

Night Riders:
Accessibility, Land Use, and Late-Night Transit

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Abstract

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Late-night transit service is an overlooked and underappreciated aspect of public transportation. Service is often unreliable and very often non-existent. When night service is available, routes are limited and circuitous, headways are long, and coverage is poor. The negative impacts of poor service are overwhelmingly born by those who have to work the late-shift. Late-night workers make less, travel farther, and are more likely to be non-white than their daytime counterparts, yet late-night service is rarely discussed in matters of transit equity. This paper seeks to situate the needs of late-night transit riders by conducting an analysis of King County Metro's Night Owl bus service. First, the paper created and mapped an index of potential late-night transit riders based on demographic and household characteristics. Second, potential late-night destinations were identified based on late-night employment concentrations and land use data. Finally, an Origins/Destinations (O/D)

analysis of the Night Owl bus network was performed between census block groups with high concentrations of potential late-night transit riders and late-night destinations. The results revealed high concentrations of late-night transit riders within the city of Seattle, as well as suburbs to the south like Kent, Auburn, and Federal Way. Late-night destinations were generally concentrated in industrial areas, the Duwamish Valley, and adjacent to arterial streets. The O/D analysis showed that late-night transit trip times are significantly longer than mid-day trips, service is generally at its best within the city of Seattle, and large swathes of the study area had little to no meaningful access to late-night transit.

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“We cannot accept the existence of differences between a diurnal and a nocturnal citizenry, the latter deprived of public services. Once he/she is obliged to work at night, why wouldn't a salaried worker have the right to public transportation?”

– Luc Gwiazdzinski

Introduction

The urban night holds a unique space in our collective understanding. Often conceived of as a space of revelry and/or deviance, the late night period is defined by diminished services. A sort of pause, in which the once active and vibrant city floats in a liminal state, no longer awake yet not entirely at rest. Despite this ambiguity, however, societal maintenance and other vital activities must take place during the evening. People perform these roles, fill these jobs, and the need to access them is as present at night as it is during the day. Yet, transit systems across the country seem to view the late-night period as unimportant, saddling these workers with rigorously awful commutes. One participant in a focus group of hospital cleaning staff in the Bronx illustrated the sense of frustration these commuters often feel: “The [bus] is a problem...11:40 PM, gone, and then no service until 5 AM...It's 12:30 to 1 o'clock in the morning, it's at least a half hour wait for the bus. My commute takes anywhere from an hour and forty minutes to two-and-a-half hours” (Weintraub 2018, 27).

The mobility provided by a transit network can be taken for granted until it disappears.

Whole swathes of cities and metro areas become suddenly inaccessible, economic

opportunity restricted, and quality of life severely reduced. For daytime transit riders, this may seem like a worst case scenario, yet for those who ride at night it is a constant reality. While many fewer people ride transit at night than during the day, these pains are acutely felt because the infrastructure is often already weak and riders have almost no other options. As of this writing, only twelve cities in the United States offered some sort of fixed-route transit through the night, often leaving shift-workers stranded at their jobs until the morning buses arrive (Williams 2019).

Beyond the transportation challenges, working the night shift can be a grueling and difficult experience, still, millions of American workers clock in when the sun sets. Night workers make 14% less than their counterparts, are more likely to be Black or Latino, and have fewer educational credentials (Zalewski et al. 2019). These workers are more likely to drive to their job, more likely to be transit cost-burdened, and face higher turnover rates often precipitated by transportation issues (Zalewski et al. 2019). Night shift workers even face higher rates of cancer, cardiovascular issues, and routinely report their work time isolates them from friends and family (Franciscan Health 2018).

For most people travelling at night is a choice, for others however, it is a necessity. Getting around late at night by transit is an arduous experience, one that can be dangerous, difficult, and expensive. For many of these workers public transit is simply not an option because transit agencies so routinely fail to provide adequate service during these hours. When night

service is available routes are limited and circuitous, headways are long, and coverage is poor (Dentel-Post, Cooper, and Huang 2017).

Until 2017, Seattle's late night bus network—the Night Owl service—was emblematic of careless late-night transit planning. Designed in the 1950s, it was a hub-and-spoke model made up of several short, meandering one-way loops that converged downtown. Its coverage was poor and it served the minimal utility of last-resort transportation. Ridership was low, costs were high and the whole network was planned to be scrapped due to budget shortfalls (Nourish 2014). After an extended political effort was launched to save the Night Owls, the network was redesigned in 2017 to operate more like a pared down version of the standard system (Packer 2016). Community groups and transit riders noted particularly the lack of service to the rapidly growing working class suburbs of south King County. The service changes were particularly meant to be beneficial to the communities on Seattle's fringe like White Center, SeaTac, Shoreline, and Auburn. (King County Metro 2017b).

The new network deleted the looping mid-century lines, replacing them with extended service hours on recognizable daytime routes. Funded almost exclusively by the city of Seattle, King County Metro's Night Owl network currently operates 12 routes with 49 regular bus trips and 18 RapidRide trips between midnight and 5 AM.

This research will evaluate the efficacy and utility of Seattle's Night Owl bus service redesign, and in the process, investigate who rides late night transit, what their destinations are, and how land use impacts ridership. It also attempts to situate late-night transit as an important, yet under-discussed element of transportation equity. It seeks particularly to answer the following research questions: How do different land-use patterns affect late-night transit ridership? How does King County's late night transit network connect potential late night transit riders to their destinations?

To answer these questions, I created a Transit Propensity Index (TPI) of household, demographic, and land use characteristics shown to contribute to late-night trip generation and transit ridership. Using GIS software, the TPI was then mapped at the census block group level capturing the service area of Seattle's Night Owl bus network and demonstrating where future late-night service ought to be routed.

Service coverage is a limited metric, however, since the utility of a transit system is also defined by the availability of service. The looping, bendy routes of the original Night Owl system were typical of coverage networks, designed to maximize the amount of potential passengers served by a route at the expense of efficiency and speed (Walker 2011). To evaluate the utility of the service, the paper created a nighttime land use index based on Bureau of Labor Statistics data delineating which industries have the highest concentration of late-night workers. The concentration of these industries was then mapped at the block

group level. An origin/destination analysis was performed with TPI blocks set as the origin and nighttime land use blocks as the destination. Using Google Maps' routing API, the transit travel times between the two types of block groups were measured at 2:30 AM and 2:30 PM. To provide a comparison, driving times were measured at 2:30 AM as well. The paper concludes with specific recommendations for the expansion of late night transit in the Seattle metro area.

Literature Review

Night Transit

Late-night transit is not a particularly well-covered topic in the planning or transit literature likely because ridership is low, marginal costs are high, and few cities offer late-night service (Zalewski et al. 2019). In fact even the time at which “night” takes place is unsettled in the world of transit service. Many agencies operate “night service” but not 24-hour service meaning night operations can end at 10 PM or earlier. Others run service into the wee hours but not around the clock, for example, in Austin, Texas, Night Owl service ceases operations at 3 AM. Many agencies have begun partnerships with transportation network companies (TNC) like Lyft and Via to offer ride-hailing in lieu of fixed route service and many of these programs operate well into the night (APTA 2021).

For the purpose of this paper “late-night transit” refers to some form of publicly available, fixed-route, traditional transit service that operates continuously and without prolonged interruption for 24 hours a day. These routes could operate identically at night as they do in the day; they could switch modes, e.g. rail in the day bus at night, or they may be routes exclusively offered in the late-night period. This definition explicitly excludes late-night TNC partnerships like SEPTA’s recently shuttered Owl Link and the MBTA’s RIDE Flex. While these are interesting services they are beyond the scope of this project, though they are discussed at greater length in the conclusion. As will be noted in more detail below, this

definition would include modes and networks as comprehensive as New York City's 24/7 subway and bus system and as lonely as Portland TriMet's two night bus routes.

There are at least twelve US cities that have some form of fixed-route overnight transit service: Chicago, New York, Philadelphia, Los Angeles, Miami, San Francisco, New Orleans, Las Vegas, Detroit, Pittsburgh, Portland TriMet, and Seattle (Dentel-Post, Cooper, and Huang 2017). Based off of their publicly posted route maps and schedules, these cities vary widely in the levels of service, headways, and modes of transit available. For example: New York, Chicago, and Philadelphia¹ are the only cities in the United States to offer 24/7 rail service. Buses are a much more common mode for late night transit. New York, New Orleans, Los Angeles, and Las Vegas operate on slimmed down, but still comprehensive, versions of their all-day bus networks. Seattle, Detroit, San Francisco, Pittsburgh, and Chicago offer dedicated late-night service on a select group of routes. Miami's network is a mix, offering two night-only "Owl" routes and limited service on the rest of its bus system. TriMet in Portland offers the slimmest network of 24-hour service, running with two dedicated night routes.

The reason only twelve cities offer some form of fixed-route, late-night transit is likely in part because late-night transit is a costly endeavor. The MBTA's 2015 report of its late-night

¹ This is the PATCO Speedline which has only four of its nineteen stops in the city of Philadelphia, with the remainder in Camden and suburban New Jersey

service revealed an annual cost of \$12.9 million for a limited extension of transit hours: key subway and bus routes, offered only on Fridays and Saturdays until 3:00 am. The report also showed a per-passenger subsidy over 2.5 times higher than traditional service hours (MBTA 2015). The City of San Francisco found late-night rail to be difficult both as a matter of cost and by disrupting local rail agencies maintenance and repair hours (San Francisco Late-Night Transportation Working Group 2015).

Perhaps the main reason late-night transit is expensive is because there are many fewer riders at night. The MBTA found that although systemwide ridership was much lower it followed the general ridership fluctuations observed during traditional service hours. The stations with the most boardings were found to be the ones nearest Boston's universities. Ridership decreased as the night wore on, however, it decreased less at 2:00 am during the city's 'last call' (MBTA 2015). San Francisco found that late night transit riders in its city had lower median incomes than daytime travelers. Late-night transit riders also tend to cluster in particular employment fields including, hospitality, general services, and hospitals (San Francisco Late-Night Transportation Working Group 2015).

