, transit routes within a half-mile, and commuters who use transit. Their rankings, from highest to lowest, were as follows (cities included in this study are in italics): *San Francisco*, *New York*, *Boston*, Washington D.C., *Chicago*, Philadelphia, Long Beach, Baltimore, and Newark. Remarkably, U.S. News' rankings align with the findings of this study's accessibility analysis, thereby emphasizing that the more developed a city's public transit system is, the more tourist-friendly it is.

Regarding the spatial form of public transit routes, in all cases, hotel and Airbnb grids located in the downtown and surrounding areas have the highest accessibility to city attractions. Likewise, the attraction grids located downtown and in the surrounding areas have the highest accessibility to cities' hotels and Airbnbs.

The overall accessibility analysis and the ranks associated with cities through buffer analysis indicate that New York City is a top U.S. city with tourist-friendly public transportation. Walker (2011) described ten demands that riders expect from a decent public transit system: stops/stations, connectivity, frequency, fare, span, speed, civility, reliability, simplicity, and presentation. The present study approached the research through the lens of three initial demands. The primary demand was the location of stops and stations. Our buffer analysis revealed that 95% of New York City attraction grids and 99% of hotels and Airbnb grids are within a ½-mile buffer zone of its subway stations. The second and third demands were connectivity and frequency between specific origins and destinations. Our accessibility analysis via network analysis O-D

matrix ranked New York City second in these categories since there is higher accessibility between its origins and destinations and vice versa within a specific timeframe.

San Francisco is amongst the cities with the highest overall accessibility. Interestingly, however, the buffer analysis revealed that the city's rapid transit stations are not close to visitor attractions, hotels, and Airbnbs. Nonetheless, its high accessibility reveals that visitors' origins and destinations may be connected by other forms of public transportation than only light rail, subways, and buses. For example, San Francisco's municipal transportation authority, Muni, also provides streetcars and cable cars that give visitors access to the city's historic sites and attractions. Furthermore, the city made payment easier by offering prepay options through smartphones.

Los Angeles held the third-highest rank in the buffer analysis yet was the lowest-ranked in overall accessibility. One reason for this inconsistency could be the inadequate connectivity of the study's specific origins and destinations. Los Angeles attractions, hotels, and Airbnb grids are within straight-line walking distance to rapid transit stops; however, those stops often do not provide access to specific attractions, hotels, or Airbnbs. This fact points to Walker's connectivity demand, i.e., when riders ask, "can I get from there to there?" This finding highlights the importance of determining whether a city's public transit system provides access to its visitor spots.

Limitations

This study dealt with several constraints in creating the innovative method to evaluate the accessibility of the public transit system to tourism sites. Referring to origin data, visitors may stay with friends or relatives rather than in a hotel or Airbnb, but these data are not available. Furthermore, many Airbnbs and other informal lodgings are not officially registered and thus have no associated data available. Even registered Airbnb properties are far more likely to change their

location in the future than are hotels. Despite these limitations, however, the existing data provide insightful information about the behaviors of the younger generation of visitors.

Given these constraints, the data for each city's attractions were scraped from the TripAdvisor website. Since they lacked latitude and longitude, the author added the addresses using Google Maps and later geocoded specific points based on these addresses in ArcMap. However, the geocoded points were not precisely located at the properties. They were often placed at the nearest streets to the properties. Confirming the exact location of each attraction was a time-consuming yet essential process in the grid-based analysis, as placing the point at its precise location rather than the nearest street could change its associated grid. The location of attraction clusters counts as another limitation of this study. There are many ongoing debates about different categories of environmental justice within U.S. cities. The dispersion of attractions also speaks to this issue.

Another constraint involves the public transit general transit feed specification (GTFS) data. The current research chose to use each city's rapid transit services in the analysis for the reasons mentioned earlier in the literature review. Even though some cities provided separate GTFS data for buses and rapid transit, most provided one file for all their public services. As a result, network datasets were created based on mixed data, including both buses and rapid transit services, which affected the O-D matrix and accessibility data for analysis.

CHAPTER SIX

CONCLUSION

This is the first time that the accessibility of urban visitor origins and destinations have been assessed through analyzing public transit real data with ArcMap network analysis. The current study created, revised, and refined multiple data sets for origins and destinations and analyzed several indicators, including the effects of spatial pattern, buffers, and accessibility on city visitors' choice of public transit mode. Finally, it presented top-ranked U.S. cities that provide a developed public transit system for their visitors. The findings demonstrated a positive correlation between a city's developed public transit system and a city's tourist-friendliness. One reason for this relationship might be that a developed transit system provides more access to different areas, including visitors' origins and destinations.

Insight about visitors' needs allows the provision of more public commuting opportunities, which, in turn, lead to less destruction of the environment and the destinations. Moreover, increased visitor usage of public transit will boost ridership, which will encourage residents to trust and use their city's public transit system.

The data created and the method developed in this research are valuable for the future understanding of younger generations' choices and needs when using public transportation. The research outcomes show there is a disparity in the spatial distribution of attraction within the city's different neighborhoods which may lead to unequal public transit routes or stations. More quantitative research is needed to detect the precise locations of visitors' origins and the places

they visit during their trips. In this regard, there is a need to focus on the relationship between the spatial pattern of city attractions and the city resident's demography.

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