ACCESS IN APPALACHIA
PILOT IMPLEMENTATION PROJECT

Project Report

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ACCESSIBILITY OBSERVATORY

UNIVERSITY OF MINNESOTA
Driven to Discover℠

Authorship

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1   Executive Summary

The ***Access in Appalachia Pilot Implementation Project*** report is an exploration of transportation accessibility within the Appalachian Region. By ***Accessibility***, in this report we mean the ease with which people can travel to valued destinations. Commissioned by the Appalachian Regional Commission (ARC) and led by the Maryland Department of Transportation State Highway Administration, this project represents a significant leap forward in our understanding of the intersections between economic development, land use, and transportation infrastructure. Through innovative methodologies we measure, analyze, and visualize the access of Appalachian residents to critical opportunities, including jobs, education, healthcare, entertainment, and intermodal freight facilities.

Building upon the foundational insights provided by the 2020 ***Access in Appalachia*** Primer, this project expands our understanding of transportation accessibility within the region. Leveraging the primer, we extend the concept of accessibility to include multimodal access to jobs, healthcare, education, and entertainment destinations. Additionally, we delve into measuring access to intermodal freight facilities to understand how the region is connecting its workforce to freight employment opportunities.

This pilot project aligns with the broader mission of regional state DOTs to enhance safety, mobility, and access across the region, and serves as a catalyst for change in statewide decision-making processes. Multiple state DOT partners agree that this work can help inform project decision-making. For instance, in Maryland DOT's long-range transportation plan, the Maryland Transportation Plan (MTP), and its six-year program the Consolidated Transportation Program, accessibility measures will be incorporated into planning and prioritization.

In North Carolina, the commitment to accessibility is exemplified through ongoing research projects, including this pilot. The state is actively engaging its Prioritization Workgroup to integrate enhanced accessibility metrics into the Strategic Transportation Investments (STI) framework. This approach ensures that accessibility considerations play a central role in future rounds of project prioritization, aligning with the state's commitment to a comprehensive and equitable transportation system. This pilot can help inform their approach.

Virginia's State DOT (VDOT) emphasizes a collaborative decision-making process involving multiple agencies and stakeholders. This pilot aligns with VDOT's goals by offering valuable data for project identification and fund application phases. The insights derived and lessons from the pilot can broaden future evaluations of impact on destination access in the Appalachia region. The collaboration between VDOT and the Office of Intermodal Planning and Investment (OIPI) underscores a data-driven approach to decision-making, ensuring that accessibility metrics contribute meaningfully to the statewide transportation agenda.

A multimodal, multidimensional dataset of accessibility
A primary metric for opportunity is job accessibility, the total number of jobs accessible within a set travel time for each resident, by each major transportation mode: driving, public transit, and bicycle. Our findings reveal a stark gap in job accessibility between driving and other modes, underscoring the orientation of the regional transportation network towards driving. Urban and economically vibrant counties consistently demonstrate higher overall job access compared to predominantly rural areas, shedding light on the crucial role of land use planning in shaping these disparities.

Using a different measure for other types of destinations, we estimate average travel time by mode to a set number of places. In our examination of educational access, we find travel time to a choice set of high schools by driving to be considerably shorter than travel time by walking and/or transit, or biking, revealing challenges in non-driving modes, particularly in rural areas with few transit options.

The healthcare section of the report explores access to primary health clinics, trauma centers, and urgent care facilities. Again, in this important dimension of services for residents, we identify disparities between urban and rural counties. The observation that economically distressed and rural counties often experience longer travel times to essential healthcare services underscores the need for targeted interventions and infrastructure investments in these areas.

Our examination of entertainment accessibility, including major sports venues, fairgrounds, and convention centers, sheds light on how these destinations are distributed across the region. The limited access to these facilities, particularly by non-driving modes, prompts a critical discussion on the economic implications for the region and the potential for strategic interventions to enhance accessibility and spur economic development.

The final class of destinations reported on here is intermodal freight. Our analysis of these facilities offers a unique perspective on workforce connectivity and economic development. By measuring driving access to airports, rail terminals, and pipeline terminals, we identify spatial patterns that highlight the economic and urban-rural divides in accessibility.

Key findings

Our analyses highlight the following key results in transportation dynamics, accessibility nuances, and potential pathways for strategic development:

- **Urban-rural divide:** Urban clusters exhibit robust accessibility across modes, while rural and semi-rural areas face distinct challenges. For example, residents of rural counties face a median travel time penalties of 30-40% to reach equivalent secondary and post-secondary opportunities to urban county residents. This highlights the importance of tailoring transportation strategies to address the diverse needs of Appalachia's varied landscapes.

- **Land use, transportation, and economic hubs:** A strong correlation emerges between access metrics and land use planning, revealing the influence of economic hubs in county economic status. Counties with higher access to jobs and other essential destinations often align with economic centers within the region. In counties rated as distressed, auto travel time to important freight locations like air cargo terminals (average 53 minutes) and internodal rail locations (average 56 minutes) are much higher than those in counties rated as competitive (average travel times 37 and 34 minutes, respectively). This relationship emphasizes the interconnectedness of transportation and economic development.

- **Healthcare Deserts:** Measuring access to healthcare unveils significant gaps, especially in rural counties. Most strikingly, the typical resident of a rural Appalachian county is a 38 minute drive from an identified trauma center; compared to the region wide urban 24 minute drive. These are precious minutes in an emergency. Identifying healthcare deserts becomes imperative for informed decision-making, urging a strategic approach to bridge connectivity gaps.

In the final chapters of the report, we delve into the practical implications of the accessibility metrics developed through this project and their potential to inform decision-making processes, support equitable planning, and catalyze economic growth within the region. Moreover, the project's commitment to transparency and knowledge sharing is evident in the accessible datasets made available to users. The report details how stakeholders, researchers, and policymakers can access and explore the datasets, encouraging further analysis and research.

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4 Introduction

In 2020, the Appalachian Regional Commission produced a report outlining a new way of understanding the role of transportation in economic development and quality of life in the region. Building upon the foundational insights provided by this **Access in Appalachia** Primer, the current project expands our understanding of transportation accessibility within the region.[1] Leveraging the primer, we extend the concept of accessibility to include multimodal access to jobs, healthcare, education, and entertainment destinations. Additionally, we delve into measuring access to intermodal freight facilities to understand how the region is connecting its workforce to freight employment opportunities. This introductory section establishes background on the region, the sponsors, and the project goals.

4.1 The Appalachian Regional Commission (ARC)

Established in 1965, the Appalachian Regional Commission is a federal-state partnership committed to fostering sustainable economic development in the Appalachian region. Spanning 13 states, including Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia, the ARC plays a crucial role in addressing the unique challenges and opportunities that define this geographically diverse and culturally rich area.

4.2 The Appalachian Region

The Appalachian region, spanning 13 states from southern New York to northeastern Mississippi, is characterized by a vast and diverse landscape, home to over 25 million people. Notably rural, with 42% of its population residing in rural areas—double the national average—the region has undergone significant economic shifts, transitioning from a historical reliance on extractive industries to a more diversified economic profile, including manufacturing and professional services. The ARC's mission is to innovate, partner, and invest to build community capacity and strengthen economic growth in Appalachia. Roads, highways, and public and personal transit are critical for economic growth, quality of life, and accessing employment opportunities and related employment supports.

Appalachia continues to struggle with equitable access to reliable, quality transportation systems that can efficiently and conveniently transport goods and people. Despite strides in

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[1] Access in Appalachia Primer: https://www.arc.gov/wp-content/uploads/2020/12/ARC-Access-Primer-20201110.pdf

reducing the poverty rate from 31% in 1960 to 14.5%[2] in the 2012–2021 period, economic contrasts persist within the region. While certain communities have successfully diversified their economies, others face ongoing challenges, particularly in the realm of basic infrastructure needs such as roads, clinics, and water and wastewater systems.

Central to the region's narrative is the critical importance of access to opportunities. As the Appalachian region grapples with economic contrasts, ensuring equitable access to jobs, education, healthcare, and essential services emerges as a linchpin for fostering economic inclusion and addressing disparities. Improved transportation accessibility becomes pivotal, not only bridging geographic gaps but also connecting individuals to employment centers, educational institutions, and healthcare facilities, thereby enhancing overall quality of life.

4.3 Accessibility, and the Accessibility Observatory

Accessibility is defined as the ease of reaching valued destinations. Accessibility metrics combine the concept of mobility with an understanding of how transportation and land-use systems work together to connect people to destinations. These metrics incorporate both the costs and the benefits of travel — and provide a more complete view of how well cities and regions satisfy traveler needs.

As the nation's preeminent resource for accessibility-based transportation data, the work of the Accessibility Observatory is dedicated to empowering organizations such as state Departments of Transportation (DOTs), transit agencies, and metropolitan planning organizations with the tools and insights necessary to analyze, evaluate, and strategically plan transportation systems and land use within their regions.

Our work is made possible through the sustained support of state DOTs, including the participation of Maryland, Virginia, and North Carolina. These states, participating sponsors of an FHWA pooled-fund study called the National Accessibility Evaluation, contribute to the Observatory's mission to measure multimodal job access across the entire United States on an annual basis. Through this study, we annually publish the "Access Across America" series of reports that serve as a comprehensive resource, offering insights into job accessibility trends, challenges, and opportunities on a national scale. As part of our commitment to transparency and reproducibility, all tools, methods, and software developed by the Observatory are open source, encouraging collaboration and advancement in the field.

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[2] ARC website at https://www.arc.gov/news/arc-releases-new-data-revealing-appalachias-economic-improvements-key-vulnerabilities-compared-to-the-rest-of-the-u-s/

4.4 Project Objective

Our collaborative effort with the ARC focuses on refining and expanding accessibility measurement within the Appalachian region. Leveraging the expertise and resources of the Accessibility Observatory, this project provides enhanced access measures, innovative mapping products, and contributions to the broader professional dialogue on multimodal accessibility.

Building upon the foundational insights provided by the Access Primer conducted in 2020, the current project signifies a dynamic evolution in comprehending and addressing transportation accessibility within the Appalachian Region. [3] We explore multimodal access to pivotal aspects of daily life, including jobs, healthcare, education, and entertainment destinations. This comprehensive examination enables a nuanced understanding of the region's accessibility dynamics. Additionally, we delve into the critical realm of intermodal freight facilities, measuring driving access to explore how the region effectively connects workers to employment opportunities within the freight sector. Our work also measures access to key freight hubs, providing insights into the intricate dynamics of freight transportation across the region.

We build on our understanding of the different destination-based access metrics by conducting a detailed analysis of the performance of various counties based on their common characteristics. This examination is structured around factors such as economic status as defined by the ARC and urbanicity, considering distinctions within different states and across the region.

This report details the methodologies employed, data collected, and the insights gained through our exploration of job accessibility across driving, transit, and biking modes. As we present our findings, we invite stakeholders, policymakers, and the community at large to engage with the outcomes of this endeavor, contributing to the ongoing conversation about fostering economic development and accessibility within the ARC region.

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[3] Access in Appalachia: https://www.arc.gov/report/transportation-access-in-appalachia/

5   Data

Quantifying access means combining data sources from a wide variety of sources. To calculate the access to a particular destination, specific data are required (see also **Methodology**):

- an origin place
- information about who lives at each origin place
- a destination place
- information about each destination place
- a network to travel between origins and destinations

Each dataset is described in detail below. Further information about the sources of the data, metadata descriptions, and potential limitations can be found in a separate document delivered in this project.[4]

5.1   Origin places

We use geographies as defined by the U.S. Census Bureau, for consistency across jurisdictions and to allow linking to other data. Census blocks are the fundamental unit of geography, generally representing the smallest area bounded by public roadways. We use the center of each census block as an origin point for all the access calculations, excluding blocks which contain no land area. This means the travel time of each trip is measured from the public roadway on the edge of a census block, to the destination point. These block-level results are aggregated and analyzed at other geographic levels (tract, county, state, and ARC region – see **Data aggregation**).

The geography definitions provided by the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER)[5] program are updated with each decennial census. To conform with other datasets in this analysis we used the 2010 definitions.

The main benefit of using Census geography is to be able to link easily to descriptive information about the size and type of the populations residing in the blocks. As part of the worker and jobs destination dataset described below, we obtained information on the number of employed people residing in each block; the number of employed people who

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[4] Access in Appalachia Pilot Implementation Project Task II Report: Data Collection (https://drive.google.com/file/d/1FaeiE2zlXuZpz2oCX3pAPjtsUgYVaQCa)

[5] https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html

have a low income job ($1250/month or less); the number of employed people who have less than a High School education; and the number of people who self-identified as Black, Indigenous, or People of Color (BIPOC; including Hispanic or Latino).

We also characterize the county in which each origin is located, according to classifications useful for reporting in the aggregate. From the Appalachian Regional Commission, we adopt the economic status variables,[6] classifying each county along the five-class spectrum from Distressed to Attainment. **Figure 5.1** shows the status by county within the region. Due to the interest in differences across the urban-rural gradient, we also characterize each county according to its membership in U.S. Census county-based statistical areas (CBSAs).[7] Each county is classified as being urban (part of a metropolitan area), semi-rural (part of a micropolitan area), or rural (not in a CBSA). **Figure 5.2** shows the status of urbanicity of counties according to this definition.
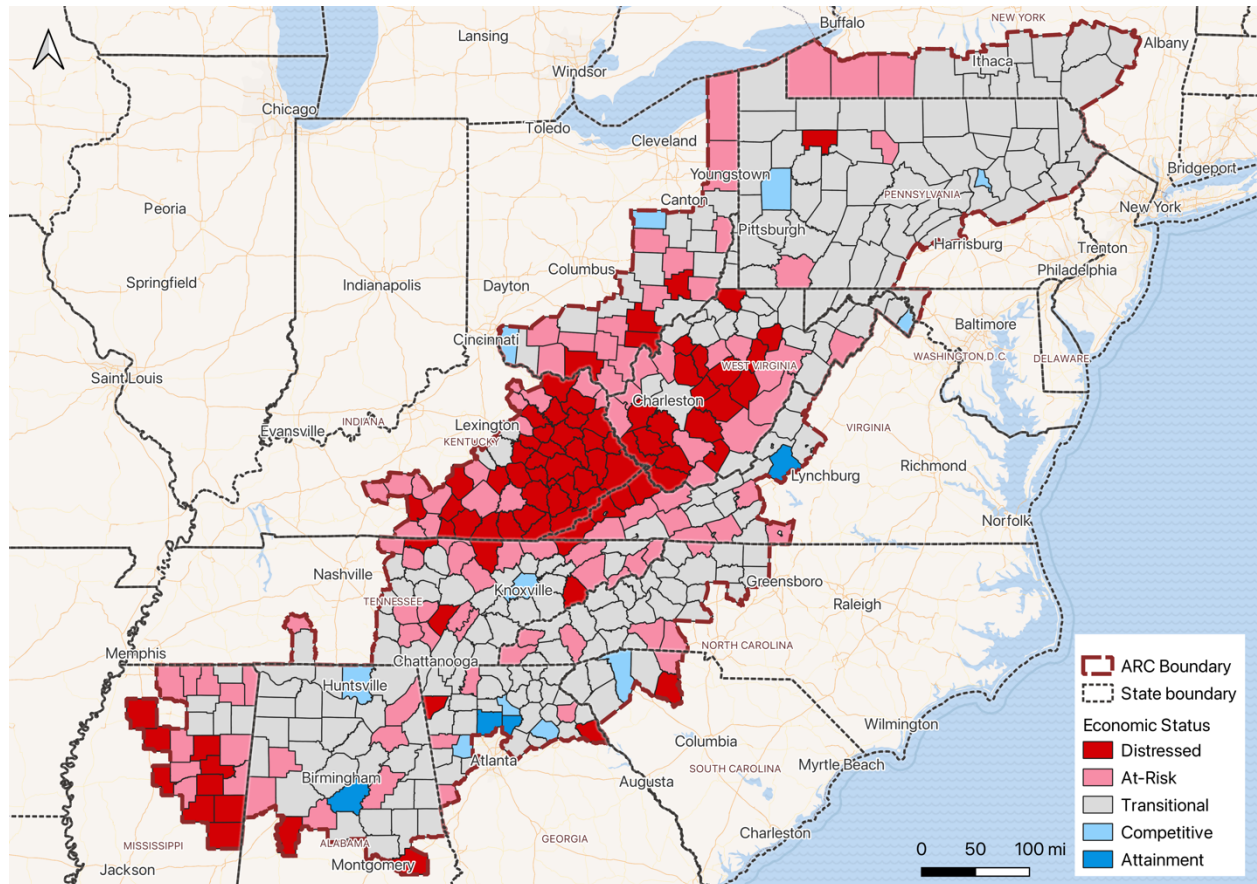
Figure 5.1: A map showing economic status of ARC Counties for fiscal year 2024.

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[6] https://www.arc.gov/distressed-designation-and-county-economic-status-classification-system/
[7] https://www.census.gov/geographies/reference-maps/2020/geo/cbsa.html
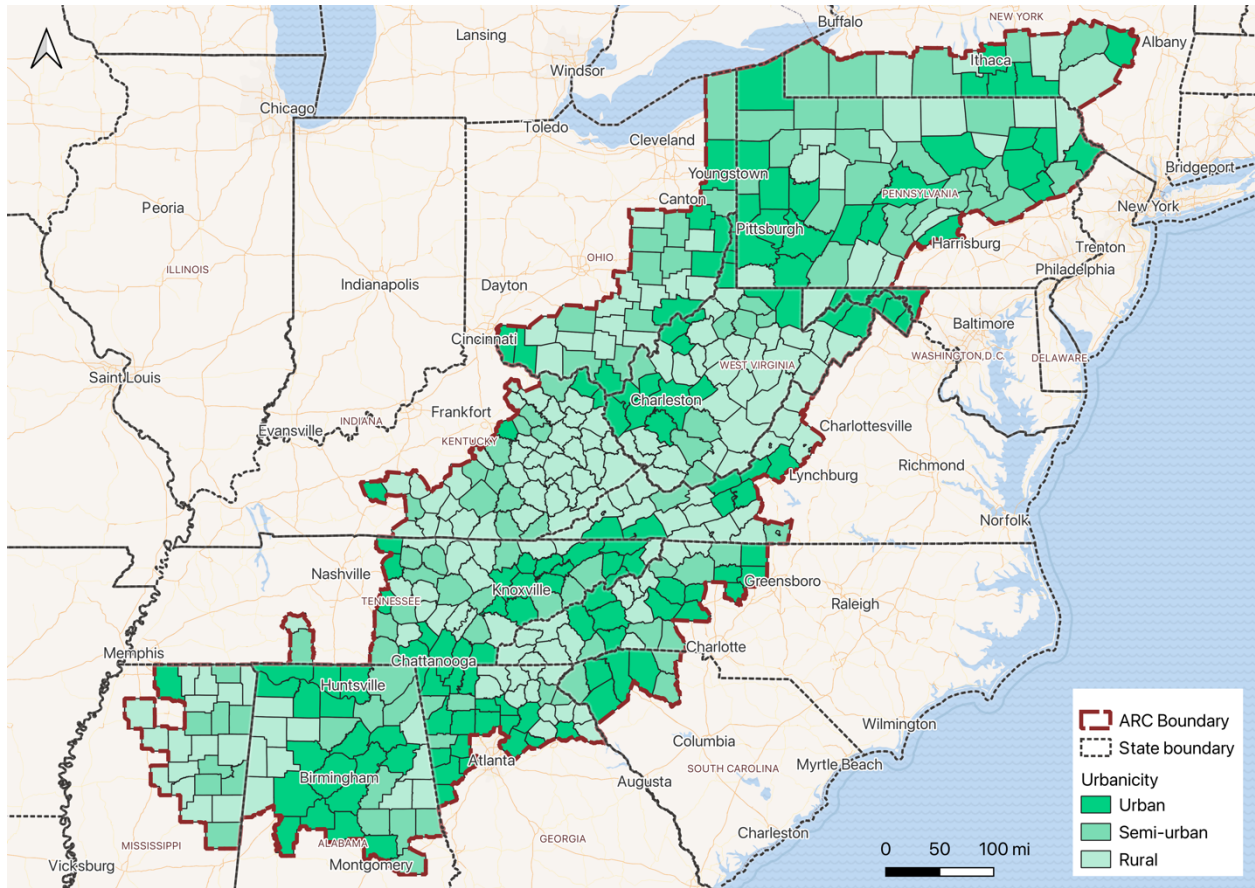
Figure 5.2: A map showing urbanicity of ARC Counties according to the classification used.

5.2   Destination places

For each of the destination place types below, a geographic point (latitude, longitude) was identified to serve as the endpoint in the travel time calculations. For jobs, this was the geographic center of the containing Census block (similar to the origin points); for all other destination types, a point location was included in the original dataset.

5.2.1 Jobs and Enumerated Job Sectors

Data describing the distribution of labor and employment in the region are drawn from the U.S. Census Bureau's Longitudinal Employer-Household Dynamics program (LEHD).[8] The LEHD Origin-Destination Employment Statistics (LODES) dataset, which is updated annually, provides Census block-level estimates of employee home and work locations. This project uses LODES data from 2018, the most recent available as of the original performance of the 2020 accessibility calculations. These jobs are mapped as a count, by total and by job

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[8] detailed LODES data release notes: https://lehd.ces.census.gov/data/lodes/LODES8/LODESTechDoc8.0.pdf

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category as described in the LODES data, assigned to the point location at the center of the census block in which they are located.

5.2.2 Education

Other than jobs, the next most common destination for regular daily travel is a school. We used data on location and type of schools nationwide from the National Center for Education Statistics (NCES). There are three broad groups of education destinations included, within which we used a few specific destinations within each group.

We included K-12 public schools as defined by the U.S. Department of Education, separated by grade type. These schools were reported as operational at the time of the data publication (March 2021). Schools were classified as elementary (grades K – 5), middle (grades 6-8), high school (grades 9 – 12), pre-K (public pre-kindergarten). Schools that were inclusive across grades (K-12) were a separate category.

We also included private schools as defined by the NCES as a school not supported primarily by public funds, providing classroom instruction for one or more of grades K-12 or comparable ungraded levels, with one or more teachers. Organizations or institutions that provide support for homeschooling without offering classroom instruction for students are not included. The private school destinations are classified by grade level in the same way as the public schools (elementary, middle, high school, pre-K).

Finally, we included post-secondary educational destinations as key places with opportunities for economic development. The NCES dataset contains data about every college, university, and technical and vocational institution that participates in the federal student financial aid programs. We classified the institutions by the highest degree program offering in the data. Specifically, we classify schools by whether the institution has less than 2 year, 2 year, 4 year, or 4 year or higher program offerings.

5.2.3 Health Care

Health care destinations vary by type of service offered, degree of public subsidy, interactions with health insurance, and other complexities of the U.S. health care system. To quantify a baseline degree of access to health care, we used nationally available datasets on public health care facilities which accept Medicare and Medicaid, maintained by the U.S. Department of Health and Human Services (HHS). These providers were further classified into locations serving two distinct roles in the healthcare ecosystem.

Rural health clinics (RHCs) are located in a rural area designated as a shortage area by HHS, and are not rehabilitation agencies or a facility primarily for the care and treatment of mental diseases. RHCs operate exclusively for the purpose of providing primary care services to Medicare patients located in rural and shortage areas. Federally Qualified Health Centers (FQHCs) are a reimbursement designation from the Bureau of Primary Health Care and the Centers for Medicare and Medicaid Services of HHS. FQHCs provide primary care services and dental care services to rural and urban areas, as well as shortage areas. In our reporting RHCs and FQHCs are preventative health care locations.

In addition to preventative health care, we calculated access to urgent and emergency care. The U.S. Department of Homeland Security (DHS) maintains data on locations of these services. We used two destination types. Urgent care is defined as the delivery of ambulatory medical care outside of a hospital emergency department on a walk-in basis without a scheduled appointment. These locations do not include locations co-located within hospitals. In contrast, trauma centers are units within a hospital equipped and staffed to provide care for patients suffering from major traumatic injuries. We included all trauma center levels (I-IV) as well as pediatric trauma centers identified in the DHS data.

5.2.4 Entertainment & Tourism

Ability to access destinations supporting a full life includes being able to reach places that are only occasional destinations. While trips made to them may be more rare than those to a job, school, or health care destination, they remain important markers of opportunity.

We used entertainment and tourist destinations maintained by DHS to calculate these access values. For large annual events, we used fairgrounds or convention centers large enough to house a convention, trade show, or fair. To capture opportunities to see sports and other large performances like concerts, we used major sports venues. The DHS definition of major sports includes Facilities within the United States, Canada, and Mexico that host events for the National Association for Stock Car Auto Racing (NASCAR), Indy Racing League (IRL), Major League Soccer (MLS), Major League Baseball (MLB), National Basketball Association (NBA), Women's National Basketball Association (WNBA), National Hockey League (NHL), National Football League (NFL), Professional Golfers Association (PGA) Tour, National Collegiate Athletic Association (NCAA) Division 1-Football Bowl Subdivision (FBS), National Collegiate Athletic Association (NCAA) Division 1 Basketball, Minor League Baseball (MiLB) Class Triple-A, and thoroughbred horse racing.

5.2.5 Freight

Access to freight destinations captures an important dimension of economic activity that has not been widely quantified with accessibility metrics. To address this, we utilized datasets from the U.S. Department of Transportation (USDOT) Bureau of Transportation Statistics (BTS) on intermodal freight facilities. These are places where over-the-road trucks can load and offload freight with rail, shipping, air, and other cargo modes.

We used the following types of intermodal freight destinations. Airports with cargo facilities are defined by all official and operational (at time of data acquisition) airports and aerodromes that have cargo facilities in their BTS data. Marine roll-on/roll-off ports are included, which are places for truck and marine shipping to interface, as well as potential marine-rail interfacing. We also included so-called principal ports, which indicate the top 150 ports by tonnage. We included each occurrence of Rail intermodal facilities which are served by rail and truck. Finally, the intermodal connections with pipelines served by trucks were included as an intermodal freight destination.

5.3 Network data

To calculate travel time between origin points and destination points as defined above, a transportation network is constructed for each travel mode of analysis (auto, transit plus walk, and bike). These networks are digital representations of streets and paths which can be used to travel in a region, and in the case of transit, the schedules of the transit vehicles (where and when they travel). Each mode has slightly different parameters for building a network for use in trip routing.

5.3.1 Auto networks

Data describing the auto travel network across the country were licensed from TomTom North America, Inc., and include the MultiNet and Speed Profile products. MultiNet provides auto network geometries for roadways of all functional classifications from local streets to major highways, and Speed Profile provides average roadway speed information, for each roadway segment, at a 5-minute resolution level throughout the day. The data products used in this project contain speed data collected by GPS devices during the June 2018–June 2020 period and averaged. For road segments where speed data are provided separately for different days of the week, data for Wednesday (as a typical weekday) are used.

Travel times on this network reflect observed travel speeds rather than posted travel speeds.

5.3.2 Transit networks

Routing a trip on public transportation requires two types of information. Since the vast majority of transit users walk or roll to and from the transit stop or station, the pedestrian network must be provided along with the transit service. Once at a stop, the transit schedule of times of departure and places visited by route is needed to complete the picture of where one can go on this mode.

Data describing the pedestrian network across the country were obtained from OpenStreetMap,[9] an open-access online database of transportation network structures, maps, and other spatial information. OpenStreetMap, like Wikipedia, is composed of contributions from many individuals. In urban areas, it typically provides a much more detailed and up-to-date representation of pedestrian networks than datasets available from federal, state, regional, or local sources. The data used in this project were retrieved from OpenStreetMap in January 2020. Specifically, the pedestrian network is composed of features with the "footway," "pedestrian," and "residential" tags.

Detailed digital transit schedules in a consistent format are a critical component of this project, and the widespread availability of such data is a relatively recent phenomenon. The General Transit Feed Specification[10] (GTFS) was developed to provide transit schedules for use in traveler routing and information tools. A majority of operators (at least among medium and large metropolitan areas) provide GTFS datasets via a direct website link. All GTFS datasets for this project were sourced through Transitland,[11] an open data platform that collects transit schedule data from transit providers worldwide. Utilizing Transitland's features, users can explore the actual routing and service information within a GTFS dataset on their website. This allows us the opportunity for certain levels of ground truth validation and quality control checks. Furthermore, we implemented an additional step of data quality verification using a GTFS validator[12] to ensure compliance with network routing calculation standards. Nevertheless, errors or missing data from transit schedules in this project are the responsibility of the transit agency. Travel time calculations are based on schedules valid for January 12, 2020 (a Wednesday with normal, non-holiday service). When a schedule for that date is not available for a given transit operator, the schedule which comes closest to including it is used. Only fixed route service (regular bus and rail) was included in the transit network. Travel times on this network represent the scheduled travel times of the included

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[9] https://www.openstreetmap.org
[10] https://developers.google.com/transit/gtfs/
[11] https://www.transit.land/
[12] https://gtfs.org/schedule/validate/

transit schedules, plus walk time to and from stops, and wait time between vehicles if necessary.

The transit accessibility calculations in this report do not include paratransit, demand-response, microtransit, or other on-demand services. These services are the ones most commonly available to residents in Appalachia, especially outside of urban areas, and in some cases are limited to certain populations or groups.[13] However, this form of transportation does not lend itself to a transit accessibility calculation where trips can be planned to destinations along routes according to a timetable. Instead, the accessibility of demand-response transit is more like a restricted form of auto accessibility: there is an additional burden of planning (commonly a request must be made the day before travel), restrictions on available destination zones, and some restrictions to certain members of the public. Accessibility calculations would require data on the rules, eligibility, and wait times of each demand-response provider, in combination with the auto network described above. This is an active area of development in Accessibility metric research and application.

5.3.3 Bike networks

Like the pedestrian network, data describing the bicycle network across the region were obtained from OpenStreetMap (OSM). Specifically, the bicycle network is composed of all roadway features that are not restricted-access (e.g. interstate highways) as well as all separated facilities and off-street paths on which bicycles are permitted. The bicycle network elements include OSM tag data, which describe attributes such as the presence of bike lanes; these tag data are used in the Level of Traffic Stress assignment procedure.

Level of Traffic Stress (LTS) is a metric used to evaluate how comfortable a given street is to bike on, based on physical attributes of the roadway and bicycle facilities, if any. LTS evaluation is based on a variety of roadway characteristics, such as the presence or absence of bike lanes or paths, numbers of lanes, and roadway speeds, and assigns a value of 1 (lowest stress) to 4 (highest stress) to street segments based on these characteristics. The bicycle LTS assignment heuristics employed in this study have been justified based on published research literature and agency experience, and are detailed in full in the methods of the National Accessibility Evaluation Access Across America: Bike report.[14]

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[13] Public Transportation in Appalachia – Inventory and Assessment: https://www.arc.gov/report/public-transportation-in-appalachia/

[14] https://ao-nae-reports-2021.s3.amazonaws.com/methodology/AccessAcrossAmerica-Bike2021-Methodology.pdf

Limited-access roadways that disallow bicycles, such as interstates, are not considered for routing; only street segments where bicycles are either expressly permitted, or not disallowed, are considered for the LTS ranking process. Information regarding the type of bicycle amenity implemented is first used, such as the presence of a protected bike lane. As information regarding bicycle amenities, lane numbers, and roadway speeds does not exist for some roadway segments in the OSM database, hierarchical classification of roadways as "primary," "secondary," and "tertiary" is used later in the LTS assignment process as a proxy for physical roadway design characteristics which influence LTS rank.

Intersections are handled in such a way that their LTS rank is dependent upon the LTS ranks of their approaching roadway segments. If an intersection is controlled by traffic signal devices, the LTS rank of the intersection is set to the lowest-stress rank of all approaching roadways; if an intersection is uncontrolled, the LTS rank of the intersection is set to the highest-stress rank of all approaching roadways. This approach acknowledges the importance of complete routing when considering bicycle traffic—that is, a single stressful intersection crossing along an otherwise low-stress route may deter riders from using the facilities.

In this study, networks are constructed for LTS 2 (almost all ages and abilities would feel comfortable using streets and intersections in this network), and LTS 4 (only vehicular cyclists comfortable riding in mixed traffic would use this full network). The comparison between the two networks often can reveal safety gaps in access due to the higher stress level of roads between origins and destinations.

Travel times on these networks use the same assumed speed of travel (12 km/h or 7.46 mph). Users of the LTS 4 network can use more of the road network, and so typically travel farther in the same amount of time.

6   Methodology

With data gathered on origins, destinations, and travel networks, the calculation of access proceeds through a series of steps. First, travel times between origins and destinations are calculated. Second, the characteristics of the destinations available at those travel times are scored or added to create an accessibility metric. Finally individual block-level accessibility metrics are weighted and aggregated for reporting and mapping.

6.1   Travel time calculations

Travel times are calculated by using a routing algorithm, similar to a smartphone app that might serve directions from an origin to a destination. For this project we used two different routing algorithms. For auto calculations, we used a custom implementation of Open Trip Planner[15] which was configured to dynamically assign travel speeds by auto on segment according to the observed GPS-derived speed data described in **Network data**. For transit, walk, and bike calculations we used the open source R5[16] router developed by Conveyal. Custom programs in both R and python were used for data handling, interfacing with trip routing, output handling, aggregation and to produce data products.

For each origin block, the set of destination points reachable from each origin in a given travel time are used to calculate specific travel times to each destination using each mode. We included all destination points as potentially reachable but only measured travel times up to 60 minutes, so destinations which take longer to reach than an hour are assigned no travel time estimate in the data.

For the auto and transit modes, travel time estimates vary by time of day of departure, due to impacts of congestion (auto) and service availability (transit). For all modes and data reported here, we used a departure of 8am on a typical weekday. Because of the minute-to-minute variability that is inherent to transit schedule matching, we use R5 to calculate the travel times from origin to destinations that result from departing **each minute** between 7am and 9am; the median travel time of the resulting 120 data points is the reported travel time.

A transit travel time is made up of components including walk or roll as a pedestrian from the origin block to the appropriate transit stop or station, waiting for the transit vehicle, traveling in the transit vehicle, waiting between transit vehicles if a transfer is necessary, and walk or

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[15] https://github.com/opentripplanner/OpenTripPlanner
[16] https://github.com/conveyal/r5

roll from the last transit stop or station to the destination. In the case where no appropriate transit service is available, the routing algorithm will create a walk/roll trip to available destinations. So, the full description of the travel time of this mode is "walk+transit" and in the case of no transit service, travel times are equivalent to walk travel times. **Figure 6.1** shows counties in the study area which included a GTFS schedule and thus had at least some fixed route transit service for these calculations.
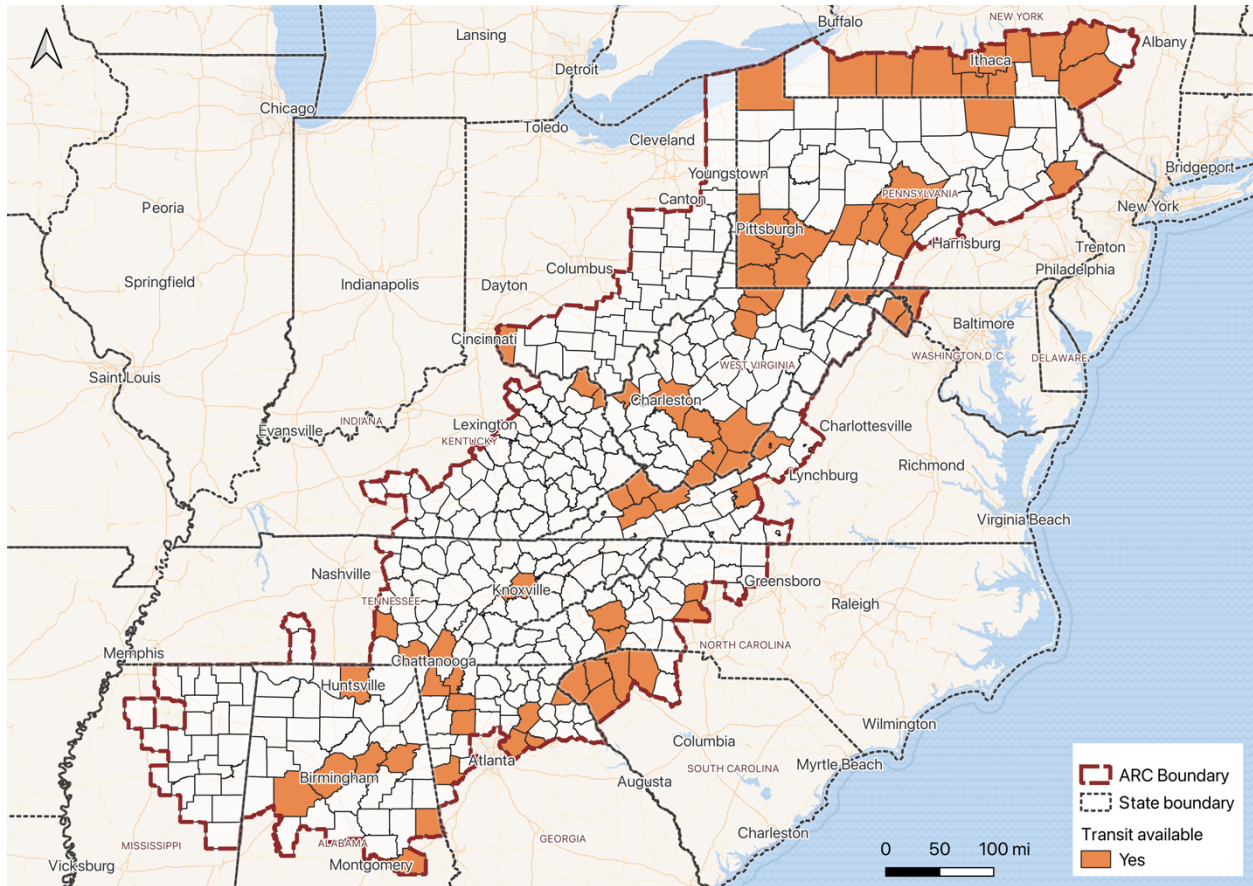
Figure 6.1: A map showing ARC counties with GTFS available for fixed-route transit services.

The outcomes of this calculation step are travel time matrices are stored with mode, origin block id, destination id, and typical (median) travel time, for each Census block and destination combination in the study area.

6.2   Access metric calculation

We use two different metric types to capture different aspects of travel to destinations. We use *cumulative accessibility* metrics to describe access to jobs, and *dual accessibility* metrics to describe access to other destination types.

Cumulative accessibility metrics are calculated by keeping the travel time of interest fixed, and summing (counting) the opportunities at destinations reachable in that amount of travel time from each origin. This is a useful metric for destinations like jobs, where the number of jobs reachable in a certain travel time (for instance, 30 minutes driving) is a comparable metric across locations that synthesizes the opportunities provided to someone at each origin, and is in directly comparable units across places. In this work we calculate access to jobs across modes for travel time thresholds every 5 minutes to 60 minutes.

Dual accessibility metrics take a different approach, by allowing the travel time to vary while keeping fixed the number of destinations of interest. This is most applicable in situations where above some satisfactory number, additional destinations have little marginal value, so it doesn't make as much sense to simply sum up as in the cumulative approach. For instance, reaching the 11th convenience store may not have as much inherent value as reaching the first or second.

The simplest dual metric is to record the travel time to the nearest destination of interest; this is a straightforward description of the availability or access to a particular destination type from each origin. Places like emergency care hospitals are well described by these metrics. We use this metric for all destination types, as the basic descriptor of access.

With destinations where there may be value in having a set of choices (as for high schools, for example), we use the travel time to the third destination. This single dual metric, travel time in minutes to the third opportunity, also captures the first and second closest by travel time, such that it represents the minimum travel time to a choice of three. The number of choices being three is somewhat arbitrary but for most of the destination types represented here, places with more than three locations for a given destination type within 60 minutes can be rare. We use both nearest, and travel time to third destination, for education and preventative health care destinations in the data and the report.

6.3   Data aggregation

The access metrics calculated at the block level result in nearly 100 values per origin block (three modes x 30 dual metrics for destination types, plus job accessibility at different thresholds of travel time). These data are provided in full (see **Deliverables**). But, for interpretation and planning purposes it is also helpful to aggregate data to larger geographic areas. Here we describe weighting and aggregating to the county level.

The raw access metrics for a block represent a value for a particular geography. More meaningful is a value which represents how **people** experience access. To connect the geographic metrics to the population, we use the number of people in the LEHD LODES dataset residing in a given block, to construct weighted averages. The basic formula is

$$Acc_{county} = \frac{\sum_{i=1}^{n} \omega_i Acc_i}{n} \tag{1}$$

where **i** indexes the blocks within a county, Acc_i is the accessibility metric in block **i**, ω_i is the number of people in the category used for weighting, and **n** represents the number of blocks in the county. The output is the person-weighted average access for a metric, or the access experienced by a typical person of that category in the county. Note that the worker populations are matched to the blocks and so are best for aggregating this geography. This does not imply that only workers are making trips represented in the accessibility metrics but provides a way to correct for the uneven distribution of people across Census blocks.

We use four different person-weighted metrics to explore differences in access across different populations. Table 6.1 describes the weights and their labels.

Table 6.1 LEHD LODES population values used for aggregation weights.

Population	LEHD Code	Description	Figure Label
All workers	C000	Total number of workers	all workers
Workers with low income	CE01	Number of workers with jobs with earnings $1250/month or less	low-income workers
Workers identifying as Black, Indigenous, People of Color (BIPOC)	C000 – CR01	All workers, less those identifying as white non-Hispanic/Latino	BIPOC workers
Workers with less than High School education	CD01	Number of workers with Educational Attainment: Less than high school	low-education workers

By weighting using the different sub-populations, differences in access as experienced by the different groups can be assessed. Unless otherwise specified, county-level and other aggregated accessibility statistics are weighted using "all workers."

7 Deliverables

In this section, we present the outcomes of our work—a comprehensive overview of the detailed accessibility metrics. Our primary focus lies in assessing multimodal access to key aspects of daily life: jobs, education, healthcare, and entertainment, as well as, understanding the how the intermodal freight facilities are spread out across the region.