A 2019 study performed by the American Public Transportation Association found an important opportunity cost in offering late-night service as many agencies use the overnight period for maintenance and repair (Zalewski et al. 2019). San Francisco's (2015) survey found its regional rail operators relied heavily on the overnight period for routine maintenance that

would otherwise have service impacts during the day. These costs render late-night rail service particularly expensive.

Academic inquiries into late-night transit are relatively limited. In 2010, researchers surveyed late-night transit riders in Athens, attempting to evaluate their perceptions of its utility and quality (Veliou, Kepaptsoglu, and Karlaftis 2010). The authors conducted both an analysis of ridership information as well as a passenger satisfaction survey. The authors found 67% of night riders were between the ages of 18-30 and an overwhelming majority, 90%, were regular public transit users (Veliou, Kepaptsoglu, and Karlaftis 2010). The survey found overall satisfaction with the service and showed 28% of riders surveyed had made the switch from single-occupancy vehicles (Veliou, Kepaptsoglu, and Karlaftis 2010).

A 2016 paper explored ridership patterns and origins and destinations of what the authors refer to as “extreme” transit riders on the Beijing metro. The definition of “extreme” was made up of four types of transit riders: “[those who] travel significantly earlier than average riders (‘early birds’); ride in unusual late hours (‘night owls’); commute in excessively long distance (‘tireless itinerants’); and make significantly more trips per day (‘recurring itinerants’)” (Long et al. 2016, 224). Using a combination of smartcard and census-like survey data to isolate trips and identify riders, the study found that 96.2% of the people identified as night owls were traveling home (Long et al. 2016). The study also found that 84.7% of night

owls were employed full time and were found to have the lowest income of the four surveyed groups. (Long et al. 2016, 230).

An equity analysis was performed on London's relatively new Night Tube transportation service, finding it favored late-night consumers at the expense of late-night workers (McArthur, Robin, and Smeds 2019). Late-night workers were found to make 50% less than their daytime counterparts yet the program replaced many lower-fair bus routes with higher-fair rail service. The authors concluded that "the value of the Night Tube to low-paid night-time workers in London is questionable" (McArthur, Robin, and Smeds 2019, 439).

A rapidly growing segment of the literature has developed around gender, class equity, and safety in late-night transit. Work in this area has centered the difficulties of late-night mobility and gender. Interviewing female hospitality workers in Sofia, Bulgaria, Anna Plyushteva (2017) found access to reliable nighttime transportation was a major determining factor in whether the interviewees were able to get and keep jobs. The study also showed that late-night workers often face two different transit systems: higher-frequency, more comprehensive day/evening service on the way to work, sparse and infrequent late-night service on the way home (Plyushteva 2017).

Another study analyzed late-night bus access in Sofia, Bulgaria examining how policies and practices can exclude women and non-men from late-night transit (Plyushteva and Boussaw

2020). Safety, or a lack thereof, was found to be a critical determinant in women's travel decisions, particularly in the late-night period. Survey and interview data demonstrated that women who travelled late at night made less than their male counterparts but were significantly more likely to take a cab (Plyushteva and Boussaw 2020). Additionally, female late-night transit riders, in response to real and perceived dangers, relied heavily on pre-planning their trips: "preparations and precautions place multiple demands on women, such as choosing particular types of clothing, or avoiding direct routes" (Farina, Plyushteva, and Boussaw 2021, 17).

Equity in Transit

Equity in transit is broken down into two smaller sub-fields: theory and evaluation. A portion of existing work attempts to establish a theoretical, qualitative, and relational framework for transportation equity. Defining equity is complex and often varies from author to author. I takes a capabilities approach when it comes to judging the equitable distribution of transit service. This framing understands mobility as a fundamental right upon which a person's ability to act is built and such "[p]olicies should...guarantee individuals a minimum level of access to those key activities that are essential for meeting basic needs, such as food stores, education, health services, and employment opportunities" (Pereira, Schwanen, and Banister 2015, 182).

A key challenge to the equitable distribution of transit service is a person's ability to access it. Accessibility can be understood as "the spatial distribution of activities about a point, adjusted for the ability and desire of people ... to overcome spatial separation" (Martens 2017). In the case of mass transit, access is an equity concern because it provides essential mobility services to low-income and working people who may have no other means of transport. Being able to get to the bus stop means being able to get work and keep that work (Griffin and Sener 2016).

Reliable service is an essential equity concern as well since delays, cancellations, and other service disruptions can have severe negative consequences on a person's ability to retain their job. Low-income jobseekers have identified a lack of access to reliable transportation as one of their key difficulties in finding and keeping a job (Abraham 2014). Evidence has linked increased access to fixed-route transit with lower levels of employee turnover, showing the powerful role transit can play in the lives of low-income workers (Faulk and Hicks 2015). Additionally, the spatial mismatch of low-income workers and their jobs results in extended commutes—including so called super commutes—with higher degrees of variability (Currie 2004). An extreme example of this is in the San Francisco Bay Area, where the search for affordable housing has pushed poor and working class Californians further and further from their jobs (Baldassari 2019).

Temporal availability is another matter of transportation equity, particularly since it has been demonstrated that different groups of people interact with the transportation system at different times (Zalewski et al. 2019; Dentel-Post, Cooper, and Huang 2017; McArthur, Robin, and Smeds 2019). Transit agencies run the highest frequency service during the morning and afternoon rush hours while the evening and late-night period tends to see the lowest frequencies. This results in late-night transit riders being underserved—if served at all—by the system, forcing them to endure labyrinthine commutes with grueling wait times (Williams 2019; McArthur, Robin, and Smeds 2019; Weintraub 2018). This means that accessibility must be considered in both a spatial and a temporal capacity, particularly for public transportation where networks may be very good at transporting people to a far-flung central business district but not necessarily destinations closer to home. Noting that, “locational proximity does not necessarily mean better access for many people,” Kwan (2013, 1082) proposed an integrated measure of accessibility that takes into account temporal as well as spatial constraints.

The concept of “transportation justice” has been developed to address issues of racial inequities in the distribution and resourcing of transportation infrastructure. Its roots can be traced back to Martin Luther King Jr who “viewed access to public transportation as an important civil right...one that has a direct bearing on the economic opportunities of poor people of color” (Inwood, Alderman, and Williams 2015). Nationally, People of color make up 60% of public transit riders in the United States and Black Americans make up a

disproportionately large share (Clark 2017). Those numbers increase further in cities with populations greater than 1 million. A majority of late-shift workers are People of Color—despite making up 39 percent of the total labor force—meaning late-night transit riders are particularly likely to be non-white (Zalewski et al. 2019).

Measuring equity in public transit has fallen into several different categories. Some emphasize job access and economic security, others provide specific data collection methods, others focus on geographic and spatial distribution. Almost all attempts to quantify and measure transit equity have included the amount of jobs that can be accessed by users of that transit service (Shen 1998; Shen 2001; Phillips and Sener 2016; Faulk and Hicks 2016).

Measuring accessibility is quite tricky and researchers have developed sophisticated methods to calculate physical and/or temporal impedance. Historically, measures were generally based on the Hansen formula (Hansen 1959) which has been critiqued for treating demand for transport services as the same across a broader area (Shen 1998). More recent methods for calculating accessibility have attempted to overcome the shortcomings of the Hansen model by incorporating measures of job competition and turnover, destination capacity, modal differences, and more (Shen 1998; Shen 2001; Faulk et al 2013; Faulk and Hicks 2016).

Transit Propensity

When developing new service plans and analyzing the efficacy of existing routes, transit agencies attempt to determine the amount of potential riders that will use the service. One of the key methods agencies use in determining ridership is a Transit Propensity Index (TPI), a basket of demographic characteristics associated with transit ridership. TCRP Report 28 Transit Markets of the Future established the basis for transit propensity by analyzing transit use and demographic characteristics from the Census, the American Housing Survey, and the Nationwide Personal Transportation Study (Rosenbloom 1998). The analysis identified 14 demographic groups that were more likely than average to take transit to work. These groups included racial minorities, households without access to a vehicle, low-income workers, workers between the age of 17 and 29, workers age 60 and up, workers with no high school, workers with some high school but no degree, workers with a college degree, workers with a graduate degree, immigrants, and workers with mobility limitations (Rosenbloom 1998).

Transit propensity analysis looks at the spatial distribution and concentration of the aforementioned demographic characteristics in order to identify the areas that would be best served by transit. Standard practice focuses on the variables of zero vehicle households, people with disabilities and mobility limitations, women, low income households, non-white people, and recent immigrants.

A 2017 study analyzing San Francisco's newly established 'Night Owl' bus network created a TPI focused on characteristics and travel behaviors that are associated with late-night transit ridership, using it to analyze the network's accessibility (Dentel-Post, Cooper, and Huang 2017). The authors used travel flow data from the Census Transportation Planning Product to map the location of late-night jobs and other activity centers and ACS responses to identify transit riders. In order to capture both current as well as potential late-night transit riders, the authors relied on ACS responses to create a geographic index of characteristics associated with transit dependence. These included the density of households without a car, the density of low-income households, and the density of late-night workers (Dentel-Post, Cooper, and Huang 2017).

Transit propensity analysis is a popular and commonplace tool for transportation planners across the United States and is considered to be a "best practice" in service planning and analysis. Despite the well documented linkages between land use and transit ridership, TPIs focus exclusively on population and household characteristics.

Land Use and Transit Ridership

Transit ridership and land use are inextricably linked and there is an extensive literature documenting the connection between travel choices and the built environment. Cervero and Kockelman (1997) coined the three D's that guide the relationship between travel

demand and the built environment: density, diversity, and design. Two more D's, distance to transit and destination accessibility were added later (Ewing and Cervero 2001). Density generally refers to population or employment figures within a given area, diversity represents the different land use types that exist within a certain area, and design takes into account the street and sidewalk network. Distance to transit generally means how far a person would travel from home or work to access transit services; and destination accessibility refers to the amount of places that can be reached by a trip (Ewing and Cervero 2010). Transit ridership is deeply intertwined with a person's ability to access that service so living close to a transit stop has been shown to be the most salient variable in determining ridership. Following proximity to a transit stop, areas with high-levels of street connectivity were found to be predictors of transit ridership as were areas with high degrees of land use variability (Ewing and Cervero 2010).

Approaches to defining and measuring "land use" vary from study to study but almost always include some measure of population or employment densities, covering Ewing and Cervero's first D. Generally, density has been found to be positively correlated with transit ridership (Dill et al. 2013). A study of bus transit and TOD factors found that "density is of primary importance relative to transit demand" (Johnson 2003, 33). In attempting to develop a travel demand model for the state of Maryland, researchers created a typology of land use based of residential density, which they then supplemented with the square footage of various land use types including healthcare, warehouses, recreation and others. Their research found a

relationship between population and employment densities and transit ridership, however, it was not uniform across residential types.

Household density was not predictive of transit ridership in suburban communities and employment density was not predictive in rural communities (Chakraborty and Mishra 2013). In a survey of land use and its impact on transit ridership Guangzhou, China, researchers found that population and employment density were the surest predictors of transit ridership, followed by allowable Floor Area Ratio (Li et al. 2020). Different residential zoning classes were shown to have an impact as well. Lower density (i.e. more expensive) residential zones were the least predictive of transit ridership and high density zones were the most (Ibid 2020).

Diversity of land use has been shown to be a driver of transit ridership, however, exactly how is debated (Dill et al. 2013; Johnson 2003; Aston et al. 2020; Hu et al. 2016; Banerjee et al. 2005; Li et al. 2020). Multi-family residential and some degree of commercial and/or mixed use zoning have repeatedly been found to be the most important land use types in predicting transit ridership (Johnson 2003). Dill et al investigated the impacts of land use mix as defined by the amount of commercial zoning, land use mix, and defined pedestrian destinations—using a set of NAICS industry codes. Their model found land use mix was predictive of transit ridership, however, it was less important than transit service indicators and population demographics. Of the land use variables tested, multi-family residential and

commercial zoning were most predictive of transit ridership as were “pedestrian destinations” (Dill et al. 2013).

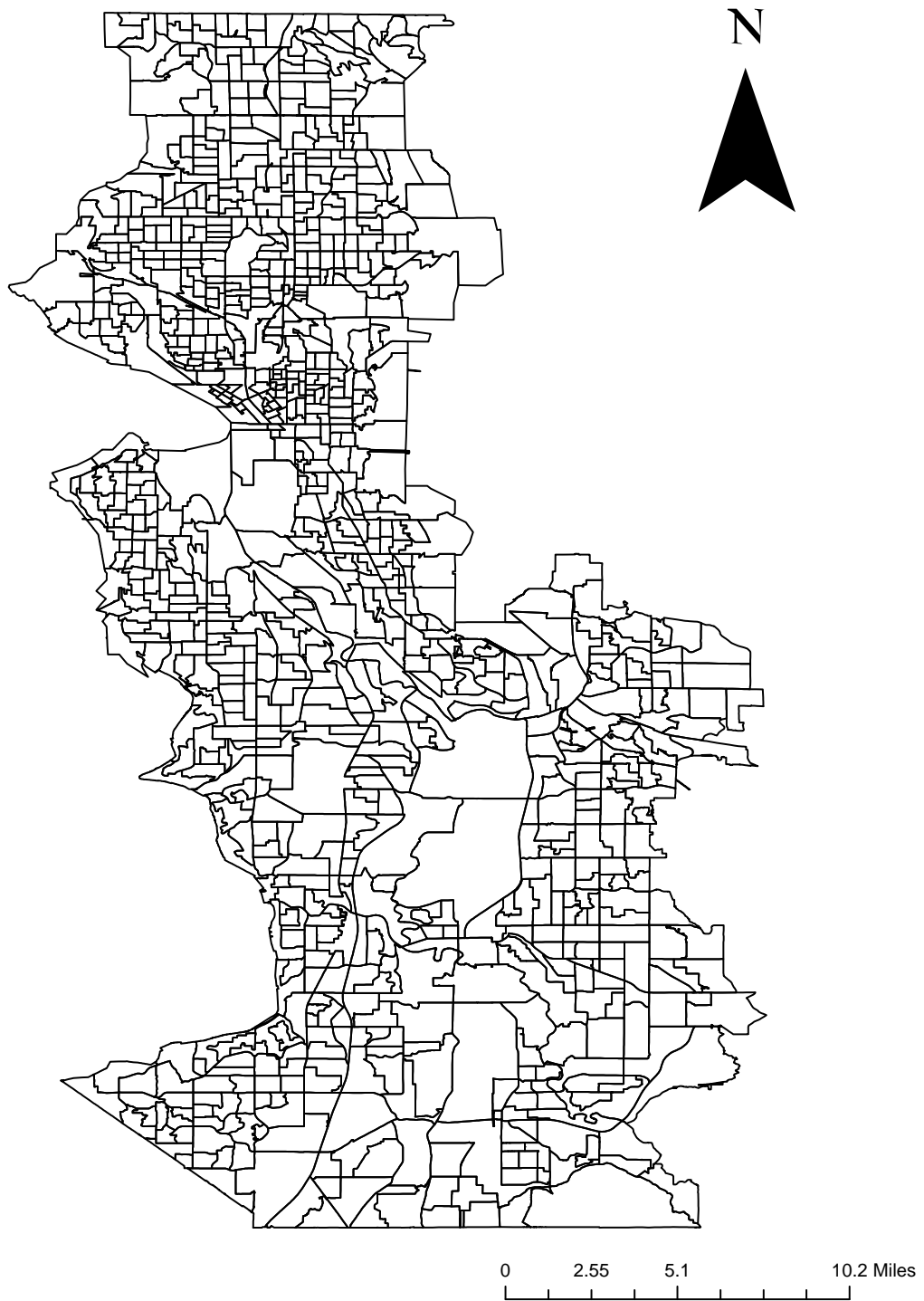


Figure 2 Project Extent

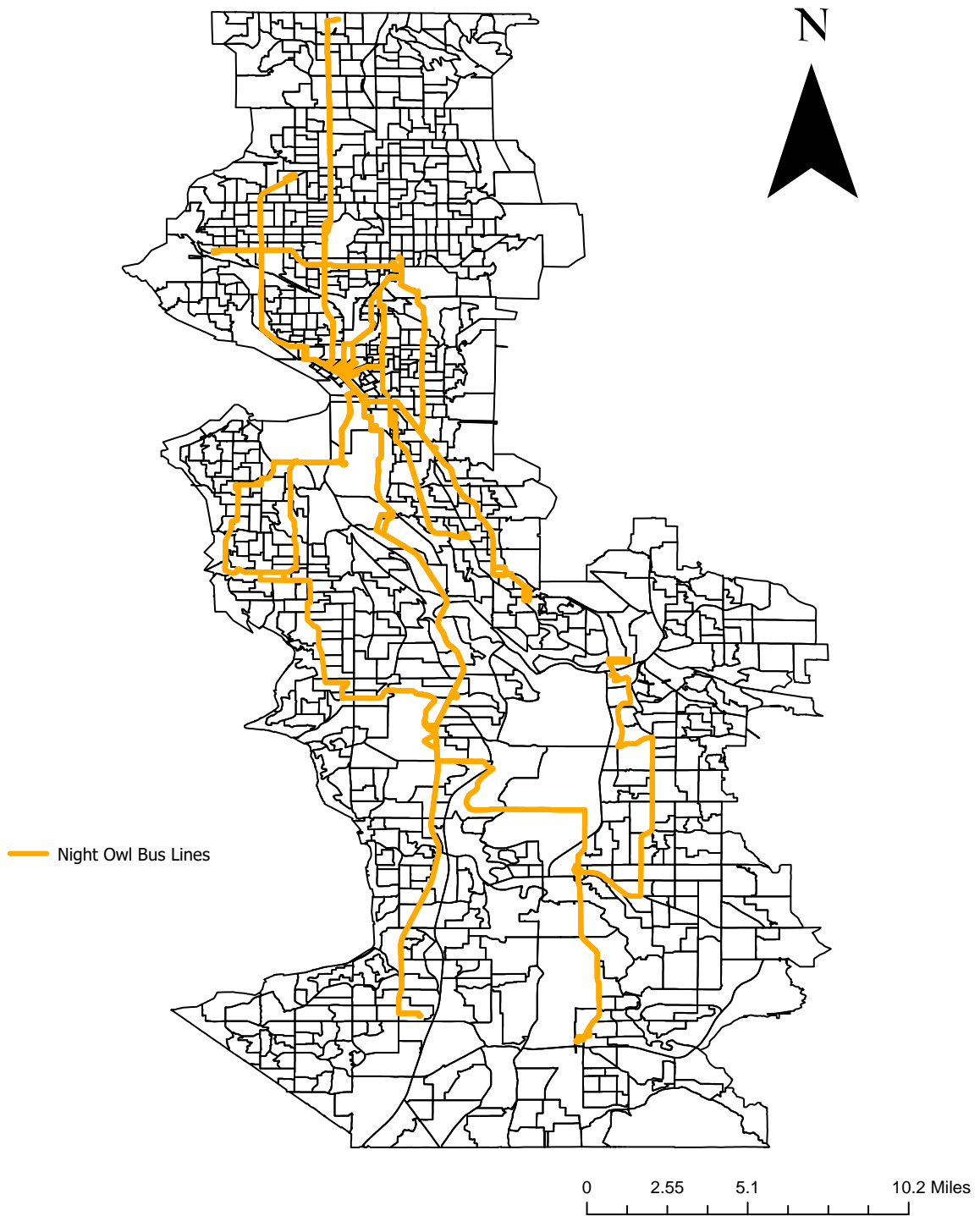


Figure 3 Project Extent and Night Owl Bus Lines

Methods

This project is guided by two specific research questions: How do different land-use patterns affect late-night transit ridership? How does Seattle's late night transit network connect potential late night transit riders to their destinations?

Transit Propensity and Late Night Land Use

To answer these questions, the first task was to locate late-night transit riders and compare their locations to King County Metro's Night Owl bus network. In order to accomplish this task, I created a Late Night Transit Propensity Index (TPI) mapped at the Census block group level. The geographic scope of the project spans the Night Owl network's greater service area and therefore focuses primarily on the west side of King County. The scope runs from Shoreline in the north to Federal Way in the South. It is primarily bounded by Lake Washington to the east although it does incorporate some communities south and east of the lake, like Renton and parts of Covington.