By leveraging the datasets and visualizations from this project, stakeholders can make data-driven decisions, identify areas for improvement, and contribute to the ongoing dialogue surrounding regional accessibility.
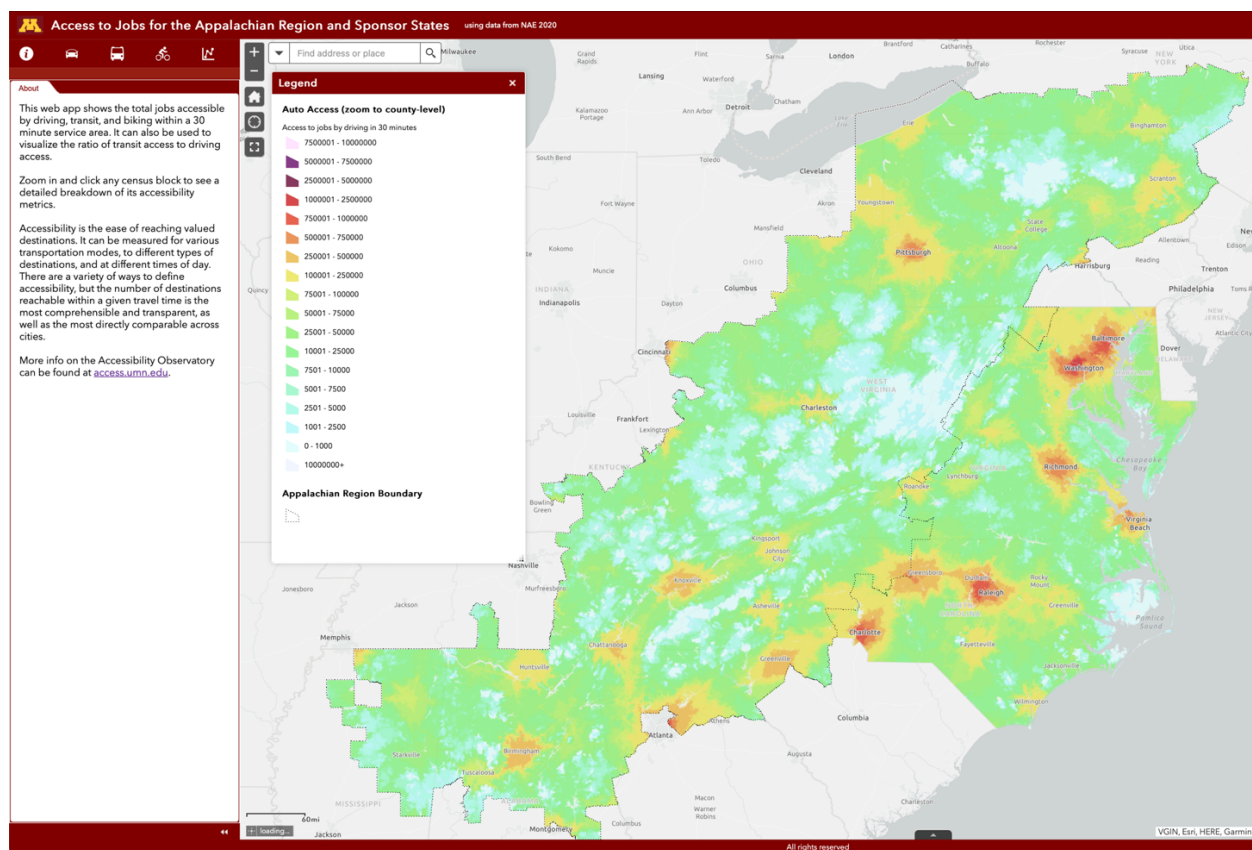
Figure 7.1: A screenshot of the interactive web app delivered as part of Task 1 showing access to jobs by driving for all the ARC region as well as the partnering states.

7.1 Mapping tool

To facilitate seamless access to job accessibility datasets by driving, biking, and transit while using walking as an egress mode, we developed an interactive web app that was delivered as

part of Task 1 of this project. [17] This application, shown in **Figure 7.1**, empowers users to delve into the performance of Census blocks across our study area, spanning the ARC region and the entire cohort of partnering states: Maryland, Virginia, and North Carolina. The interactive nature of the app provides a dynamic platform for users to gain insights into job accessibility through various transportation modes.

The web app is designed with user-friendly tabs that enable navigation between different transportation modes. Users can transition from exploring job accessibility by driving to biking or walking plus transit. To enhance accessibility understanding, the app incorporates spatial layers that illustrate the variances in job accessibility between two different transportation modes at a time. This functionality enables users to quantify the disparities and ascertain the relative advantages offered by each mode.

7.2 Accessibility Metrics

To assess job accessibility, we employed primary access metrics, where we maintained constant travel time and measured the total number of jobs reachable from each Census geography within that designated time frame. In examining access to destinations such as healthcare, education, entertainment, and intermodal freight facilities, we utilized dual access metrics. In this approach, we held the number of destinations constant and gauged the travel time required to reach these destinations from each Census geography.

For all destinations falling under education, healthcare, and entertainment categories, our measurement focused on travel time to the nearest facility. For instance, to assess access to trauma centers throughout the region, we computed the travel time from each Census block to the closest available trauma center within a maximum travel time of 60 minutes.

For certain destinations such as K-12 schools or primary care clinics, we extended our analysis to include travel time to the third nearest facility. This implies that if a Census block could reach the third closest high school within a 20-minute drive, it could similarly access the nearest or second nearest high school within the same 20-minute timeframe. This expansion of metrics to incorporate travel time to the third destination highlights the significance of dual access metrics. This approach becomes crucial when measuring access to

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[17] Web App Link:
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=1b4b5a15653b4bdfb13be92abd50c4b8

more than one destination is essential, providing end users with a range of options to choose from.

To illustrate the granularity of the data, and demonstrate the contrast between urban and rural access throughout the region, we used Allegheny County, PA, and Randolph County, WV—two distinct examples within the ARC region. Allegheny County, centered around Pittsburgh, serves as an urban contrast to Randolph County, a predominantly rural area centered around Elkins. Using Census block-level data, we map how accessibility varies in these different landscapes, providing insights into the impact of urbanicity and land use.

To portray the entire ARC region, we utilize county-level data derived from weighted aggregation of Census block-level results. This approach allows us to identify variations in average accessibility across ARC counties. Select graphs compare how counties across the region are performing with respect to their economic status or urbanicity characteristics.

Through these maps, we gain a comprehensive understanding of how the region performs concerning accessibility to various destinations. However, the static visualizations presented below represent only a select few examples. They serve as a snapshot of the vast potential inherent in the datasets that the ARC and partner states will receive through this project. These visuals showcase just a glimpse of the analytical possibilities and insights that stakeholders can derive from the comprehensive dataset.

7.2.1 Access to Jobs

Analyzing the job accessibility metrics within a 30-minute travel time for different blocks and counties in the ARC region reveals a notable trend. The total number of jobs accessible by driving considerably surpasses the jobs accessible by either walking plus transit or biking. This observation is to be expected, given the transportation and land use context of the region, and rural distances of travel.

Another trend lies in the variation in the total number of accessible jobs between Census blocks in urban areas and those in rural or semi-rural areas. Even counties hosting larger urban clusters exhibit an overall higher average job accessibility by all modes compared to predominantly rural counties. This trend is less reflective of the transportation network *per se* and more indicative of land use planning and the strategic placement of economic hubs within the region. Counties demonstrating higher access to jobs by driving, transit, and biking consistently align with being economic centers within the ARC region.

A parallel trend is observable within counties. A closer examination of Allegheny County in **Figure 7.2** reveals that blocks closer to the downtown core of Pittsburgh, the activity center, exhibit greater job accessibility across all modes compared to blocks farther away from the center. This aligns with the common practice of directing multimodal investments toward downtown activity centers in various locations.

Contrasting Allegheny County with Randolph County, shown in **Figure 7.2** to **Figure 7.5**, highlights the stark differences in land use. While Randolph County offers comparatively fewer jobs accessible by driving, the accessibility diminishes even further when transitioning from driving to walking and transit. This underscores both the limited job opportunities in the county and the scarcity of a fixed-route transit system.

This comparison of job accessibility between different places should not imply superiority or inferiority. Instead, it serves as a description of how transportation and land use interact in the ARC region. To identify areas where land use may be insufficient, a more in-depth research approach with context-based analysis is essential. However, a notable observation emerges when comparing median access to jobs by different modes for ARC counties based on their economic status: at-risk and distressed counties consistently exhibit the lowest overall access to jobs.

The observation that at-risk and distressed counties consistently exhibit the lowest overall access to jobs by different modes suggests a potential disparity in economic opportunities and mobility in these areas. It implies that residents in these counties may face challenges in accessing job opportunities, which can have cascading effects on economic development and individual well-being. This information underscores the importance of addressing transportation and land use considerations in at-risk and distressed counties to enhance job accessibility and foster economic resilience in these regions. Further, it signals the need for targeted interventions and strategic planning to improve transportation infrastructure and land use patterns to promote equitable access to employment opportunities across the ARC region.
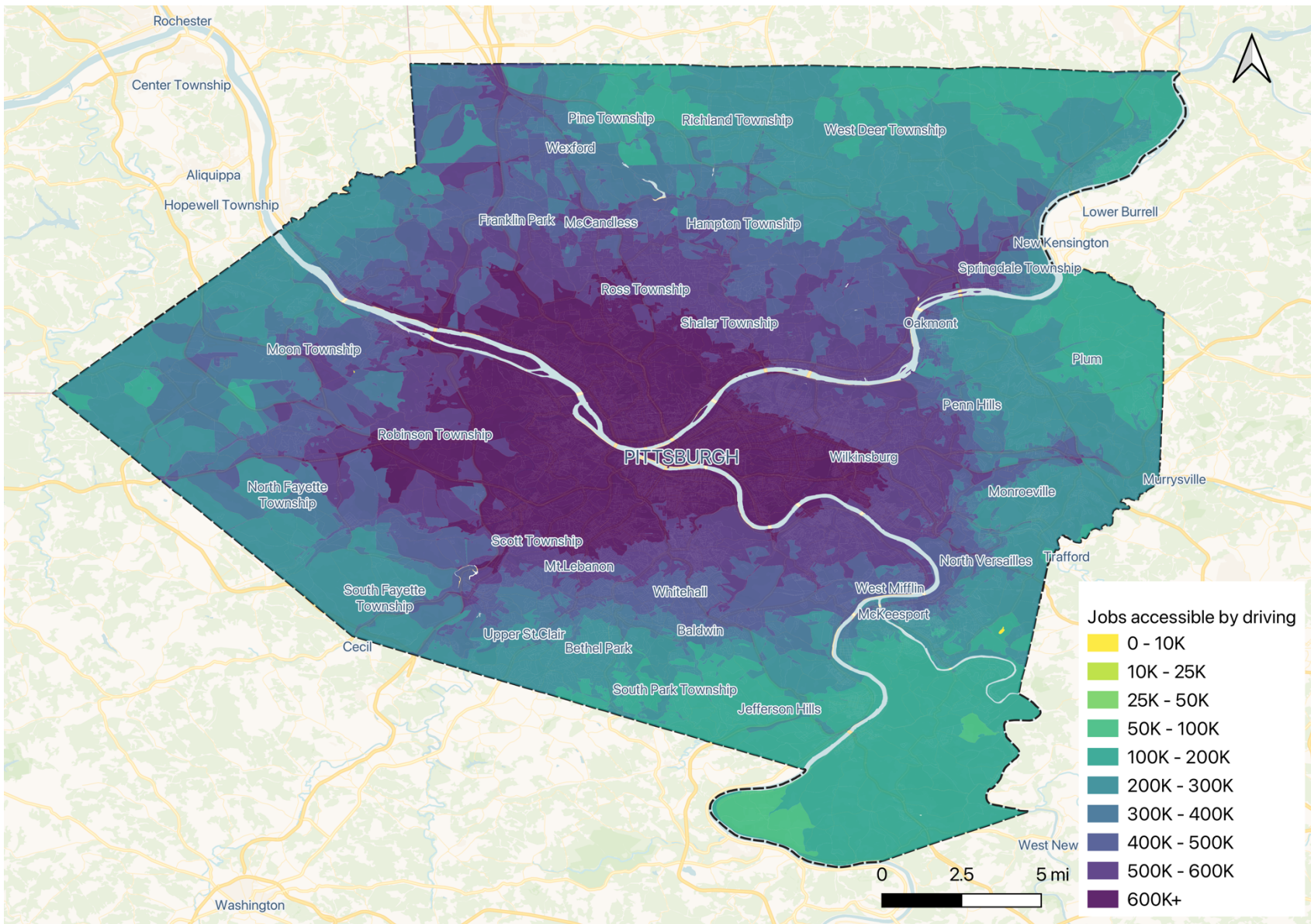
Figure 7.2: A map showing travel time to jobs by driving in 30 minutes for Allegheny County, PA.

Legend — Jobs accessible by transit:
- 0 - 10K
- 10K - 25K
- 25K - 50K
- 50K - 100K
- 100K - 200K
- 200K - 300K
- 300K - 400K
- 400K - 500K
- 500K - 600K
- 600K+
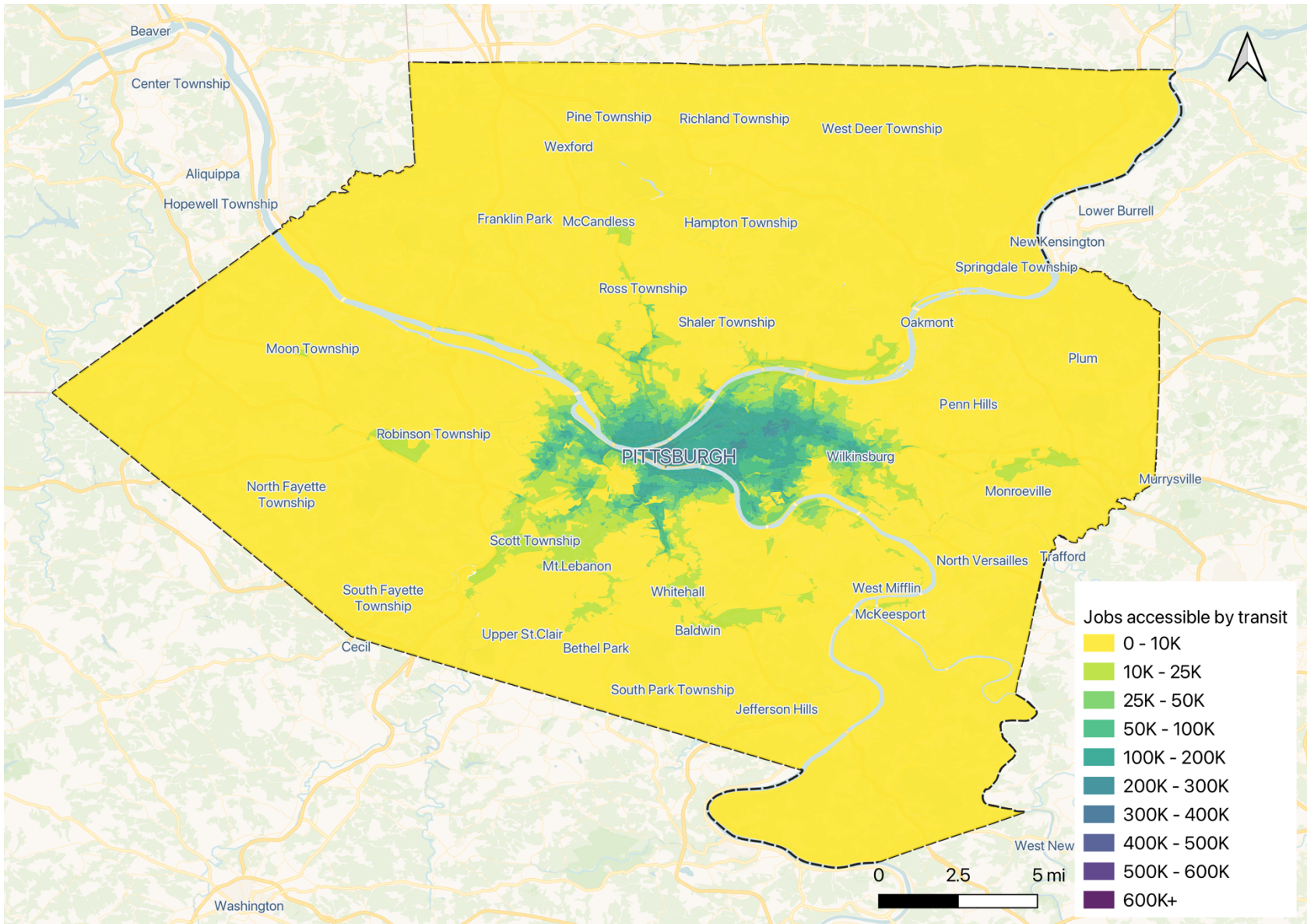
Figure 7.3: A map showing travel time to jobs by transit in 30 minutes for Allegheny County, PA.
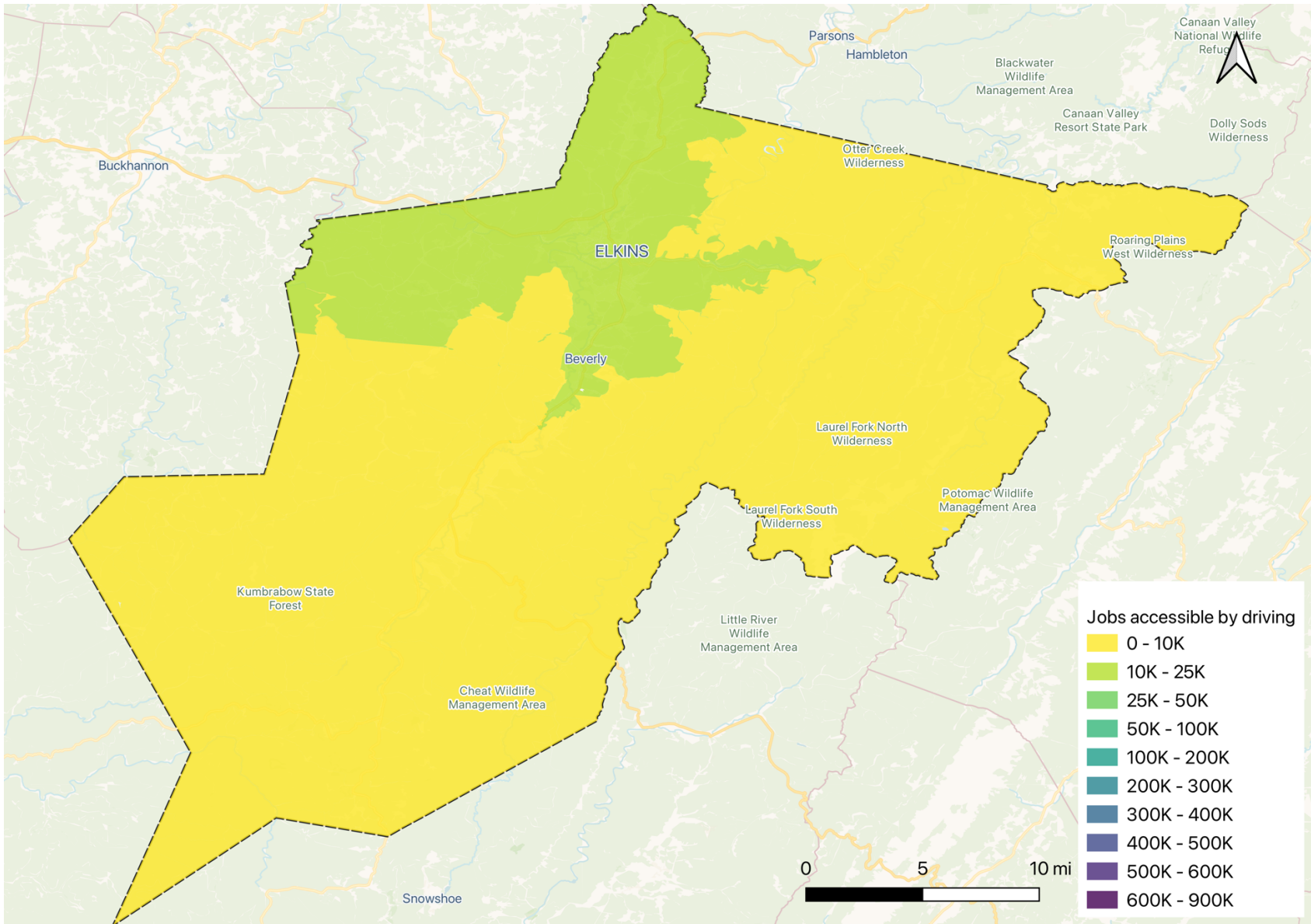
Figure 7.4: A map showing travel time to jobs by driving in 30 minutes for Randolph County, WV

33
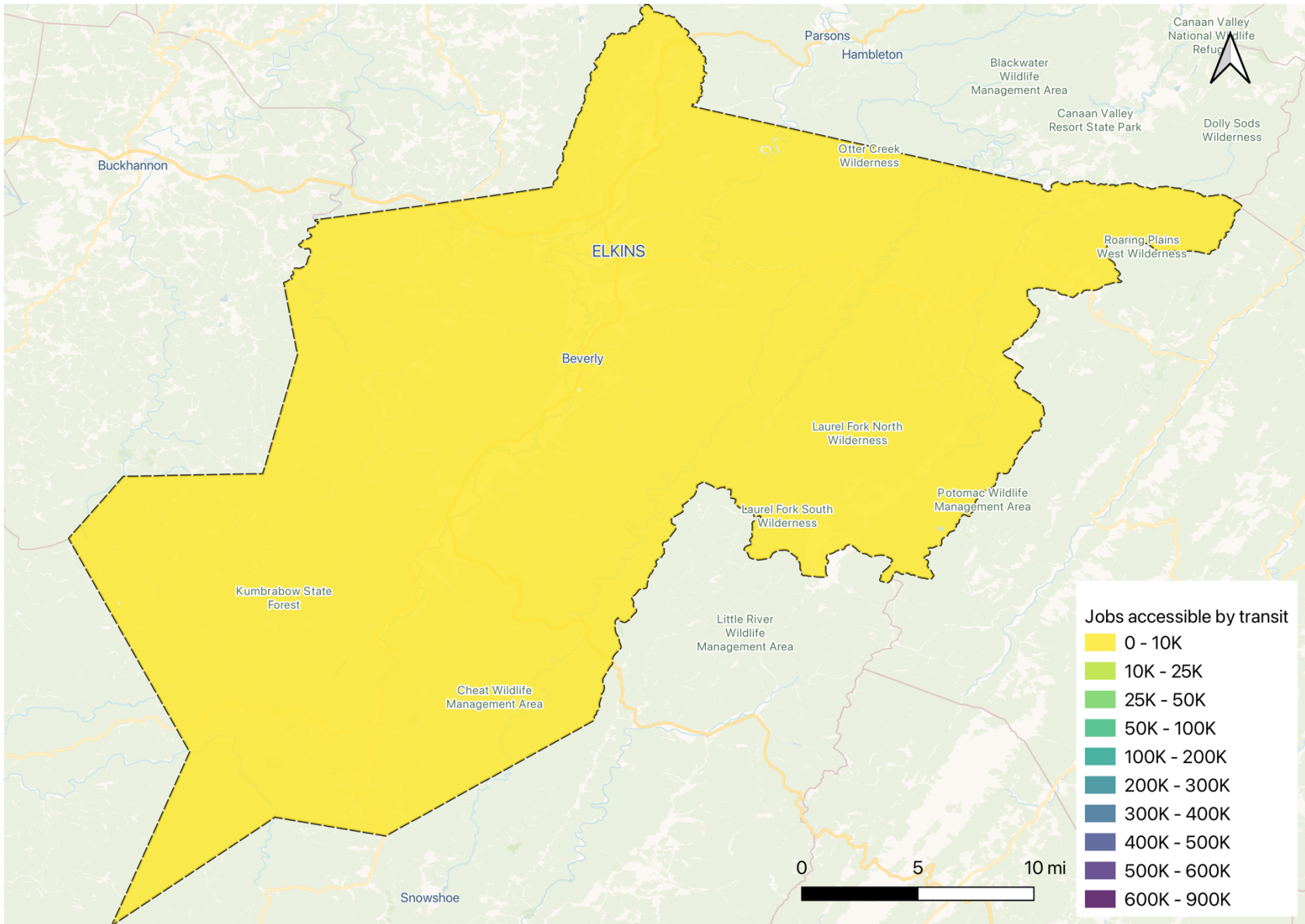
Figure 7.5: A map showing travel time to jobs by walking+transit in 30 minutes for Randolph County, WV.
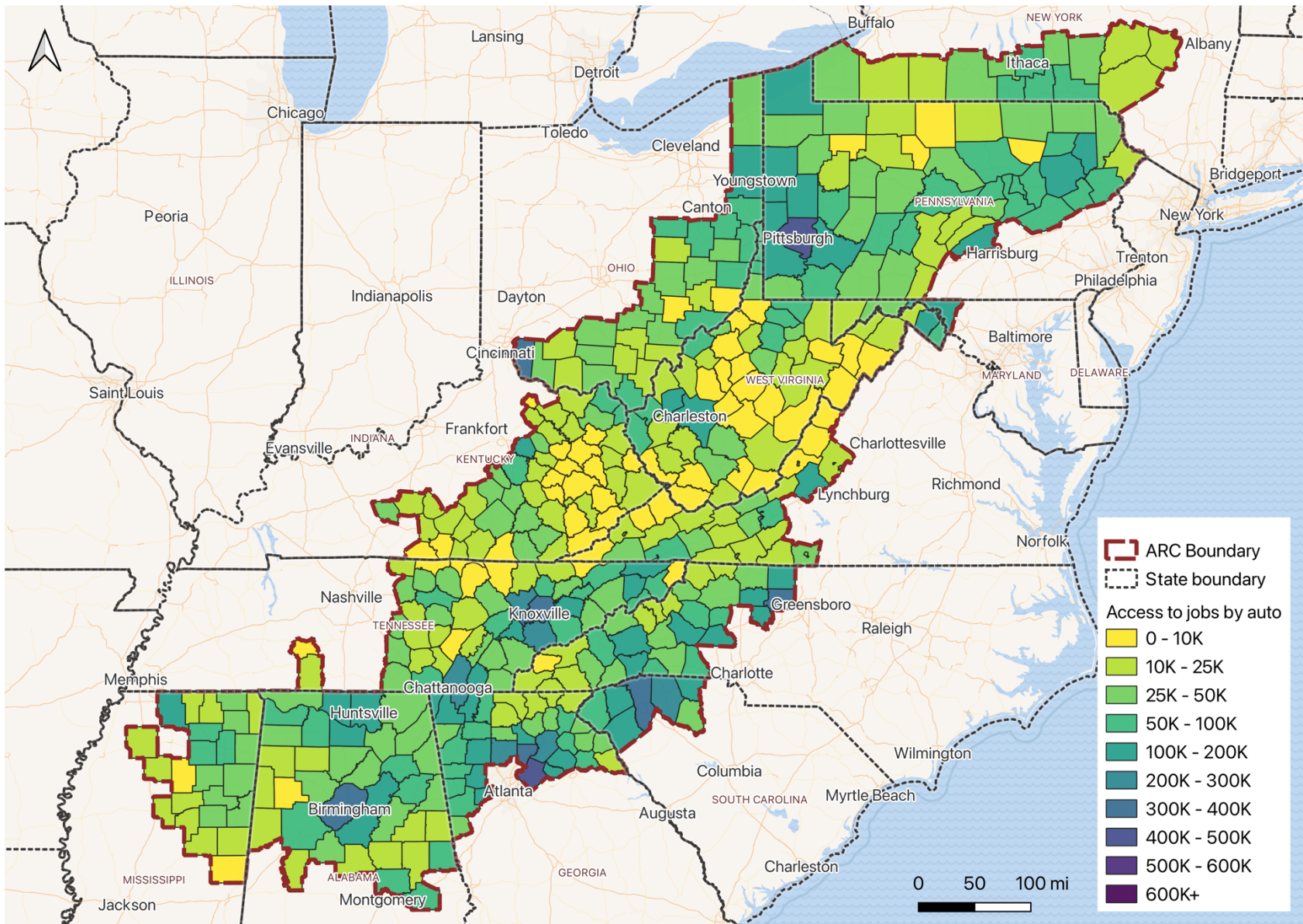
Figure 7.6: A map showing average access to all jobs by driving in 30 minutes for all ARC Counties.
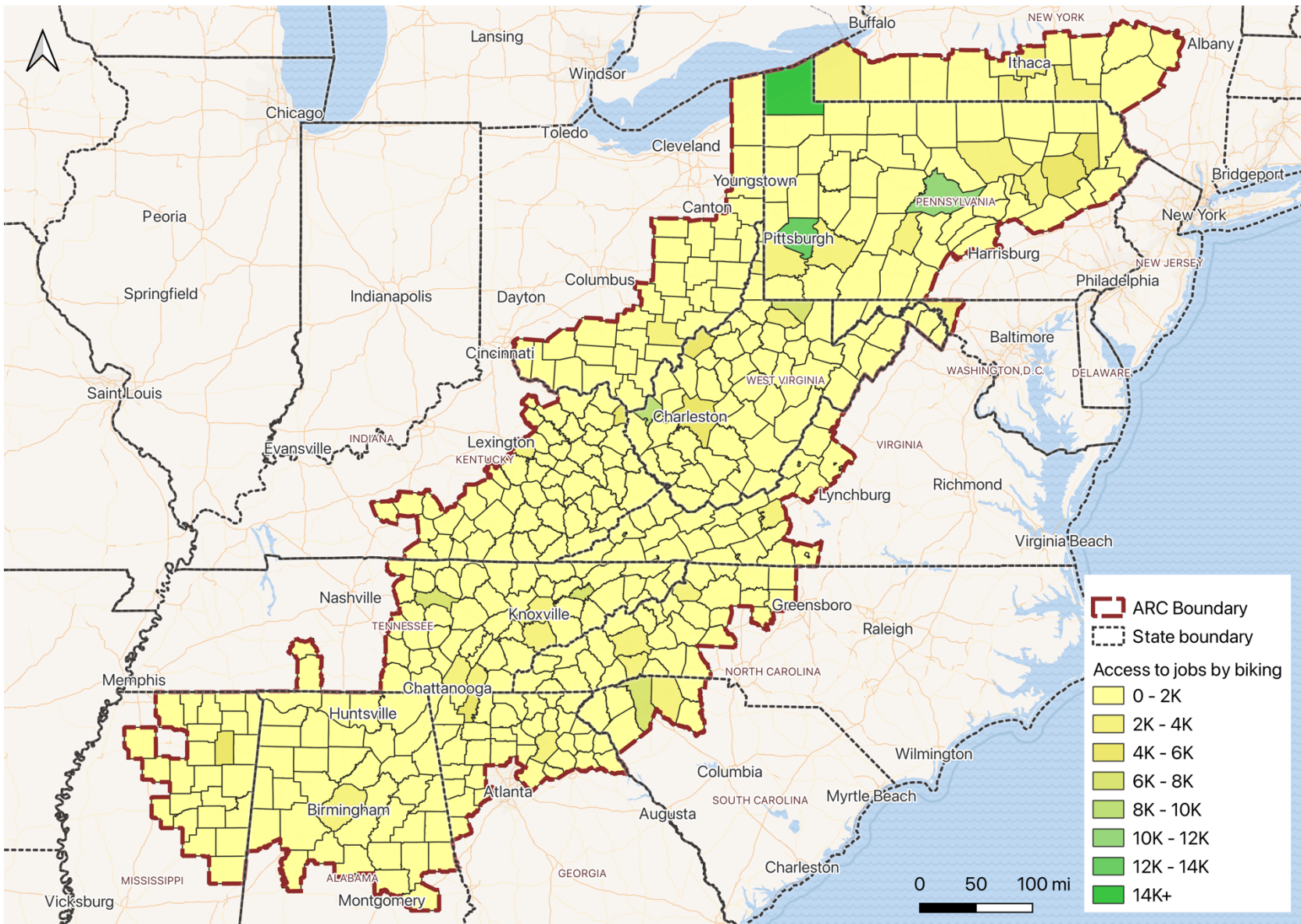
Figure 7.7: A map showing average access to all jobs by biking in 30 minutes using low stress streets (LTS 2) for all ARC Counties.
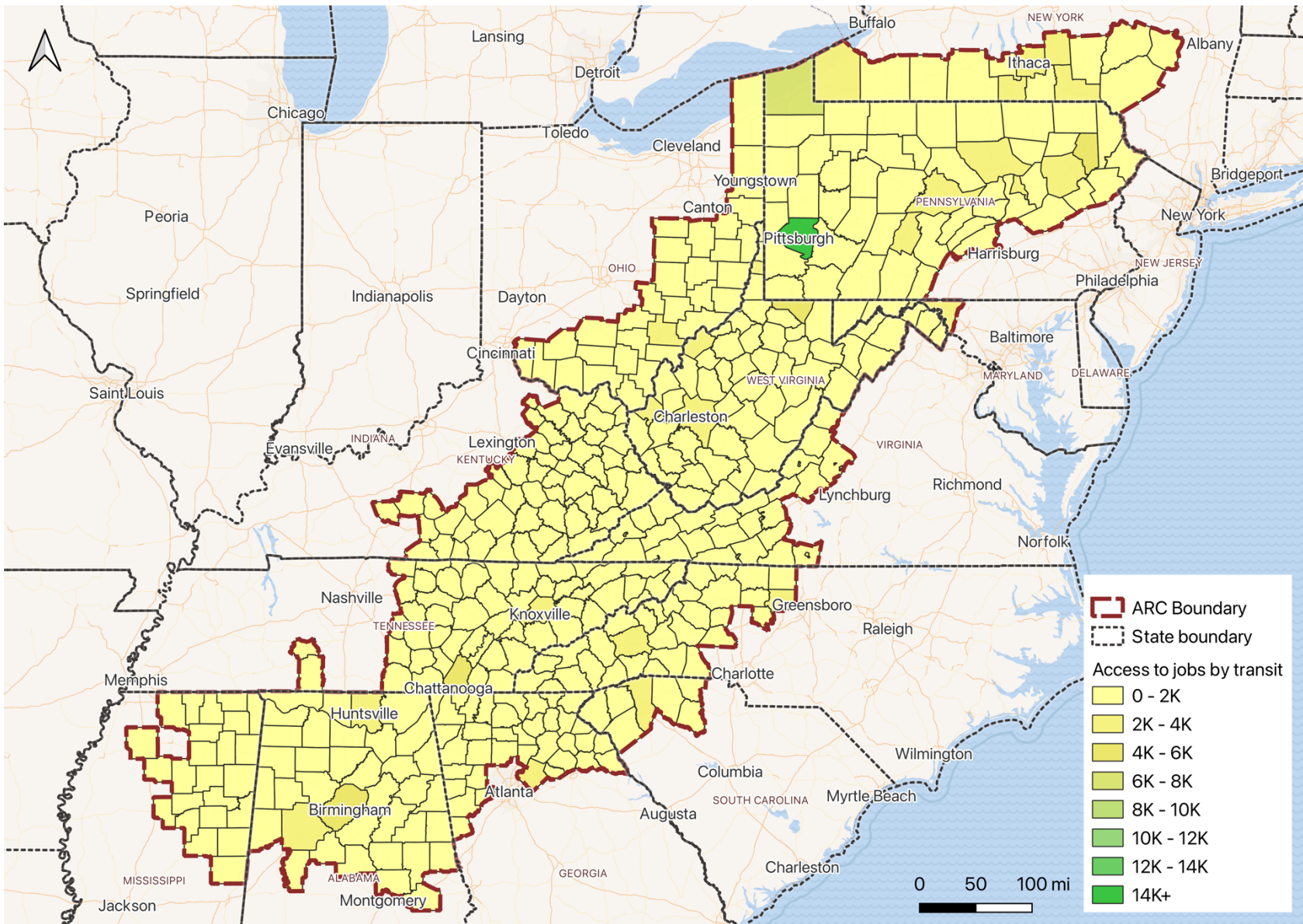
Figure 7.8: A map showing average access to all jobs by walking+transit (where transit exists) in 30 minutes for all ARC Counties.
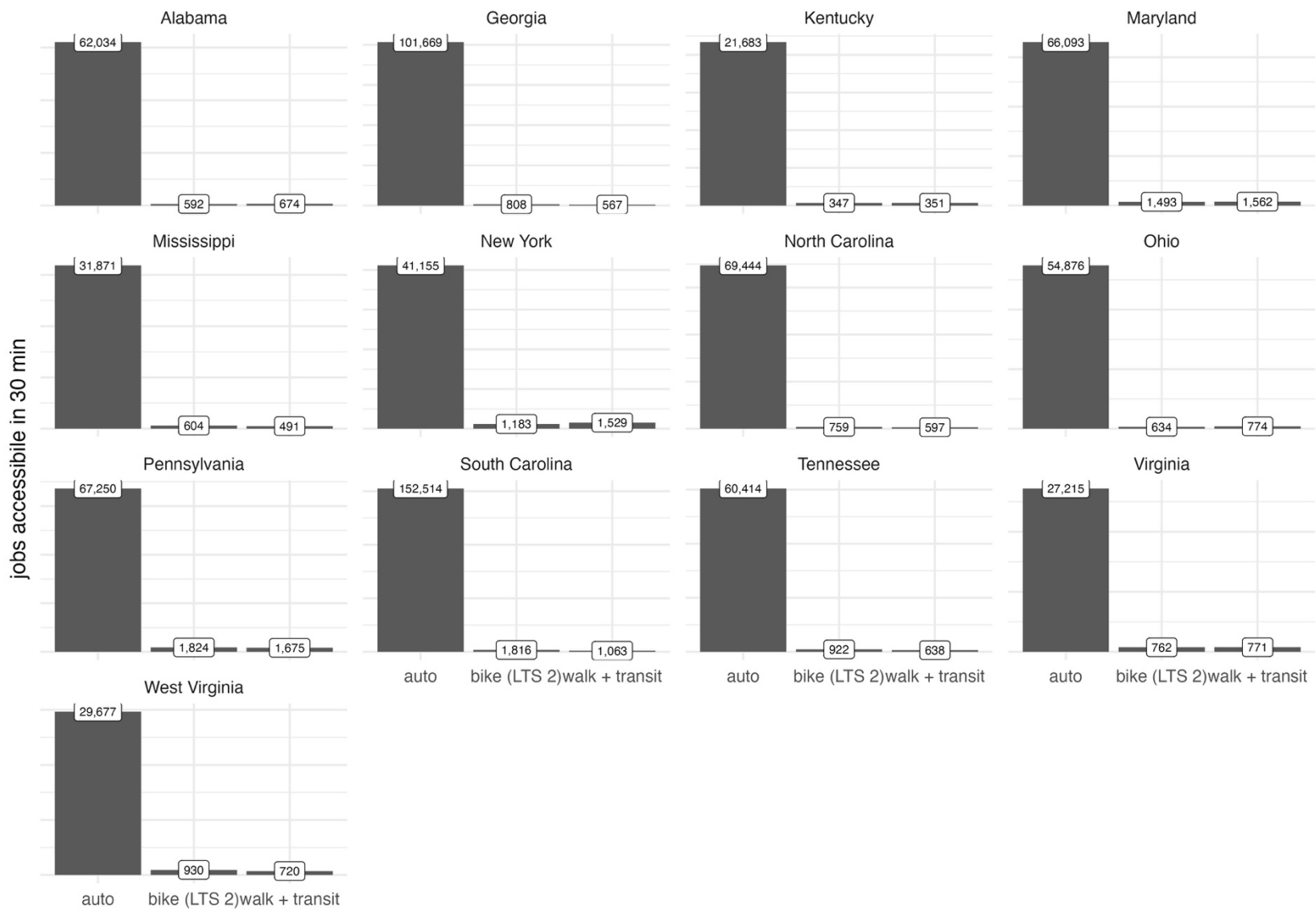
Figure 7.9: Graphs comparing median access to jobs for ARC Counties within each ARC state by driving, biking (using LTS 2), and walking+transit (where transit exists) in 30 minutes of travel time.

number of jobs accessible in 30 min by auto

mean for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
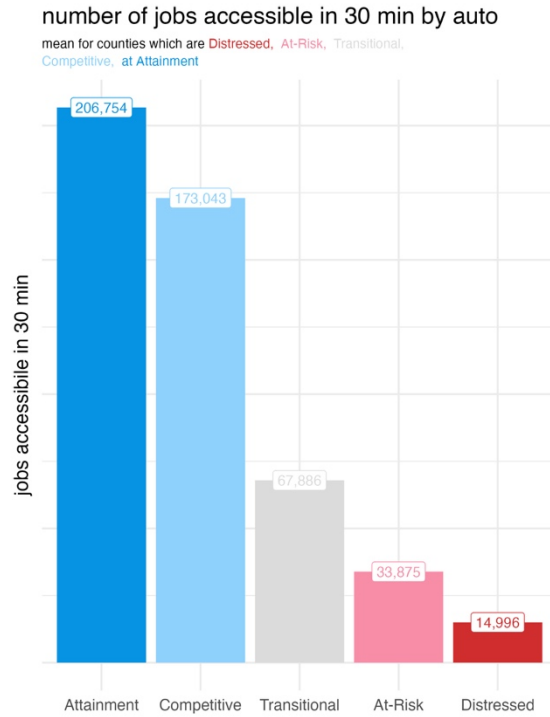
Figure 7.10: Graph comparing median access to jobs for ARC Counties by 2024 economic status by driving in 30 minutes of travel time.

number of jobs accessible in 30 min by bike

mean for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
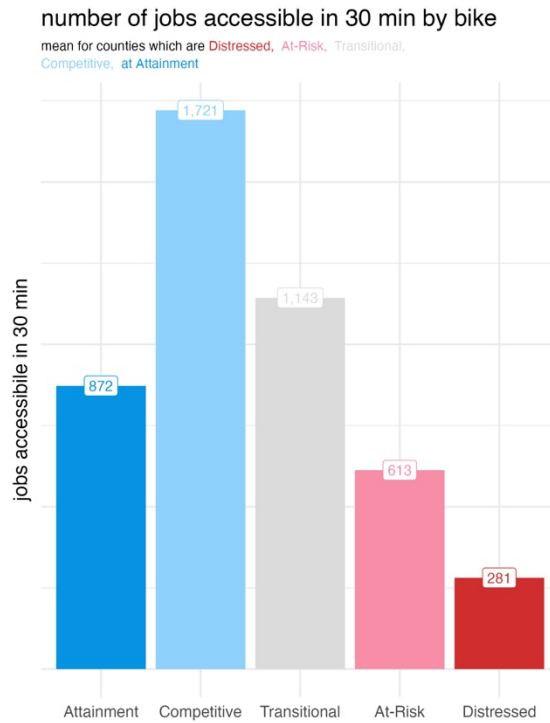
Figure 7.11: Graph comparing median access to jobs for ARC Counties by 2024 economic status by biking (using LTS 2) in 30 minutes of travel time.

number of jobs accessible in 30 min by walk+transit

mean for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

Figure 7.12: Graph comparing median access to jobs for ARC Counties by 2024 economic status by walking+transit (where transit exists) in 30 minutes of travel time.

7.2.2 Access to Education

Access to education is a pivotal metric, as it has far-reaching implications across various aspects of individuals' lives. Education serves as a cornerstone for personal development, influencing employment opportunities, economic mobility, and overall well-being. Beyond individual benefits, it plays a crucial role in shaping communities and fostering societal progress. Improved access to education enhances the potential for skill development, critical thinking, and civic engagement, contributing to the cultivation of informed and empowered citizens and high education rates are often linked with low unemployment rates.

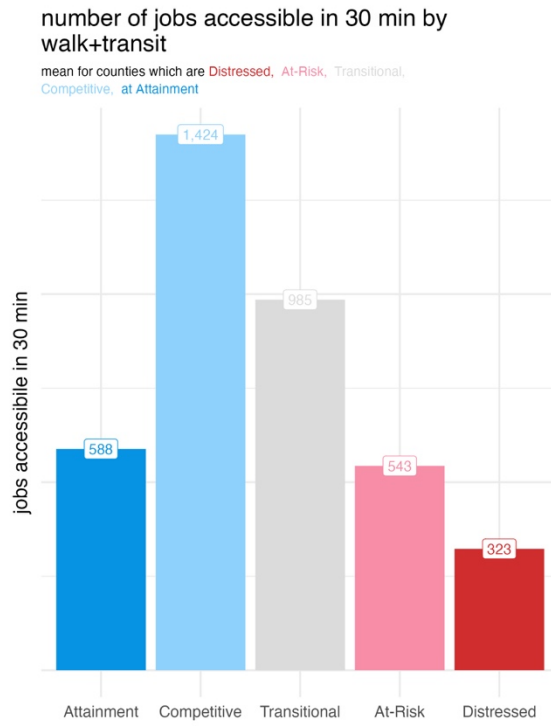In the education category, our assessment covered both public and private K-12 schools, as well as all colleges and universities offering associate's, bachelor's, master's, and doctorate degrees. For K-12 schools, both public and private institutions were categorized based on the grades they offered, resulting in the following classifications:

- Pre-K
- Pre-K through fifth (elementary schools)
- Sixth through eighth (middle schools)
- Ninth through twelfth (high schools)

In the case of post-secondary schools, they were classified according to the highest degree they offered, encompassing associate's, bachelor's, master's, and doctorate degrees. This detailed categorization allows for a comprehensive examination of educational accessibility across different levels and types of institutions.

In formulating our accessibility metrics for education, we adopted a dual access approach by maintaining a constant number of educational institutions and measuring travel time up to 60 minutes. Specifically, for K-12 categories, we assessed travel time to both the nearest and the third nearest institutions, providing options and choices, particularly relevant in the context of K-12 education.

In our visualizations and sample results presented for this report, our emphasis has been on examining access to the third nearest public high school by various modes—driving, biking, and walking plus transit. For postsecondary schools, our analysis is directed toward institutions offering associate and bachelor's degrees as the highest degrees available.

7.2.2.1 Access to K-12 Schools

Visualizing access to the third high school by different modes for Allegheny County, as depicted in **Figure 7.13**, reveals that, on average, a student or family from any block can

reach at least three public high schools within a driving time of 20 minutes. This indicates that the majority of the County is highly accessible for public high schools by driving, offering families multiple options. However, looking at **Figure 7.14** and **Figure 7.15**, the average travel times from each block considerably increase when transitioning to walking+transit or biking modes, emphasizing the mode-dependent variations in accessibility across the County. There are also blocks that cannot reach three public high schools within a traveling time of 60 minutes by either of the non-driving modes.

In addition to the observed variations in travel times across modes, it's noteworthy that access to three high schools within a 60-minute travel time is predominantly available for blocks near high schools when using non-driving modes. This pattern underscores the influence of geographical location on educational access, revealing that areas nearer to high schools are more conducive to diverse transportation options, such as transit, walking, or biking. Moreover, this trend is notably pronounced in areas closer to downtown regions, signifying the presence of robust transit and walking/biking infrastructure in densely populated urban centers.

In contrast to Allegheny County, using **Figure 7.16** to **Figure 7.18**, visualizing the same metric for Randolph County reveals distinct accessibility patterns. Due to the county's lower population and rural nature, the number of available schools is limited, resulting in only a handful of blocks having access to three high schools within a driving time of 60 minutes. Notably, when transitioning from driving to walking+transit and biking modes, it becomes evident that only blocks in close proximity to high schools can achieve such accessibility. This limited reach is likely attributable to the scarcity of both schools and transit, walking, and biking infrastructure in the county. These findings underscore the unique challenges posed by rural and sparsely populated areas, emphasizing the critical role of infrastructure development in enhancing educational access within such regions.

Expanding the analysis to county averages across the Appalachian region, as depicted in **Figure 7.19** to **Figure 7.21**, reveals consistent trends. On average, most counties and their blocks exhibit the capability to access three public high schools within a driving time of 30 minutes. However, this accessibility significantly diminishes when transitioning from driving to non-driving modes. These contrasting access patterns underscore the considerable reliance on personal vehicles for optimal access to high schools, emphasizing the influence of existing land use and infrastructure.

This insight holds broader implications, illustrating the challenges placed on students and families who may require personal vehicles for improved access to education. Furthermore, it serves as valuable information for school administrations and city planners, offering guidance on areas where investments in school buses and transit infrastructure can effectively bridge access gaps and contribute to more equitable educational opportunities within the region.

7.2.2.2 Access to Postsecondary Schools

Upon scrutinizing access to postsecondary schools offering associate's (often offered at community colleges) and bachelor's degrees as the highest offered, as illustrated in **Figure 7.24** to **Figure 7.31**, a notable trend emerges. Across most counties, with a few exceptions, there is generally favorable access to postsecondary schools within a driving distance of 60 minutes. In contrast, transit access to these schools within a 60-minute travel time appears considerably limited, often confined to the counties where the schools are located. This discrepancy highlights the predominant reliance on personal vehicles for accessing postsecondary education. The limited transit access underscores potential challenges for individuals relying on public transportation to access higher education institutions. Addressing these disparities may involve targeted efforts to enhance transit infrastructure and connectivity to better serve students and communities seeking access to postsecondary education.

When examining the education metrics across the region by urbanicity and economic status, a clear distinction emerges. Driving access tends to be more favorable in most urban counties and those with robust economic standings, in contrast to rural counties and those categorized as distressed or at-risk. Interestingly, the implications for transit access follow an opposite trend, aligning with the common practice of investing in transit infrastructure in economically weaker areas. These findings emphasize the interconnected nature of transportation access, urban development, and economic well-being, underscoring the need for nuanced and context-specific strategies to address disparities and enhance overall accessibility across diverse regions.
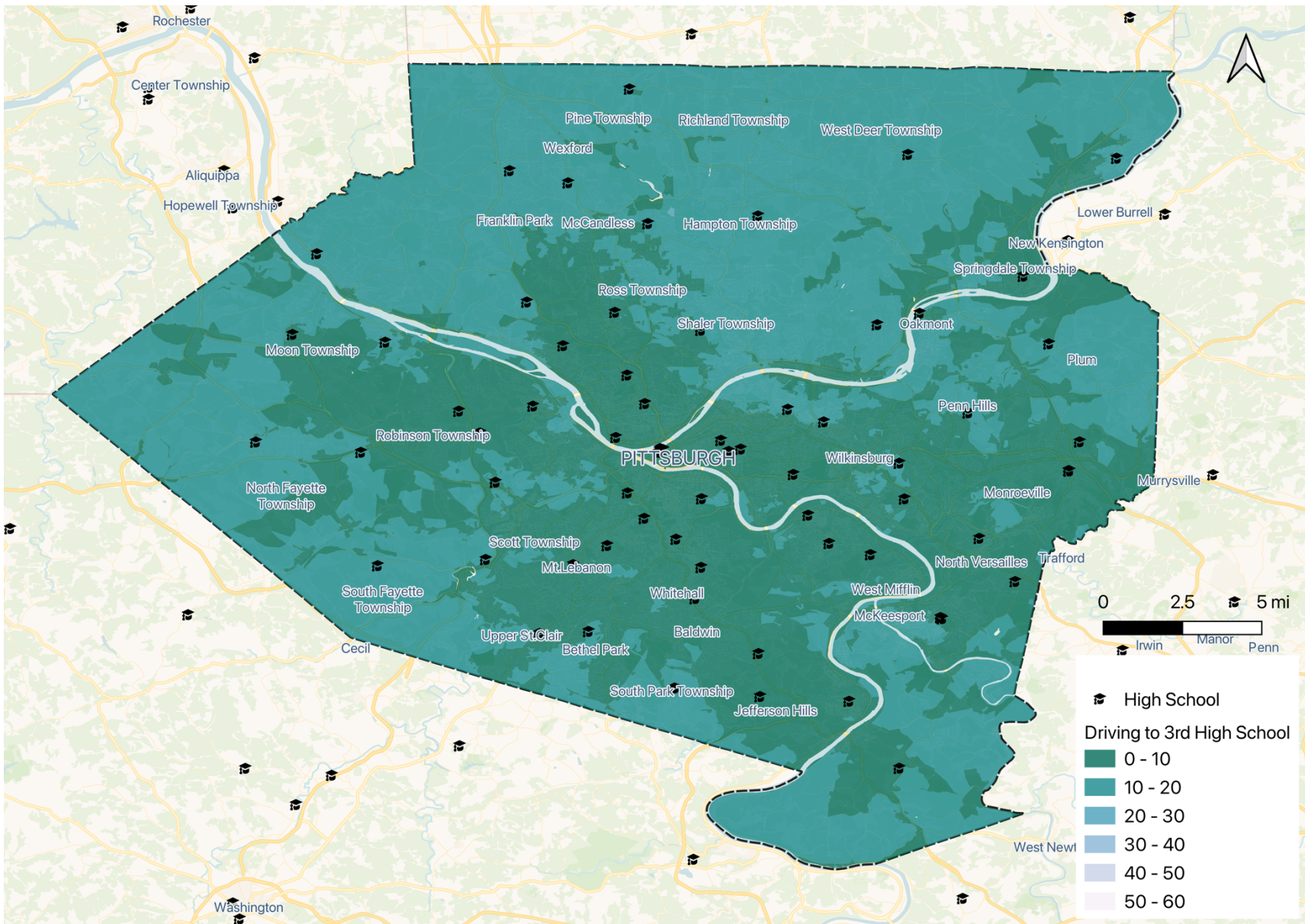
Figure 7.13: A map showing travel time to the third nearest public high school by driving for Allegheny County, PA.
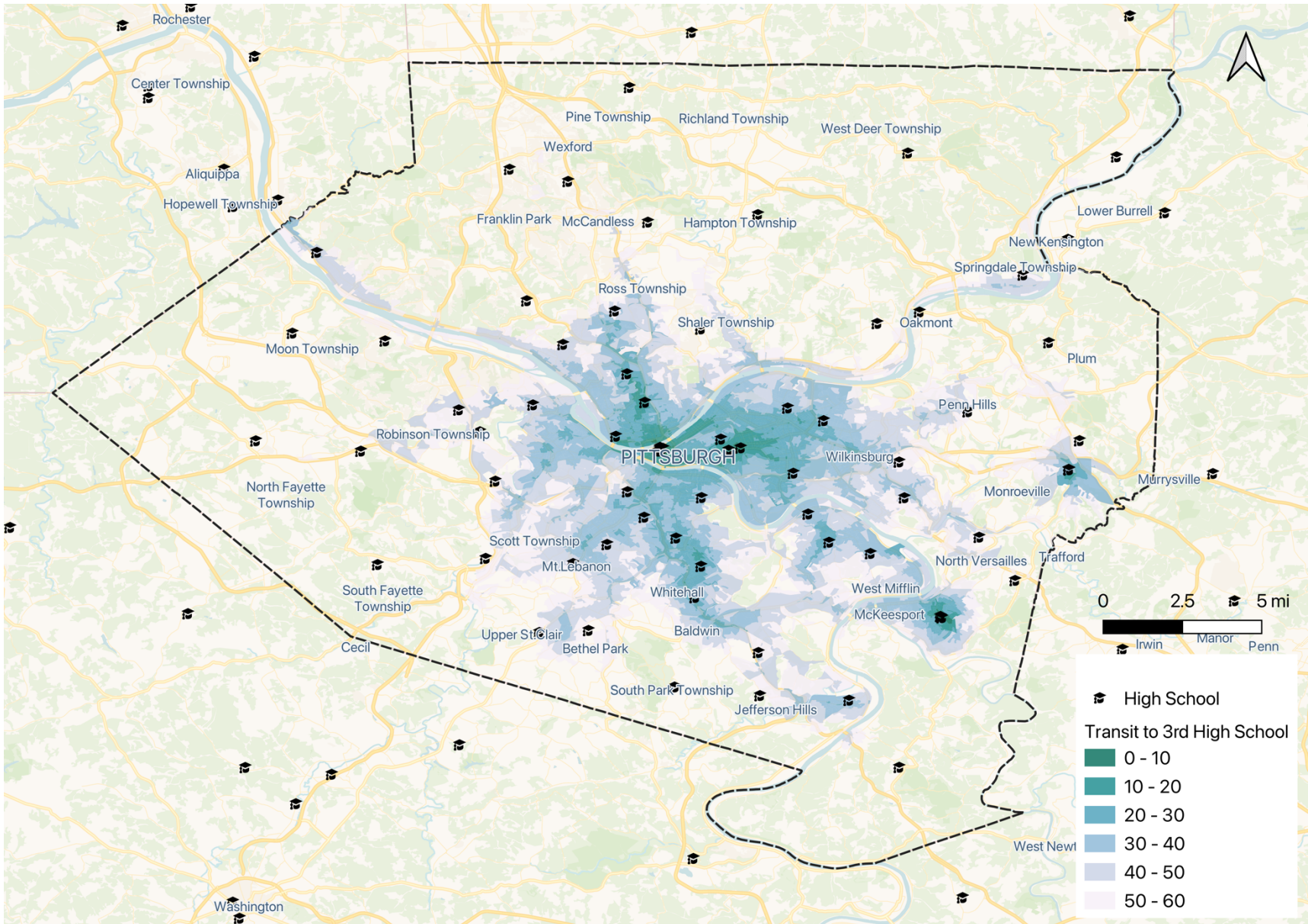
Figure 7.14 A map showing travel time to the third nearest public high school by walking+transit for Allegheny County, PA.

Figure 7.15: A map showing travel time to the third nearest public high school by biking on low stress (LTS 2) streets for Allegheny County, PA.

Figure 7.16: A map showing travel time to the third nearest public high school by driving for Randolph County, PA.
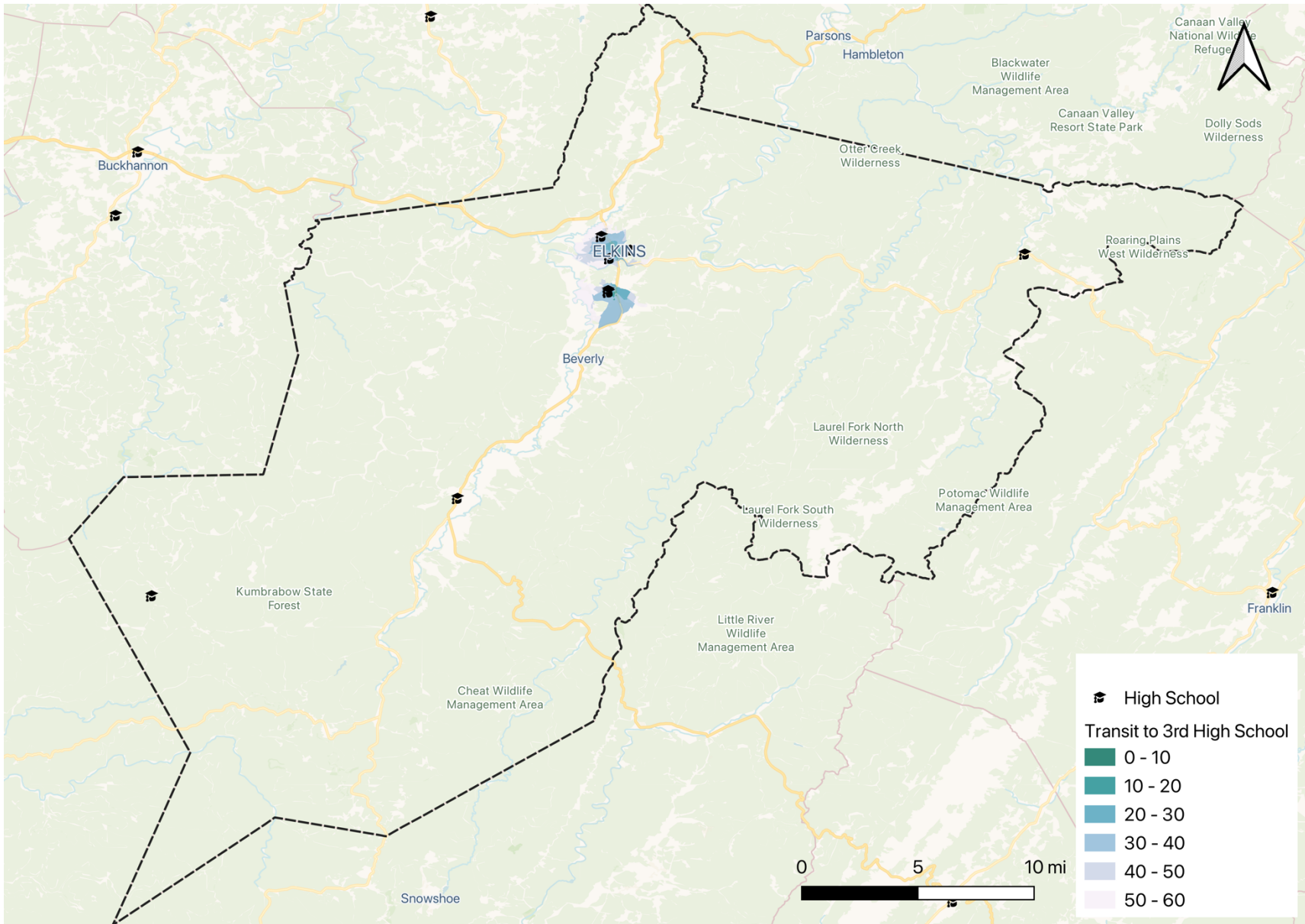
Figure 7.17: A map showing travel time to the third nearest public high school by walking+transit for Randolph County, PA.
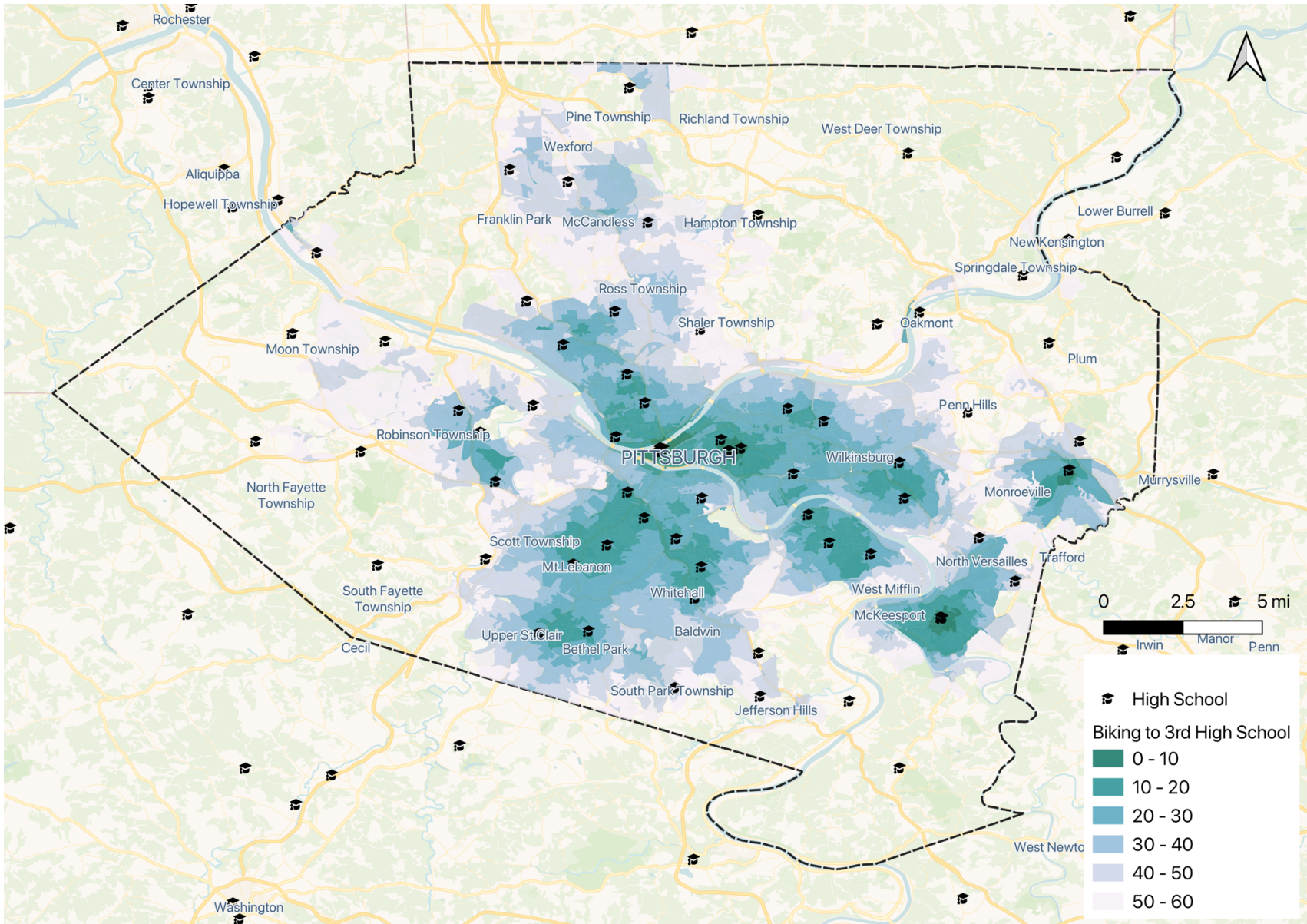
Figure 7.18: A map showing travel time to the third nearest public high school by biking on low stress (LTS 2) streets for Randolph County, PA.

Figure 7.19: A map showing average travel time to the third nearest public high school by driving for ARC Counties.

Figure 7.20: A map showing average travel time to the third nearest public high school by walking+transit (where transit exists) for ARC Counties.
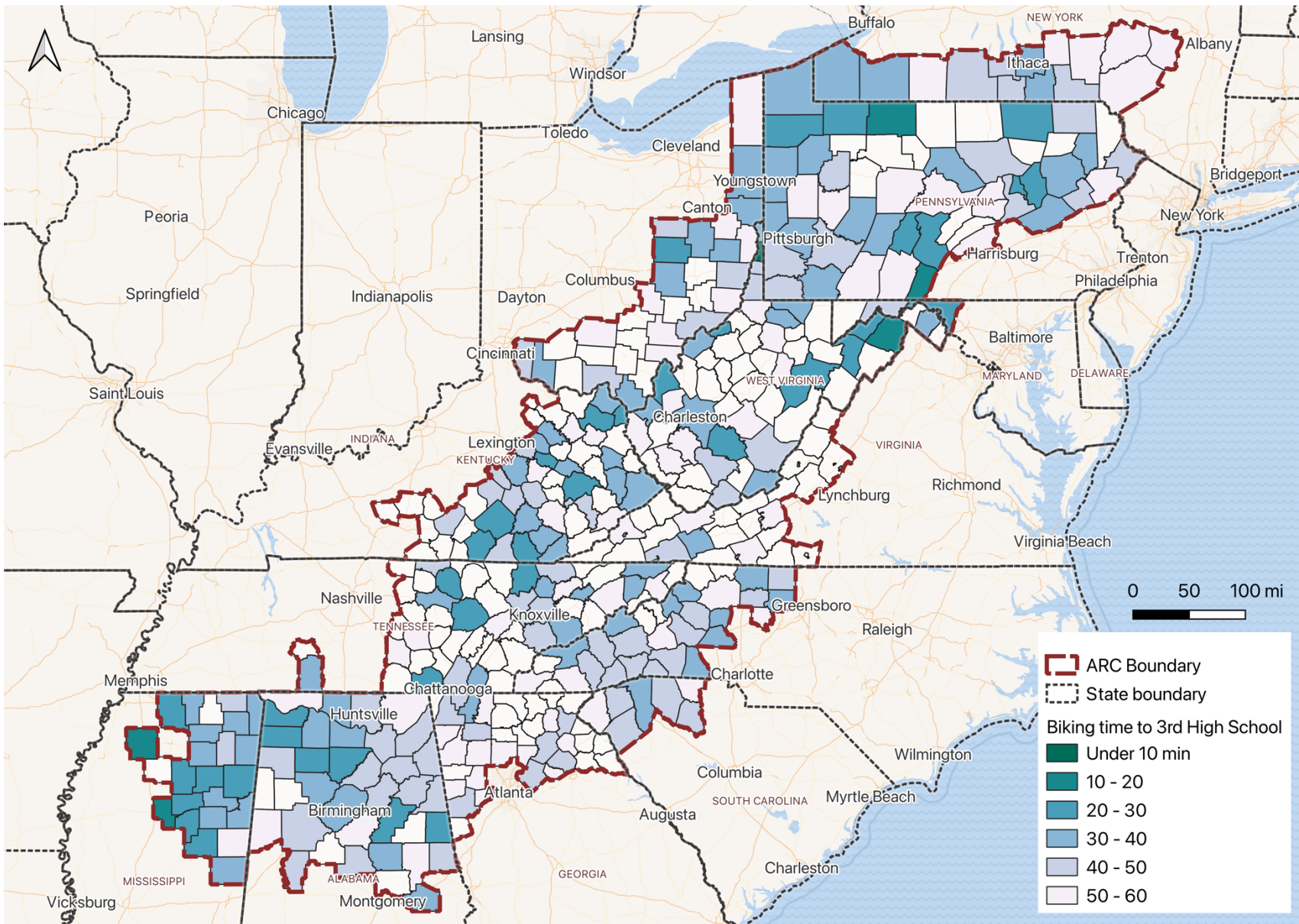
Figure 7.21: A map showing average travel time to the third nearest public high school by biking on low-stress (LTS 2) streets for ARC Counties.
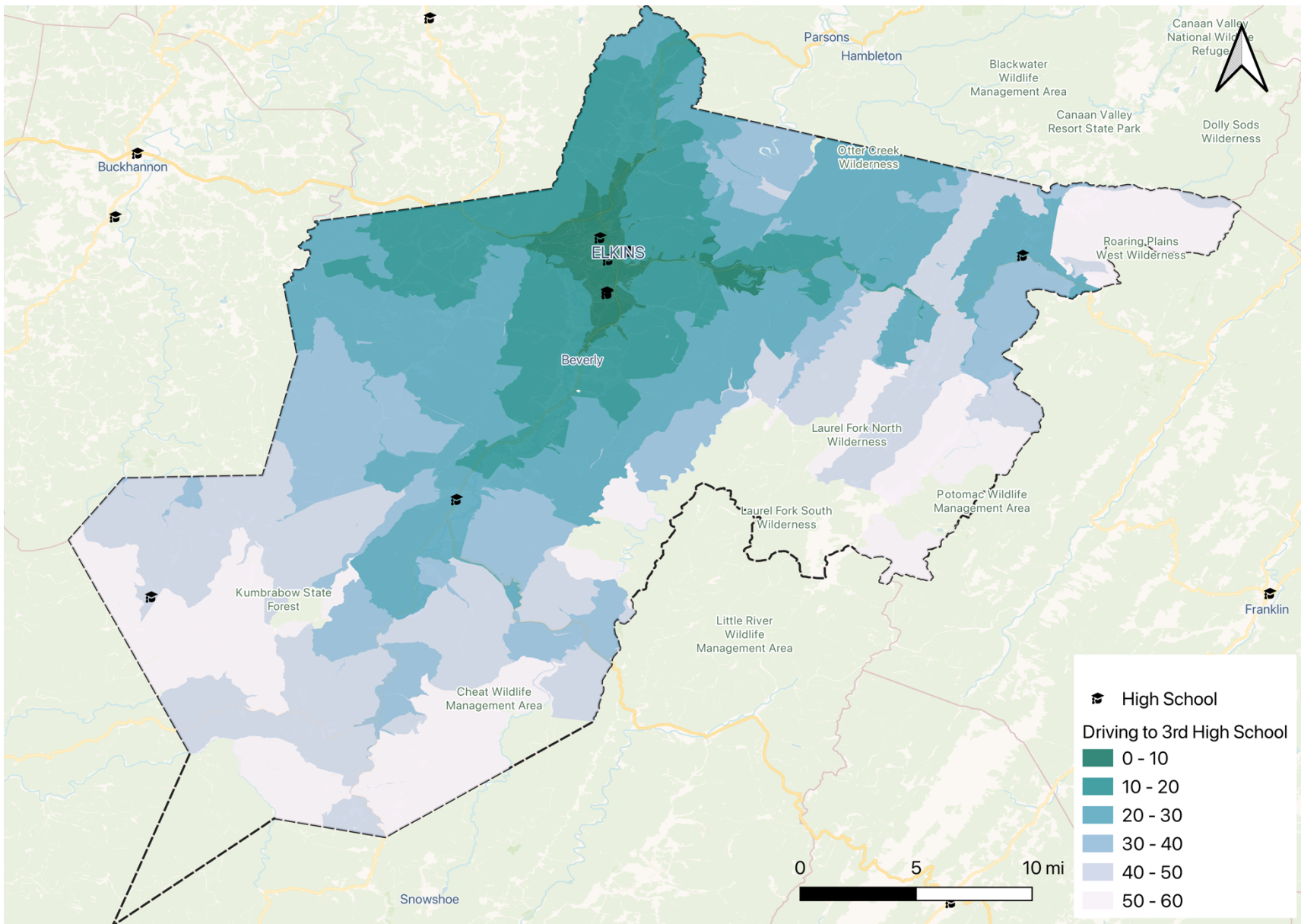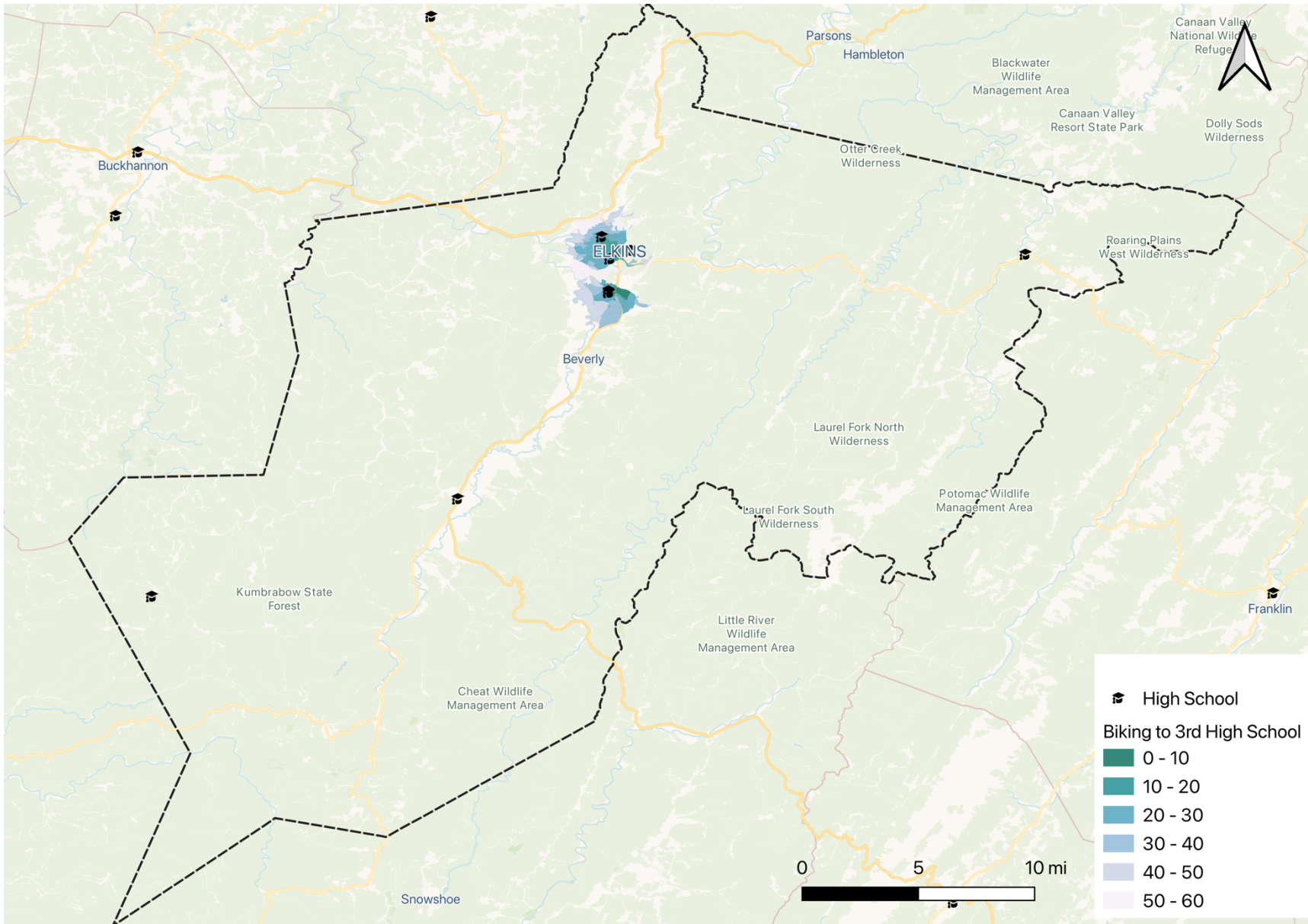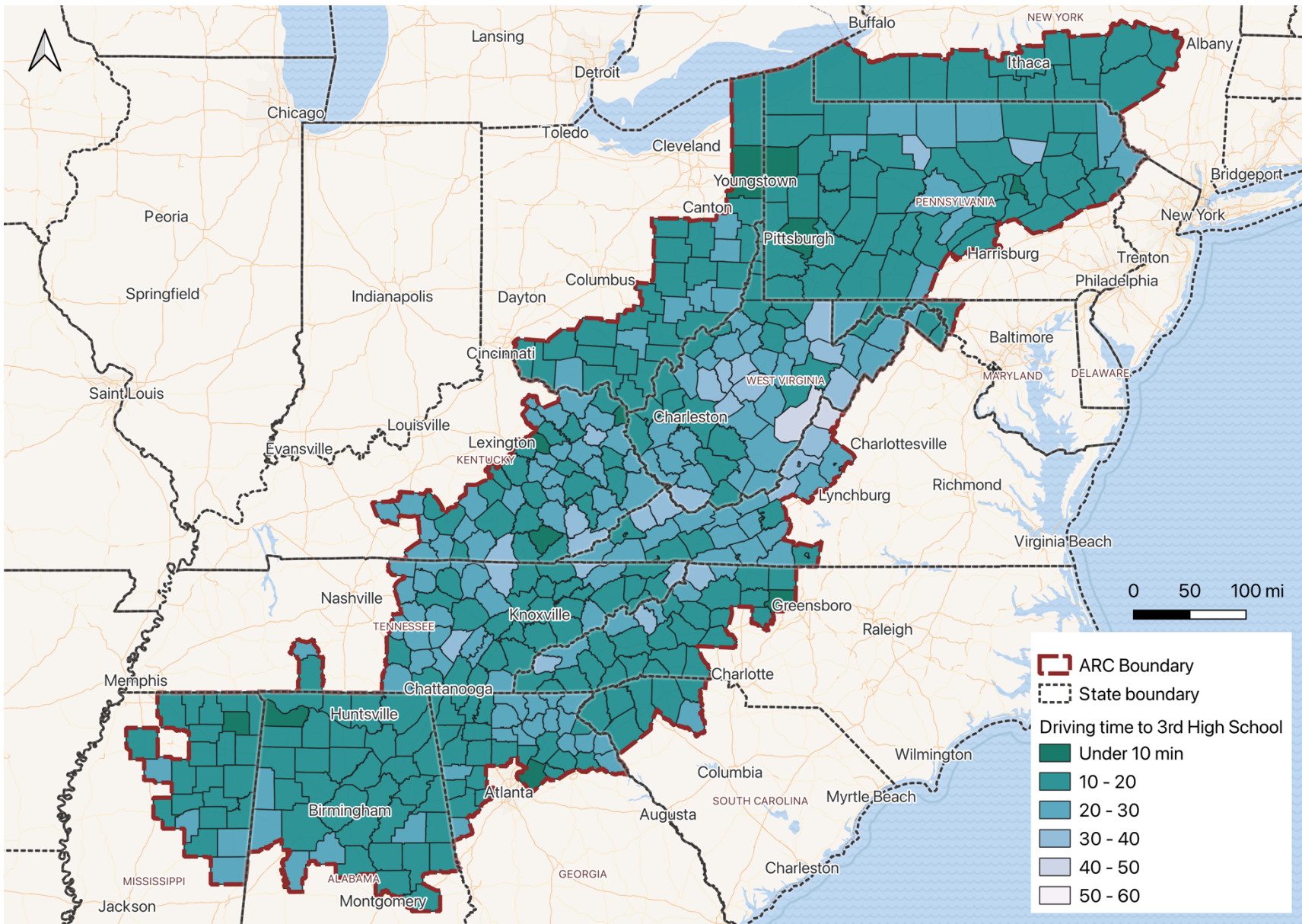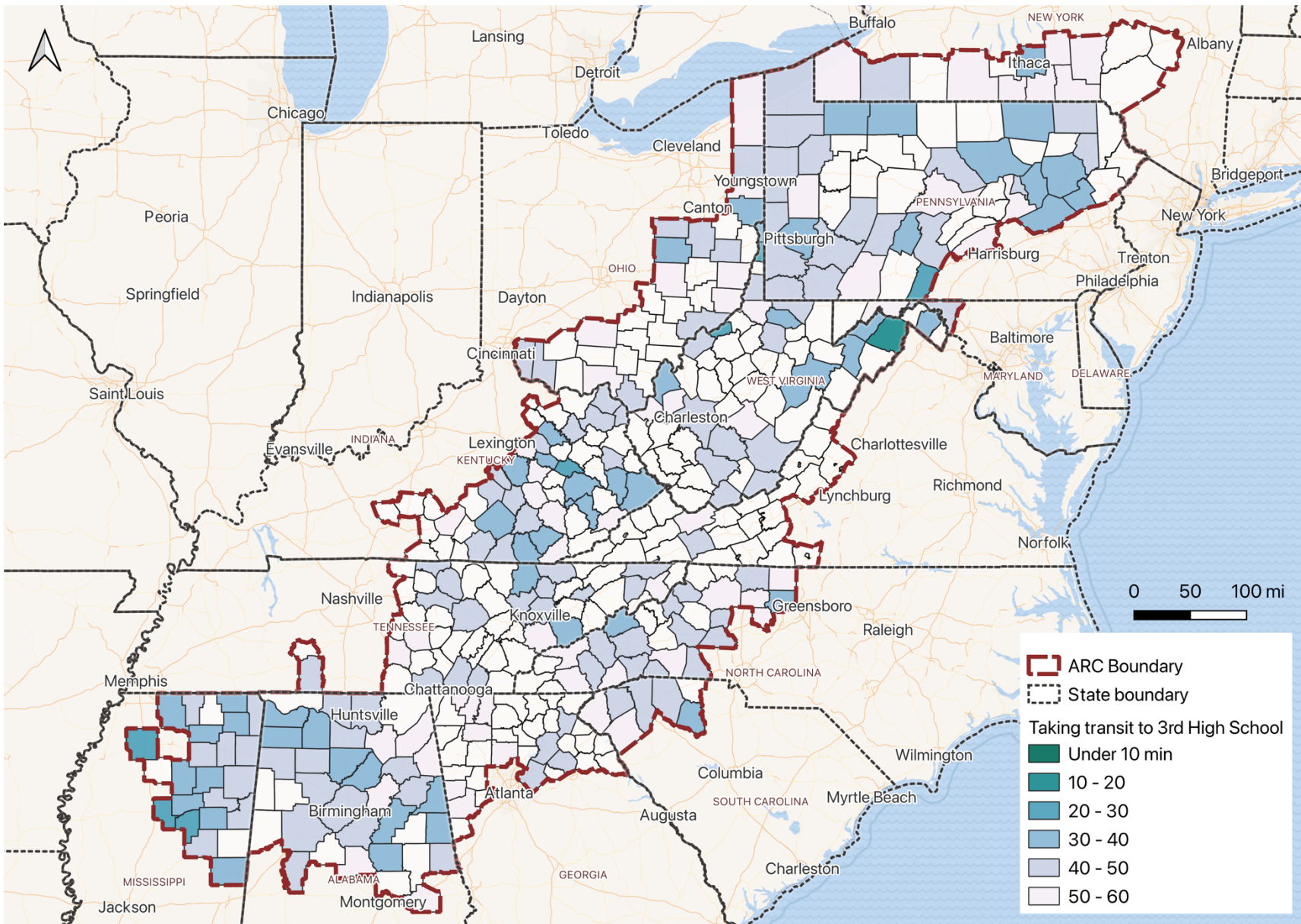
travel time to public high school by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
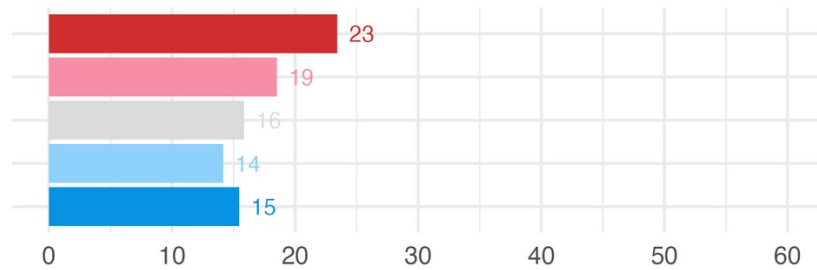
travel time to public high school by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

Figure 7.22: Graphs showing median travel time to the third nearest public high school by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to public high school by auto

median for counties which are urban, semi-urban, rural

travel time to public high school by walk+transit

median for counties which are urban, semi-urban, rural
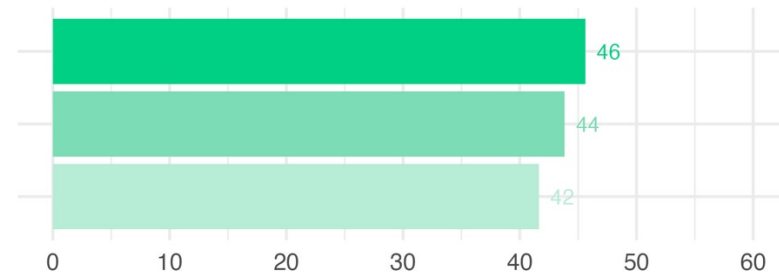
Figure 7.23: Graphs showing median travel time to the third nearest public high school by driving (left) and walking+transit (right) for ARC Counties by urbanicity.

Figure 7.24: A map showing average travel time to the nearest college with associate degree as the highest offered by driving for ARC Counties.