The TPI brings together several land use and population characteristics associated with transit ridership more generally and night ridership more particularly. Population and demographic characteristics for the TPI are derived from the American Community Survey 2019 five-year estimates. Block group boundaries are defined by the 2010 Tiger/Line shapefiles accessed via King County, Washington's GIS Data Portal.

The demographic characteristics that make up the Late Night TPI are: young adults (18-34), those with an educational attainment of “some college or less,” households making \$74,999 or less per year, people who left for work between the hours of 4 pm and 4:59 am, households without access to a vehicle, and people of color. These characteristics were chosen in part because they are associated with late night transit ridership and the late night labor force. Zalewski et al. 2019 survey of the late night economy provides detail into who may be interested in riding late night transit. They found that these workers were more likely to be non-white, younger, and less likely to have a college degree than the general population. These workers also make 14% less than their daily counterparts, nationally around \$28,000 per year for an individual. Income figures for the late night TPI are higher because they are based on a two-income household and because of Seattle’s (as of this writing) \$17.21 per hour minimum wage.

As detailed in the previous section, land use has been shown to be as salient a predictor for transit ridership as demographic characteristics. Despite this, traditional TPIs do not generally include land use data, instead analyzing it’s effects separately from demographic characteristics. This project attempts to reconcile this by incorporating select land use features into the Late-Night TPI: population density and multi-family residential parcels.

Land use and parcel data came from the King County Assessor's Office and was accessed via King County's GIS Portal. Parcels were assigned to their corresponding block groups then delineated based on the Assessor's "Present Use Description". The dataset also defines the zoning for each parcel, however, the zoning code includes present as well as potential uses. The present use category was chosen for its granular detail about what is actually and currently taking place on a given parcel.

To calculate the Late Night TPI, the present uses chosen were any non-single family residential parcel, this included the categories: Duplex, Apartment, Condominium and more. The number of those parcels was then tallied and divided by the total number of *residential* parcels in each census block group. The demographic characteristics were similarly calculated as proportions for each census block group. Population density was derived from the Decennial Census and calculated per block group using GIS software. The population density was then normalized to match the other variables, falling on a scale of 0 – 1. The final Late Night TPI score was then calculated by summing the proportions of each variable and normalizing the total to create a 0 – 10 score with 10 indicating the highest transit propensity and 0 the lowest. The resulting TPI scores were then mapped in order to assess how effectively they are served by the Night Owl bus network.

$$\text{TPI} = \text{Var}_1 + \text{Var}_2 + \text{Var}_3 + \text{Var}_4 + \text{Var}_5 + \text{Var}_6 + \text{Var}_7 + \text{Var}_8$$

$$\text{TPI}_{\text{normalized}} = (\text{TPI} - \text{TPI}_{\text{maximum}}) / (\text{TPI}_{\text{minimum}} - \text{TPI}_{\text{maximum}})$$

Figure 4 TPI Formula

GIS software was used to convert King County GTFS data into a viewable format and overlaid onto the Late Night TPI map. ArcGIS' Network Analyst tool was then used to create stop-level service areas for each late night bus line allowing for a detailed understanding of transit access.

While the Late Night TPI helps understand where Seattle's transit riders may be coming from, in order to properly understand the utility of late night service it is necessary to consider where they might be going. According to their latest rider/non-rider survey, 53% of King County Metro's passengers are using the service to get to or from work (Mimms 2020). Understanding this, this project used King County land use data to visualize where late night work may be taking place in the greater Seattle area.

Late night land use parcels were similarly identified using the King County Assessor's Parcel map and its "Present Use Description" category. In order to assign parcels as late night, industry and labor data was taken from the Bureau of Labor Statistics, Zalewski et al. 2019, and King County employment data. The BLS report identified several industries with high

concentrations of late night workers, including “arts, design, and entertainment,” “food preparation,” “healthcare,” “warehousing” and many others. Zalewski et al. 2019 found similar results in their analysis of the late night economy. Particularly they found that “food service and drinking places,” “administrative and support services,” and “hospitals” were the three industries with the highest concentration of late night employees. These reports were used to inform which land uses within the “Present Use Description” category would be included as a late night parcel. Because there were so many more industrial/warehouse parcels than other types, each late night land use parcel was then weighted based on King County employment figures pertaining to its given industry. The results were summed to create a weighted index, then mapped in GIS and overlaid with the Night Owl bus routes and their service sheds to get a better understanding of how these block groups are served by the late night transit network.

X = # of parcels in block group of particular land use type
Y = countywide employment proportion for given land use type

$$\text{Index} = (X_1 * Y_1) + (X_2 * Y_2) + (X_3 * Y_3) + \dots (X_{21} * Y_{21})$$

Figure 5 Late-Night Land Use Index Formula

Table 1: Late Night Land Uses Included in Index

Present Use Description
Warehouse
Restaurant/Lounge
Industrial (Gen Purpose)
Industrial (Light)
Restaurant (Fast Food)

Hotel/Motel
Industrial (Heavy)
Retirement Facility
Tavern/Lounge
Terminal (Marine)
Terminal (Rail)
Vet/Animal Control
Nursing Home
Hospital
Terminal (Marine/Comm Fish)
Air Terminal and Hangers
Historic Prop (Rec/Entertainment)
Resort/Lodge/Retreat
Historic Prop (Loft/Warehouse)
Historic Prop (Eat/Drink)
Terminal (Grain)

Origin/Destination Analysis

In order to evaluate the temporal accessibility of the late-night transit network, an origins and destinations analysis was conducted between select TPI block groups and the 50 highest scoring late-night land use block groups. Coordinates were calculated in GIS based on the centroid of each block group. Using the Google Maps API, travel times between the block groups were evaluated for public transit and private automobile. Transit trips began at 2:30 AM and 2:30 PM and the results account for waiting and walking times as well as the amount of time spent on a transit vehicle. Driving times were also calculated at 2:30 AM in order to highlight the modal choice faced by a would-be late-night traveler.

Limitations

The research for the project was conducted primarily in early 2022 and was unable to incorporate data from the 2020 Census. This provides a major limitation to the accuracy of the results, however, the methods could be easily replicated with up to date data as it becomes available.

There is a wonderful amount of data available about *where* jobs are located and *what* the particular industry and/or roles of that job are. There is frustratingly little about *when* the work itself is performed. As such, the late-night land use index is an educated guess based on available data about what types of industries make up the late-night economy.

Because of the infrequency of late-night transit, the semi-arbitrarily chosen 2:30 AM trip start time could potentially exaggerate the amount of time spent waiting for a bus if, for example, one had just departed at 2:20 AM. The opposite could be true as well, minimizing the amount of waiting time because a bus can be caught at 2:35 AM.

Results

Transit Propensity Index

High scoring TPI block groups are concentrated largely within the densely populated areas of Seattle as well as throughout much of south King County. Notably there are few high scoring TPI block groups along the coastal portions of the study area with occasionally stark changes between a waterfront block group and a block group immediately inland. Within the city of Seattle the areas with the highest concentration of high scoring TPI block groups include Downtown, the Rainier Valley, the U District, Ballard, Northgate, Bitter Lake, Lake City, Delridge, South Park, and Georgetown. The unincorporated communities of White Center and Skyway scored high as did most of the cities of Des Moines, Federal Way, Kent, SeaTac, Tukwila, and Auburn. The city of Renton also had several high scoring census blocks particularly the communities adjacent to I-405. For maps showing the distribution of the individual TPI characteristics, please refer to Appendix A.

Four of the five highest scoring TPI block groups were in Seattle's U District. 91.9% of the residential parcels in the highest scoring block group, #52001, are multi-family. 92.4% of households make less than \$74,999 per year, and 92.4% of its residents are between the ages of 18 and 34. With 53.6% of its population being non-white it was above the area wide mean of 34.4%. Of the twenty highest scoring block groups all but three were either located in Downtown Seattle or the U District.