Figure 7.25: A map showing average travel time to the nearest college with associate degree as the highest offered by walking+transit for ARC Counties.

travel time to college with associate's degree as the highest offered by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

travel time to college with associate's degree as the highest offered by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
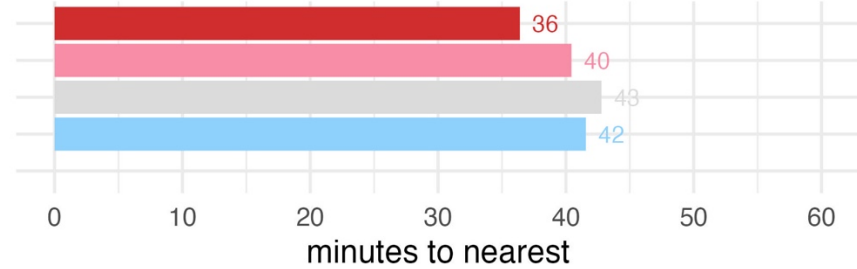
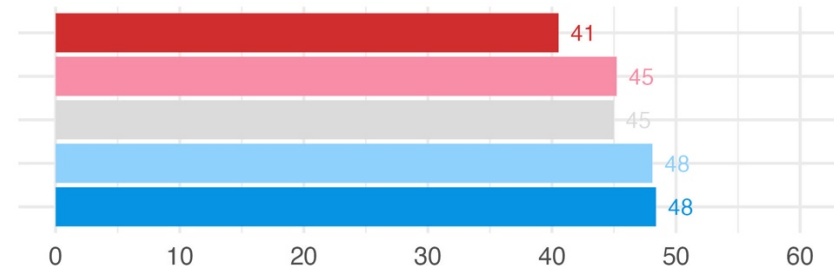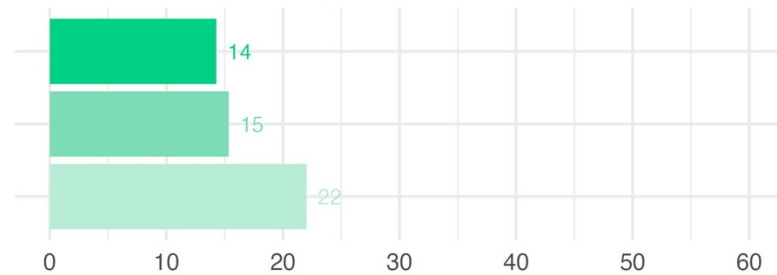*Figure 7.26: Graphs showing median travel time to the nearest college with associate degree as highest offered by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.*

travel time to college with associate's degree as the highest offered by auto

median for counties which are urban, semi-urban, rural

travel time to college with associate's degree as the highest offered by walk+transit

median for counties which are urban, semi-urban, rural

Figure 7.27: Graphs showing median travel time to the nearest college with associate degree as highest offered by driving (left) and walking+transit (right) for ARC Counties by urbanicity.
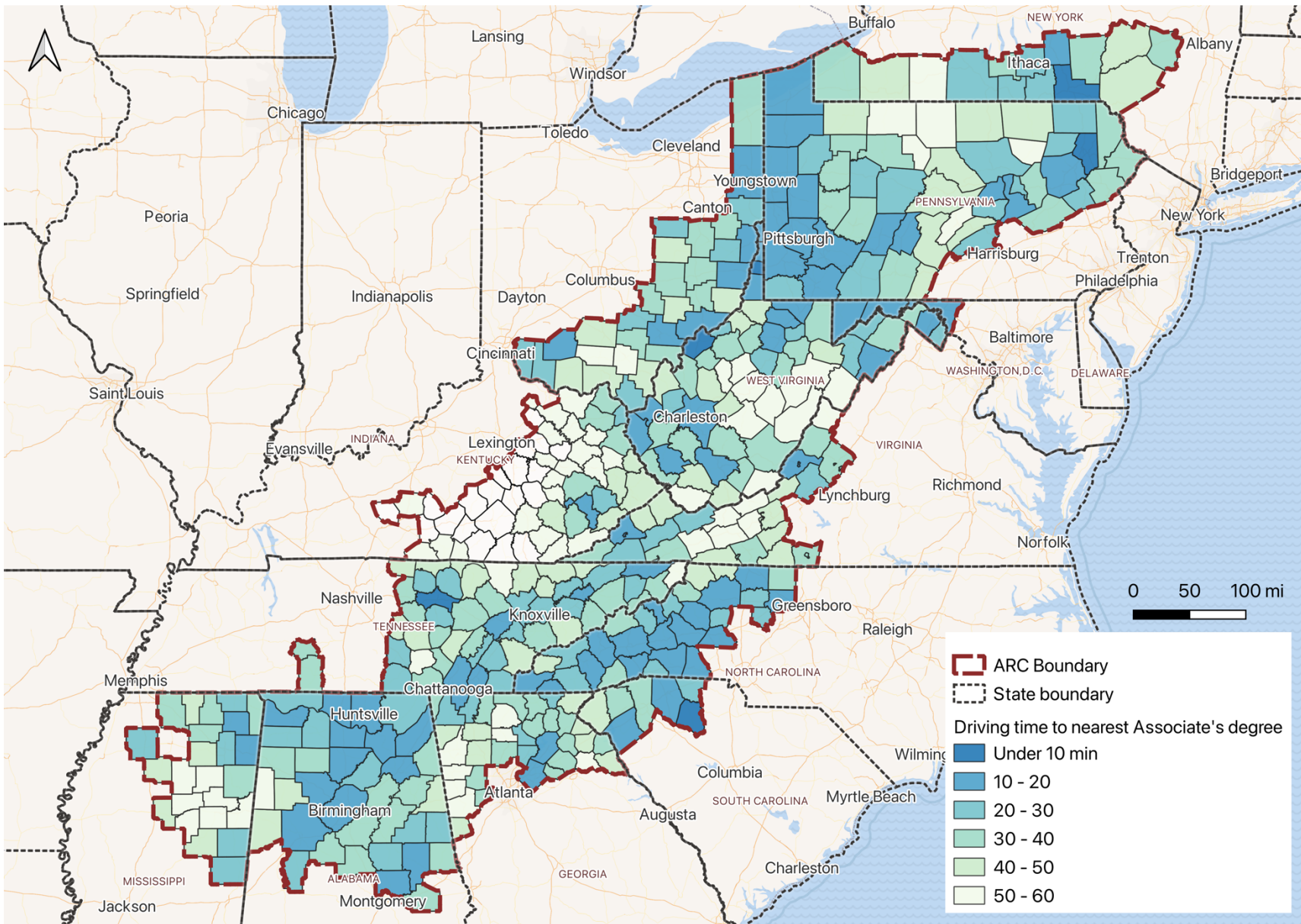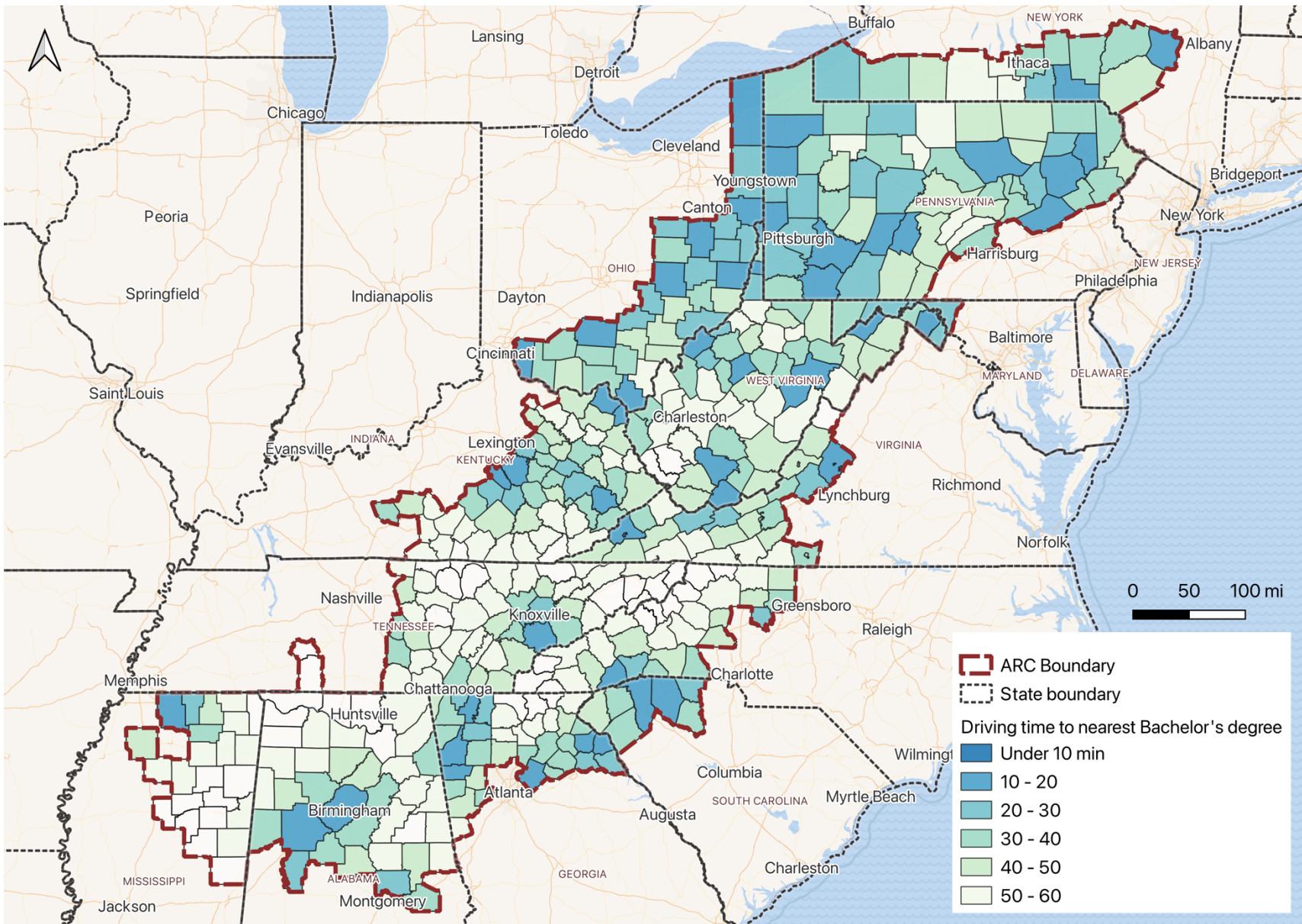
Figure 7.28: A map showing average travel time to the nearest college with bachelor's degree as the highest offered by driving for ARC Counties.
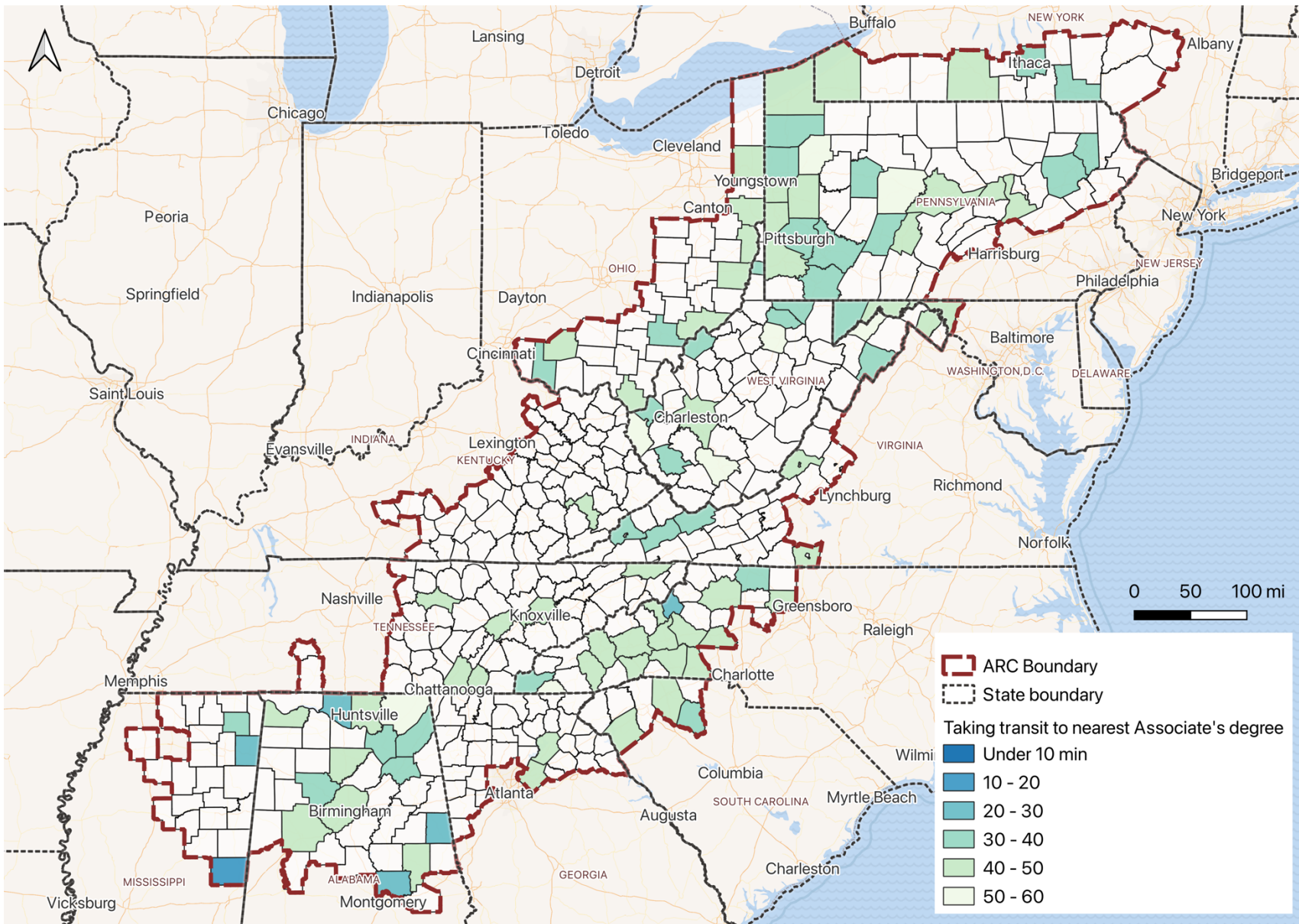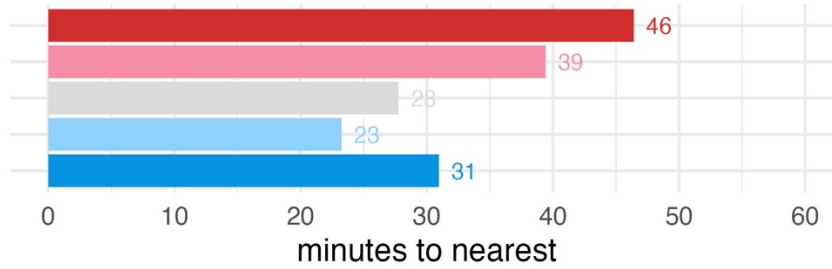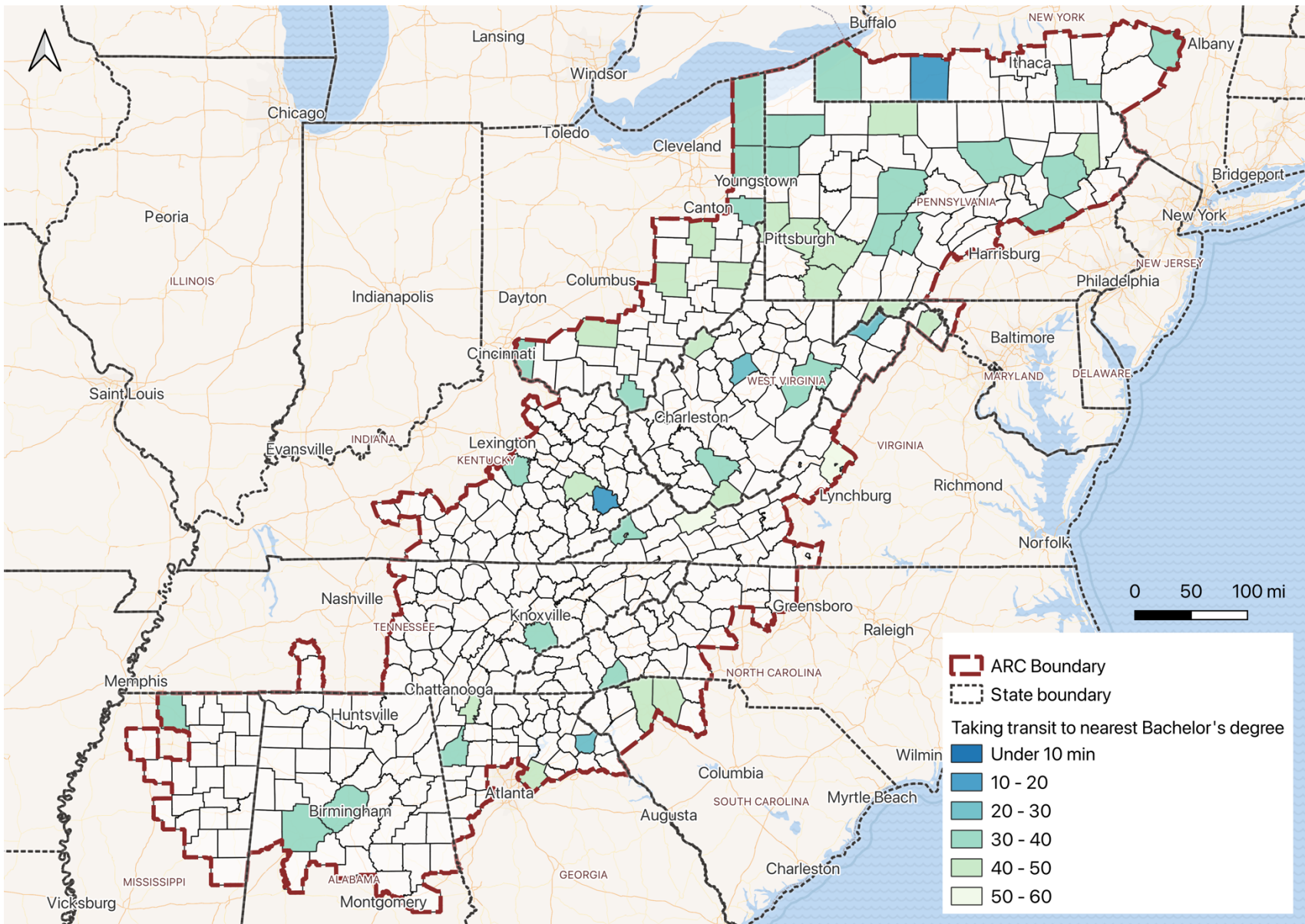
Figure 7.29: A map showing average travel time to the nearest college with bachelor's degree as the highest offered by walking+transit for ARC Counties.

travel time to college with bachelor's degree as the highest offered by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
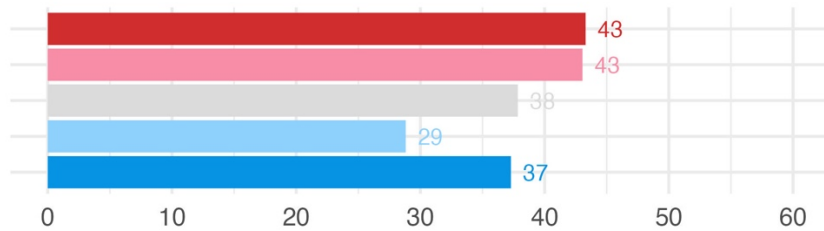
travel time to college with bachelor's degree as the highest offered by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
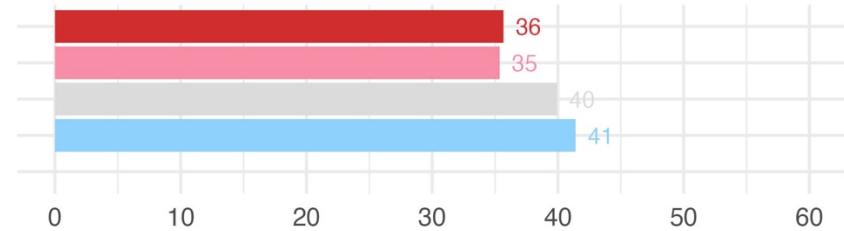
Figure 7.30: Graphs showing median travel time to the nearest college with bachelor's degree as highest offered by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to college with bachelor's degree as the highest offered by auto

median for counties which are urban, semi-urban, rural

travel time to college with bachelor's degree as the highest offered by walk+transit

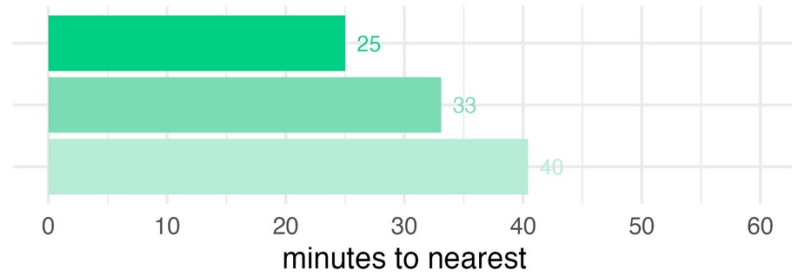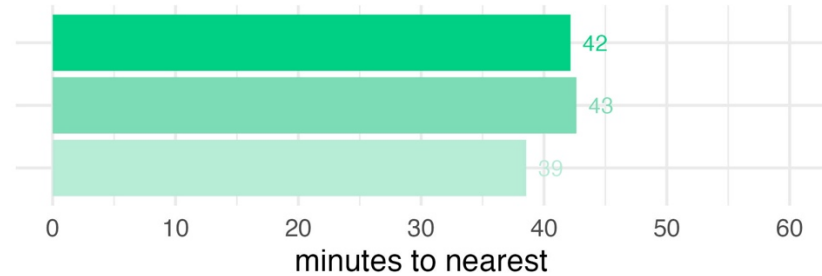median for counties which are urban, semi-urban, rural

Figure 7.31: Graphs showing median travel time to the nearest college with bachelor's degree as highest offered by driving (left) and walking+transit (right) for ARC Counties by urbanicity.
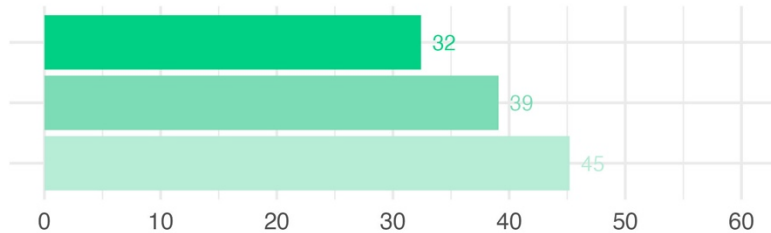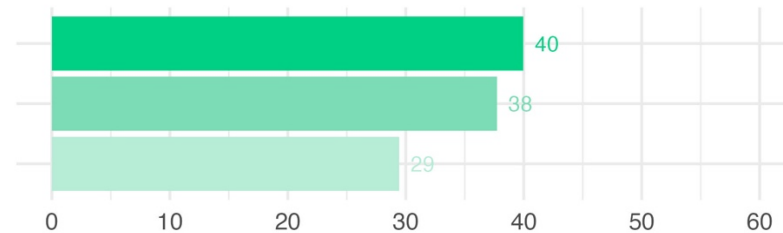
7.2.3 Access to Healthcare

Measuring access to healthcare is a pivotal metric due to its profound impact on health equity and overall community well-being. Equitable access ensures that individuals, regardless of their geographical location or socio-economic status, can avail themselves of essential medical services. By quantifying healthcare accessibility, decision-makers gain insights into disparities, allowing for targeted interventions to create a more inclusive and resilient healthcare infrastructure. This metric is not just about proximity to medical facilities; it is a strategic tool for enhancing public health outcomes, emergency preparedness, and workforce productivity. It guides the allocation of resources, facilitates the development of new healthcare infrastructure, and inspires innovative solutions such as telehealth to address healthcare deserts and improve connectivity in underserved areas.

Beyond its immediate health implications, measuring healthcare access holds economic significance. Healthy communities foster a more productive workforce, positively influencing economic outcomes. Preventive care encouraged by accessible healthcare contributes to early disease detection and management, reducing the overall burden on public health systems. In essence, this metric serves as a cornerstone for building resilient communities, promoting health equity, and ensuring that healthcare is not just a service but a fundamental right accessible to all.

Our analysis delves into the intricate network of medical facilities within the Appalachian region. To comprehensively gauge healthcare access, we employed a multifaceted approach. Our measurements encompass access to the nearest CMS-approved primary health clinics—those offering Medicaid and Medicare services—trauma centers, and urgent care facilities. Additionally, we delved into the accessibility of the third nearest primary health clinics, recognizing the significance of providing residents with multiple options for healthcare services.

Given the rural nature of a substantial portion of the Appalachian region, the measurement of healthcare access assumes paramount importance. Our focus extends to understanding not only the proximity to healthcare facilities but also the specific designations under the CMS-approved primary care clinics, including Federally Qualified Health Centers (FQHCs) and Rural Health Clinics (RHCs).

In this report's discussion and sample results, our focus is directed towards examining access to primary care clinics and trauma centers. However, it is essential to note that users will have the capability to access comprehensive data encompassing urgent care clinics as well.

Analyzing the travel time to FQHCs in Allegheny County provides valuable insights into healthcare accessibility. The visual representation in **Figure 7.32** and **Figure 7.33** indicates that, by driving, most blocks within the county can access three FQHCs within a time frame of 60 minutes. However, a noticeable increase in travel time is observed for blocks located farther away from the city boundary, where the majority of healthcare facilities are concentrated. The analysis also reveals that transit access to FQHCs is limited, with only blocks in close proximity to the facilities having access within a walking+transit travel time of 60 minutes.

Conversely, when examining Randolph County through **Figure 7.36** to **Figure 7.39**, the findings illustrate a similar pattern for driving access, where a majority of blocks can reach three FQHCs within 60 minutes. However, the transition to walking+transit mode unveils challenges in healthcare accessibility, with only blocks in immediate proximity to the FQHCs and their adjacent counterparts having feasible access within the stipulated time frame. This stark contrast highlights the disparities in transit-oriented healthcare access in a predominantly rural county like Randolph, emphasizing the importance of targeted interventions to bridge these gaps.

The overarching observations persist when broadening the scope to encompass the entire Appalachian region. An analysis of healthcare accessibility across the region reveals a commonality: the majority of counties can reach three Federally Qualified Health Centers (FQHCs) within a driving time of 60 minutes. However, a significant shift occurs when transitioning to walking+transit mode, as only a limited number of counties retain this level of access. While most counties can access their nearest FQHC, the ability to choose between clinics within an hour of travel diminishes when relying on walking and/or transit.

The visualizations of average travel time by driving and walking+transit to RHCs reveal consistent spatial patterns across the Appalachian region, as can be seen in **Figure 7.46** and **Figure 7.47**. In the context of driving, all counties demonstrate the capability to reach their nearest RHC within a travel time of 60 minutes. However, a notable contrast emerges when considering walking and/or transit modes, where a significant number of counties face challenges in reaching their nearest RHC within the same travel time frame.

The comparison of counties based on their economic status reveals an intriguing observation regarding travel times to both FQHCs and RHCs. In economically distressed and at-risk counties, travel times are shorter for either mode (driving and walking+transit) compared to

economically stable or growing counties. This finding underscores a positive trend, indicating that health clinics providing Medicaid and Medicare facilities are strategically located in economically struggling communities, aligning with the goal of enhancing healthcare accessibility where it is most needed.

Additionally, the comparison across urbanicity levels unveils interesting insights. Average travel time to FQHCs is shorter for urban areas and longer for rural areas, while travel time to RHCs exhibits the opposite pattern—shorter for rural areas and longer for urban areas. These observations suggest that healthcare planning decisions in the region align with the specific needs and characteristics of urban and rural areas, emphasizing the importance of tailored strategies for healthcare accessibility based on the unique attributes of each community.

7.2.3.2 Access to trauma centers

Visualizing access to trauma centers in Allegheny County, as depicted in **Figure 7.50**, reveals a robust healthcare infrastructure, with the county being served by nearly six trauma centers. The overall accessibility is noteworthy, as most areas within the county can reach a trauma center within a reasonable driving time of one hour. However, these visualizations also highlight disparities between neighborhoods, illustrating that access to trauma care varies significantly across different areas. In some neighborhoods, residents can reach a trauma center within just 10 minutes of driving, while for others located farther from the facilities, the travel time extends to almost 50 minutes to an hour.

Analyzing trauma center access in Randolph County, illustrated in **Figure 7.51**, reveals a distinct contrast to the urban setting of Allegheny County. Randolph County is served by a single trauma center shared with an adjacent county, resulting in comparatively weaker access across the entire rural county. This disparity between urban and rural access to trauma care becomes more apparent when examining all counties within the Appalachian region in **Figure 7.52**. The data highlights significant variations in trauma care access, with some counties averaging mere minutes of driving distance to a trauma center, while others face average driving times exceeding an hour. These findings underscore the critical importance of tailoring healthcare infrastructure to address the unique challenges posed by rural landscapes and ensuring that all communities have timely access to essential trauma services.

In further examining access to trauma centers across various Appalachian counties, our analysis revealed discernible patterns related to economic status and urbanicity. Notably, counties characterized as rural or economically distressed consistently exhibited longer

travel times to trauma centers in contrast to their urban or economically stable counterparts. This observation underscores a critical dimension of healthcare inequality, where residents in economically disadvantaged or rural areas face extended travel times during emergencies.

The time it takes for individuals to reach trauma centers directly influences the effectiveness of life-saving interventions during critical situations. Shorter travel times signify swifter access to crucial medical care, thereby enhancing the potential for positive health outcomes. This metric not only gauges the efficiency of emergency response but also serves as a key indicator of healthcare equity. Disparities in travel time shed light on regions where accessing trauma centers may pose greater challenges, necessitating targeted interventions for improved healthcare access. Our exploration of travel time to trauma centers is integral to understanding the dynamics of emergency medical services across the Appalachian Region, guiding informed decision-making for resource allocation and strategic healthcare planning.

Figure 7.32: A map showing travel time to the nearest primary care clinics (FQHCs) by driving for Allegheny County, PA.

Figure 7.33: A map showing travel time to the third nearest primary care clinics (FQHCs) by driving for Allegheny County, PA.

Figure 7.34: A map showing travel time to the nearest primary care clinics (FQHCs) by walking+transit for Allegheny County, PA.

Figure 7.35: A map showing travel time to the third nearest primary care clinics (FQHCs) by walking+transit for Allegheny County, PA.
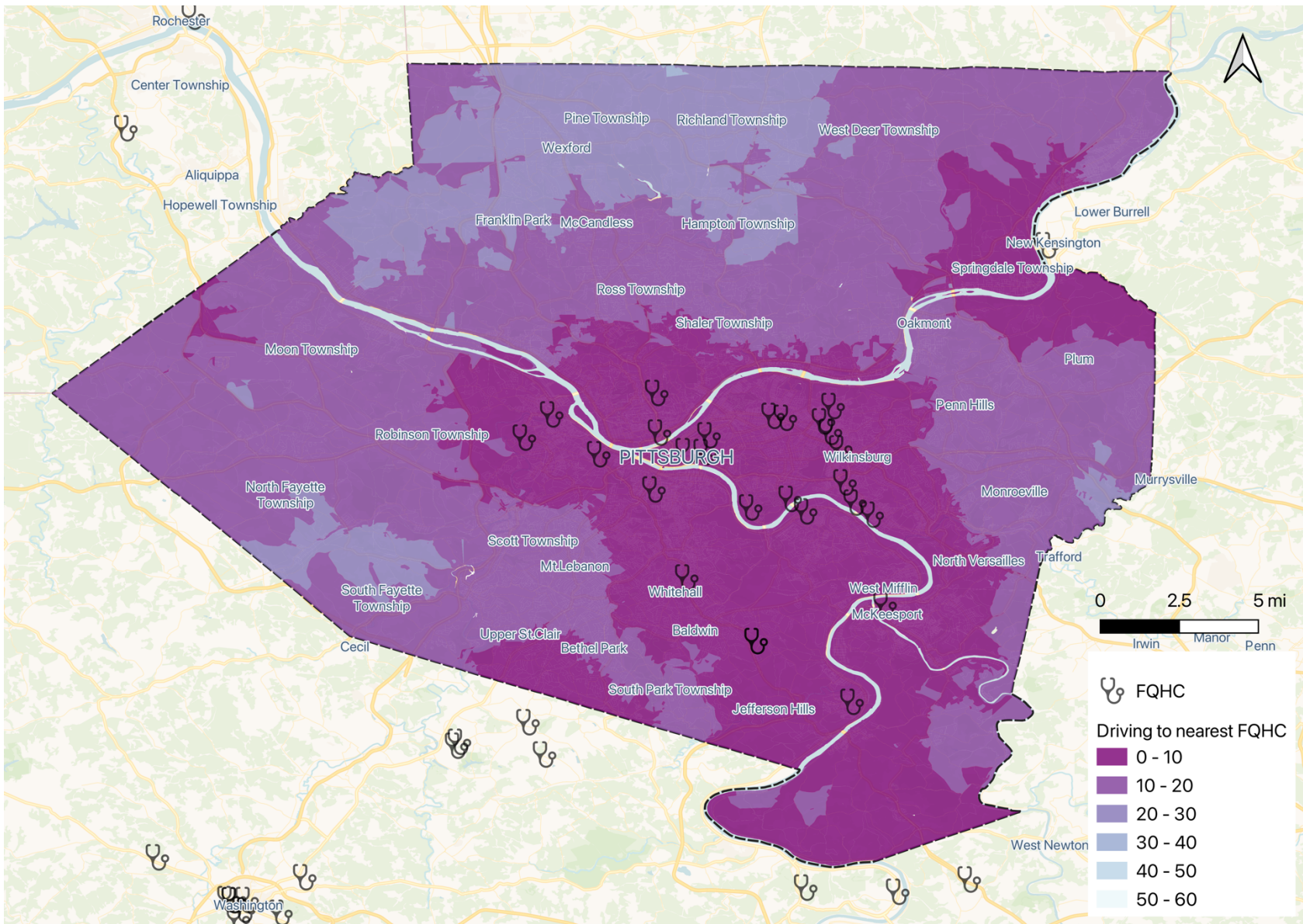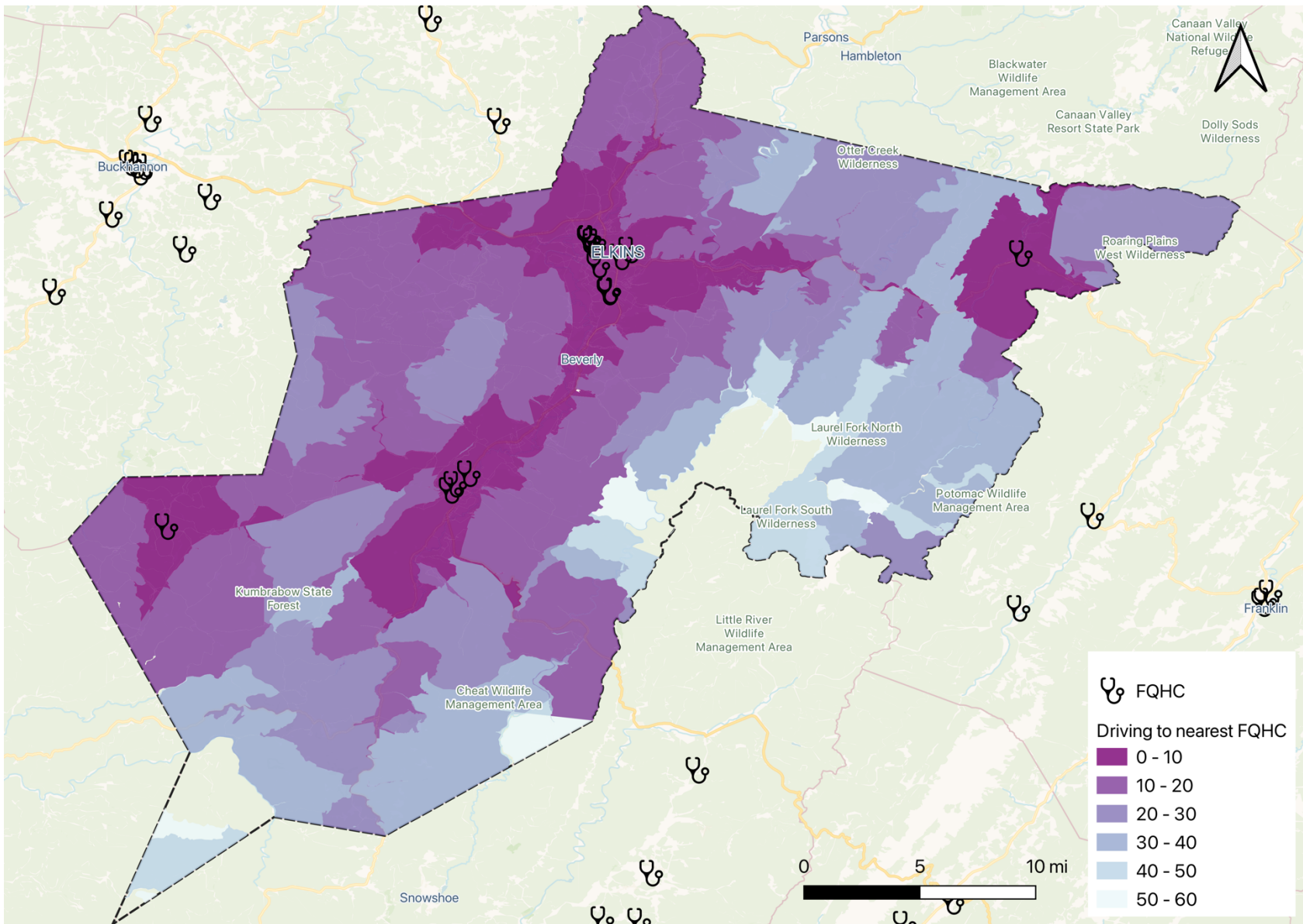
Figure 7.36: A map showing travel time to the nearest primary care clinics (FQHCs) by driving for Randolph County, WV.
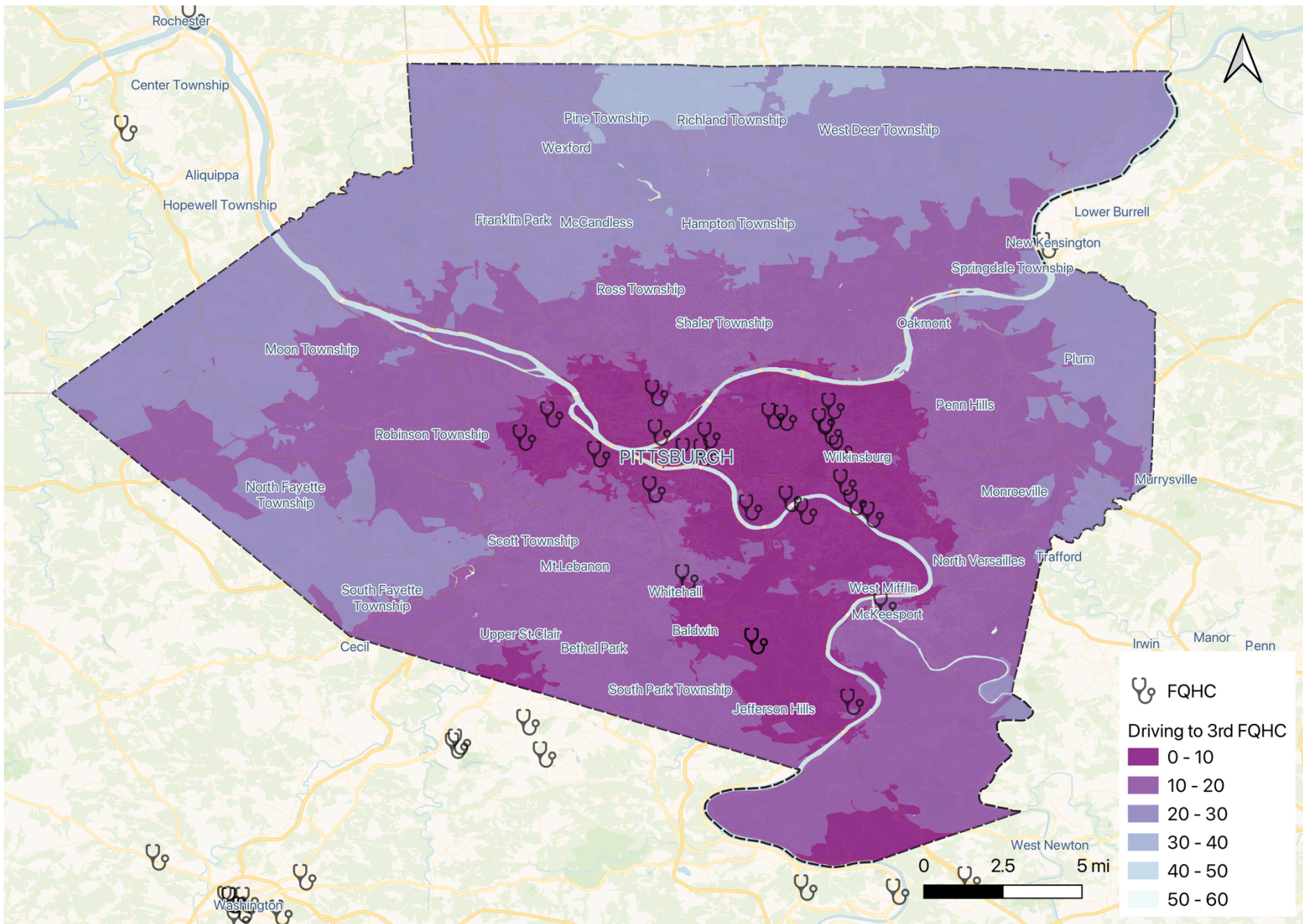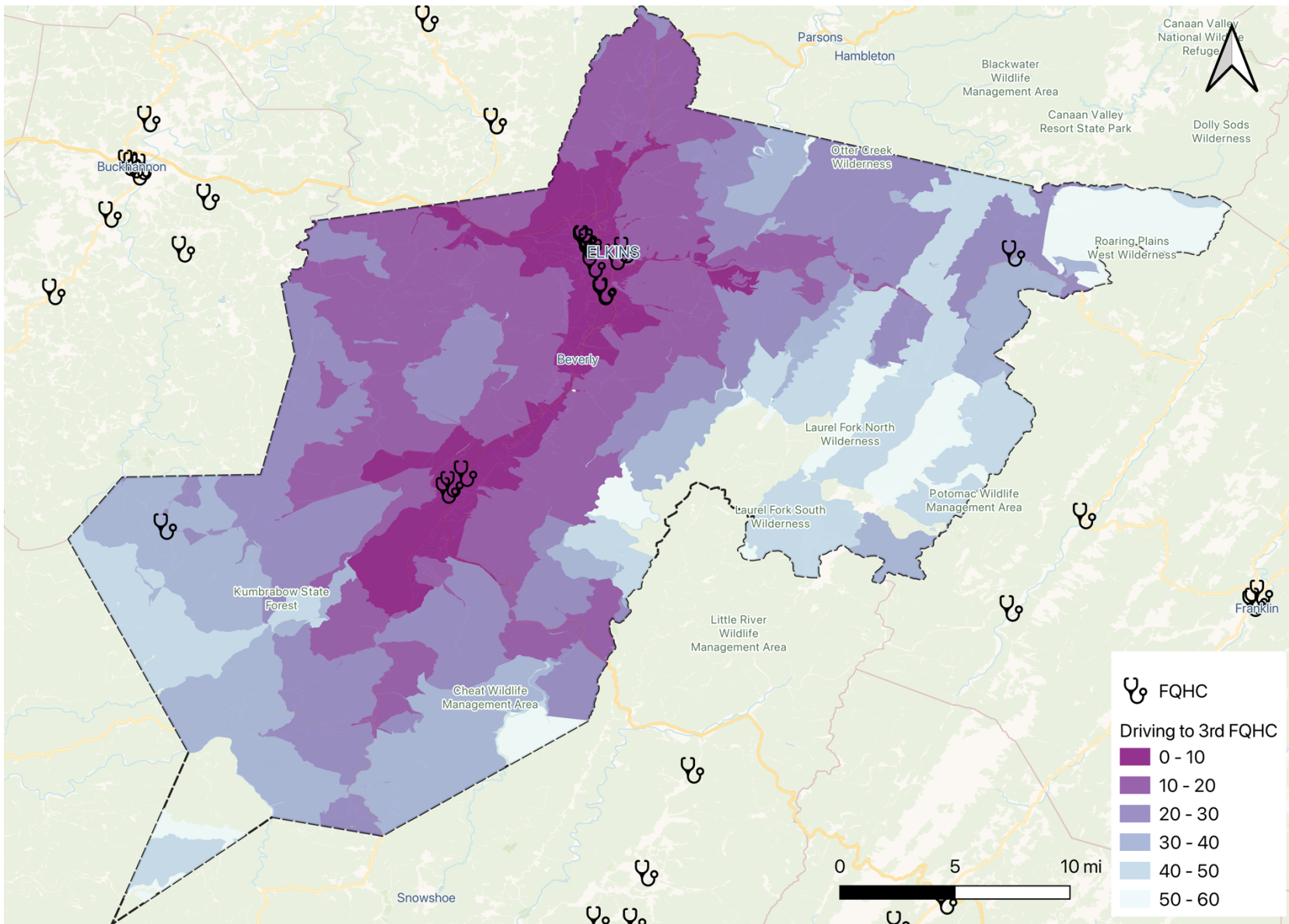
Figure 7.37: A map showing travel time to the third nearest primary care clinics (FQHCs) by driving for Randolph County, WV.
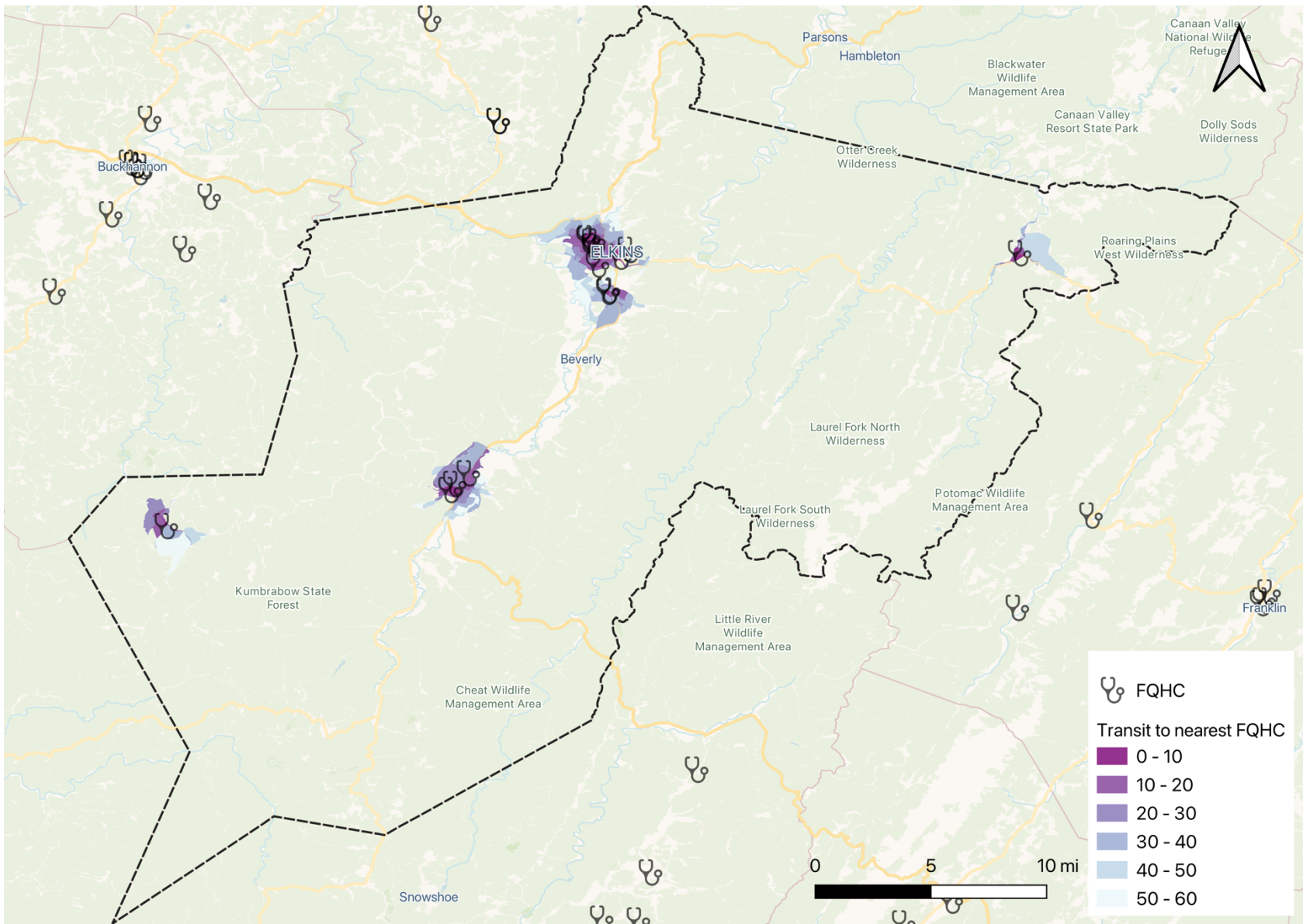
Figure 7.38: A map showing travel time to the nearest primary care clinics (FQHCs) by walking+transit for Randolph County, WV.
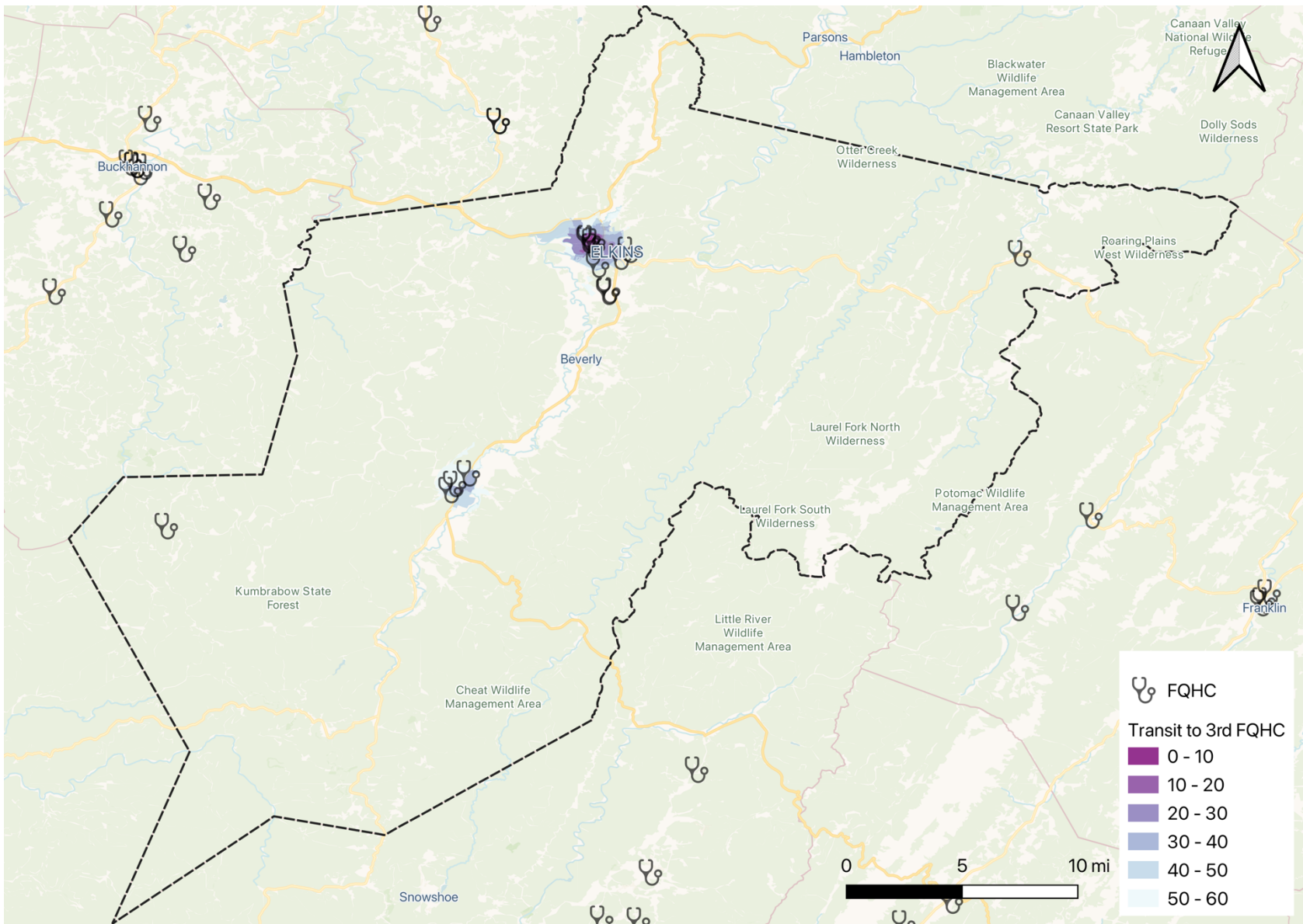
Figure 7.39: A map showing travel time to the nearest primary care clinics (FQHCs) by walking+transit for Randolph County, WV.

Figure 7.40: A map showing average travel time to the nearest primary care clinics (FQHCs) by driving for ARC Counties.

Figure 7.41: A map showing average travel time to the third nearest primary care clinics (FQHCs) by driving for ARC Counties.
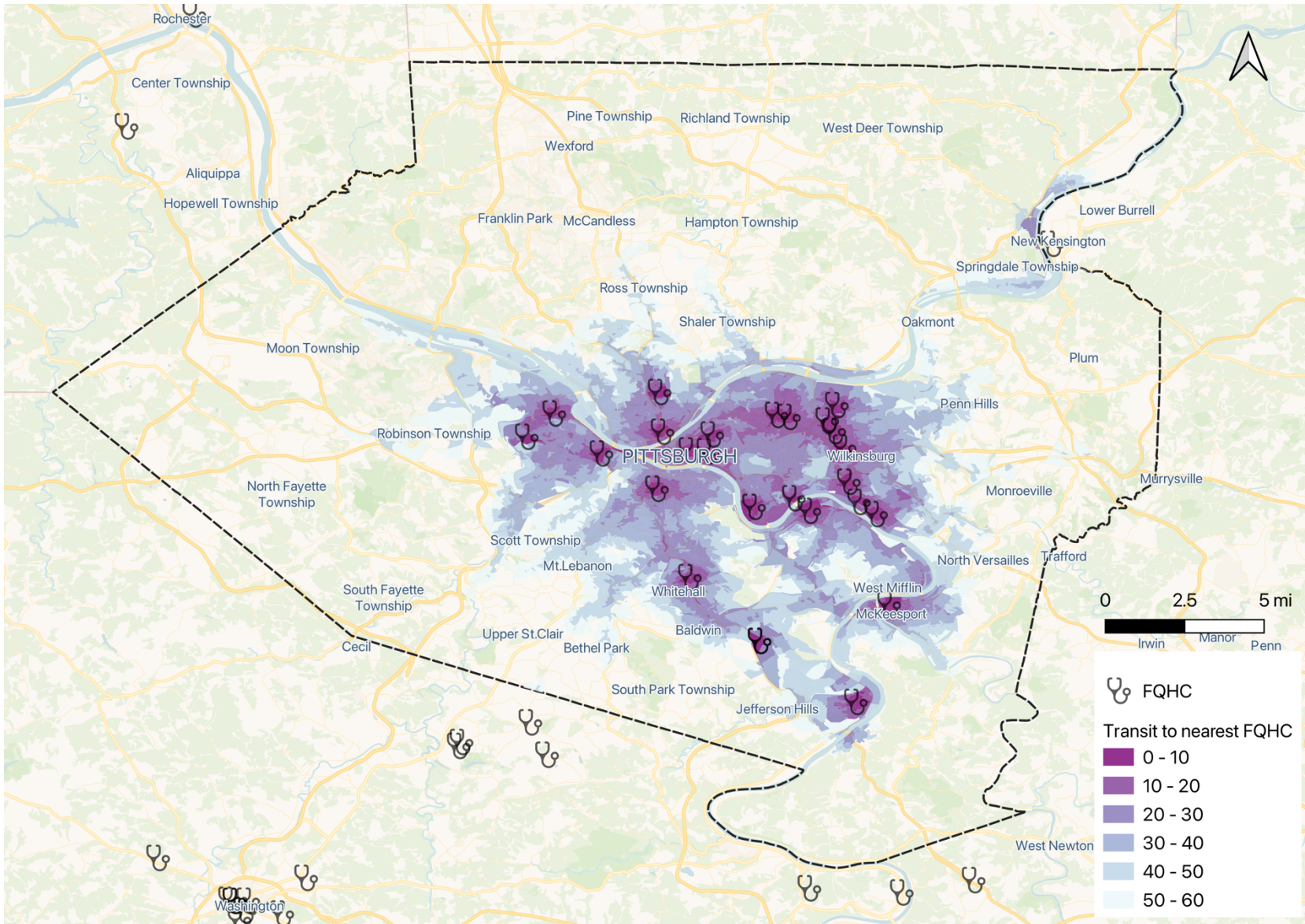
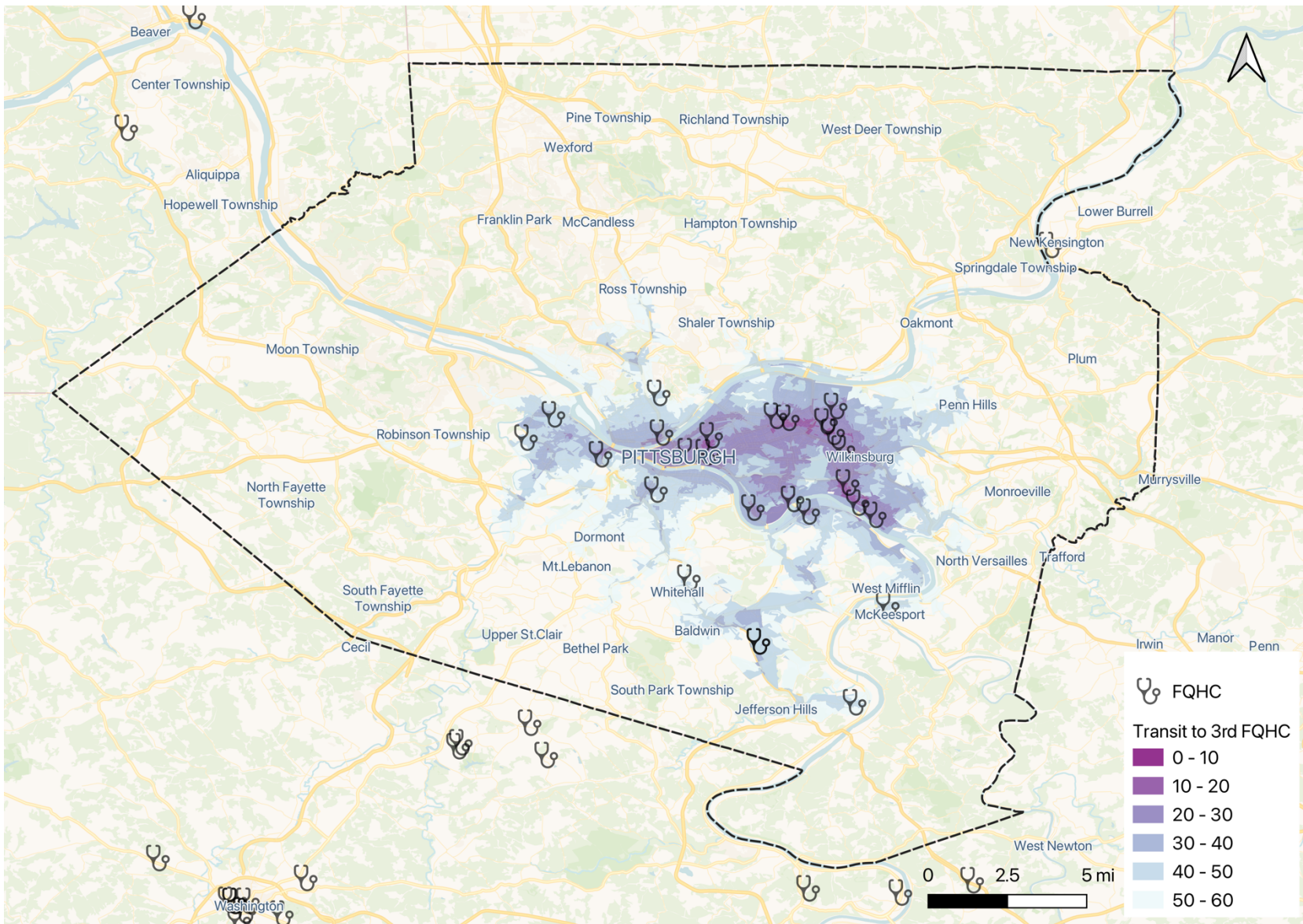*Figure 7.42: A map showing average travel time to the nearest primary care clinics (FQHCs) by walking+transit for ARC Counties.*

Figure 7.43: A map showing average travel time to the third nearest primary care clinics (FQHCs) by walking+transit for ARC Counties.

travel time to FQHC by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

Distressed	11
At-Risk	10
Transitional	11
Competitive	10
at Attainment	18

travel time to FQHC by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
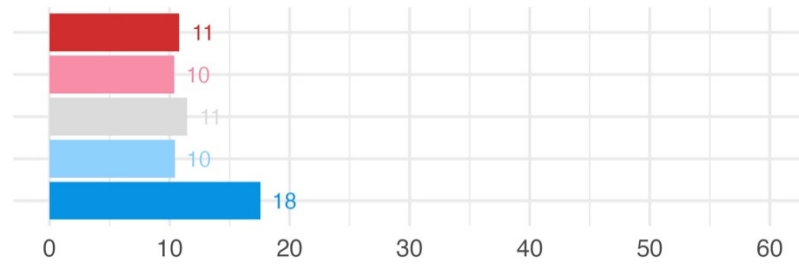
Distressed	33
At-Risk	32
Transitional	34
Competitive	38
at Attainment	33

Figure 7.44: Graphs showing median travel time to the nearest primary care clinic (FQHC) by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to FQHC by auto

median for counties which are urban, semi-urban, rural

urban	10
semi-urban	11
rural	11

travel time to FQHC by walk+transit

median for counties which are urban, semi-urban, rural

urban	36
semi-urban	35
rural	32
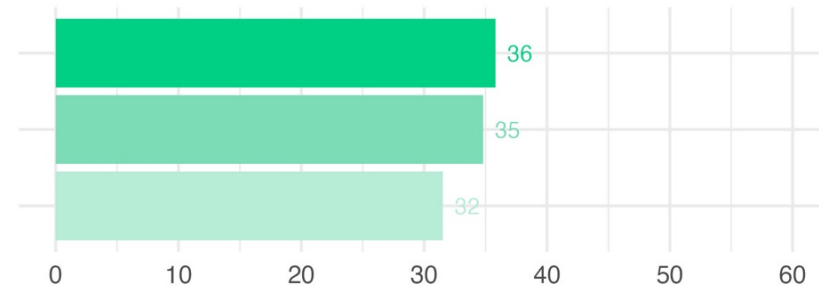
Figure 7.45: Graphs showing median travel time to the nearest primary care clinic (FQHC) by driving (left) and walking+transit (right) for ARC Counties by urbanicity.
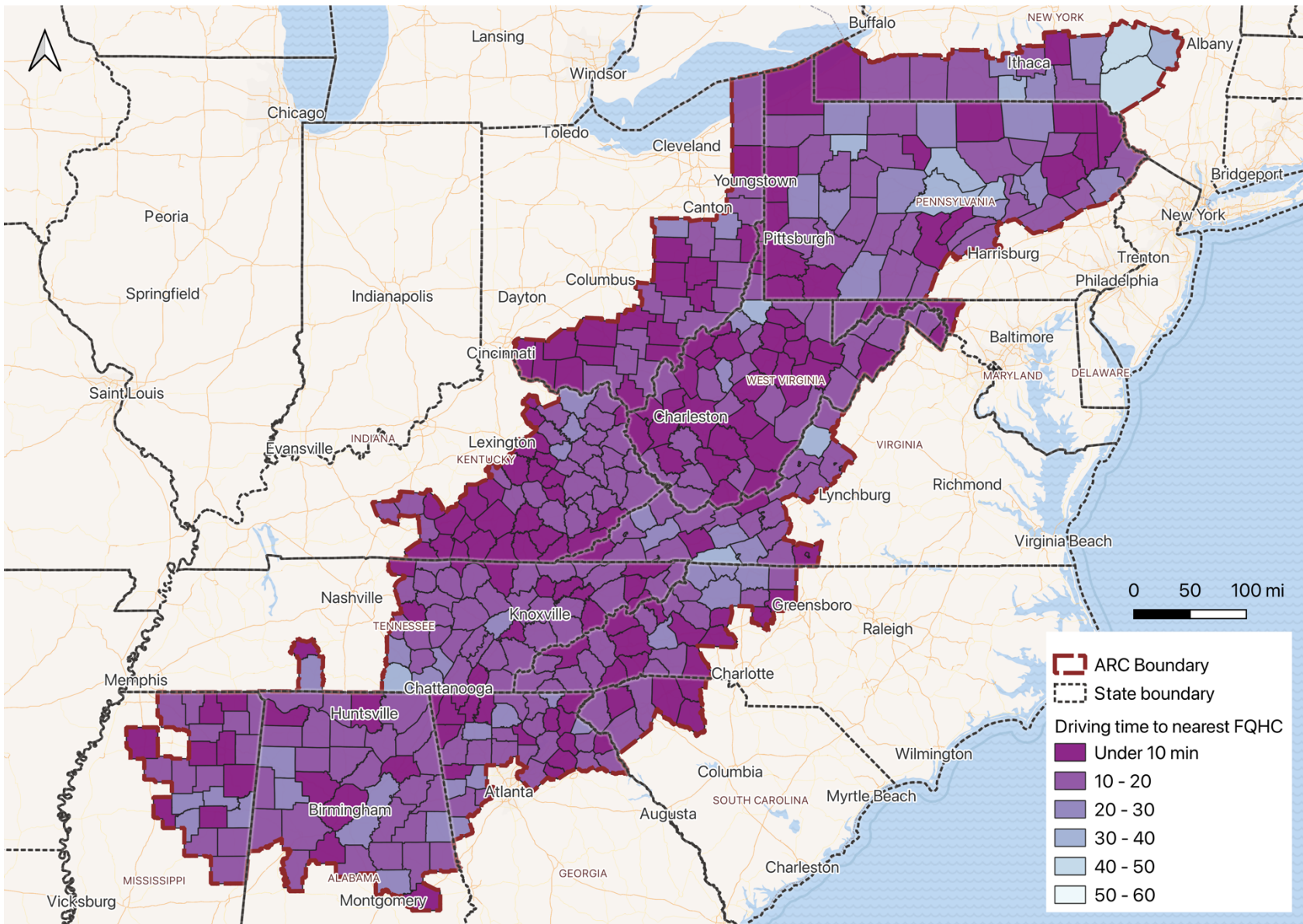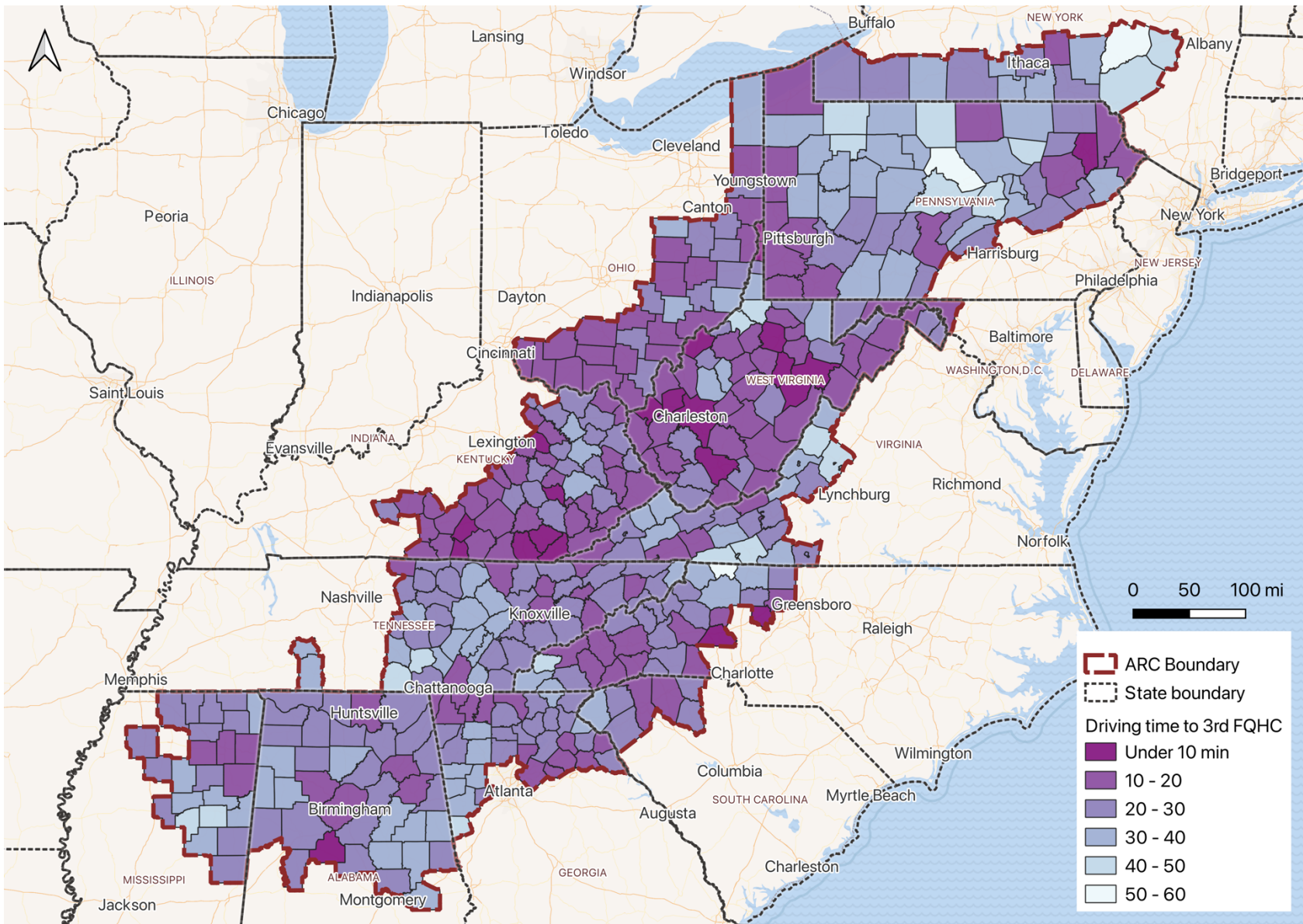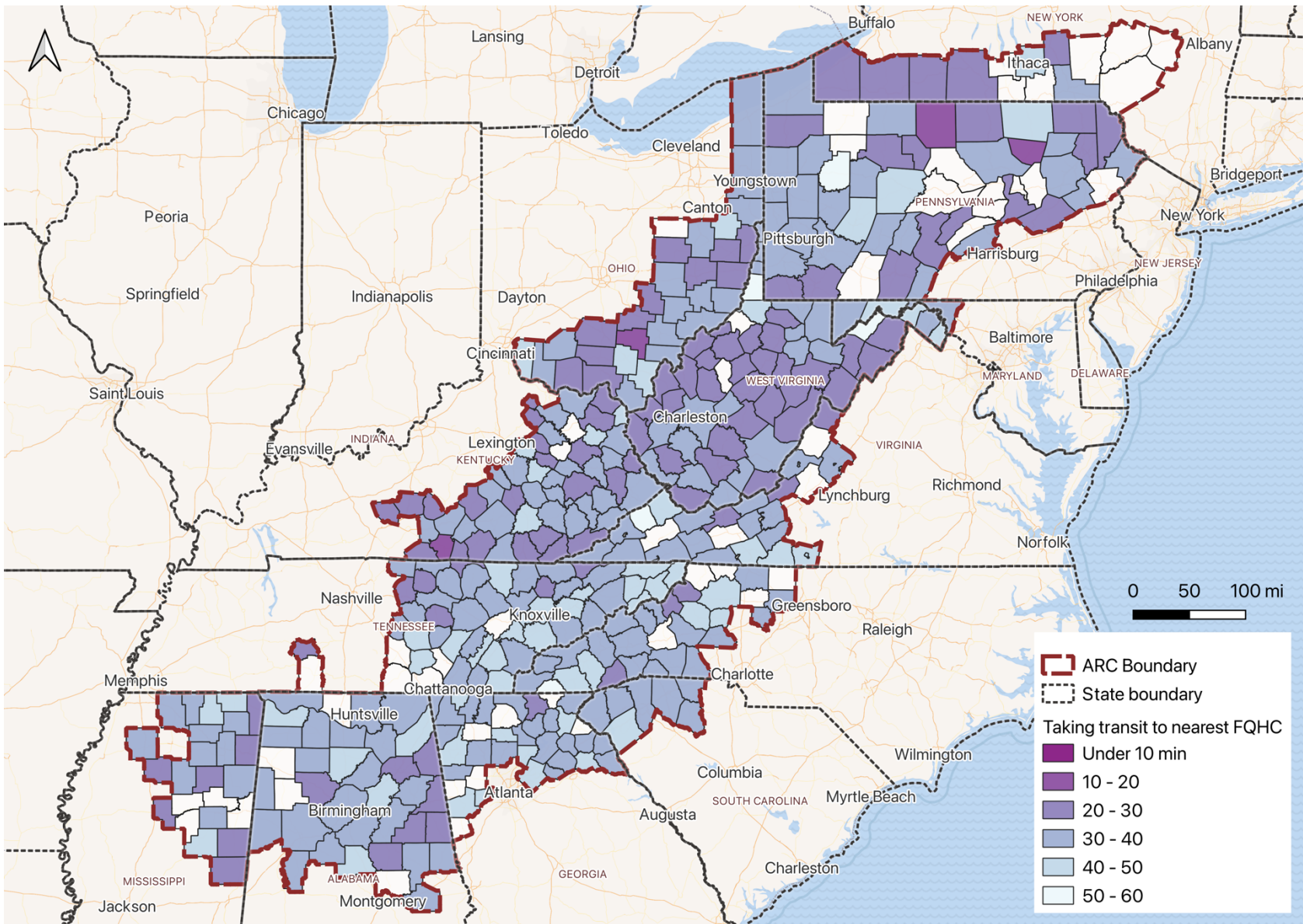
76
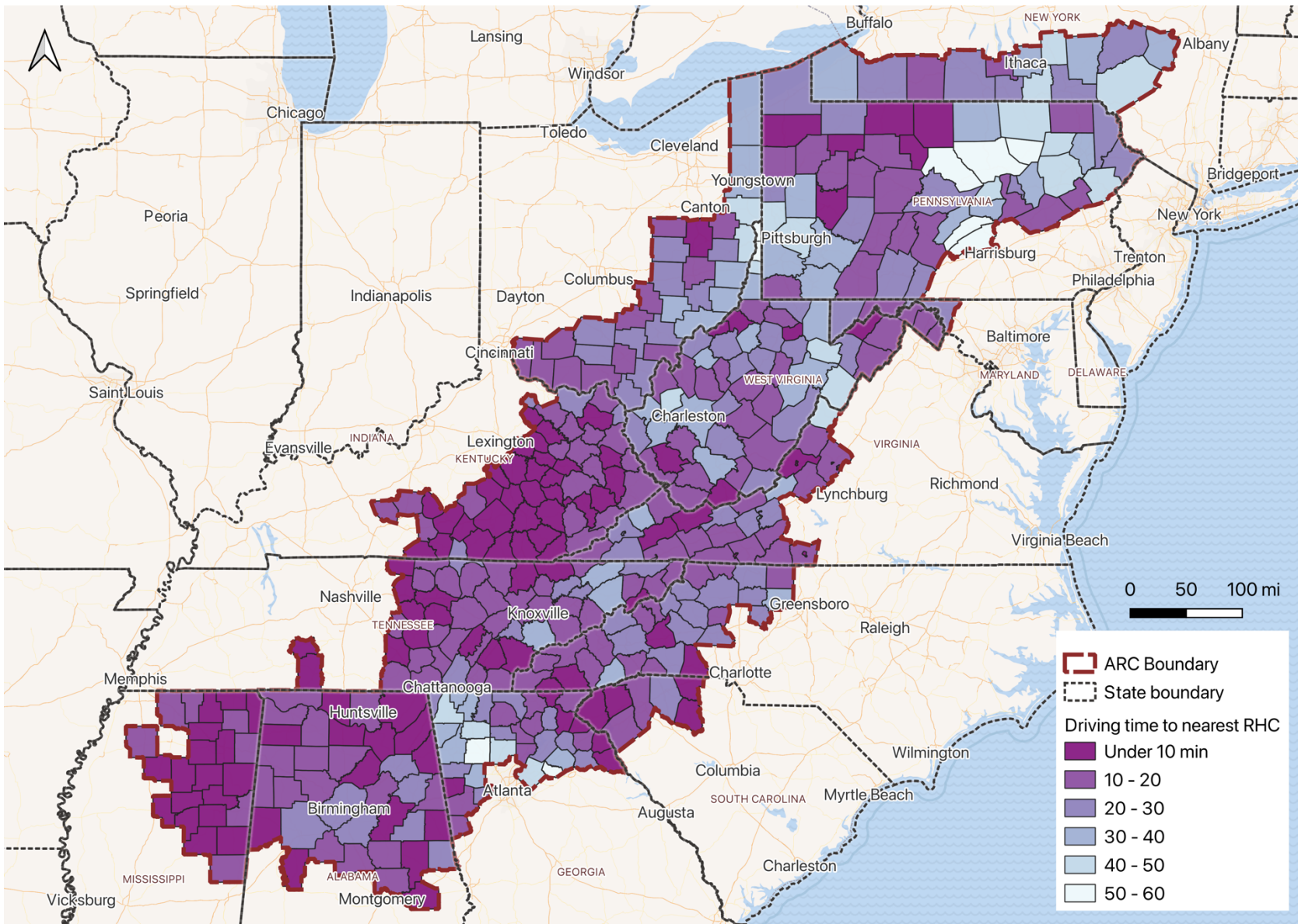
Figure 7.46: A map showing average travel time to the nearest primary care clinics (RHC) by driving for ARC Counties.
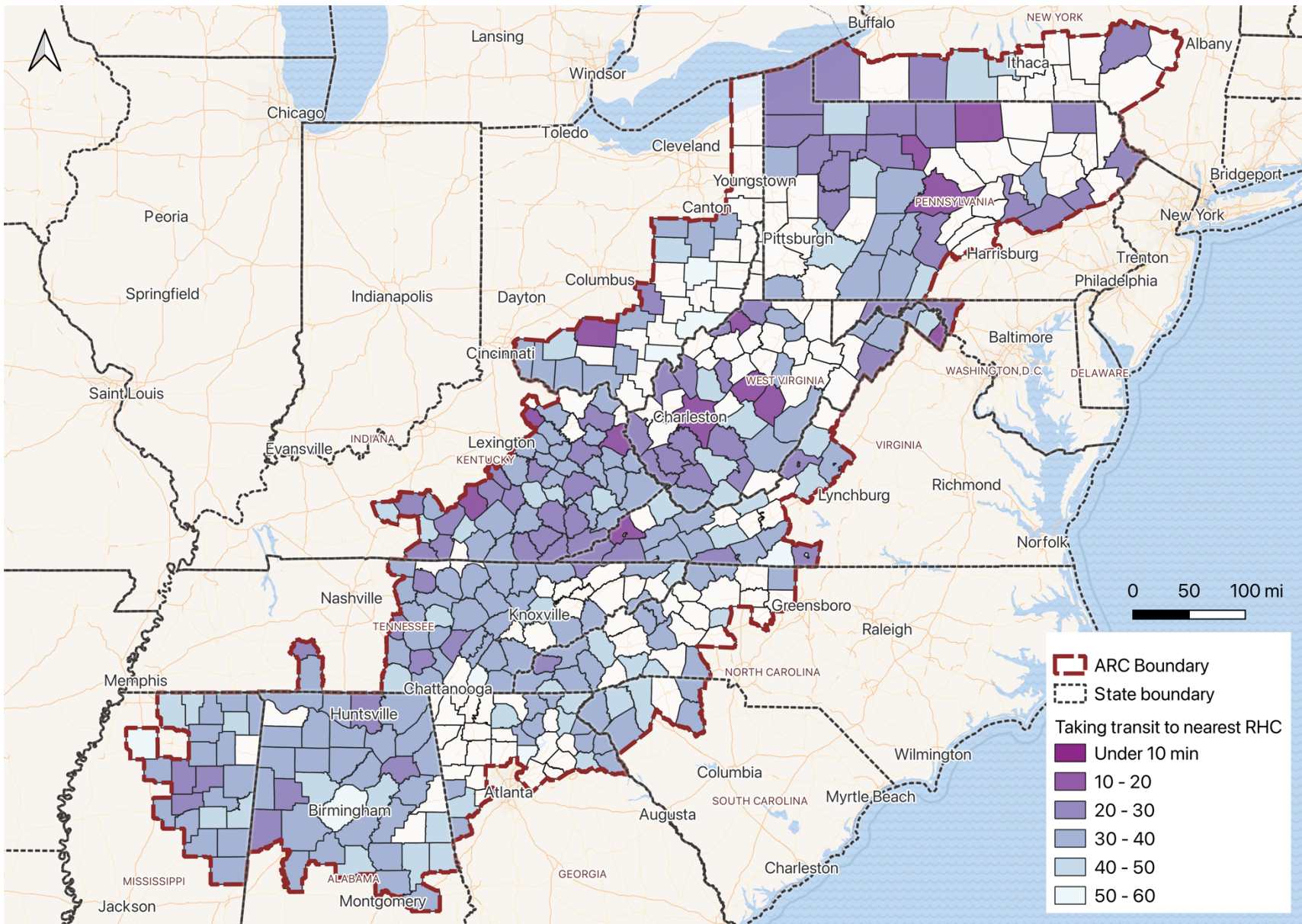
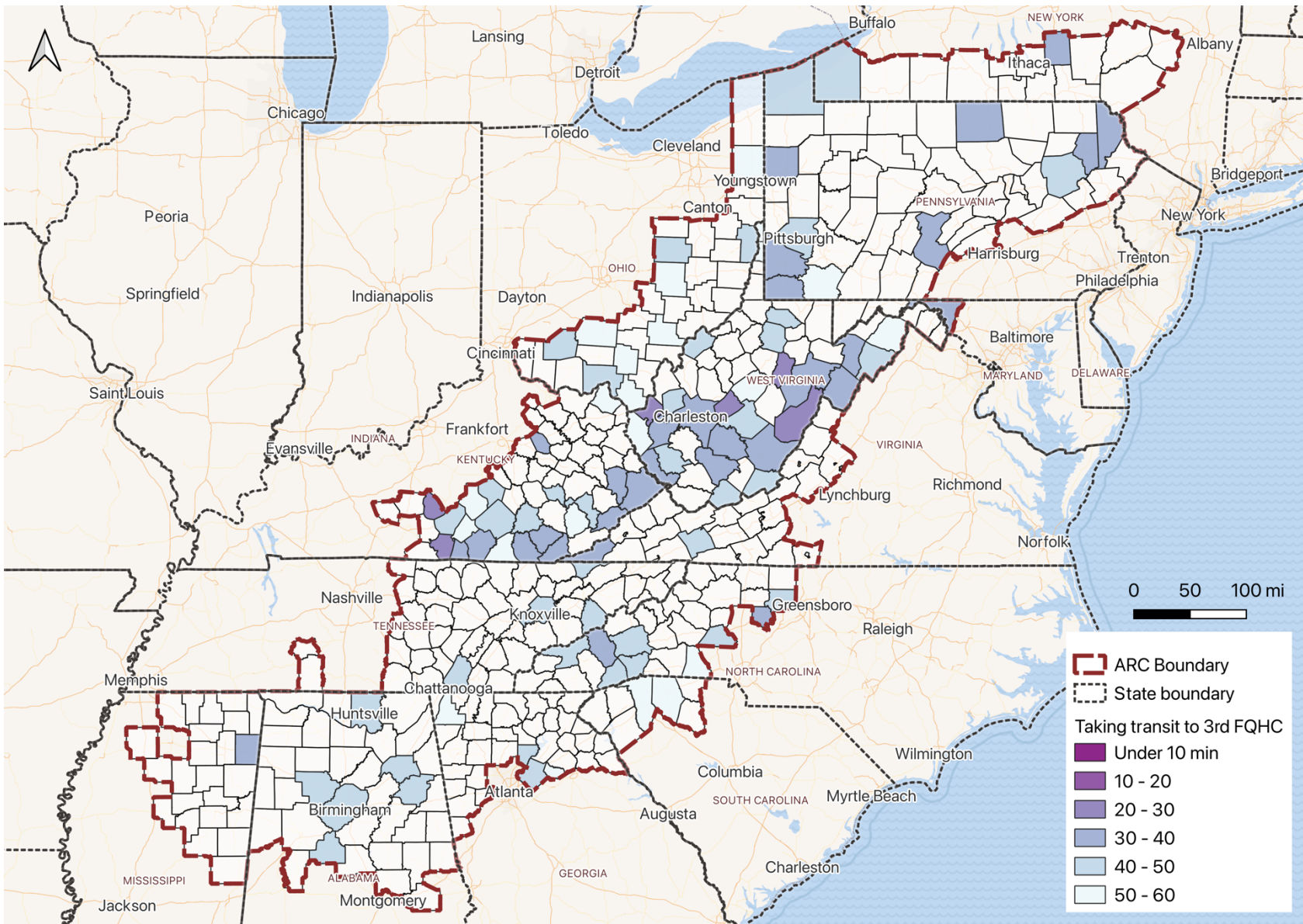*Figure 7.47: A map showing average travel time to the nearest primary care clinics (RHC) by walking+transit (where there is transit) for ARC Counties.*

travel time to RHC by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
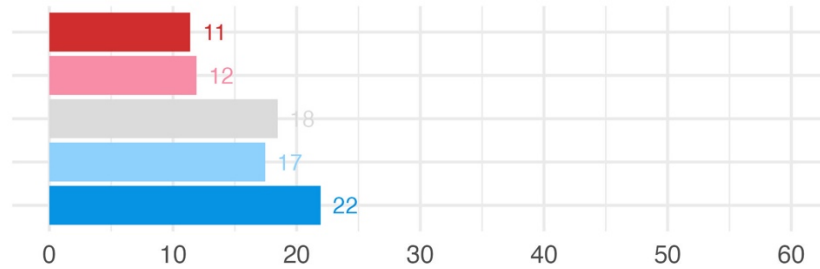
travel time to RHC by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
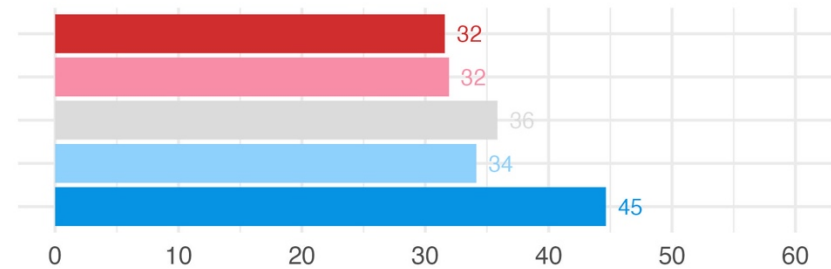
Figure 7.48: Graphs showing median travel time to the nearest primary care clinic (RHC) by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to RHC by auto
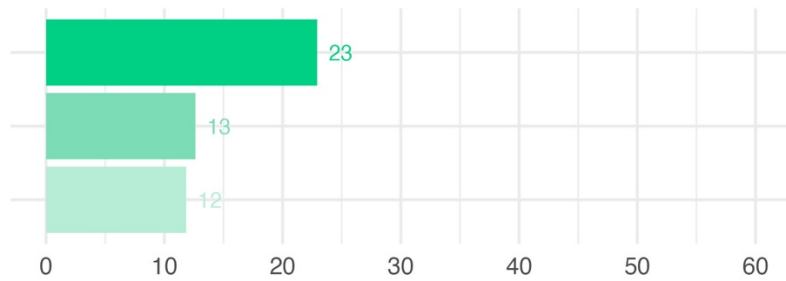
median for counties which are urban, semi-urban, rural

travel time to RHC by walk+transit

median for counties which are urban, semi-urban, rural

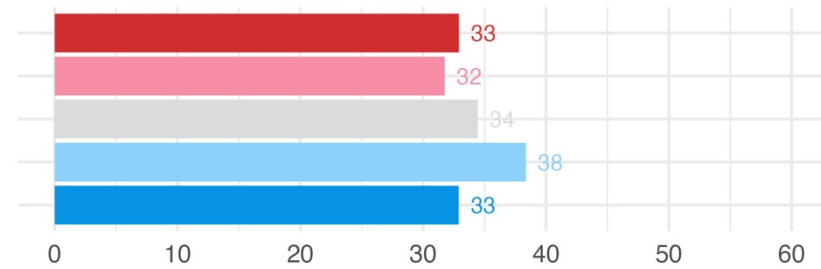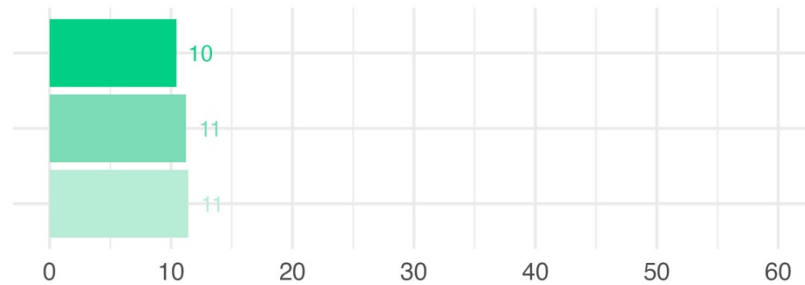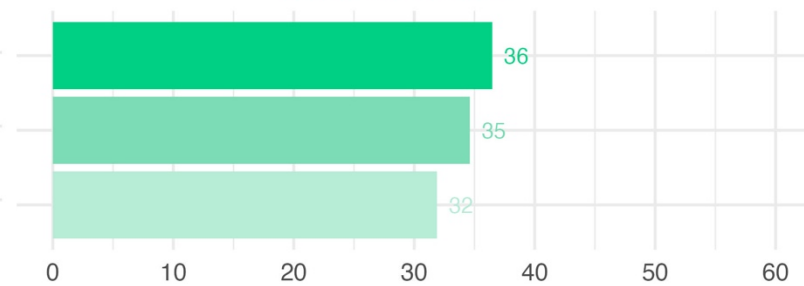*Figure 7.49: Graphs showing median travel time to the nearest primary care clinic (RHC) by driving (left) and walking+transit (right) for ARC Counties by urbanicity.*