Figure 6 TPI Scores at Census Block Group Level

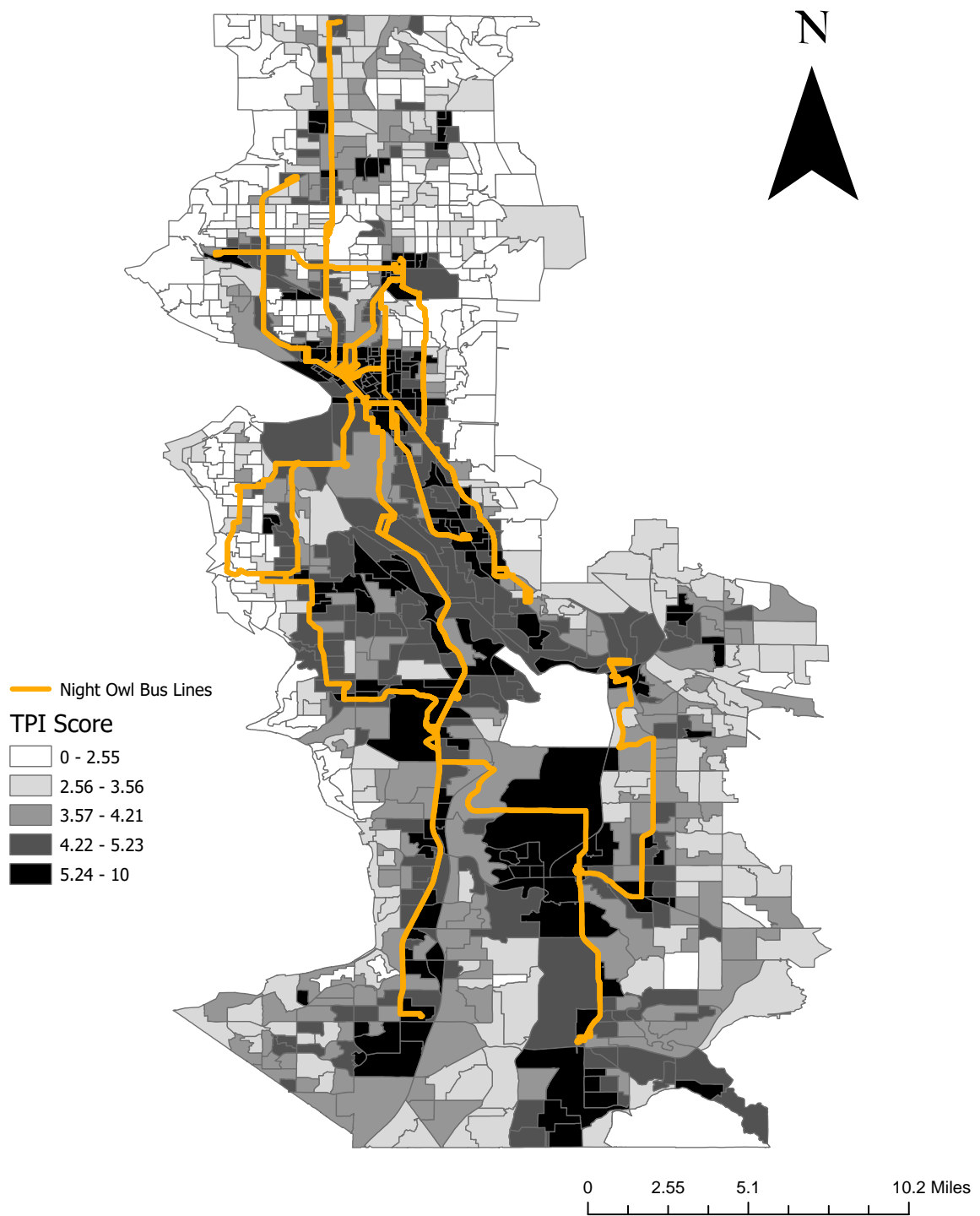


Figure 7 TPI Score and Night Owl Bus Lines

The highest scoring non-Seattle block group was #292062 in the city of Kent. Its TPI score was 8.89 and driven largely by its high concentration of households making less than \$74,999 per year and households with some college or less.

The lowest scoring block group was #211004 in the city of Shoreline. Since it primarily encompasses the city's Hamlin Park it has a documented population of 0. The second lowest was in Seattle's Laurelhurst neighborhood with a TPI score of .57 out of 10. Block group #41006 had single digit proportions for almost every TPI variable. Every household had access to at least one vehicle and none reported going to work between the hours of 4 pm and 4:59 am. Population density is low and 0% of residential parcels are multi-family (duplex or higher). 8.6% of the population is nonwhite, 4.8% of households make less than \$74,999 per year, 5.2% had an educational attainment of some college or less, and 8.3% were between the ages of 18 and 34.

Broadly speaking, the lowest scoring TPI block groups were concentrated along the Puget Sound and Lake Washington waterfronts within the city of Seattle, particularly neighborhoods north of the shipping canal. Coastal Burien, Renton, and Normandy Park also had several low scoring block groups.

Late Night Land Use

Late night land use destination parcels were primarily concentrated along the regions industrial belt, primarily the Duwamish Valley. The highest scoring late night destination block group was located in the SODO neighborhood of Seattle. Its high score was due to the high concentration of industrial and food service land uses. The city of Kent also had a high concentration of late-night destination block groups including block group #292061 which had the second highest weighted land use score, again in part because of a high concentration of light industrial and food service land uses. Seattle has fewer late night destination block groups than TPI block groups, however, they are generally concentrated in the same area. Downtown Seattle, Ballard, the U District, SODO, Georgetown, South Park had the most late night destination parcels within the city. There are also several block groups along Rainier Ave S and MLK Way S that had high proportions of late night land use, their inconsistent pattern along the corridor likely indicates where commercial land uses are and are not allowed.

Unlike the TPI, almost half of the area block groups had 0 identified late night land use parcels, 416 of 943. This is likely because late night land use parcels are all non-residential and great swathes of the Puget Sound area are zoned exclusively for residential uses.

Overall the Night Owl bus network does a decent job of covering both the high scoring TPI block groups as well as the destination land use block groups. Using a half-mile walkshed

centered around the Night Owl bus stops reveals that the network passes through 545 of the 945 census block groups in the study area. Looking more specifically at the TPI block groups, parcels were divided into two groups based on their TPI score with the line set along the 50th percentile.

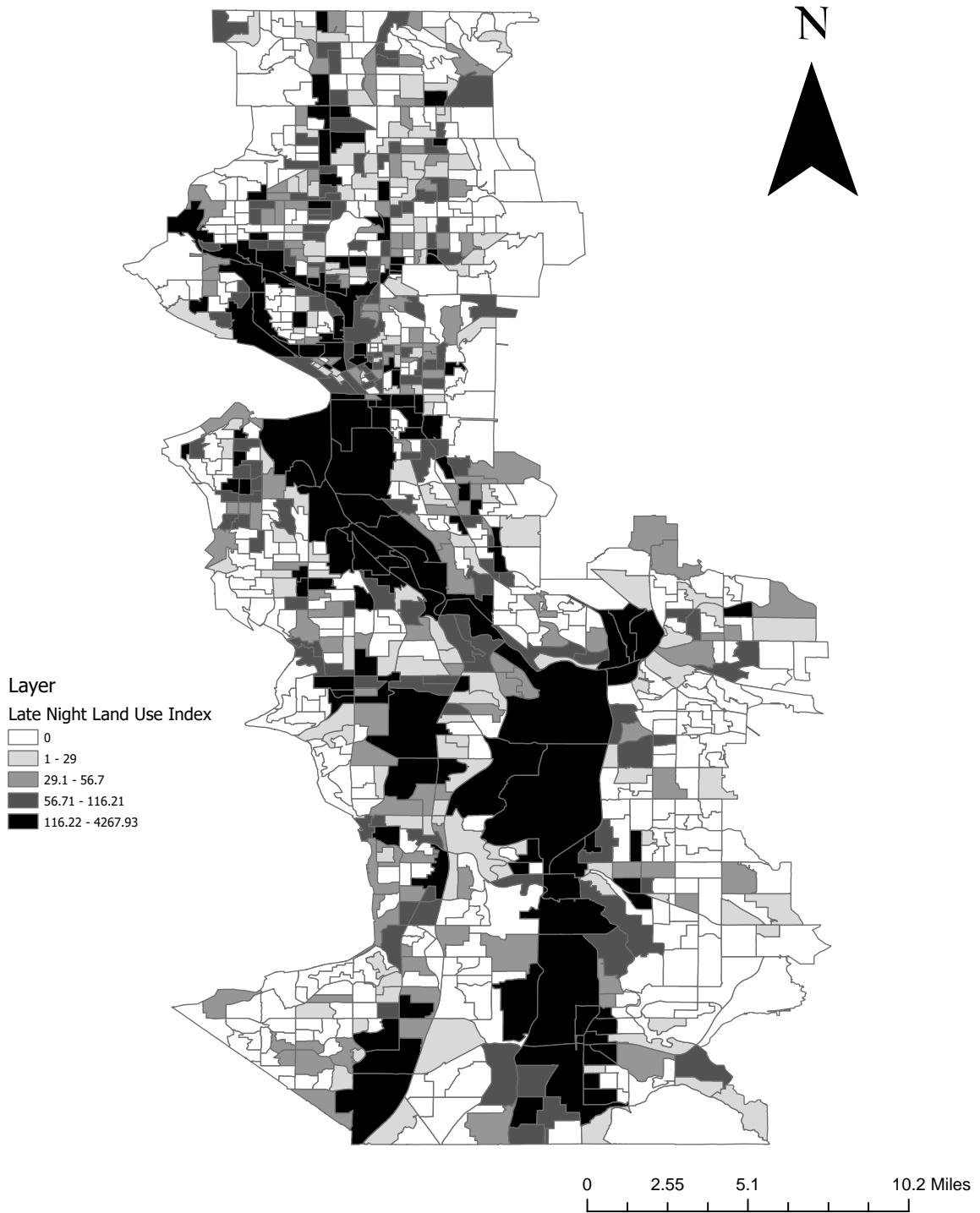


Figure 8 Late-Night Land Use

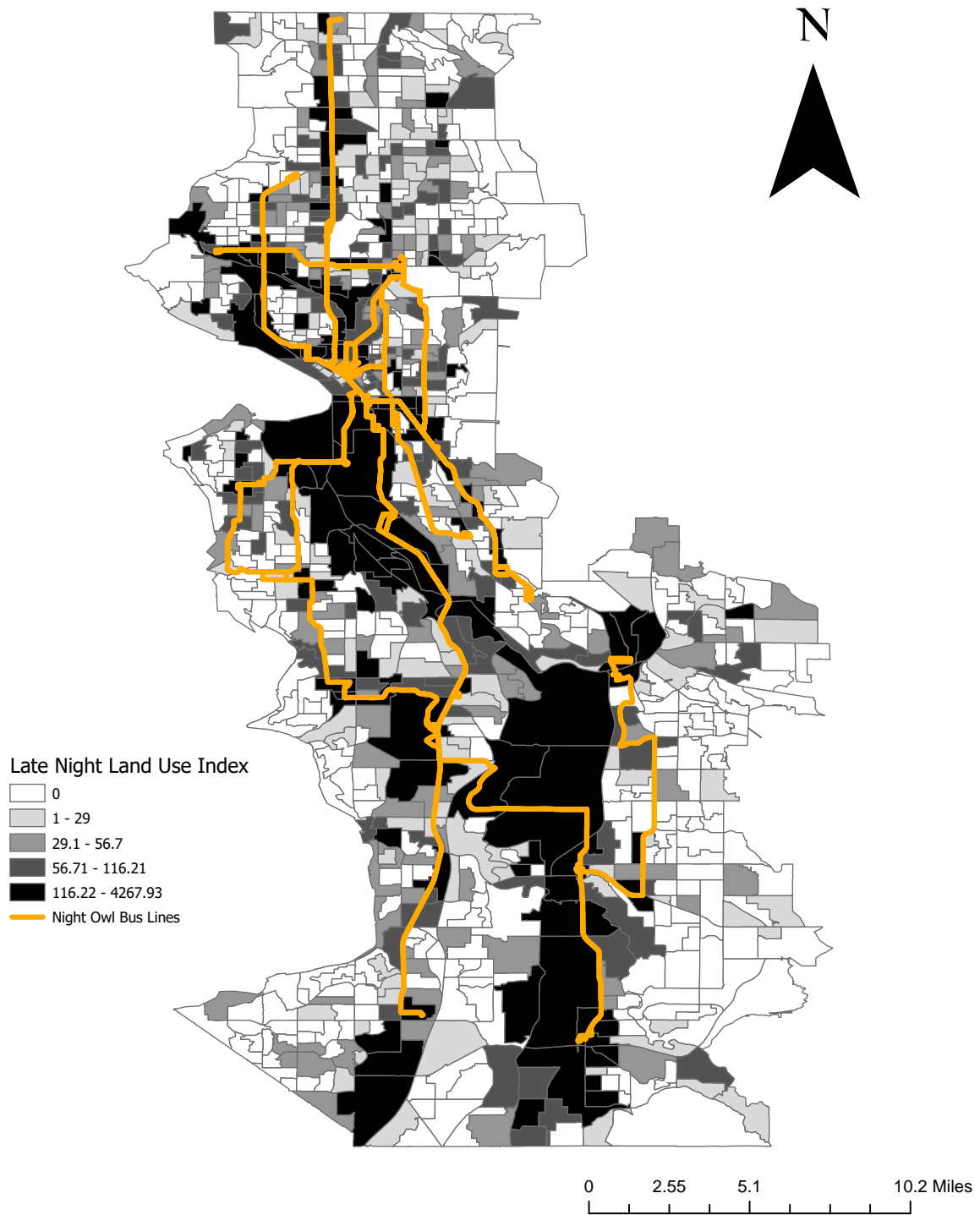


Figure 9 Late-Night Land Use and Night Owl Bus Lines

There are 472 of these high scoring TPI block groups in the general project area and of those, 205 fall within a half-mile walkshed of a Night Owl bus route.

There are several concentrations of high scoring TPI block groups that have no meaningful access to late night transit service. These areas include the southern portions of Federal Way and Auburn, as well as the cities of Algona and Pacific. Other areas with limited to no service include the unincorporated communities of Skyway and Highline, central Renton, and Seattle's Northgate and Lake City neighborhoods.

Origin and Destination Analysis

To better evaluate the practical utility and coverage of King County's late night transit network, transit route and travel times were calculated, with select TPI block groups set as origins and the top 50 Late Night Land Use block groups set as destinations. Trips were evaluated on a Monday at 2:30 AM—the midway point of the late night period—as well as at 2:30 PM in order to establish a base of daytime transit service. Drive time and distances were also calculated at 2:30 AM. Total trip time includes waiting, walking, and the time between 2:30 and the beginning of the trip.

The origin blocks are generally concentrated in the city of Seattle, 40 of 50, with the University District neighborhood having 10 of the 50 highest scoring TPI block groups

overall and 6 of the top 10. TPI groups that are outside of Seattle that were evaluated in this analysis include Federal Way, Des Moines, White Center, Skyway, Kent, and SeaTac. Both Kent and Federal way had multiple top 50 TPI block groups. Destination block groups had slightly more geographic diversity than the origin block groups with 37 of 50 coming from the city of Seattle. Outside of Seattle the cities of Kent, Auburn, Federal Way, Skyway, Renton, Burien, and Lakeland had block groups in the top 50.

The analysis revealed three distinct service areas for late night transit: the U District and Downtown Seattle, other Seattle neighborhoods, and the rest of the study area. Outside of Seattle, late night transit service is spotty at best and in many cases non-existent. The analysis also revealed some gaps within the city, particularly for the Lake City neighborhood which had no meaningful late-night service.

The University District is home to the largest share of TPI origin block groups and the O/D analysis revealed it as one of the most connected neighborhoods in the late-night period. Riders beginning their journey at 2:30 am in the University District would have access to 41 of 50 destination block groups, this compared to Downtown's 33 of 50. During the daytime, all destination block groups were accessible via public transportation. Areas inaccessible from the U District via late-night transit included Lake City, Richmond Beach, Renton, Skyway, west Burien, Lakeland, and Auburn.

Travelling by transit at night is, unsurprisingly, a time consuming and often arduous experience. For the University District, the average late night trip took about 107 minutes compared to 69 during the daytime. The median late-night trip time was much lower than the average at 89 minutes, likely due to a handful of longer regional trips. Comparatively, the midday median and average were much closer together at 65.5 and 69 minutes respectively. This would seem to indicate that regional transit connectivity is much more limited during the late-night period than it is during the mid-day.

46.2% of the average daytime trip was made up of waiting and walking with an average of .46 miles of walking. At night, walking distances nearly double to an average of .86 miles, with the proportion of the trip made up of waiting and walking increasing to 57.4%. Public transit trips have roughly the same amount of transfers during the late-night and mid-day periods, 69.26% of mid-day trips required a transfer compared to 70.44% for the late-night.

The origin block groups that make up downtown, though connected to fewer destinations than the University District, had a similar average trip time of 106 minutes. Median trip time was similarly lower at 89 minutes. Mid-day riders in Downtown had a much shorter average trip time at 60 minutes though the median trip took 10% less time at 54 minutes. This would again seem to indicate that regional travel takes less time during the day than it does during the late-night period. Walking distances were shorter as well in the mid-day than during the

late-night period, .73 miles on average compared to 1.05. Waiting and walking made up 69.89% of late-night trip times compared to just 46.34% during the mid-day period.

Outside of Seattle, access to late-night transit service varied too widely to make any generalizable claims. For example, the highest scoring non-Seattle TPI block group was in Kent and was unable to complete any of the trips during the late-night period. Block group #288024 in the city of SeaTac had access to 24 of the 50 destination via late night transit. For the destinations that were accessible, a high degree of patience would be required to take late-night transit from the city of SeaTac. The average late-night trip took 155.26 minutes and involved an average of 112 minutes of waiting and walking. Mid-day trips took a fair amount of time as well with an average trip time of 84.26 minutes.

Unincorporated White Center, just on Seattle's southern boundary, had access to the most destinations of the non-Seattle origin block groups during the late-night period, 34 of 50. Journeys beginning in White Center also had the lowest average trip time of these block groups at 130.66 minutes and an average wait/walk time of 82.2 minutes. Despite this, late-night transit took almost six times as long as driving while providing access to far fewer destinations. The journeys that were unable to be completed during the late-night period were generally either to the east or the west of White Center, while destinations to the North and South remained accessible. Despite geographic proximity to the Georgetown and

South Park neighborhoods, White Center transit riders have no options to reach these areas during the late-night period.

For block groups south of Seattle, access to late-night transit was highly dependent on being near the Route 161 or the RapidRide A line. For example, of the 27 destination block groups that could be reached from Des Moines via late-night transit, every single trip began on the A Line. During the mid-day period, 49 of 50 journeys from Des Moines began on the A Line and one began on the Route 161. In general the mid-day transit network was able to connect the origins and the destinations, though median trip times were significantly longer than for block groups located in Seattle. Block groups in White Center, Kent, and Federal Way had mid-day trip times of 82 minutes, 98 minutes, and 122 minutes respectively. This is to be expected given the distance from these communities to many of the destination block groups, again broadly concentrated in Seattle. Commuters in Skyway had no access to late-night transit yet had the lowest mid-day transit travel time of the non-Seattle origin block groups at 76.9 minutes.

Private automobile trips took drastically less time than both late-night and mid-day transit trips for every origin and destination pair. For example, the longest recorded drive time for trips that began in the University District was 50 minutes, a journey that connected to a block group in the suburban city of Auburn. In comparison, late-night transit travel time for the same pair was 252 minutes, over five times as long, and required four different bus routes

with a staggering 138 minutes of waiting and walking. In the mid-day, that same transit trip took 191 minutes, over four times as long as driving. For University District origins, the average and median drive times and distances were similar. The average trip covered 21.25 miles and took 21.7 minutes, the median trip distance was 20 miles and the median trip length was 20 minutes. By contrast, the median mid-day transit trip took nearly three times as long as driving.

Some closer block groups like those in Seattle's Lake City neighborhood or in the unincorporated community of Skyway had no late-night service. Skyway stood out as an easy community to incorporate into the late-night transit network since almost all of its mid-day trips began using the Rt 101. The most used mid-day non-Night Owl routes were the 101, 150, 132, 60. Other popular mid-day routes included Sound Transit Express Buses and the Pierce Transit 500 and 402 lines. Outside of bus routes, the Link 1-Line light rail was by far the most used service during the mid-day period. Also popular was the Sounder South commuter train.

The most used Night Owl routes were the 124, 49/7, 70, 120, and the RapidRide D Line. Not all journeys could be completed exclusively on the Night Owl network and the most called for bus routes to complete those journeys were the 165, RapidRide F Line, 132, Link 1-Line, and Pierce Transit 502.