79
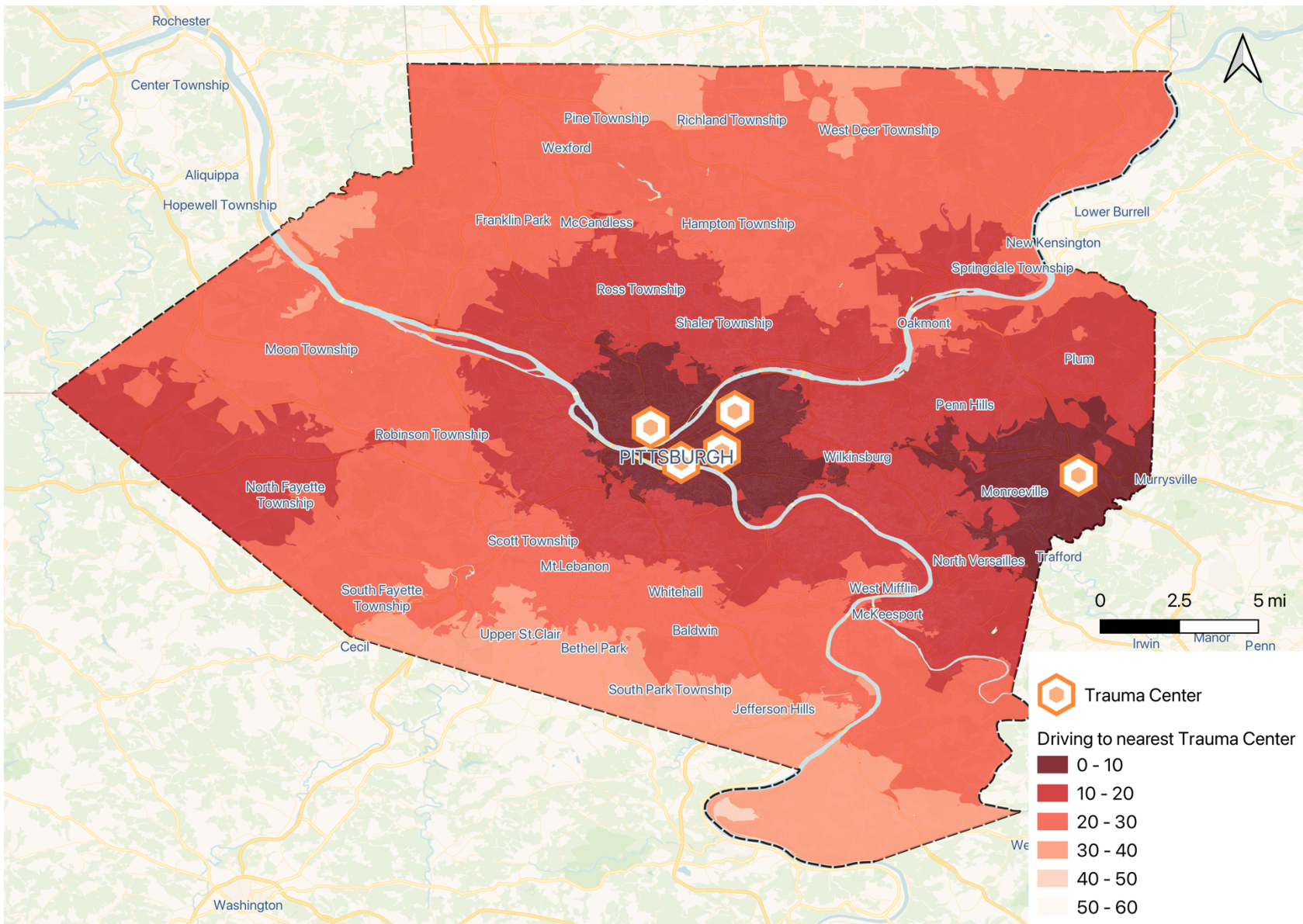
Figure 7.50: A map showing travel time to the nearest trauma center by driving for Allegheny County, PA.
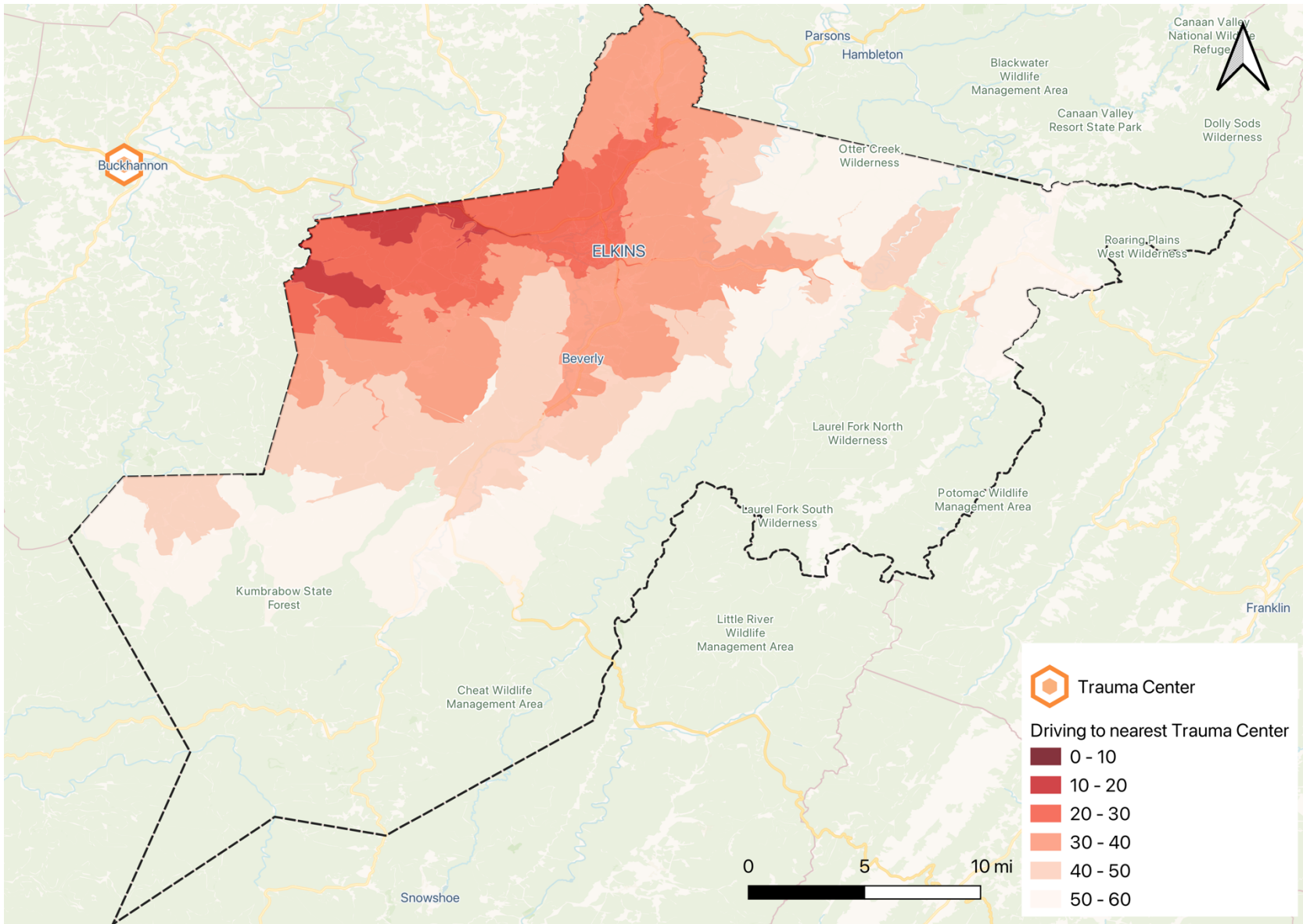
Figure 7.51: A map showing travel time to the nearest trauma center by driving for Randolph County, PA.
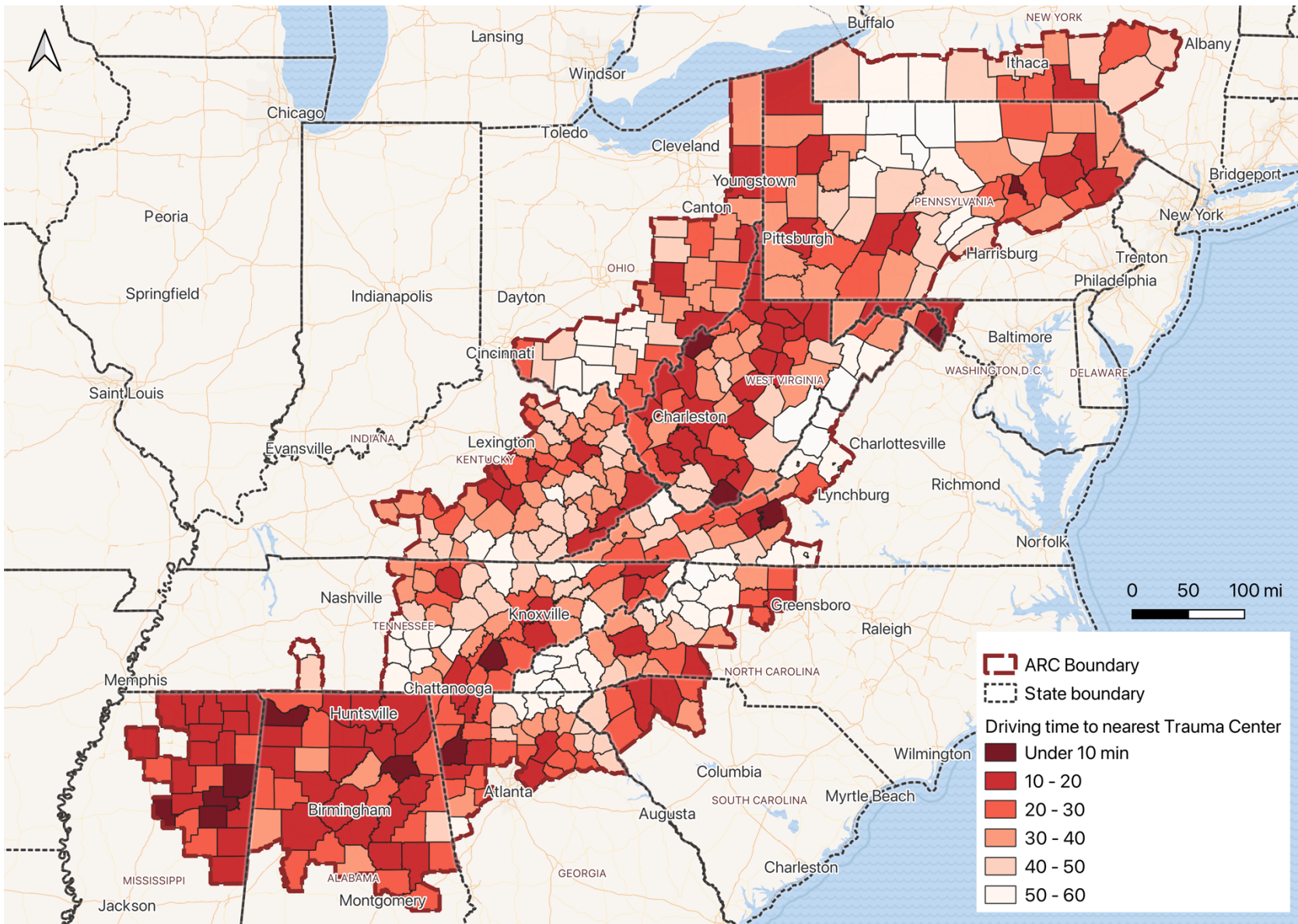
Figure 7.52: A map showing average travel time to the nearest trauma center by driving for ARC Counties.
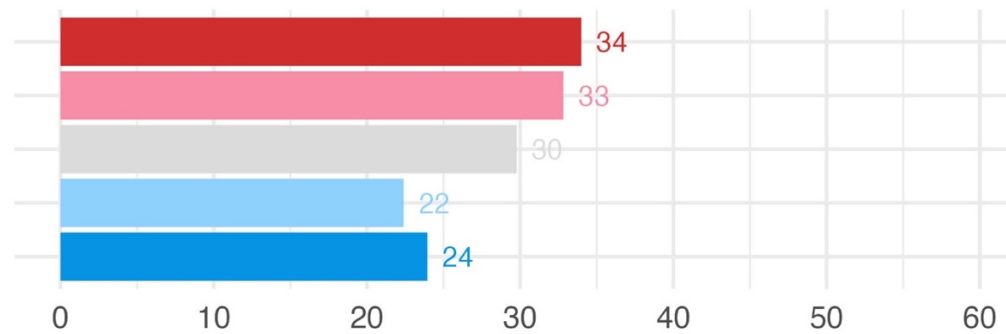
Figure 7.53: Graphs showing median travel time to the nearest trauma center by driving for ARC Counties by 2024 economic status.
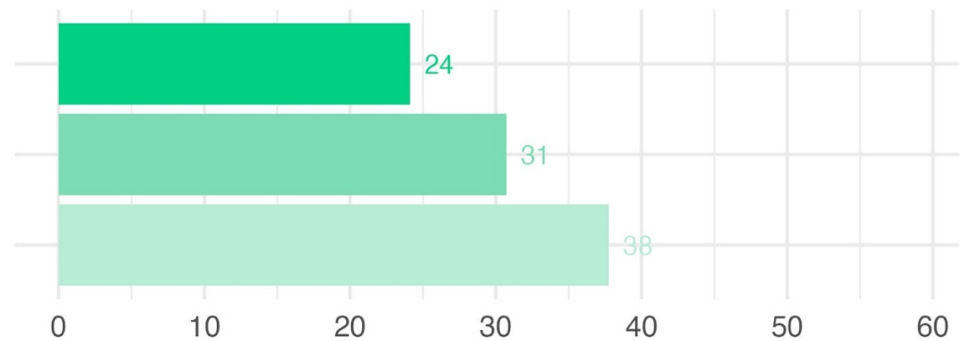
Figure 7.54: Graphs showing median travel time the nearest trauma center by driving for ARC Counties by urbanicity.

7.2.4 Access to Tourism and Entertainment

In the realm of tourism and entertainment, assessing access to key destinations, including convention centers, fairgrounds, and major sports venues, holds paramount importance for both the cultural fabric and economic vitality of the region. These entertainment hubs not only contribute significantly to the social well-being of residents by providing spaces for community engagement and shared experiences but also play a pivotal role in shaping the economic landscape.

From a cultural standpoint, these venues serve as focal points for communal activities, fostering a sense of identity and pride within the community. The impact extends beyond local residents, attracting visitors and tourists to partake in diverse events, exhibitions, and sports competitions. This influx of visitors translates into a boost for local businesses, hotels, and the hospitality sector, ultimately contributing to the economic development of the region.

Through our analysis of accessibility to these entertainment destinations, we aim to shed light on areas where connectivity may be limited, providing valuable insights for strategic decision-making. Improving access to these cultural and recreational hubs not only enhances the overall vibrancy of community life but also ensures that the benefits of tourism and entertainment are equitably distributed across the region.

7.2.4.1 Access to Major Sports Venues

In the context of major sports venues, looking at **Figure 7.55** to **Figure 7.60** our analysis reveals a landscape where access is intricately tied to the geographical distribution of these key facilities. The limited presence of major sports venues within the Appalachian region directly translates into constrained access, primarily confined to the counties where these venues are situated. Driving within a one-hour travel time emerges as the dominant mode for accessing these sports hubs, indicating the reliance on personal vehicles for such recreational pursuits.

Moreover, our findings underscore the challenges associated with alternative modes of transportation, such as walking and transit, in reaching major sports venues. The limitations in accessibility by these modes suggest a potential gap in infrastructure or planning, which could impact the broader community's ability to engage with and enjoy these entertainment destinations.

7.2.4.2 Access to Fairgrounds

In **Figure 7.61** to **Figure 7.64**, the examination of access to fairgrounds within the Appalachian region echoes the patterns observed in our analysis of major sports venues. Our findings highlight that counties housing fairgrounds enjoy relatively robust access to these recreational spaces by driving within a one-hour travel time. This indicates a concentration of access for residents residing in or near counties with fairgrounds, reinforcing the notion that driving remains the dominant mode for reaching such entertainment destinations.

The access to fairgrounds sharply diminishes for individuals relying on these non-driving modes, signaling a substantial limitation in accessibility within a travel time of one hour. This disparity underscores potential challenges in the existing infrastructure or transit options available, which may impact the broader community's ability to engage with fairgrounds and participate in associated events without relying on personal vehicles.

Limited access to these entertainment hubs for residents relying on non-driving modes may curtail the potential economic benefits associated with vibrant local events. Improved accessibility through walking and transit not only broadens the audience for fairs, festivals, and sports competitions but also enhances foot traffic for local businesses. The economic implications extend to increased spending on amenities and services in the vicinity, bolstering the region's economic landscape.

7.2.4.3 Access to Convention Centers

In context of access to convention centers, through **Figure 7.65** to **Figure 7.68**, we observed limited walking and transit access within the Appalachian region. While driving access may be more prevalent, the constrained accessibility for those relying on non-driving modes implies missed opportunities for economic growth. Convention centers serve as crucial hubs for conferences, trade shows, and events that attract businesses, professionals, and tourists. By addressing barriers to walking and transit access, the region can broaden its reach and appeal to a more diverse audience, fostering increased participation and engagement.
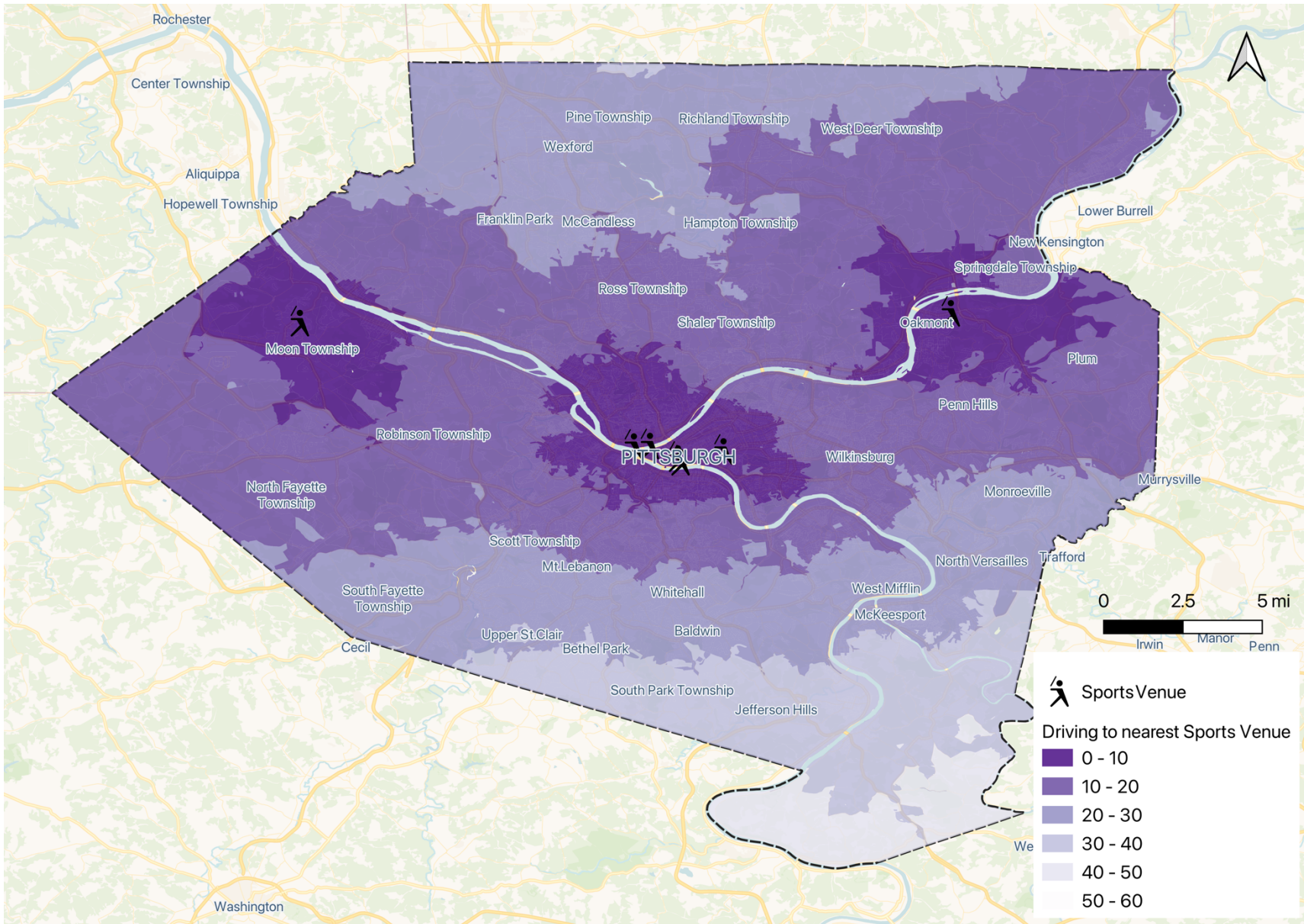
Figure 7.55: A map showing travel time to the nearest major sports venue by driving for Allegheny County, PA.
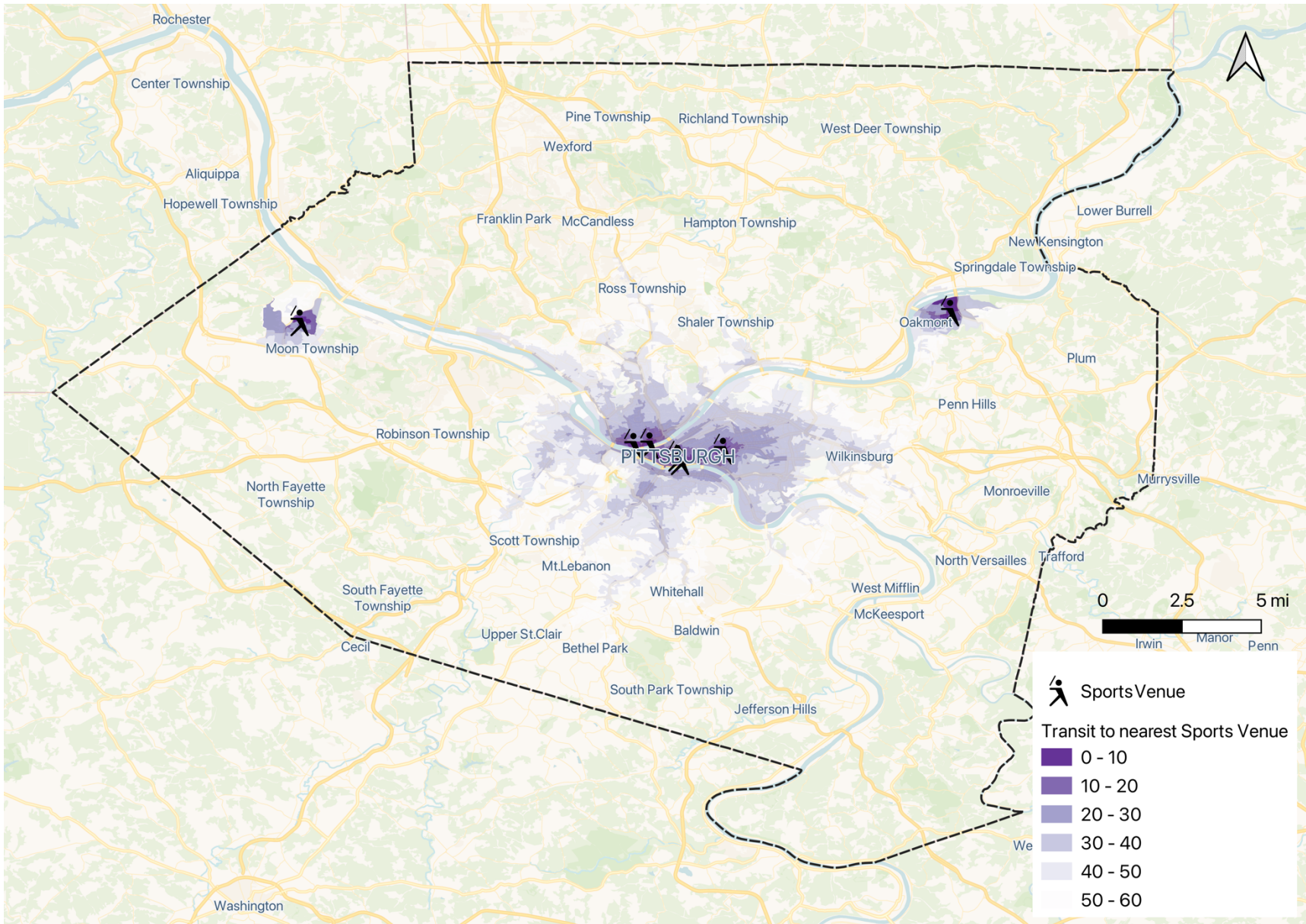
Figure 7.56: A map showing travel time to the nearest major sports venue by walking+transit for Allegheny County, PA.

Figure 7.57: A map showing average travel time to the nearest major sports venue by driving for ARC Counties.
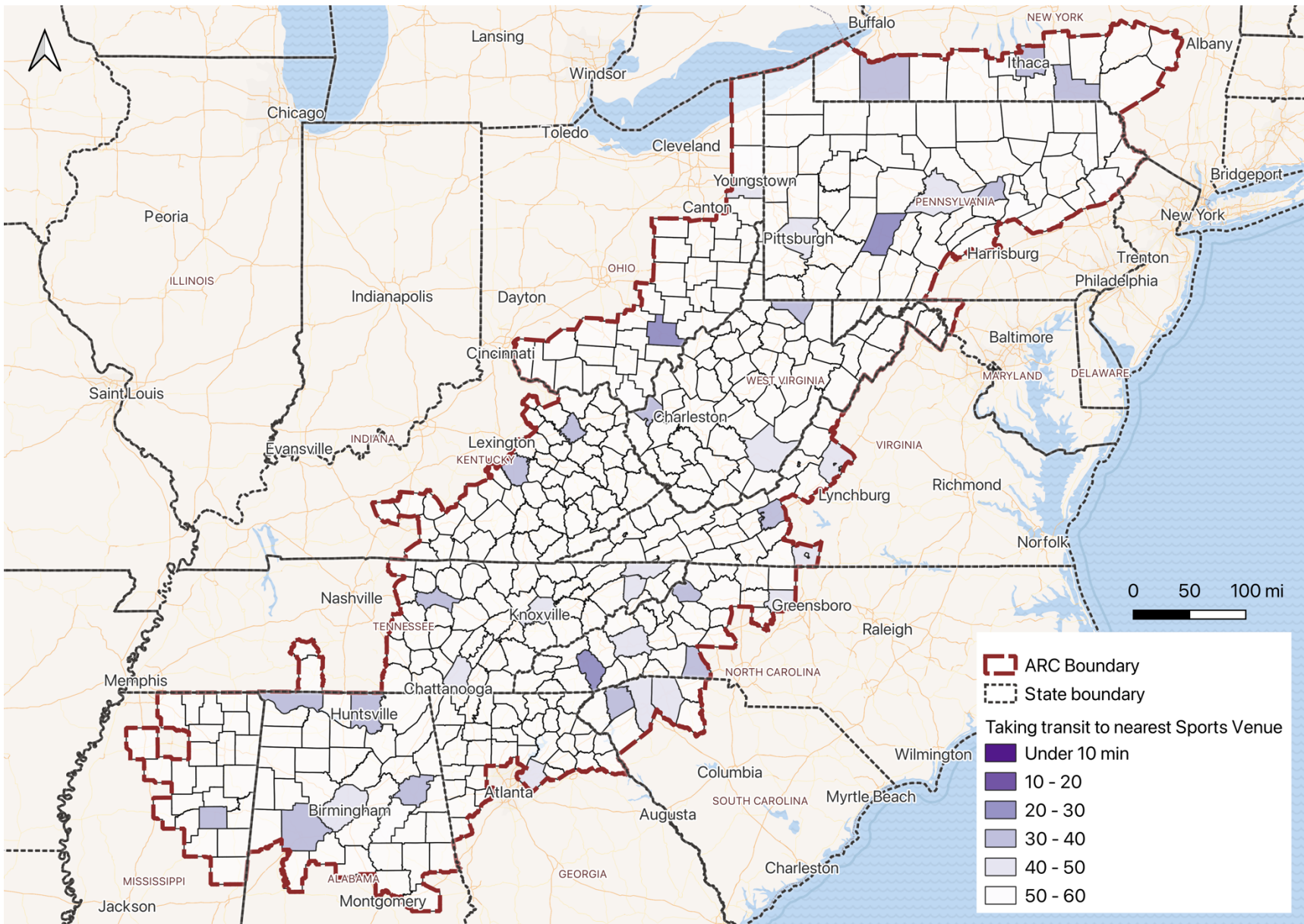
Figure 7.58: A map showing average travel time to the nearest major sports venue by walking+transit for ARC Counties.

travel time to sports venue by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
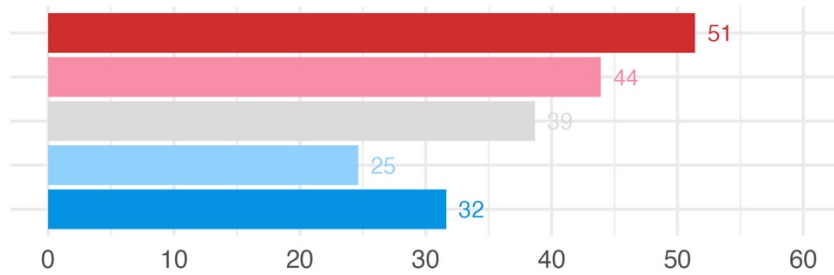
travel time to sports venue by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

Figure 7.59: Graphs showing median travel time to the nearest major sports venue by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to sports venue by auto

median for counties which are urban, semi-urban, rural

travel time to sports venue by walk+transit

median for counties which are urban, semi-urban, rural

Figure 7.60: Graphs showing median travel time to the nearest major sports venue by driving (left) and walking+transit (right) for ARC Counties by urbanicity.
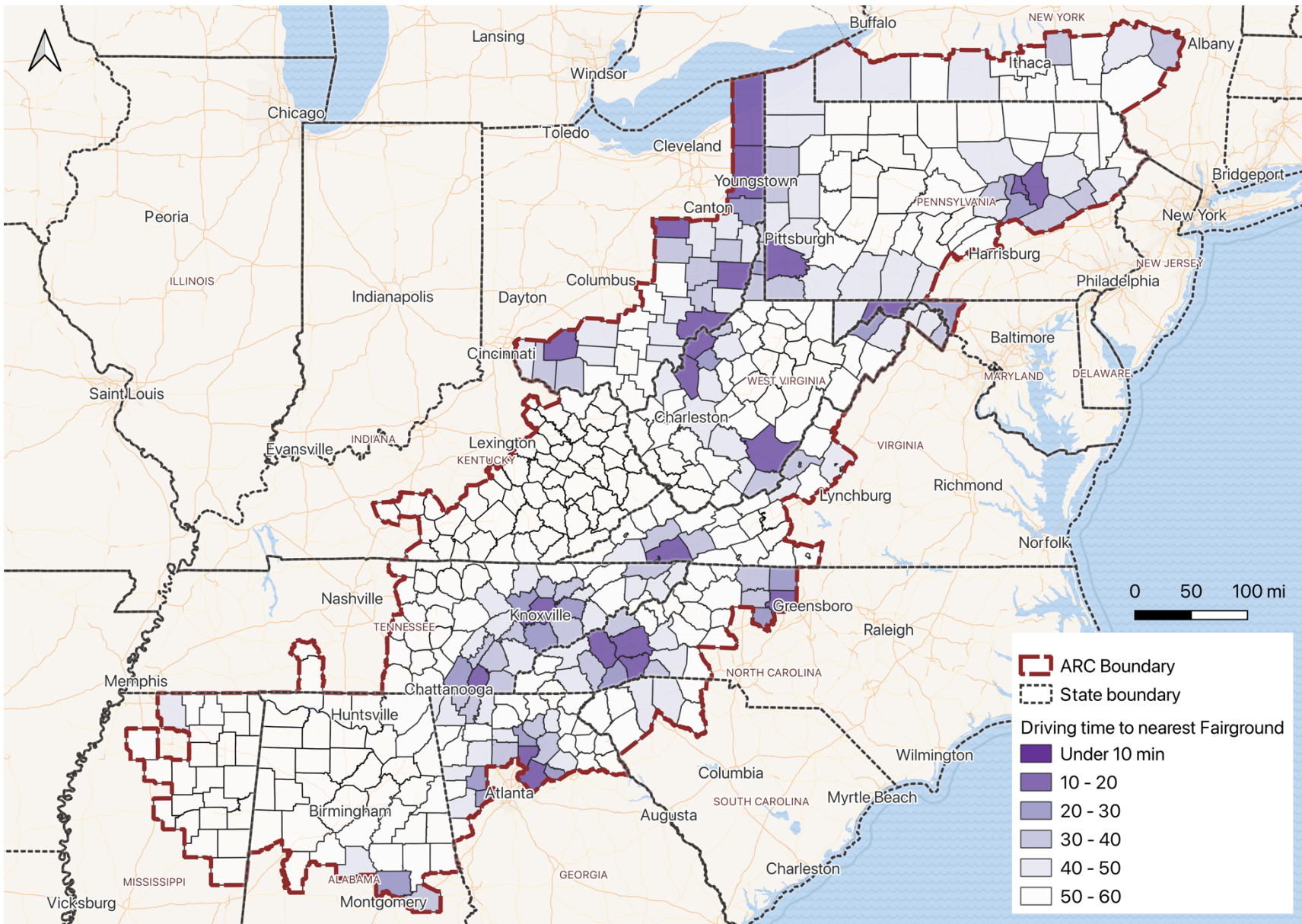
Figure 7.61: A map showing average travel time to the nearest fairground by driving for ARC Counties.
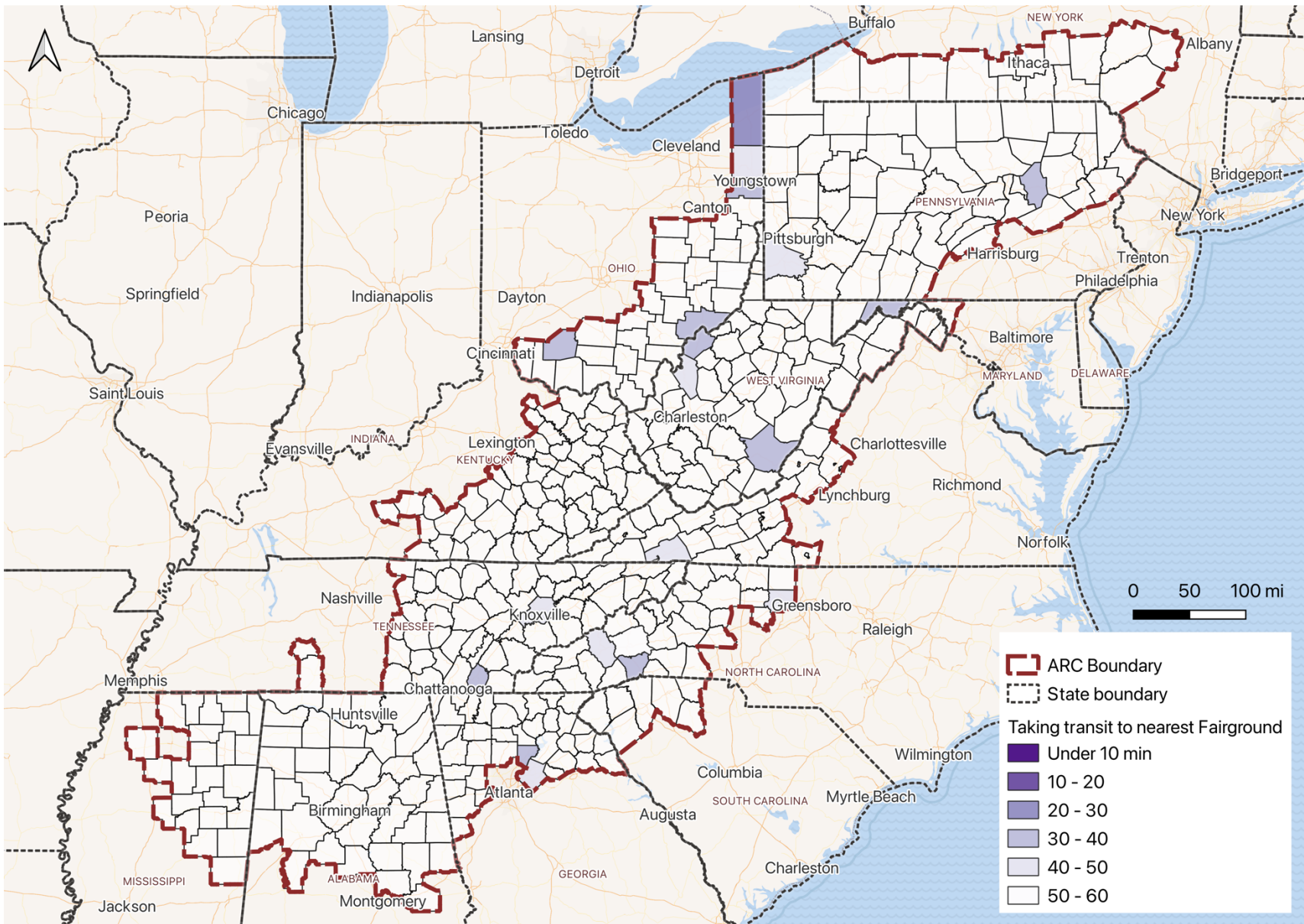
Figure 7.62: A map showing average travel time to the nearest fairground by walking+transit for ARC Counties.