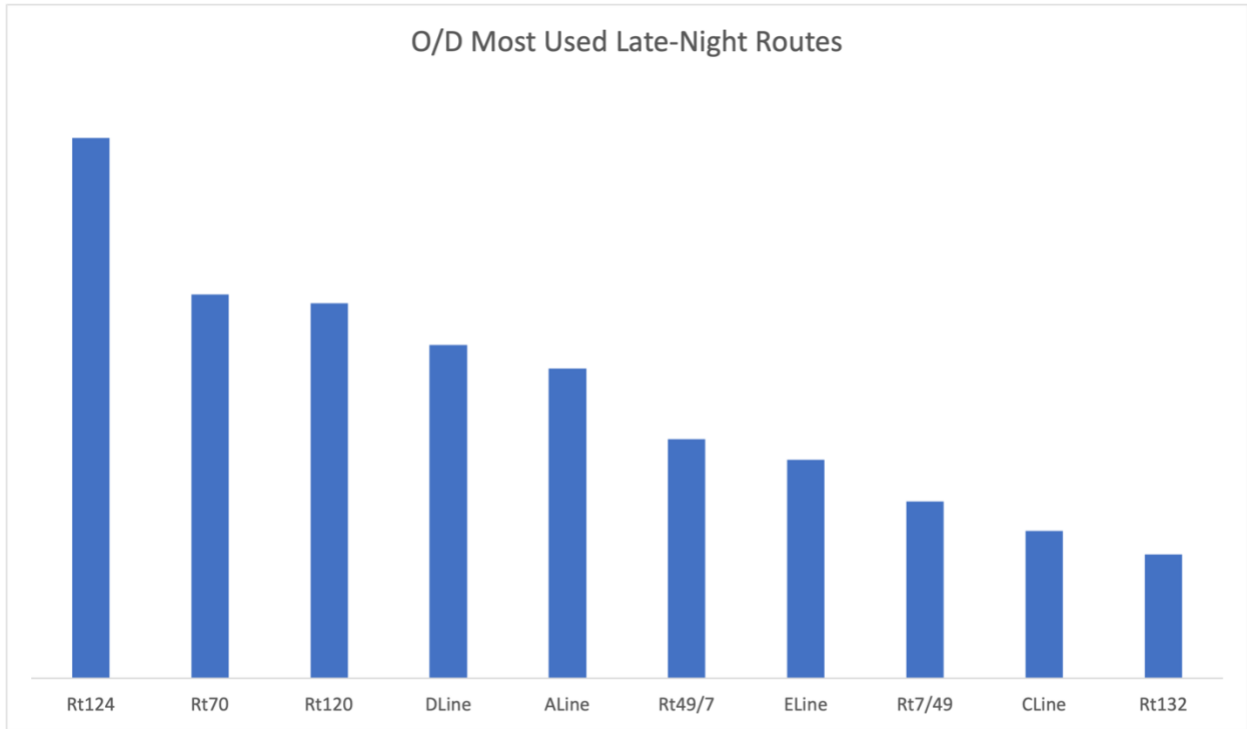


Figure 10 Most Used Late-Night Routes

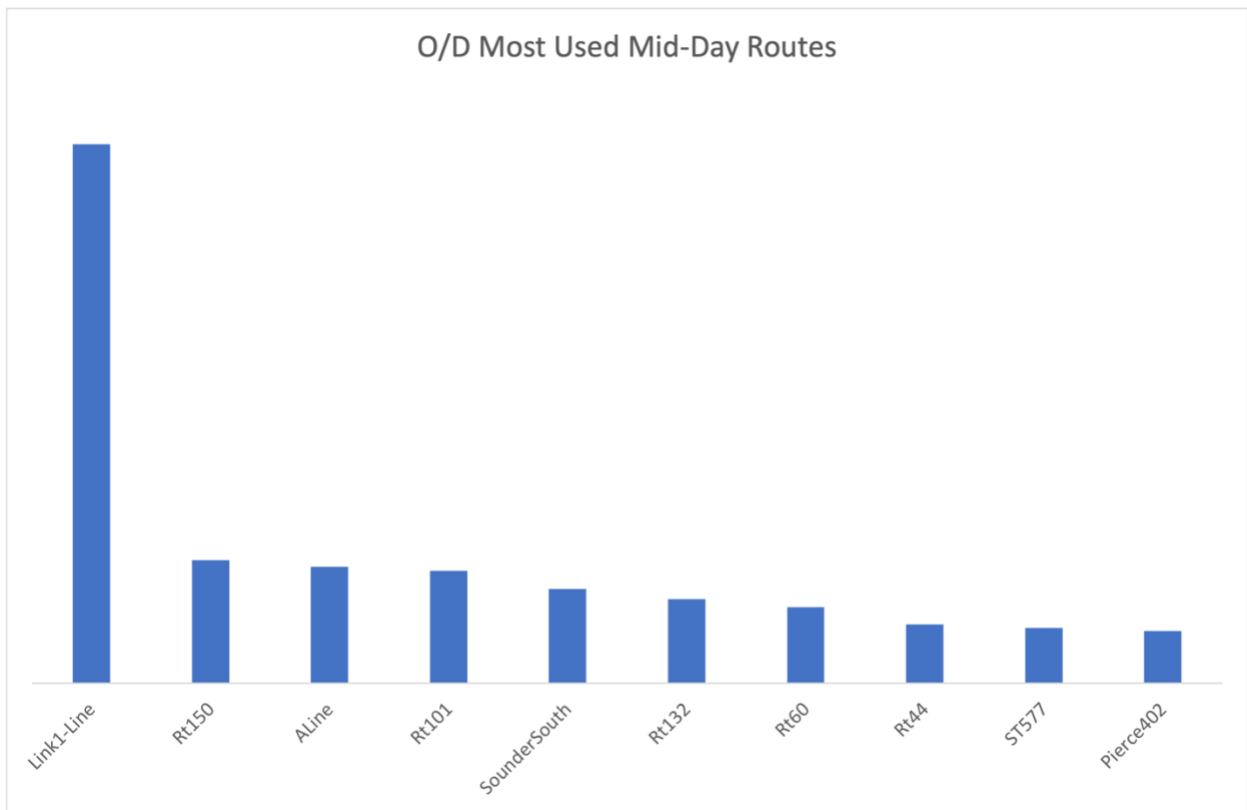


Figure 11 Most Used Mid-Day Routes

Discussion

The O/D analysis revealed that the highest levels of service for the Night Owl bus network were concentrated in the University District and Downtown. These areas also have the highest population density in the study area, showing that the Night Owl network is likely designed this metric.

The single greatest driver of long transit trip times in the overnight period is driven almost entirely by the low frequencies with which service operates during this period. Many trips in the O/D analysis had substantial waiting/walking time because a bus had left just before the 2:30 AM cutoff time, leaving potential passengers waiting an hour or more for the next bus. Increasing frequencies on the existing Night Owl network, even by one more trip per night, could have cascading positive effects on overall trip time.

The architecture of the transit network greatly limits riders ability to conveniently get to their destinations. The O/D analysis showed that riders can generally travel from Seattle to destinations outside of the city, however, the reverse was often impossible without hour plus layovers waiting for a different route's first run of the day. Additionally, the network features a decent level of north/south connectivity but relatively poor east/west connectivity, particularly outside of Seattle. These results are to be expected given that Seattle's Transportation Benefit District funds the vast majority of the service.

Using King County Metro route data, ArcGIS, and service gaps identified in the analysis, several additions to the Night Owl bus network have been suggested. Ideally the Link 1-Line would be extended to cover the late-night period, it provides the greatest connection to the greatest amount of TPI origins and late-night land use destinations. Useful routes that could be included are the 20, 105, 106, 107, 132, 182, and 184. The 101, 106, and 107 would provide service to the Rainier Valley, Skyway, and East Renton. The 132 would provide service for the parts of White Center, South Park, Highline, and North Burien that currently do not have service. Outside of the U District there are no Night Owl buses in Seattle east of I-5, leaving high scoring TPI areas like Lake City and Northgate without service. Adding the Route 20 to the Night Owl network would add service between Lake City and the U District via Northgate. At the southern end of the county Route 184 would extend service from Auburn down through the cities of Algona and Pacific, all high scoring TPI blocks with no late night service. Moving west past the highways, added service on Route 182 would help provide service to the areas of Federal Way that have high TPI scores but are not served by the RapidRide A Line.