travel time to fairgrounds by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
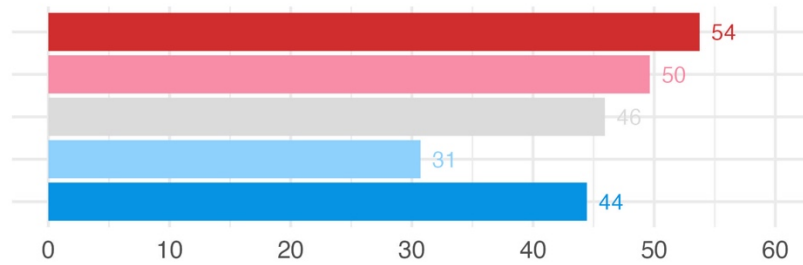
travel time to fairgrounds by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
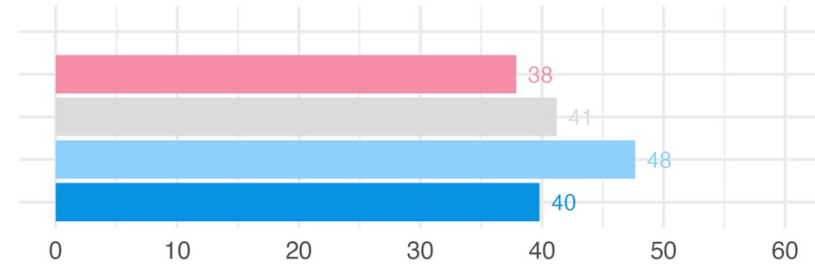
Figure 7.63: Graphs showing median travel time to the nearest fairgrounds by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to fairgrounds by auto
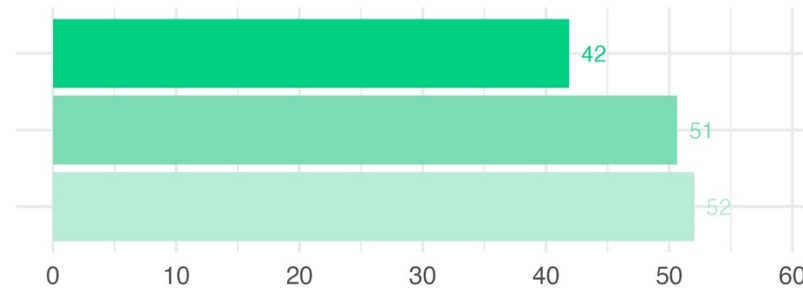
median for counties which are urban, semi-urban, rural

travel time to fairgrounds by walk+transit

median for counties which are urban, semi-urban, rural
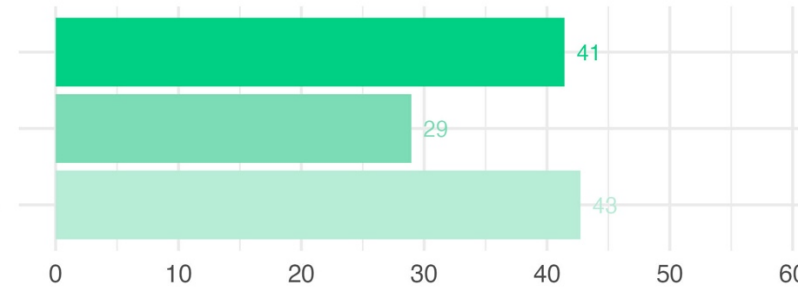
Figure 7.64: Graphs showing median travel time to the nearest fairgrounds by driving (left) and walking+transit (right) for ARC Counties by urbanicity.
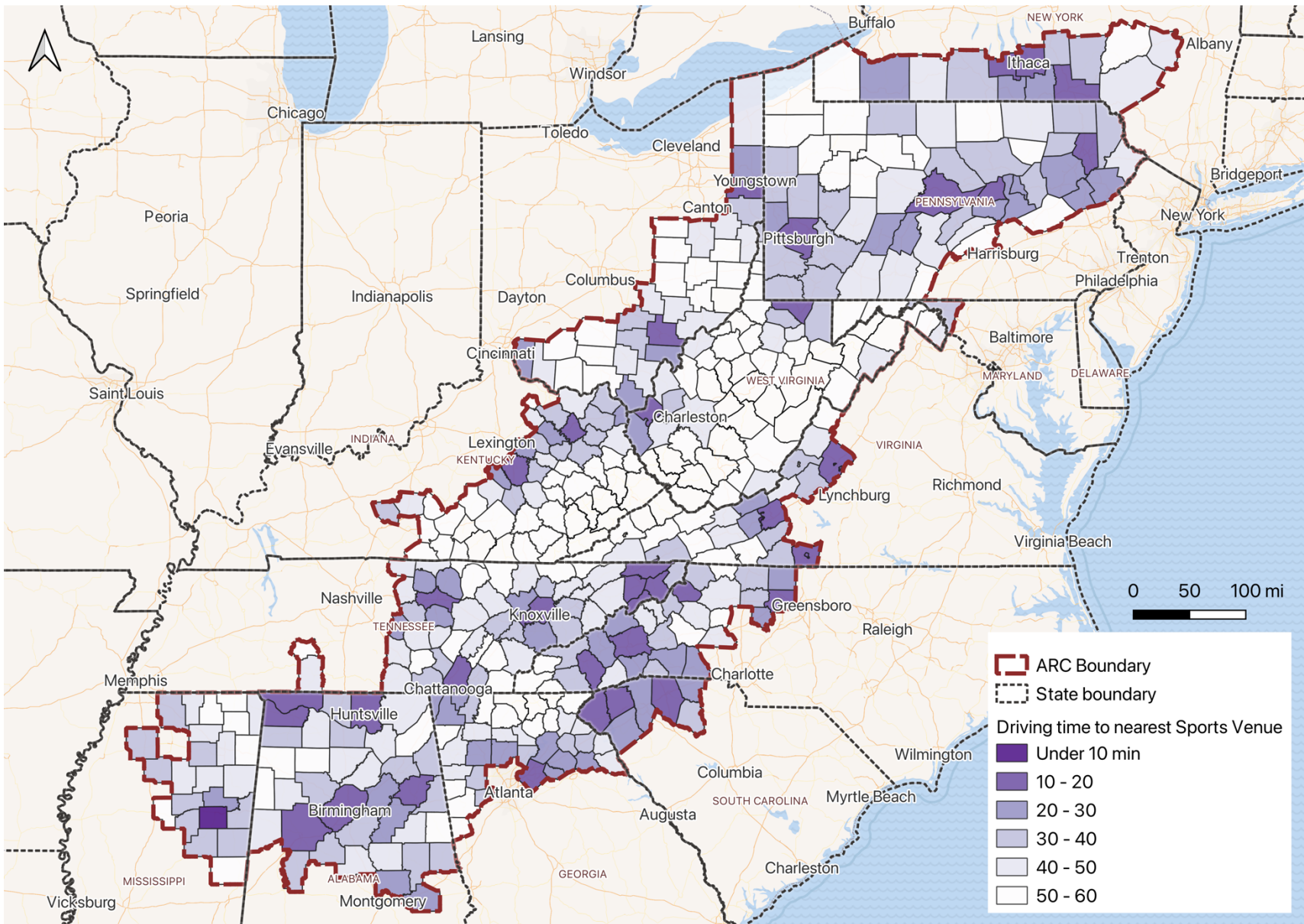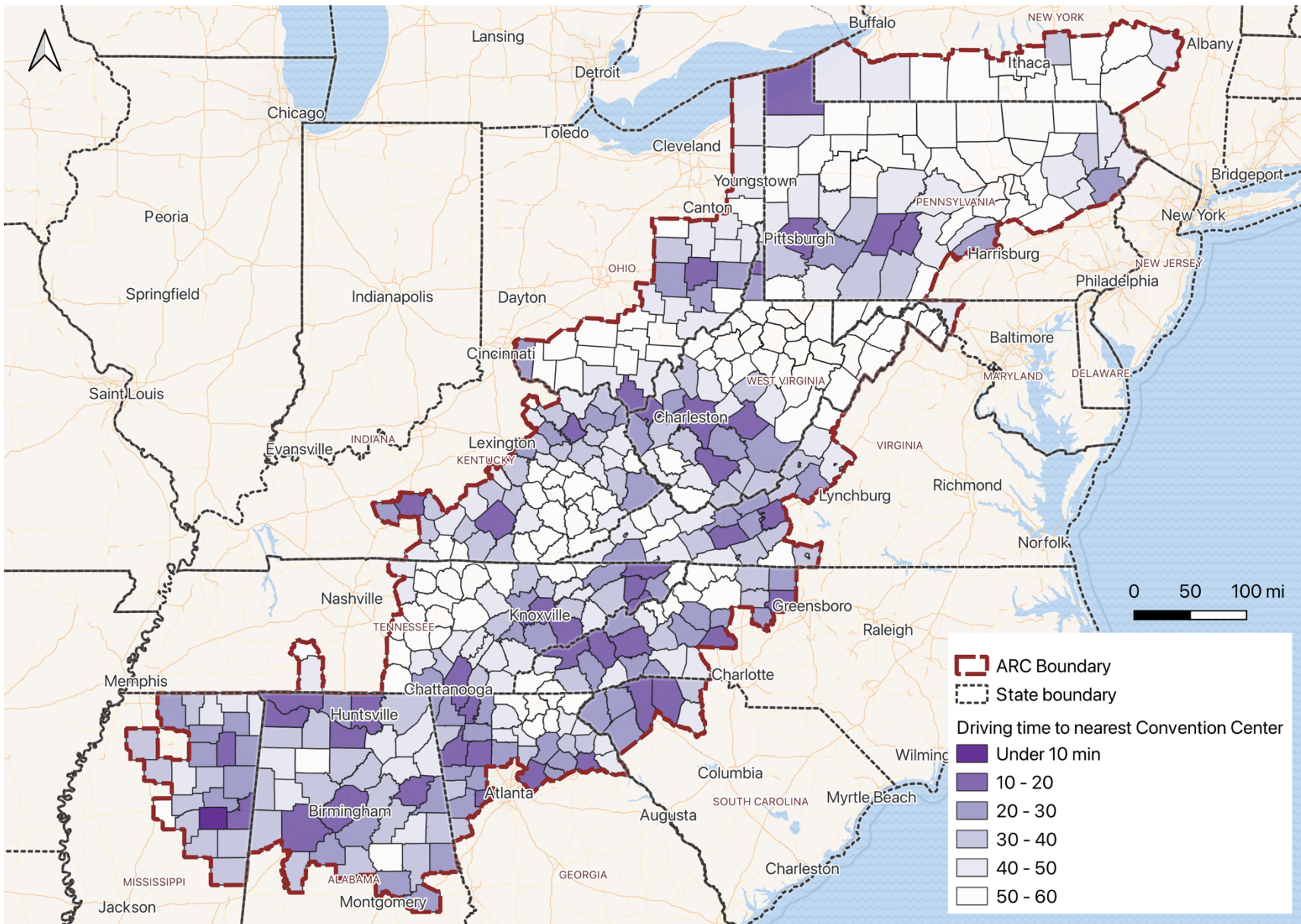
Figure 7.65: A map showing average travel time to the nearest convention center by driving for ARC Counties.
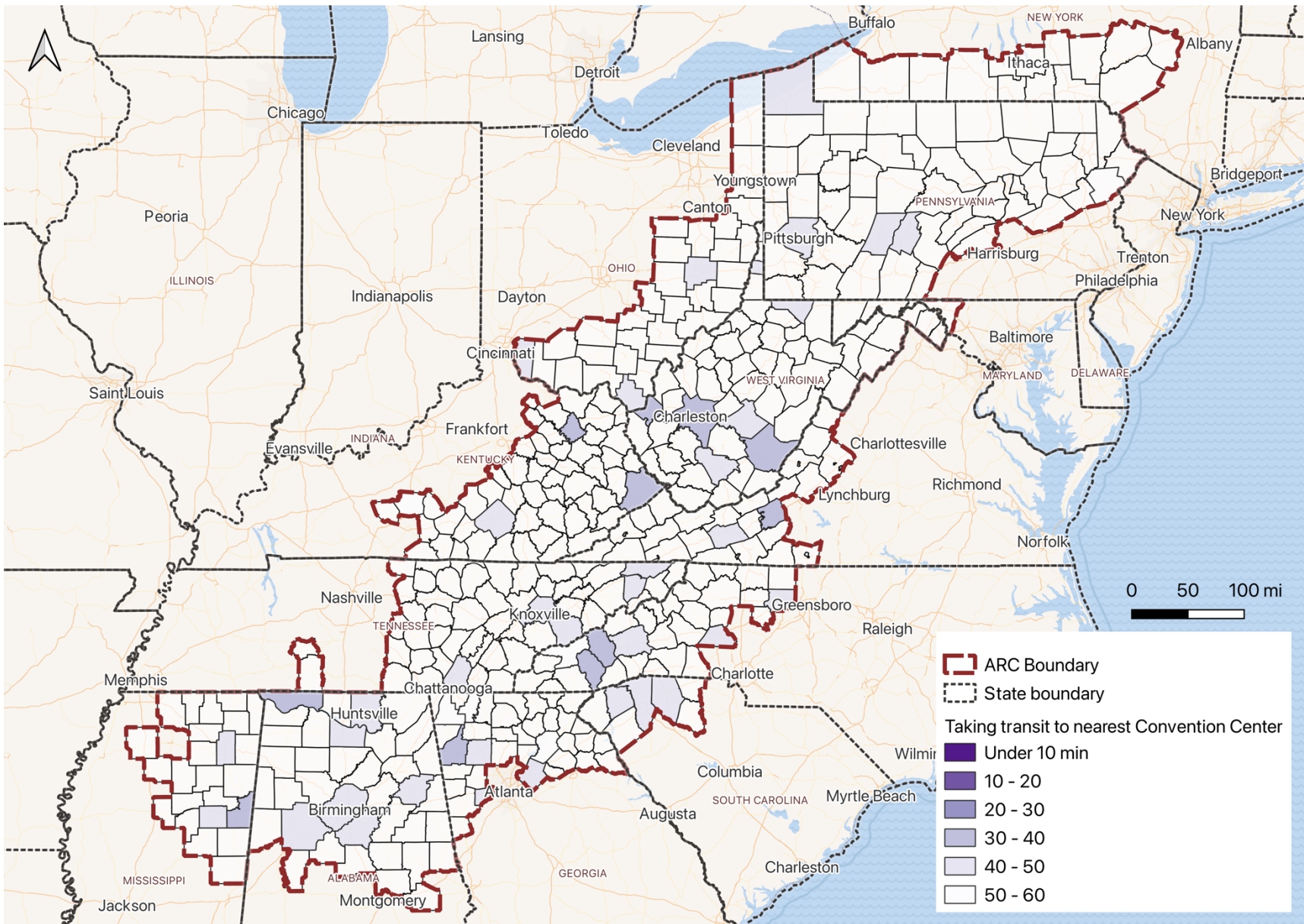
Figure 7.66: A map showing average travel time to the nearest convention center by walking+transit for ARC Counties.

travel time to convention centers by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
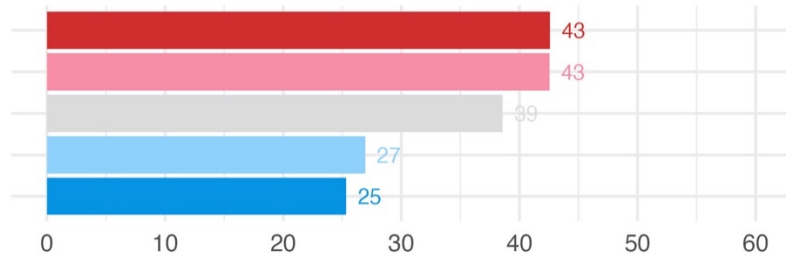
travel time to convention centers by walk+transit

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
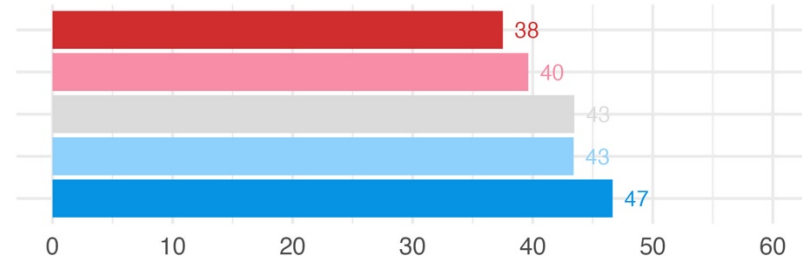
Figure 7.67: Graphs showing median travel time to the nearest convention center by driving (left) and walking+transit (right) for ARC Counties by 2024 economic status.

travel time to convention centers by auto

median for counties which are urban, semi-urban, rural
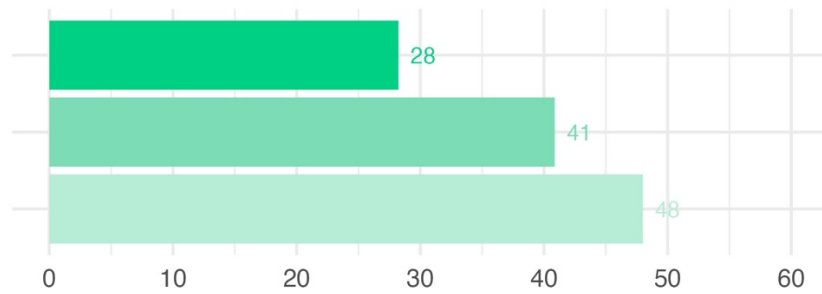
travel time to convention centers by walk+transit

median for counties which are urban, semi-urban, rural
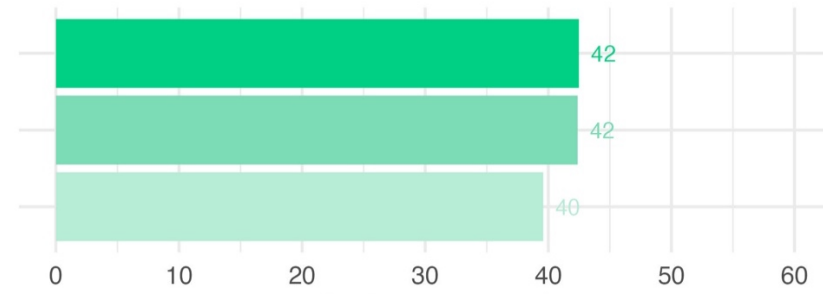
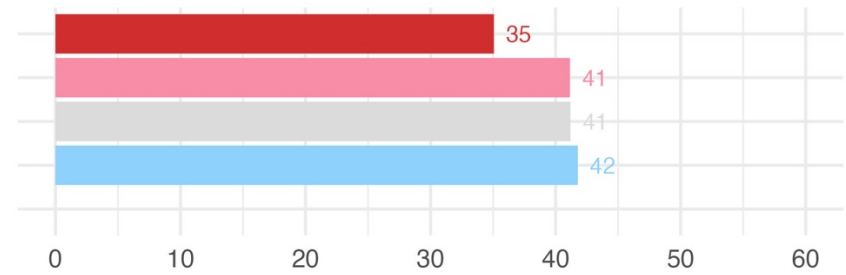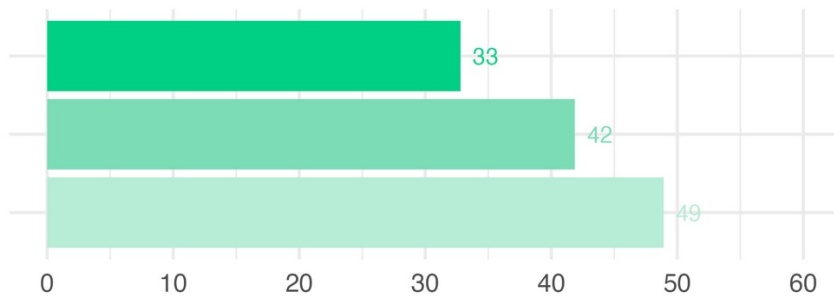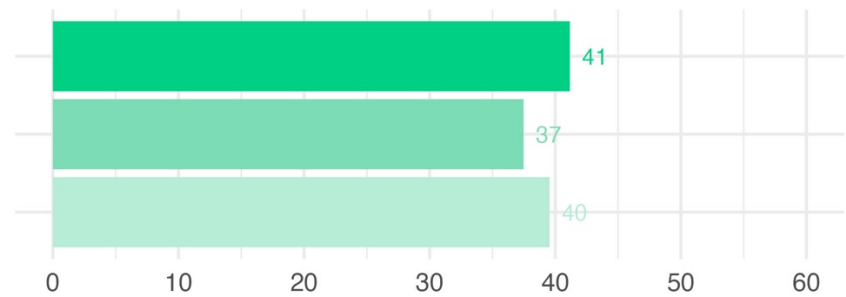*Figure 7.68: Graphs showing median travel time to the nearest convention center by driving (left) and walking+transit (right) for ARC Counties by urbanicity.*

7.2.5 Access to Intermodal Freight Facilities

Access to intermodal freight facilities within a driving distance of an hour serves as a critical accessibility metric for understanding the efficiency and connectivity of the region's freight transportation network. It provides insights into the ease with which businesses and industries can connect to these facilities, facilitating the movement of goods and supporting regional economic activities. A robust and accessible intermodal freight network is essential for optimizing supply chains, reducing transportation costs, and enhancing overall economic competitiveness.

This metric is also important for understanding regional workforce dynamics. It not only fosters employment opportunities in logistics, transportation, and warehousing but also catalyzes the growth of industries tied to these facilities. The diverse skill requirements of the intermodal workforce, ranging from truck drivers to supply chain specialists, contribute to a versatile regional labor pool.

In assessing access to intermodal freight facilities, our methodology adopted a dual access approach, considering both the travel time to these critical nodes and their proximity to the workforce. By measuring driving access to the nearest cargo-providing airport, rail terminal or principal port, and pipeline terminal, we aimed to capture the comprehensive landscape of freight connectivity. This methodology not only gauges the temporal efficiency of accessing these key facilities but can also be used to understand their geographical proximity to potential workers.

7.2.5.1 Access to Airports with Cargo Facility

In analyzing access to the nearest airport with cargo facilities within a driving time of 60 minutes, in **Figure 7.69** to **Figure 7.71**, our observations reveal a nuanced pattern. Counties hosting intermodal freight facilities, along with their neighboring counterparts, generally enjoy access to these critical nodes. Notably, urban counties exhibit better accessibility than their semi-urban or rural counterparts. Furthermore, there is a discernible correlation between economic strength and access, as economically robust counties tend to boast superior connectivity to airports with cargo facilities. This intricate relationship between urbanicity, economic vitality, and accessibility underscores the importance of strategic spatial planning and infrastructure development for fostering efficient freight transportation networks and supporting regional economic growth.

7.2.5.2 Access to Rail Terminals and Principal Ports

Our analysis, focused on the intermodal railway terminals and top 150 principal ports of the U.S. based on tonnage, offers insightful perspectives into the accessibility of intermodal freight facilities. Despite constraints imposed by limited open-source datasets, in **Figure 7.72** to **Figure 7.76** our findings parallel those observed for airports. Counties hosting rail terminals and principal ports, predominantly situated in the northern and southern regions, exhibit favorable access within a driving time of 60 minutes. Interestingly, a noticeable gap in accessibility appears in the central region. This suggests that strategic planning for the placement of intermodal freight facilities has contributed to concentrated accessibility in specific geographical areas.

7.2.5.3 Access to Pipeline Terminals

Through **Figure 7.77** to **Figure 7.79**, our analysis of pipeline terminals reveals patterns akin to those observed for airports, principal ports, and rail terminals. While pipeline terminals exhibit a more dispersed distribution across the region, a discernible gap emerges in the central Appalachian region. The findings underscore a trend where urban and economically robust counties enjoy more favorable access to pipeline terminals, while rural and economically challenged counties face limitations. This echoes the broader theme of infrastructure concentration and its implications for economic disparities within the Appalachian region. Recognizing these patterns is pivotal for policymakers, as it underscores the importance of strategic investments to bridge accessibility gaps, promoting economic development and resilience in regions that may currently face disadvantages in the intermodal freight landscape.
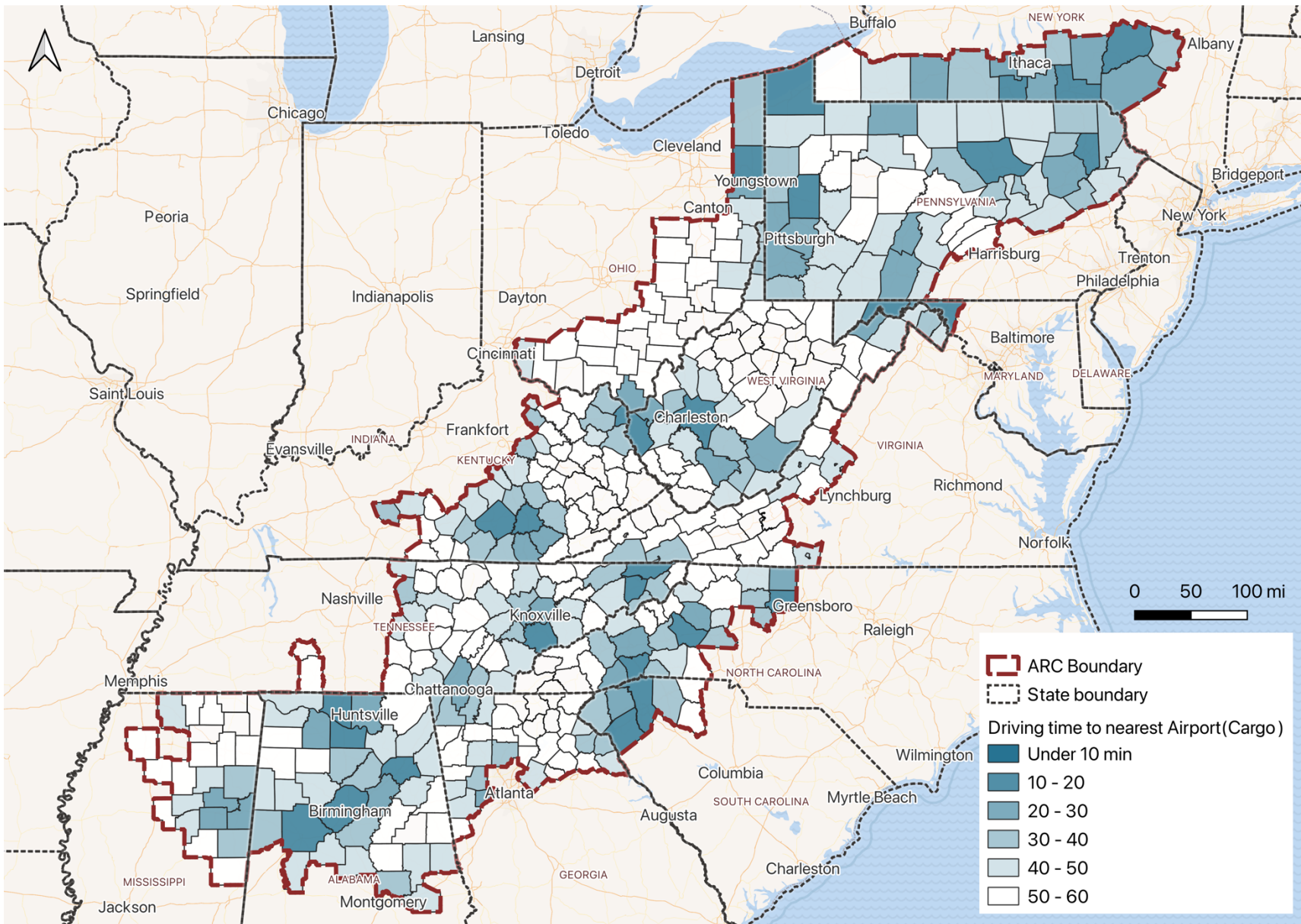
Figure 7.69: A map showing average travel time to the nearest airport offering cargo facility by driving for ARC Counties.

travel time to airport with cargo facility by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment

Figure 7.70: Graph showing median travel time to the nearest airport offering cargo facility by driving for ARC Counties by 2024 economic status.

travel time to airport with cargo facility by auto

median for counties which are urban, semi-urban, rural

Figure 7.71: Graphs showing median travel time to the nearest airport offering cargo facility by driving for ARC Counties by urbanicity.
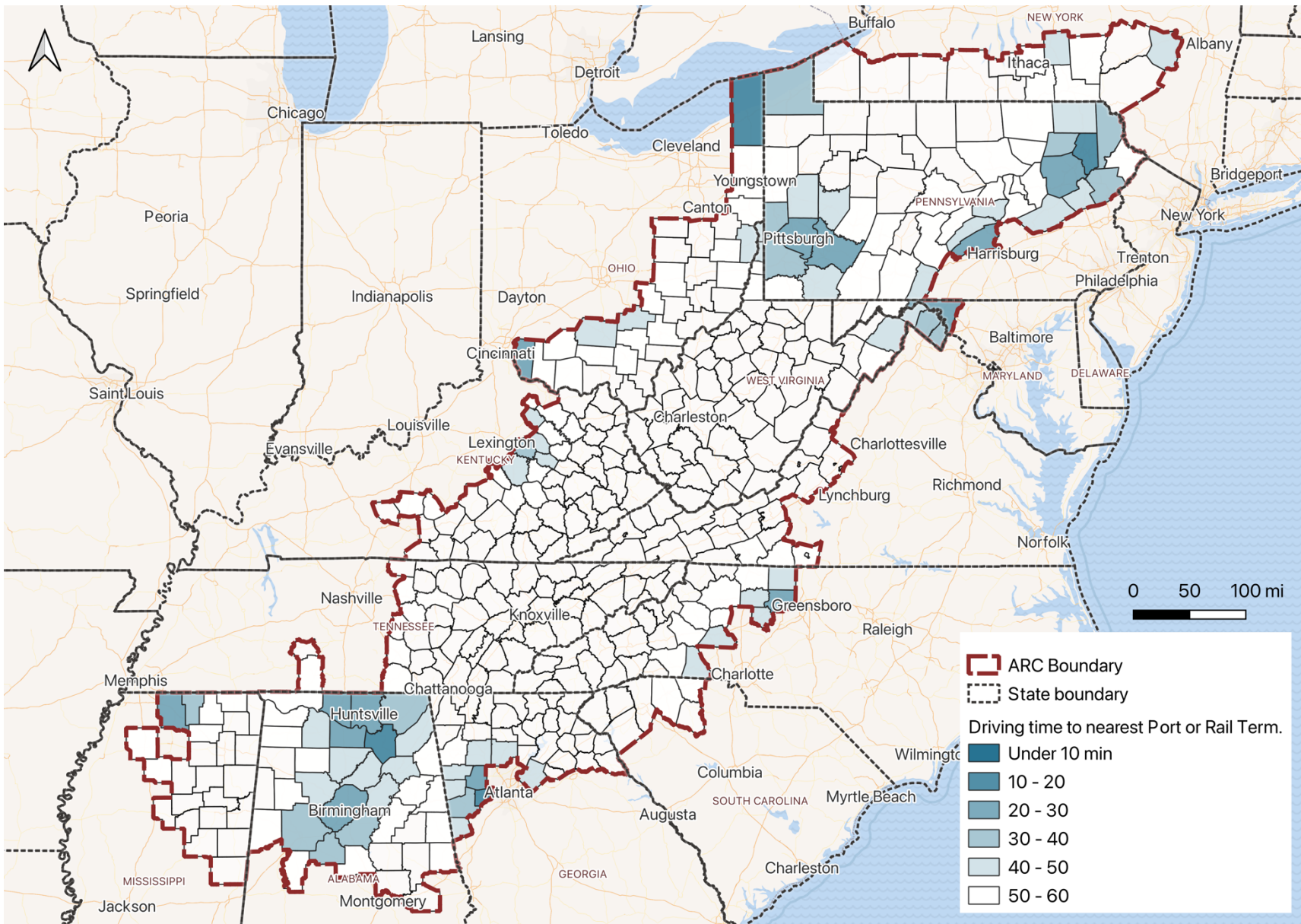
Figure 7.72: A map showing average travel time to the nearest principal inland port or rail terminal by driving for ARC Counties.

travel time to principal port by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
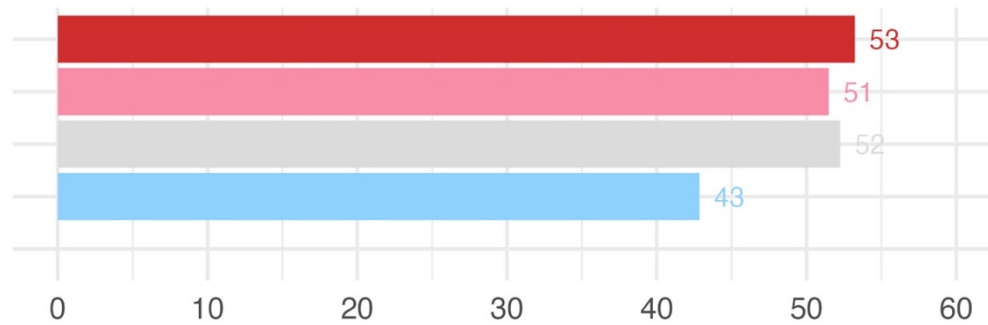
Figure 7.73: Graph showing median travel time to the principal in-land port by driving for ARC Counties by 2024 economic status.

travel time to principal port by auto

median for counties which are urban, semi-urban, rural
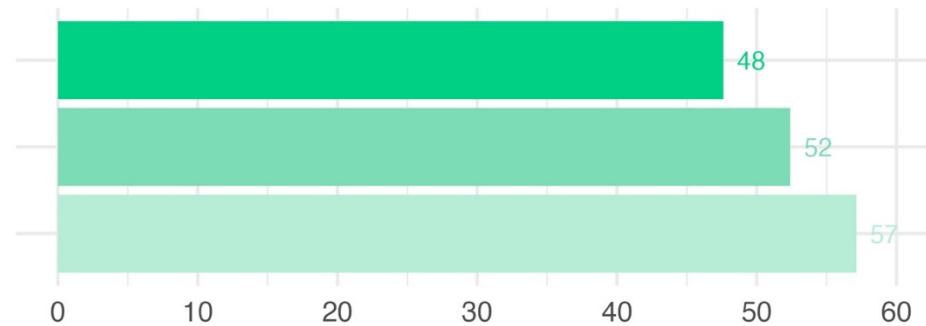
Figure 7.74: Graphs showing median travel time to the nearest principal in-land port by driving for ARC Counties by urbanicity.

travel time to rail terminal by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
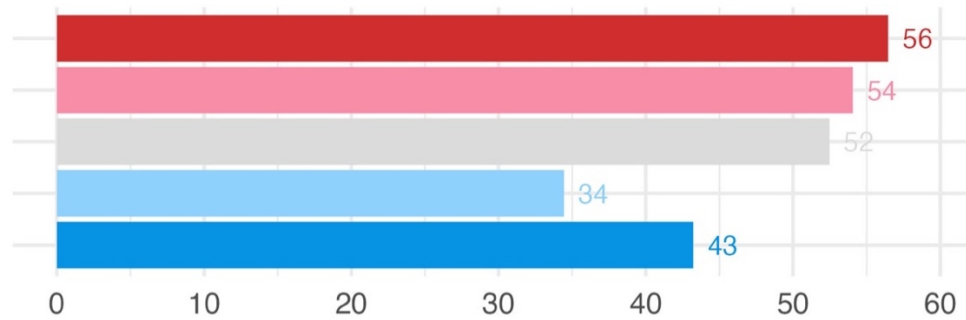
Figure 7.75: Graph showing median travel time to the principal in-land port by driving for ARC Counties by 2024 economic status.

travel time to rail terminal by auto

median for counties which are urban, semi-urban, rural
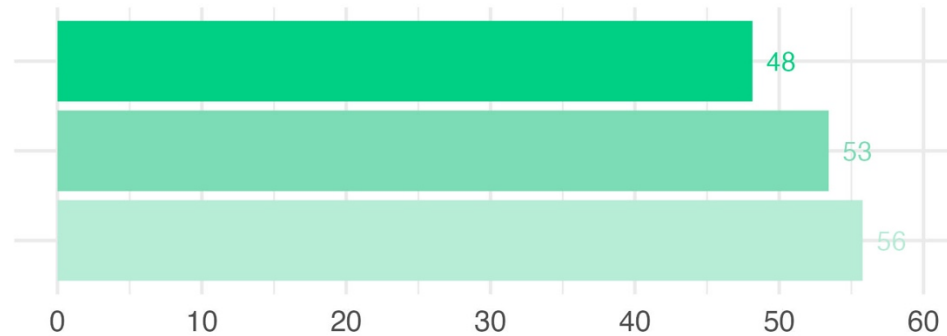
Figure 7.76: Graphs showing median travel time to the nearest principal in-land port by driving for ARC Counties by urbanicity.
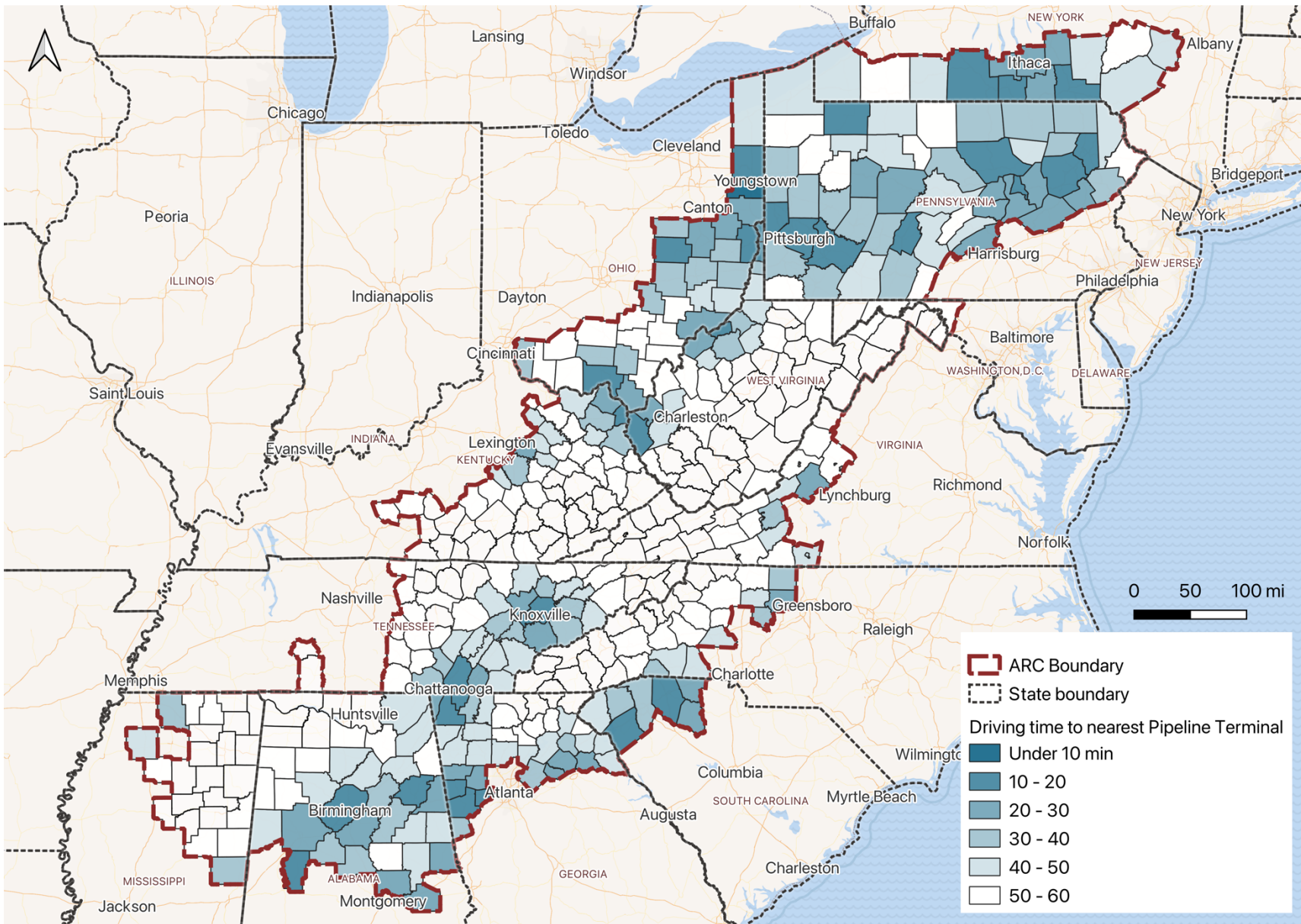
Figure 7.77: A map showing average travel time to the nearest pipeline terminal by driving for ARC Counties.

travel time to pipeline terminal by auto

median for counties which are Distressed, At-Risk, Transitional, Competitive, at Attainment
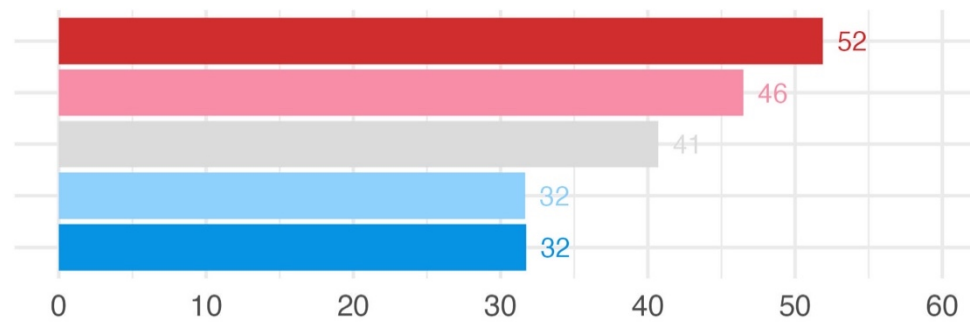
Figure 7.78: Graph showing median travel time to the nearest pipeline terminal by driving for ARC Counties by 2024 economic status.

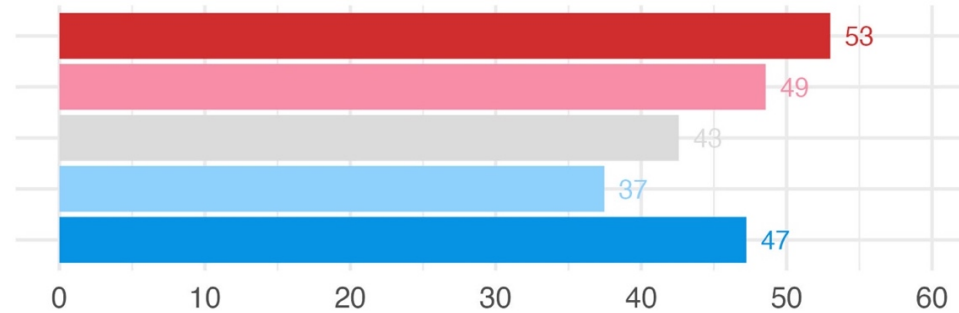## travel time to pipeline terminal by auto
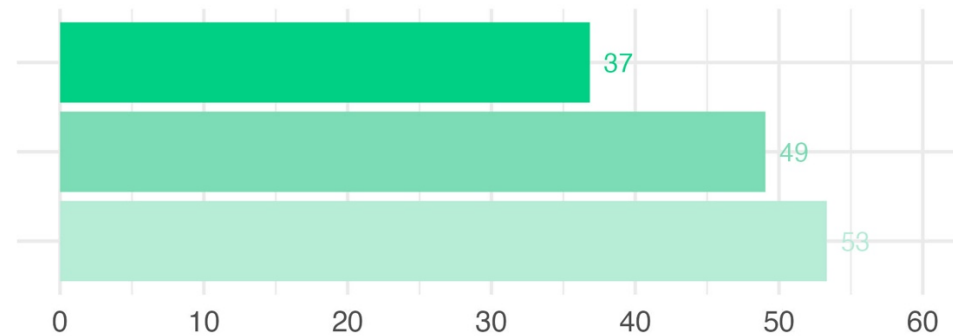
median for counties which are urban, semi-urban, rural
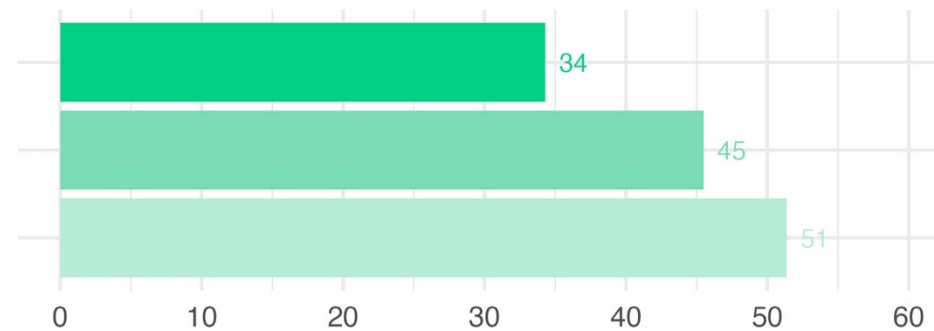
Figure 7.79: Graphs showing median travel time to the nearest pipeline terminal by driving for ARC Counties by urbanicity

8 Moving Forward: Reproducibility and Future Research Opportunities

A key goal of this pilot implementation of accessibility evaluation in Appalachia is to demonstrate the calculation and use of accessibility data as a tool for supporting long-term decision making to improve access throughout the region. This section discusses how the results of the pilot implementation can be carried forward as an ongoing resource for accessibility evaluation. **Section 8.1** discusses the reproducibility of this work and its potential for ongoing implementation. **Section 8.2** describes possible future directions for this work, focusing on enhancements and additions to the snapshot-style accessibility evaluation implemented in this pilot project.

8.1 Reproducibility

8.1.1 Data

The various data sources used in this project, discussed in detail in **Section 5**, were selected to maximize reproducibility through the use of open and public datasets. The selected datasets are suitable for ongoing use, with two important caveats related to transit and road network data.

8.1.1.1 Transit Network Data

The transit network and schedule datasets used in this project were published by individual transit operators and collected by Accessibility Observatory researchers. While these datasets themselves are publicly available, gathering them from numerous individual transit operators, and preparing them for analysis can be a time-consuming task. In this case, the project was able to make use of transit schedule datasets already collected by the Accessibility Observatory for use in its National Accessibility Evaluation project. Future accessibility evaluation would need to plan for this data collection step, or potentially coordinate with the National Accessibility Evaluation.

8.1.1.2 Road Network and Speed Data

The road network and speed data used to calculate auto travel times in this project were licensed from a commercial data vendor. While public options exist for road network data, such as OpenStreetMap, there a no comprehensive public options for speed data than facilitate the analysis of how access is influenced by speeds varying over time of day. The best

option is likely the National Performance Management Research Data Set[18] (NPMRDS), which provides speed data covering the National Highway System. However, this can be difficult to integrate with local roads for routing. Using a fully-public data sources such as OpenStreetMap, on the other hand, would provide consistent routing but would preclude detailed speed-based analysis.

8.1.2 Routing Software

Travel time calculations in this project were performed using two open-source tools. Travel times for walking, biking, and transit were calculated using R5[19], the open-source routing engine used by Conveyal Analysis. Travel times for auto were calculated using a version of OpenTripPlanner[20] customized by Accessibility Observatory researchers to make use of commercially-sources road and speed data. For future implementations it would be beneficial to reduce complexity by making the modifications necessary to use a single routing engine for all modes.

8.2 Future Directions

This pilot implementation of accessibility evaluation provides a foundation on which future improvements and additions might be built. Since the pilot provides a snapshot evaluation of accessibility at a single point in time, it is intuitive to imagine evaluations that can track changes in accessibility over time, and in response to specific proposed or implemented transportation or land use changes.

8.2.1 Performance Management

A performance management approach to accessibility evaluation would involve ongoing accessibility evaluation at regular intervals, providing predictably updated data that transportation agencies could use in tracking accessibility as a performance metric. Some state DOTs in the FHWA National Accessibility Evaluation pooled fund project have begun to do this. In Minnesota, Accessibility to jobs by mode is one of the annually reported statewide and MPO performance measures.[21] In Massachusetts, a statewide dashboard using the NAE data has been used for project prioritization, and the concept of accessibility is a new pillar of long term planning.[22]

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[18] https://ops.fhwa.dot.gov/publications/fhwahop20028/index.htm
[19] https://github.com/conveyal/r5
[20] https://www.opentripplanner.org/
[21] https://www.dot.state.mn.us/measures/
[22] https://beyond-mobility-massdot.hub.arcgis.com/

When using accessibility as a performance management tool, it is important to recognize that accessibility reflects both transportation and land use, and evolves with both of those systems. Changes in accessibility therefore reflect both the decisions and actions of transportation agencies, and those of independent private-sector firms and households.

8.2.2 Scenario Evaluation

Scenario evaluation can be applied to both transportation and land use planning options as a way to estimate potential benefits in accessibility. An advantage of this approach is that the scenarios are measured in terms of opportunity, rather than forecast use. There are fewer assumptions about, for instance, traffic volume or public transit ridership.

The data provided in this project can serve as the baseline for such scenario evaluation. To proceed, planners would develop data to describe the proposed network or land use changes. Specifically:

- Add, remove, or alter links in the road network by editing a copy of the Open Street Maps input data
- Add or remove routes, or change frequencies of service in a GTFS transit schedule
- Re-classify road segments into lower (all-ages, all-abilities) level of traffic stress for bike travel
- Add future destination locations, or alter distribution of residents in blocks through new residential development

Once these proposed changes are captured in the necessary input data, an accessibility analysis of the change scenarios will produce detailed, comparable estimates of the change in opportunity (increase or decrease) by block. These can be aggregated to regional change, used to identify communities of benefit, or used in communication with the public. This can be a powerful tool for evaluating a pool of potential projects, ranking them by their potential to improve access. However it can be a labor-intensive process due to the need to specify changes for all potential scenarios.

Scenario evaluation can be particularly powerful when closely integrated with an ongoing performance management program, since performance management can provide both the baseline for scenario evaluation as well as a post-hoc evaluation of actual project impacts after implementation.

Appendix

1 Accessibility User Guide

This section provides basic guidance on using the accessibility data produced by this project. **Appendix Section 1.1** describes the organization of the accessibility data files, their contents, and how to download them. **Appendix Section 1.2** provides examples of how the accessibility data can be used to investigate locations' access by different modes and to different destinations to provide input to decision making processes about transportation investments. **Appendix Section 1.3** describes how to access and use the web maps created during the project.

1.1 Data Use

1.1.1 Selecting and Downloading Data

The data results produced in this project are available in downloadable CSV files, organized by geography, state, travel mode, and access type. A data file index is available to help select the appropriate data file(s) for your use. The data file index is available in PDF or Excel formats.[23],[24]

Within the data file index, columns indicate the subject and scope of each data file:

- **Geography**
    - "county" indicates a file containing population-weighted data summarized to the county level
    - "block" indicates a file containing unweighted block-level data
- **State**
    - Indicates the state covered by the data file. County-level datafiles cover all states.
- **Mode**
    - Indicates the travel mode — auto, bike, or transit — described by the data file. The "bike" mode is divided into "LTS-2" and "LTS-4" to describe different bike stress levels as discussed in **Section 5.3.3**.

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[23] PDF: https://ao-aapip-data-2020.s3.amazonaws.com/data-download-links.pdf
[24] Excel: https://ao-aapip-data-2020.s3.amazonaws.com/data-download-links.xlsx

- **Type**
    - Indicates the type of access metric and destinations described by the data file, as discussed in **Sections 5.2** and **6.2**.
        - "jobs" indicates a file describing primary access to jobs.
        - "dual" indicates a file describing dual access to other destination types.
- **data_url**
    - Provides the URL for downloading the data file.

To download a data file, use the columns above to identify a specific file of interest, then open the link in the "data_url" column either by clicking or by copying into a web browser. When downloading block-level job access data files, be prepared for large file sizes — for example, then block-level job auto access file for Pennsylvania is 754 MB compressed. [25]

1.1.2 Reading Data Files

All data files are in a tabular CSV format, a text-based data format that is readable by a wide variety of software. To reduce file sizes and download times, block-level data files use "gz" compression. Most operating systems, including Windows an MacOS, will automatically uncompress these files either after downloading or when double-clicking the downloaded ".gz" file.

1.1.2.1 Data File Contents

The columns contained in each data file vary by geography (county or block) and access metric type (primal or dual). A metadata file lists the columns available in each file type, and their meanings.[26]

There are important difference between primal and dual access files due to the different types of access metrics that they contain:

- **Primal** access files describe access to jobs, as discussed in **Sections 5.2.1** and **6.2**. In these files, access values indicate the number of jobs that can be reached within a given travel time threshold. Jobs are categorized using job characteristics and sector codes derived from LEHD data sources.[27] For example, the "W_C000_18" column

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[25]Auto access file for Pennsylvania: https://ao-aapip-data-2020.s3.amazonaws.com/auto/42-block-auto-jobs-access-data.csv.gz

[26] Link to the metadata file: https://ao-aapip-data-2020.s3.amazonaws.com/Metadata_for_AAPIP_datasets.xlsx

[27] https://lehd.ces.census.gov/data/lodes/LODES7/LODESTechDoc7.5.pdf

indicates the total number of reachable jobs, and the "W_CA02_18" column indicates the number of reachable jobs that are held by workers between the ages of 30 and 54.

- **Dual** access files describe access to non-work destinations as discussed in **Sections 5.2.2 – 5.2.5** and **6.2**. In these files, access values indicate the travel time required to reach the closest and third closest locations of a particular destination type. For example, the "edupu01_1" column indicates the travel time to the nearest public elementary school, and the "fqhc_3" column indicates the travel time to the third nearest federally-qualified health center.

1.1.2.2 Mapping Access Data

Each data row in the CSV data files is associated with a specific county or block using geocode values compatible with 2010 Census data. To create maps of the access data, it is first necessary to separately obtain county or block geography data, available from the Census "Mapping Files" web site.[28] This data is often also available in local agency GIS databases. The access data CSV files can then be joined to the geography data by matching geocode files, typically done in GIS software such as ArcGIS, QGIS, or a PostGIS database system.

1.2   Using Access Data in Decision Making

A key goal of this project is to make access concepts and data available for use in decision making within transportation agencies. By taking access considerations into account in project selection, funding, and prioritization decisions, agencies may be able to more reliably select and implement those projects which offer the greatest improvement in people's ability to reach important destinations. In addition to internal decision-making, access data can also help strengthen applications for external project funding.

This pilot project aligns with the broader mission of regional state DOTs to enhance safety, mobility, and access across the region, and serves as a catalyst for change in statewide decision-making processes. Multiple state DOT partners agree that this work can help inform project decision-making. For instance, in Maryland DOT's long-range transportation plan, the Maryland Transportation Plan (MTP), and its six-year program the Consolidated Transportation Program, accessibility measures will be incorporated into planning and prioritization.

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[28]Census "Mapping Files" web site: https://www.census.gov/geographies/mapping-files.html

In North Carolina, the commitment to accessibility is exemplified through ongoing research projects, including this pilot. The state is actively engaging its Prioritization Workgroup to integrate enhanced accessibility metrics into the Strategic Transportation Investments (STI) framework. This approach ensures that accessibility considerations play a central role in future rounds of project prioritization, aligning with the state's commitment to a comprehensive and equitable transportation system. This pilot can help inform their approach.

Virginia's State DOT (VDOT) emphasizes a collaborative decision-making process involving multiple agencies and stakeholders. This pilot aligns with VDOT's goals by offering valuable data for project identification and fund application phases. The insights derived and lessons from the pilot can broaden future evaluations of impact on destination access in the Appalachia region. The collaboration between VDOT and the Office of Intermodal Planning and Investment (OIPI) underscores a data-driven approach to decision-making, ensuring that accessibility metrics contribute meaningfully to the statewide transportation agenda.

1.2.1 Targeting Investments

Access data can help to make decisions about where to target transportation investments. Because they combine travel time and land use data, access data is particularly useful at identifying locations where lack of transportation infrastructure, or high travel times, is the barrier to improved access. In the following three examples, access data produced by this project is used to identify locations where access could be improved through transportation investments.

1.2.1.1 Example 1: Low-Stress Bike Facilities

Appendix Figure 1 and **Appendix Figure 2** show access time by biking to the third nearest high school in Allegheny County, PA. In these maps, darker colors indicate blocks with higher (faster) access to high schools, and lighter colors indicate lower (slower) access. **Appendix Figure 1** shows access when bike routing is restricted to the low-stress parts of the bike network (LTS 2), while **Appendix Figure 2** shows access when routing on all roads where biking is legal, including those where most travelers would find biking stressful and dangerous (LTS 4).

The difference between these two maps effectively quantifies the potential for low-stress bike facility investment to improve low-stress bike access to high schools:

- A location where **both LTS 2 access and LTS 4 access are high** would likely see only small benefits from additional low-stress bike facility investments, because sufficient facilities already exist to provide good access to high schools.
- A location where **both LTS 2 access and LTS 4 access are low** would also likely see only small benefits from additional low-stress bike facility investments, because the low LTS 4 access indicates that even if the entire network became low-stress, high schools are too far away to see usable access benefits.
- A location where **LTS 2 access is low and LTS 4 access is high** would likely see large benefits from additional low-stress bike facility investments. The high LTS 4 access indicates that the high stress levels on the local network play a large role in limiting low-stress access, and that improving parts of the local network to be low-stress could meaningfully improve low-stress access to high schools.
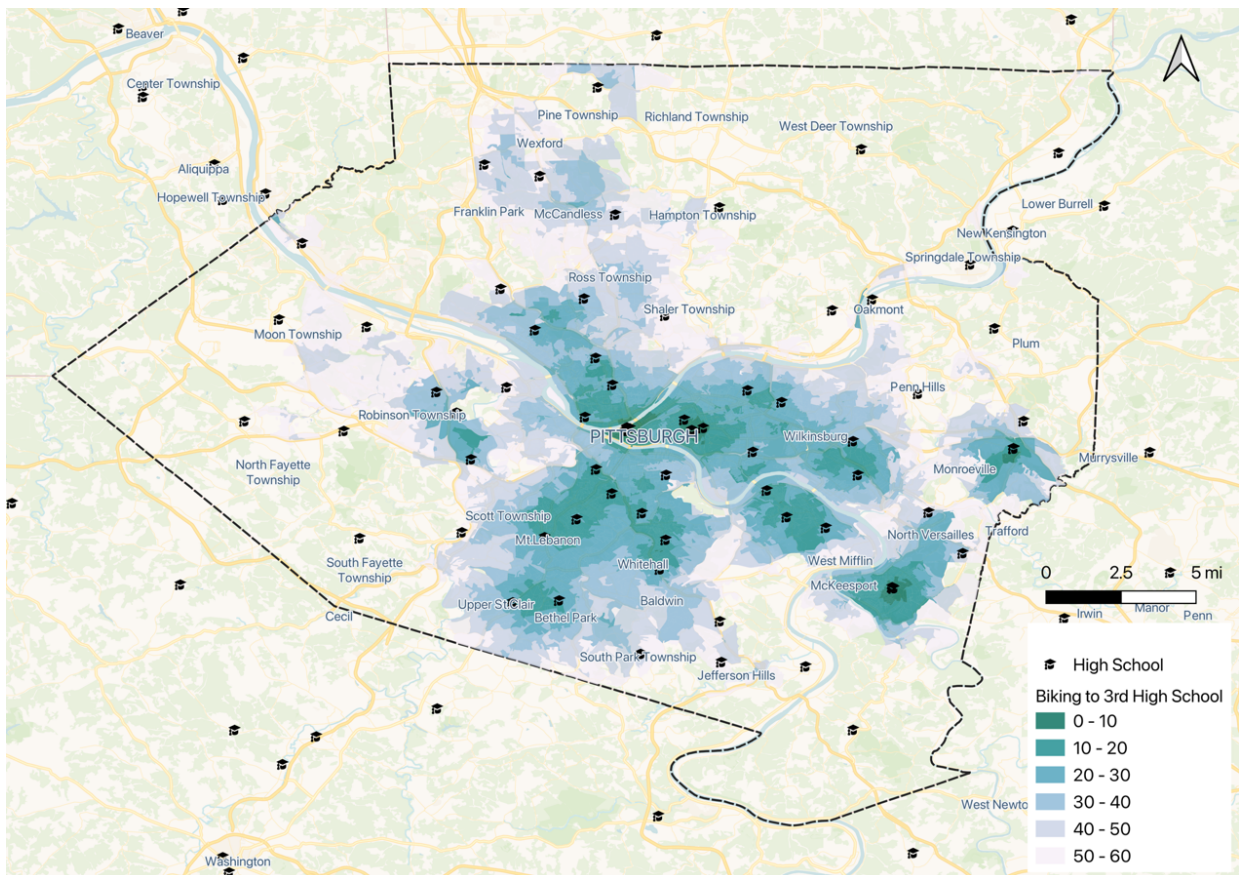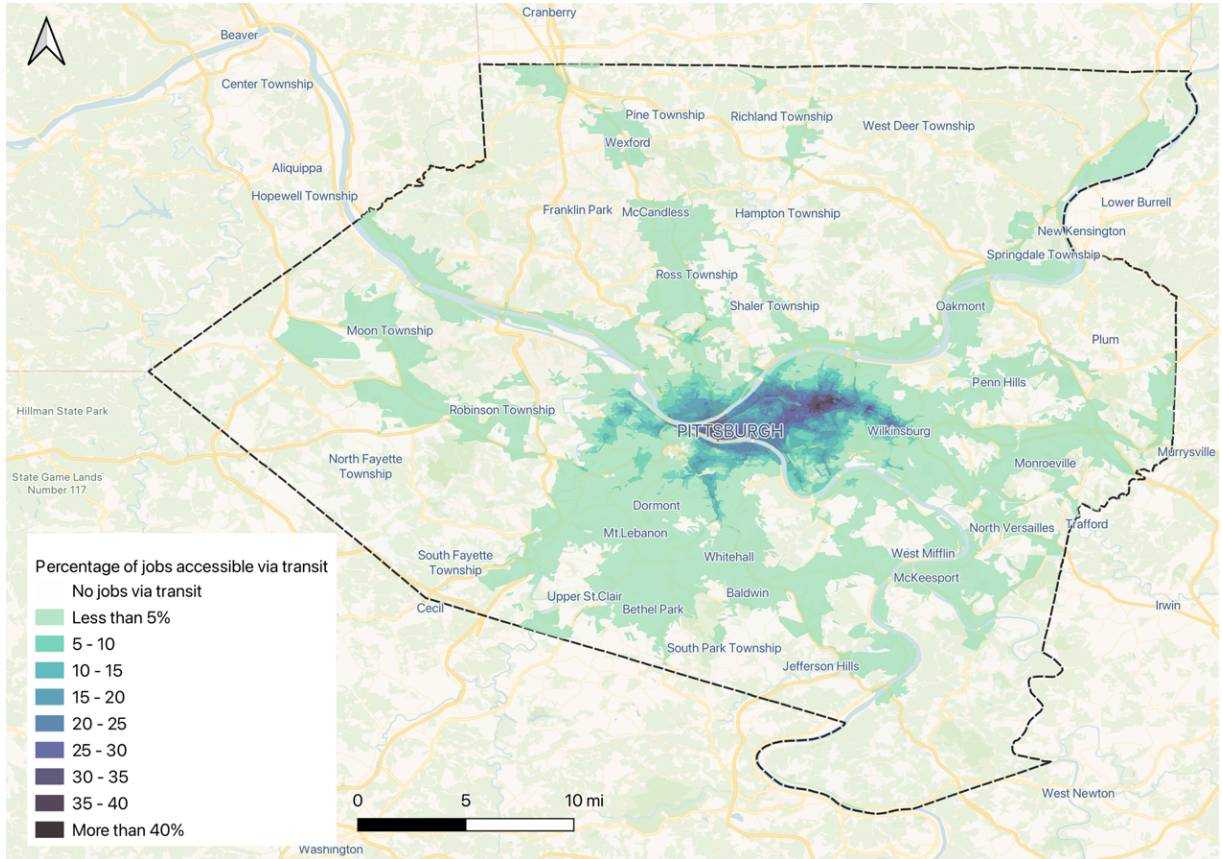

Appendix Figure 1: A map showing travel time to the third nearest public high school by biking on low stress (LTS 2) streets for Allegheny County, PA.
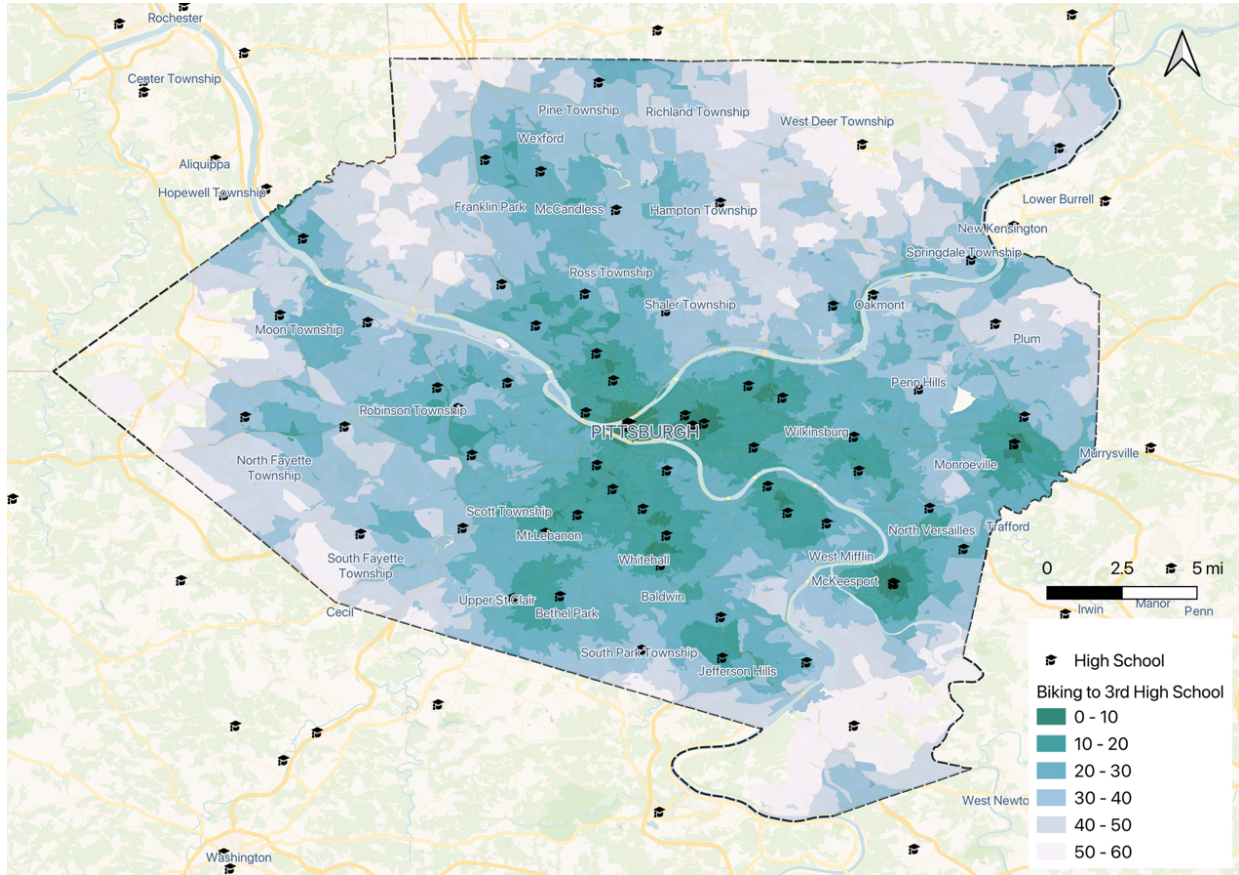
Appendix Figure 2: A map showing travel time to the third nearest public high school by biking on all stress (LTS 4) streets for Allegheny County, PA.

1.2.1.2   Example 2: Transit Access vs. Auto Access

Appendix Figure 3 shows the ratio of jobs reachable within 30 minutes by transit to jobs reachable within 30 minutes by auto in Allegheny County, PA. In this map, darker colors indicate locations (blocks) where the number of jobs reachable by transit is closer to the number of jobs reachable by transit, while lighter colors indicate locations where only a small share of the jobs reachable by auto could also be reached by transit. A low transit/auto access ratio suggest a location where transit network investment could make a meaningful improvement to transit job access, especially if transit investments are coordinated with existing and expected future job locations.

Appendix Figure 3: A map showing jobs accessible by walking+transit within a 30-minute travel time as a percentage of jobs accessible by driving for Allegheny County, PA.

1.2.1.3 Example 3: Trauma Center Access

Appendix Figure 4 shows trauma care access at the county level throughout Appalachia. Each county is colored based on the population-weighted average travel time by driving to the nearest trauma center. In counties colored white, the average resident can reach a trauma center within 30 minutes by driving. In counties colored orange, the average resident needs longer than 30 minutes to reach the nearest trauma center by driving. Within each county, trauma center access times from individual blocks may be higher or lower than the county average. Using 30 minutes (or a different selected travel time) as a target, this map can identify counties where trauma center access is worse than desired, and suggest additional investment to improve access.

In this example, it is not immediately clear whether the most impactful investment would be to improve travel times by driving (perhaps by improving highway standards or adding missing links in the road network) or by increasing the availability of trauma care centers (by adding new centers in locations where the current closest is far away). This is a useful

reminder that while access evaluation and investment consideration is typically viewed as a transportation concern, there are many cases where the greatest potential access improvement would come from a land use change.
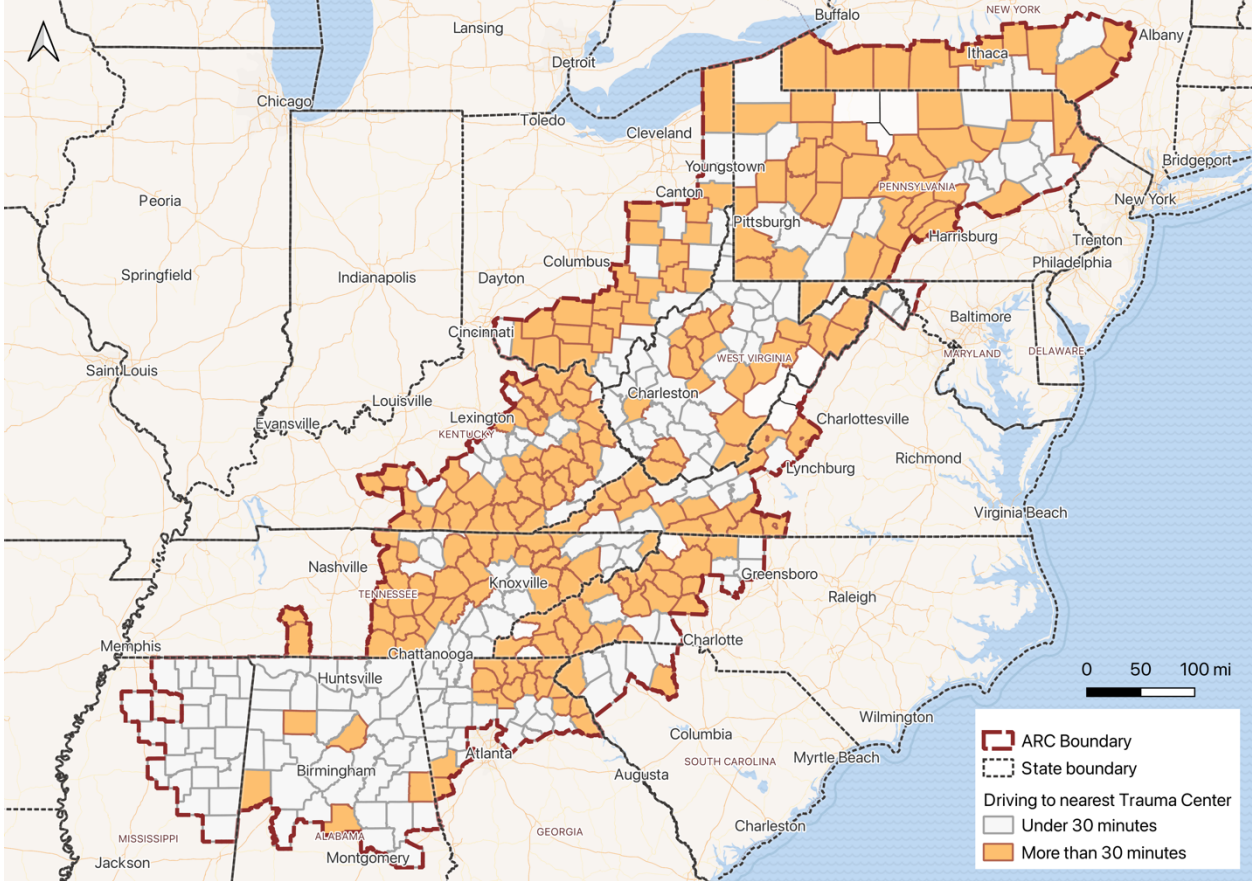
Appendix Figure 4: A map highlighting ARC counties where the average travel time to the nearest trauma center is more than 30 minutes.

1.2.2 Where should infrastructure be added?

The examples in **Appendix Section 1.2.1** demonstrate how access data can be used to identify locations where transportation investments or policy changes could have the greatest impact on destination access. However, it is important to recognize that this type of targeting indicates *where benefits could be seen*, but not necessarily *where infrastructure should be built*. The access improvements recognized through infrastructure depend on the arrangement of destinations, and on the network connecting to those destinations.

For example, in **Appendix Section 1.2.1.1**, a candidate investment location might be identified based on low LTS 2 access and high LTS 4 access. Improving bike lanes on residential streets in the targeted areas might improve cyclists' experience, but have little

impact on high school access if the true barrier to low-stress access is an arterial road several blocks away with no bike crossings.

Similarly, in **Appendix Section 1.2.1.3**, a candidate investment location might be identified based on excessive travel time to trauma centers. Depending on the locations of the closest trauma centers, the key to improving access might be adding a highway interchange in an adjacent county.

1.3 Web Map

Selections of the data produced by this project are available through web map interfaces. The web maps are designed to provide a quick way to explore and compare access data across different modes, locations, and destination types. More in-depth analysis is possible by downloading the underlying accessibility data files as described in **Appendix Section 1.1**.
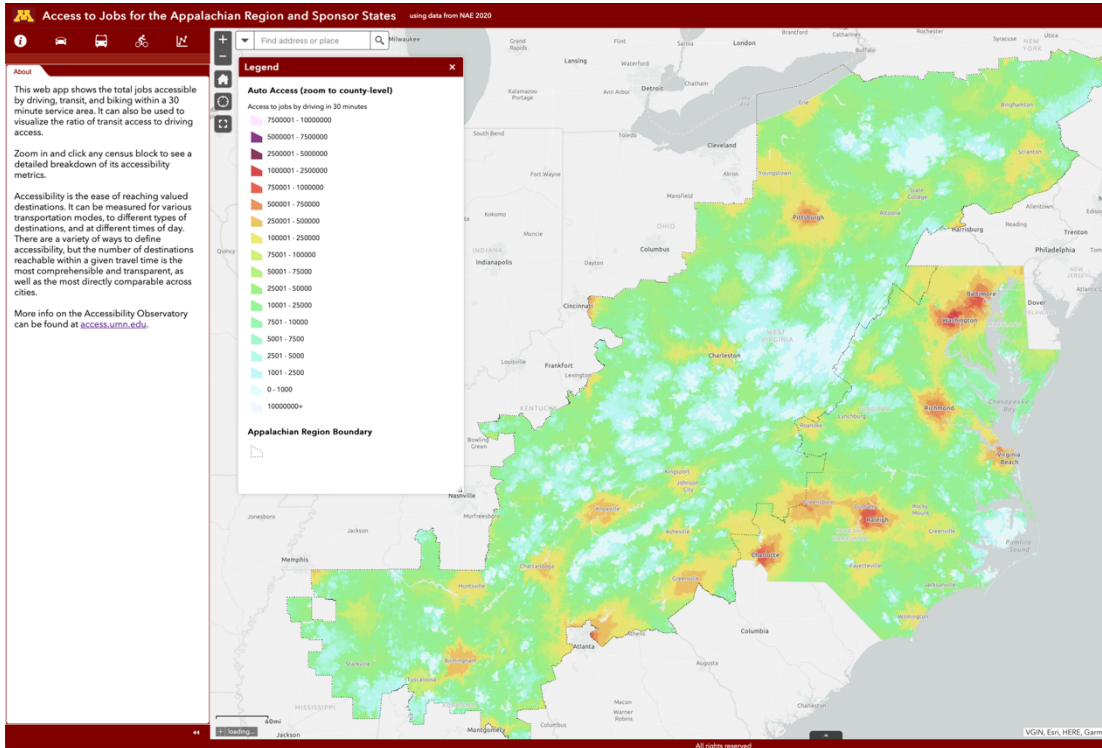
1.3.1 Job Access Web Map

The job access web map[29] provides an interactive interface for exploring block-level job access data throughout the study area. **Appendix Figure 5** shows the main interface of the web map. Navigation is accomplished by dragging the map, and the +/- buttons will zoom in and out. At closer zoom levels, clicking on the map will select an individual block and show access data for that location. The legend button in the top-right corner will show and hide the legend for the current selected map.

The layers interface on the left can be used to control what data is displayed. The car/bus/bike icons organize the available layers by mode, while the chart icon allows access to comparison layers between modes. It is possible to activate multiple layers at the same time, though most of the time it will be most useful to activate only one or two layers of interest.

Appendix Figure 6 shows an example of the mode comparison data. In this map, lighter colors indicate locations where bike access is low relative to auto access, and darker colors indicate locations where bike access is high relative to auto access.

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[29] Job access web app link:
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=1b4b5a15653b4bdfb13be92abd50c4b8

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Appendix Figure 5: A screenshot of the interactive web app delivered as part of Task 1 showing access to jobs by driving for all the ARC region as well as the partnering states.
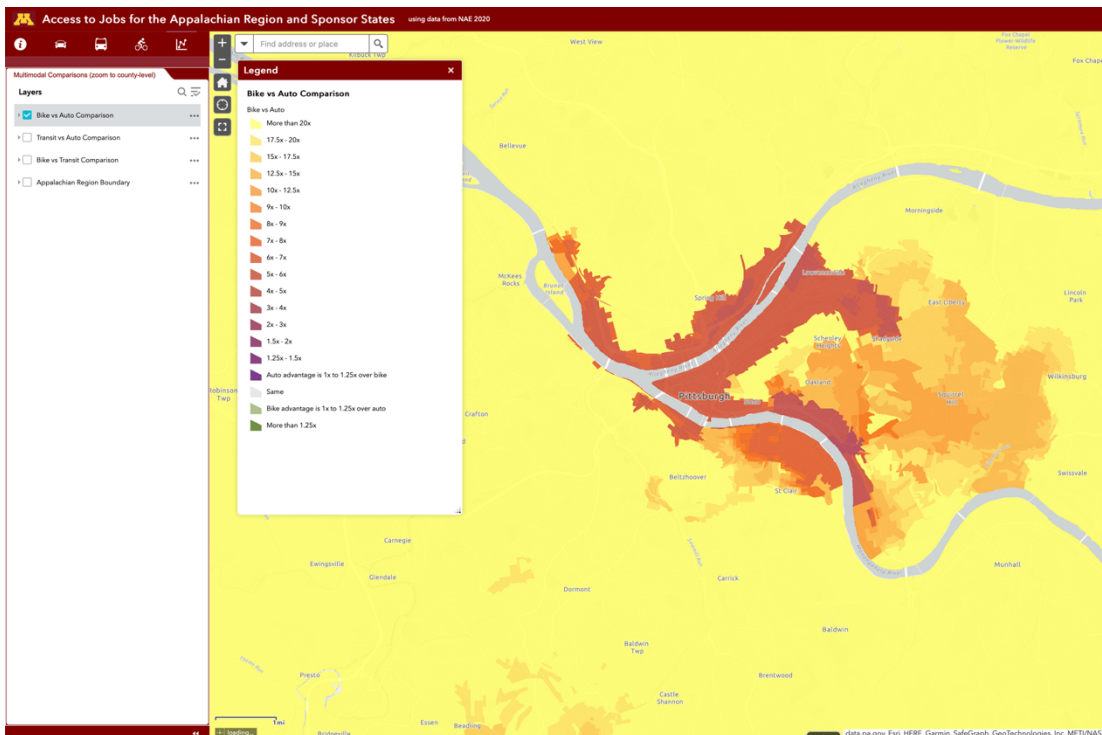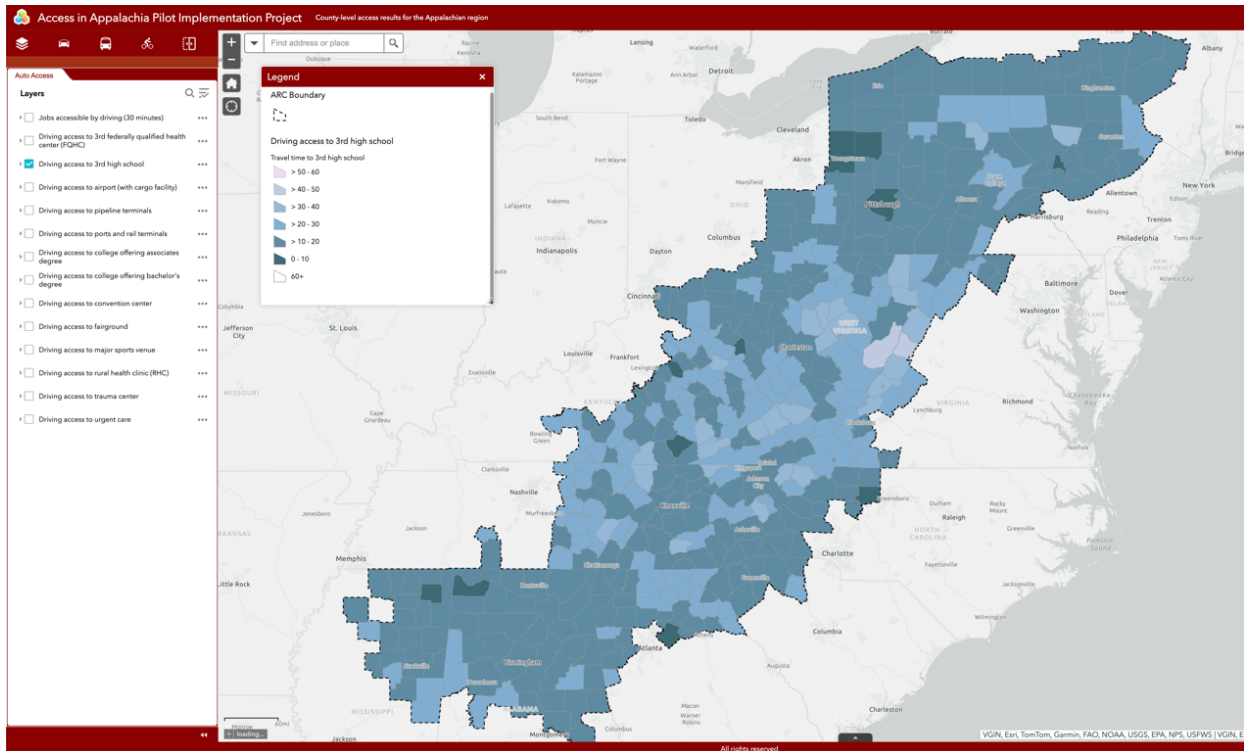

Appendix Figure 6: A screenshot of the interactive web app delivered as part of Task 1 showing the tab that can be used to compare job access via different modes.

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1.3.2 Destination Access Web Map

The destination access web map[30] provides an interactive interface for exploring access to non-work destination types throughout the study area, summarized to the county level. **Appendix Figure 7** shows the main interface of the destination access web map. The layer menu on the left can be used to select different combinations of destination type and transportation mode. Auto, transit, or bike can be selected at the top, followed by a particular destination type from the list of destination layers.
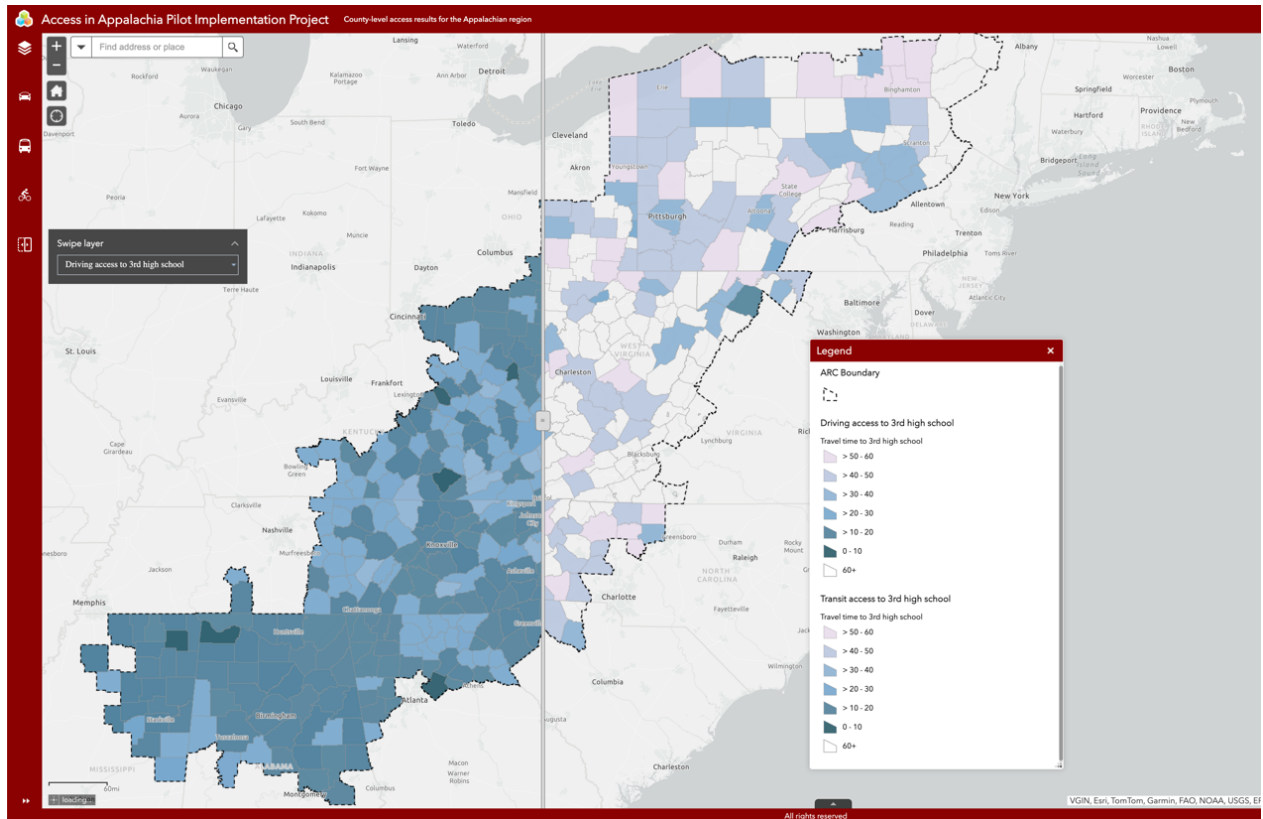

Appendix Figure 7: A screenshot of the destination access web map showing auto access to high schools, summarized to the county level.

The destination access web map also allows comparisons between access by different modes using a "swipe layer." When multiple layers are selected, the "Compare (swipe)" menu item will enable a swipe interface that alternates between the selected data layers, as demonstrated in **Appendix Figure 8**.

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[30] Destination access web app link:
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=371e7a0c5b77423e9d6a562a16798215

Appendix Figure 8: A screenshot of the destination access web map comparing access to high schools by auto and by transit.

The locations of individual destinations can also be seen using the destination access web map. The leftmost layer menu item provides a list of individual destination type layers. Selecting one of these layers will show the locations of individual destinations of the selected type. These locations can be combined with county-level destination access layers selected in the transportation mode layer menus. In **Appendix Figure 9**, locations of individual public high schools are displayed in combination with county-level transit access to high schools.
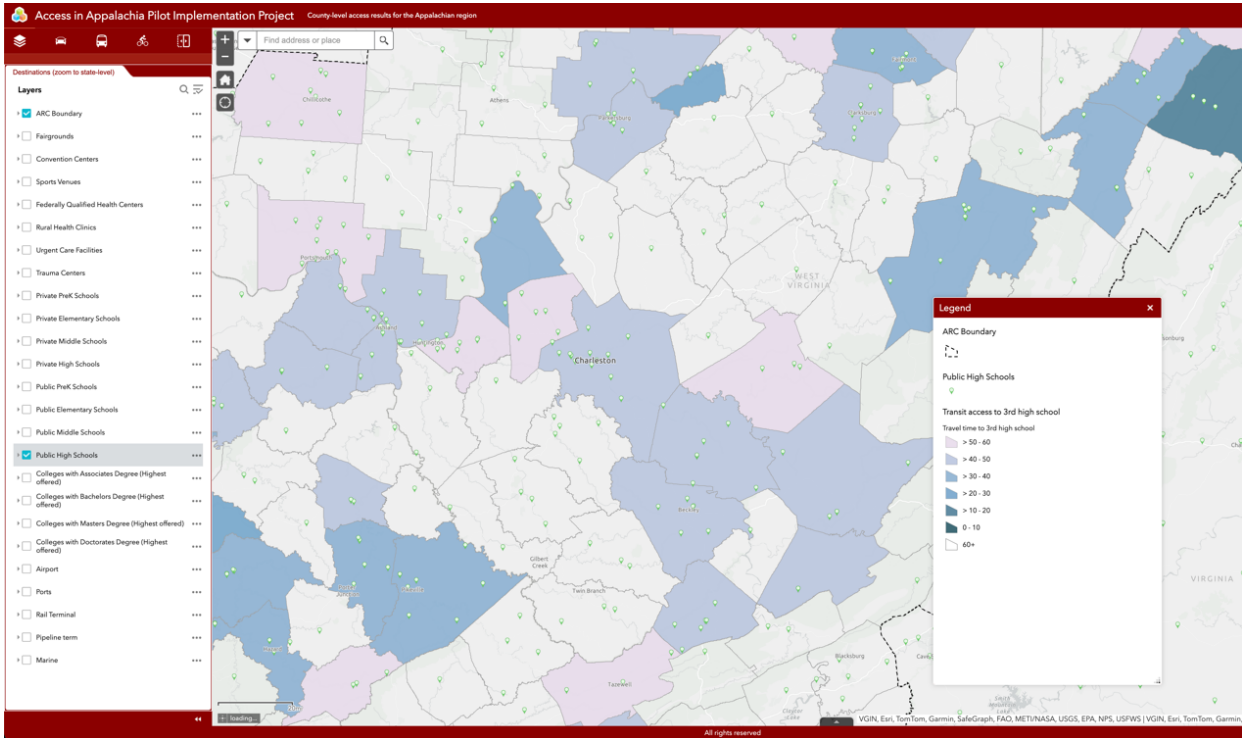
Appendix Figure 9: A screenshot of the destination access web map showing access to high schools by transit, with the specific locations of individual high schools also visible.