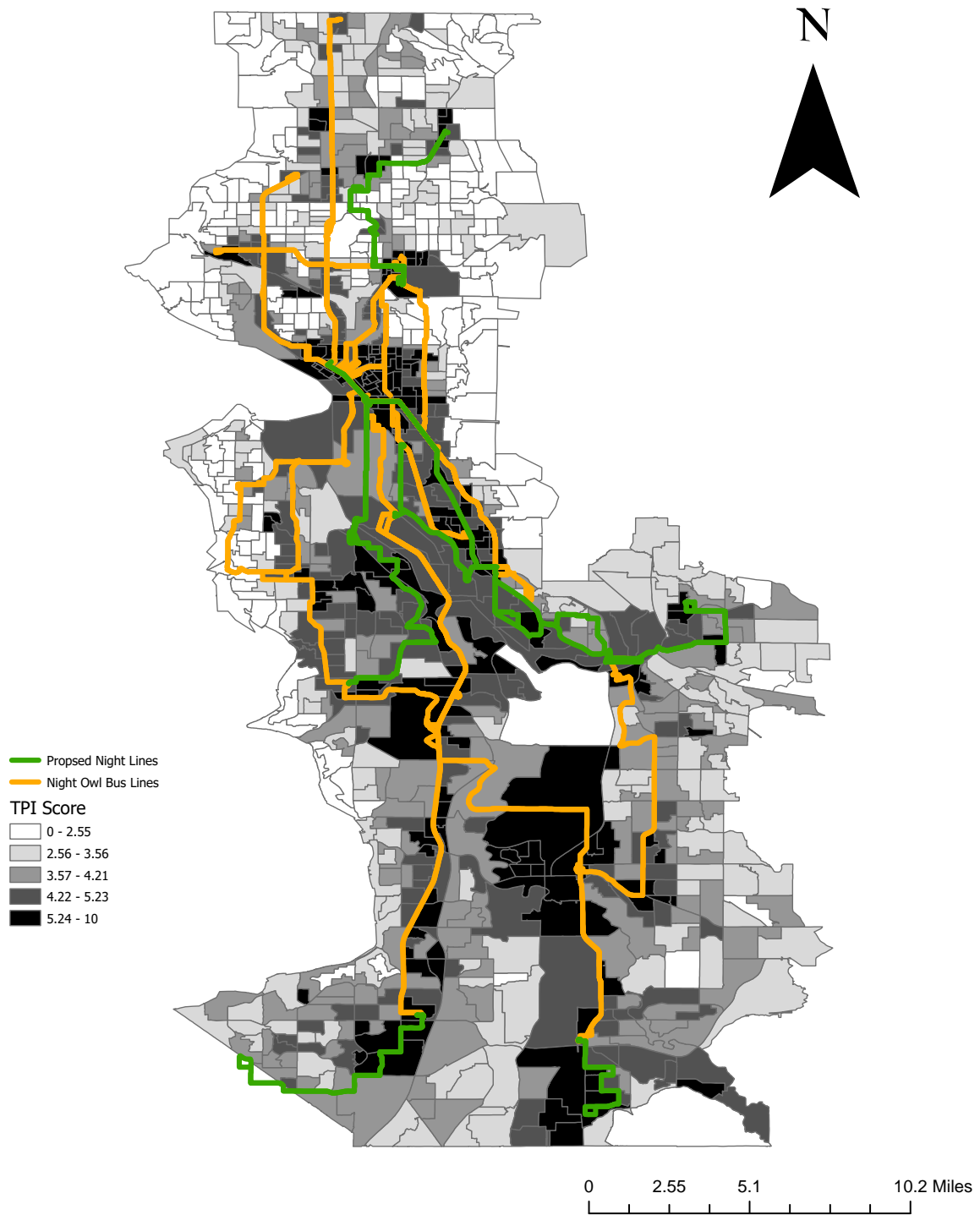


Figure 12 Existing and Proposed Night Routes and TPI

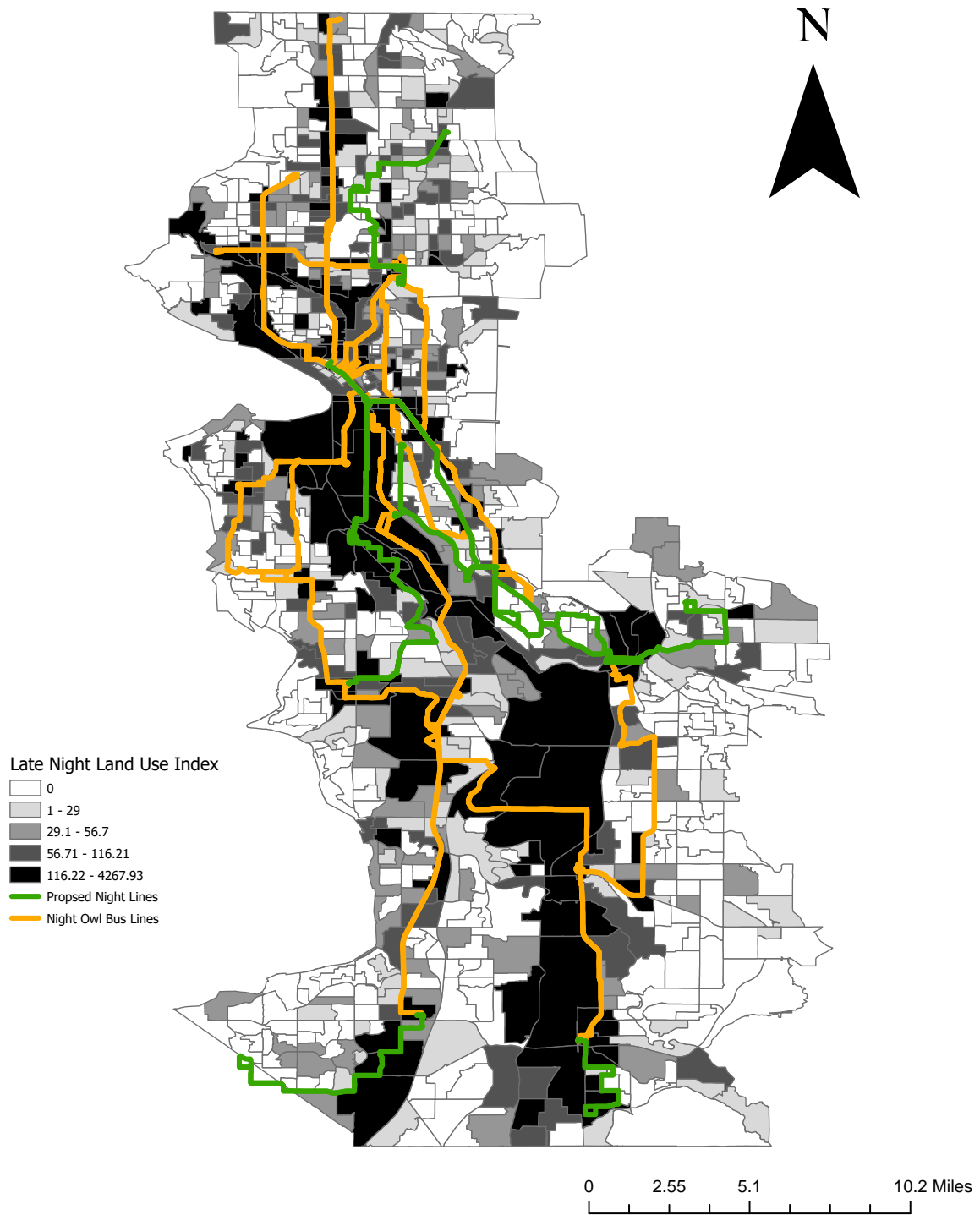


Figure 13 Existing and Proposed Night Routes and Late-Night Destinations

Conclusion

On September 23rd, 2017 King County Metro, in partnership with the city of Seattle, updated the region's Night Owl transit network for the first time in 40 years. Just a few years before the entire program seemed like it would be axed due to recession related budget constraints. Instead, the county and city invested 11,000 service hours per year in late-night transit, adding trips to almost a dozen bus routes. The new program also deleted the circuitous and infrequent 80-series Night Owl routes, replacing them with extended service on Metro's all-day transit network. The goals of the new program were described thusly in a 2017 press release by King County Metro:

Metro and SDOT sponsored a public outreach process last year that drew more than 4,500 responses and identified better late-night transit options for: Workers in jobs with late-night or early-morning work shifts such as health care and many segments of the service industry. Travelers and workers heading between downtown to Sea-Tac Airport after 1 a.m. People enjoying Seattle's nightlife, including music and arts venues. Low-income and vulnerable populations" (King County Metro 2017a).

Through this research I attempted evaluate the efficacy and utility of this newly revamped late-night transit network by trying to better understand who rides late-night transit and

what their destinations are. Based on a review of the literature surrounding transit propensity and the late-night economy, I identified seven demographic and land-use characteristics associated with late-night transit ridership. Incorporating labor, economic, and property data, I also created a late-night land use index in an attempt to understand where late-night transit riders may want to travel. The proportions of those demographics were indexed as were the land use data, and then mapped at the Census block group level using GIS software to reveal the geospatial distribution of potential late-night transit riders and potential late-night destinations.

This analysis revealed that late-night transit riders more likely to be non-white and make less money than their daytime counterparts. They tend to be younger, more male, and with lower levels of educational attainment. Geographically they are generally concentrated in a handful of neighborhoods in Seattle and suburbs to its south, particularly those in the Duwamish and Green River Valleys like Kent, Federal Way, and Tukwila. Late-night destinations were similarly concentrated in Seattle's industrial and mixed-use neighborhoods and the Duwamish Valley.

As seen above, one of King County's stated goals in revamping the Night Owls was to increase access for workers in the overnight period. To evaluate the system's accessibility, I ran an origins/destinations analysis between select TPI and late-night land use block groups, measuring transit trip time, wait/walk time, and driving time. The O/d analysis revealed

tremendous geographic disparities in temporal access to the late-night transit network. Seattle's University District and Downtown neighborhoods were able to use the late-night transit network to access the most amount of destination block groups with the shortest overall trip time. Though trip times were the lowest in these neighborhoods, they still tended to take 1.5 to 2 times as long as the same trips on the mid-day transit network. Other Seattle neighborhoods had relatively decent access to destination block groups and more elevated wait times. Outside of Seattle, however, the network begins to rapidly lose its efficacy, with access to the least amount of destinations and total trip times in excess of three hours. Areas outside of Seattle like Auburn, Kent, and Federal Way effectively had no late-night transit service, while Seattle's northeastern neighborhoods like Northgate and Lake City similarly had limited to no access to late-night transit.

The mean and median travel times tended to vary quite significantly with median trip times generally being lower than the average, likely on account of a handful of lengthy regional trips. Based on the analysis, regional connectivity is generally more difficult and takes more time during the late-night period than the mid-day. Compared to both mid-day transit times and—particularly—to late-night driving times, Seattle's Night Owl network provides basic local and regional mobility at a tremendous time cost. Combined waiting and walking times took up over 60% of a late-night transit trip. While this paper did not compare the current Night Owl network with the previous one—and therefore cannot say whether these travel times are an improvement—it is difficult to see much appealing in riding transit late at night.

Infrequent service paired with legitimate safety concerns is not a recipe to building a robust late-night transit network, let alone addressing the overwhelming difference in service provided to day-shift workers.

Over the course of this research project, SEPTA, the Philadelphia area transit agency, introduced and eventually closed a pilot project it called Owl Link. The service operated late at night and riders would use the Owl Link app to book a ride in a minibus. The program was “designed to provide ‘last-mile’ service for overnight workers” but ridership wound up being much lower than initially projected (DeNardo 2022). Despite the failure of this particular effort, micro-transit will almost certainly play a role in late-night transit moving forward.

The Pinellas Suncoast Transit Authority (PSTA) has quietly had a very successful late-night TNC partnership program called TD late-shift. Introduced in 2016, the program serves as an optional add-on to the agency’s subsidized fare program which limits it to individuals who make 150% of the federal poverty line or less. The program’s customers—who must show evidence of working a late-shift job—pay a \$9 monthly fare and receive up to 25 free TNC trips to and from work per month (APTA 2019). The scheme has proven to be effective, enduring, and popular, with PSTA often having to operate a waitlist to access the service. Its effectiveness and popularity can probably be attributed to its utility as well as the frictionless nature of using the service. Limited to people already enrolled in PSTA’s subsidized fare program, potential users have already gone through the means-testing process, making

signing up relatively simple. The service is easy to use and covers the entirety of the PSTA service area, riders simply open up a participating TNC's app to book a ride from a late-shift job to anywhere in Pinellas County (APTA 2019).

Millions of people across the United States work jobs that either begin or end during the late-night hours. Providing these workers with robust and useful transit service should be an important consideration for transit agencies, particularly those that center equity in their planning practices. This makes it troubling that King County Metro's most recent Mobility Framework barely mentions late-night service at all beyond a handful of mentions to another agency's pilot program with Uber (King County Metro 2019). If the equitable distribution of transit service is a goal for Seattle and its region, forcing late-night riders to endure extended wait times at lonely bus shelters is not an option. Metro says they "believe mobility is a basic human right that allows communities and individuals to access the opportunities needed to thrive." Time to follow through.

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Appendix A – Individual TPI Variables

