APPENDIX A

TECHNICAL APPENDIX: DESTINATION ACCESS METHODOLOGY

Appendix A describes the destination access methodology used in this study. For more details on data preparation and to access the raw data and scripts used to run both destination access and transportation cost analyses, please visit the study's Github page. Destination access analyses consist of three elements: transportation networks, destinations, and an analysis system. The sections that follow describe the purpose and set-up of each of these elements for use in this study.

A.1 TRANSPORTATION NETWORKS

For each mode, trips were routed onto the corresponding transportation network. Transportation networks are represented by spatial line data, and for this study they include driving (roadway network), public transit (public transit routes), bicycling (bicycle facilities), and walking (sidewalk network). We used Open Street Maps (OSM) for the driving, bicycling, and walking networks, which is the primary input for routing in Conveyal, and General Transit Feed Specifications (GTFS) for the public transit network. GTFS was acquired from all public transit agencies that operate in the Boston region, except Transportation Management Associations. OSM networks contain attribute tags for each segment, which can be used to set the analysis parameters. Useful attributes include roadway speed, sidewalk presence, and types of bicycle facilities.[28]

All networks reflected a typical weekday (or weekend in the case of the three park metrics) in fall 2019. We chose this time period because it was a time when the university student population was present, which was important for the higher education metric, and it avoided holiday travel during the summer. It also reflected conditions present during a season when people are more likely to bike or walk. Using 2019 networks maintains consistency

[28] For more information about OSM sidewalk tags, see *https://wiki.openstreetmap.org/wiki/Sidewalks*. For more information about OSM bicycle tags, see *https://wiki.openstreetmap.org/wiki/Bicycle*.

with analyses for the MPO's Long-Range Transportation Plan, Destination 2050: the same base year roadway and public transit network conditions are used in the travel demand model (TDM) for Destination 2050. While this decision does not account for the impacts of the COVID-19 pandemic or changes to public transit schedules in the intervening years, consistency with the TDM base year took precedence. This also allows for a pre- and post-COVID-19 comparison should this analysis be replicated in the future.

We also added congestion-related impedances from StreetLight to the roadway network to reflect traffic conditions on a weekday in 2019. These were applied to all metrics except the three parks metrics as those trips were assumed to occur on the weekend and thus impedances were not used.

A.2 DESTINATION DATA

Access can be analyzed to any destination for which consistent, up-to-date data are available. In Massachusetts, *MassGIS* maintains a repository of datasets for a wide range of destinations. Points are easiest to analyze, but lines and polygons are also possible with pre-processing to identify where the access points are. With open space polygons, for example, there may be a main park entrance that all trips are routed to. Smaller, urban parks may have multiple entrances where the park meets the road. If entrances are identified as the intersection between the road network and the line or polygon, a buffer is helpful to account for slight differences in geospatial rendering.

Another consideration for all destination data is weighting. For example, simply analyzing access to higher education institutions would weight all destinations the same regardless of the capacity of the school. In this case, the destinations can be weighted by enrollment, so that the analysis reflects that there are more opportunities available at, for example, UMass-Boston, than at a smaller school. In many circumstances, pre-processing is needed produce weighted values.

Destination data used in this study were downloaded and cleaned, then uploaded to Conveyal. The destinations and their definition and data sources are shown in Table A-1.

TABLE A-1

Destination Access Equity Indicator Metrics

EQUITY INDICATOR METRICS	DATA SOURCES	DEFINITION
Access to Jobs	Destinations: LODES 2018	Number of jobs
Access to Higher Education	Destinations: MassGIS Enrollment: NCES, school websites, College Board, and US News and World Report	Number of accredited institutes of higher education that have a graduate population and/or where at least 50% of the undergraduate population lives off-campus, weighted by enrollment
Access to Non-Emergency Healthcare	Destinations: MassGIS and MADPH	Number of community health centers, clinics, and acute care hospitals
Access to Emergency Healthcare	Destinations: MassGIS	Number of acute-care hospitals

EQUITY INDICATOR METRICS	DATA SOURCES	DEFINITION
Access to Essential Places	Destinations: MassGIS, MAPC, MADPH, and USPS	Clusters that are groups of at least four essential places—health, civic, and food destinations—linked by a maximum of 161 meters in the Inner Core subregion or 483 meters in other subregions
Access to All Parks	Destinations: MassGIS	Publicly accessible open space whose primary purpose is conservation and/or recreation
Access to Large Parks	Destinations: MassGIS	Publicly accessible open space whose primary purpose is conservation or recreation and that are at least 124 acres in size
Access to Off-street Paths	Destinations: MassGIS	Shared-use paths that are on a separate right-of-way from the road network

MADPH = Massachusetts Department of Public Health. MAPC = Metropolitan Area Planning Council. MassGIS = Massachusetts Bureau of Geographic Information. NCES = National Center for Education Statistics. USPS = United States Postal Service.

A.3 ANALYSIS SYSTEM

As described in this report, Conveyal is one of several platforms that can analyze destination access. It runs quickly, operates on an open-source platform, provides analyses for several transportation modes, and is easily customizable and scalable, which made it a good choice for this study. In addition to network and destination customization, the Conveyal platform also allows users to customize the following settings:

- **Access/egress modes.** Walking or driving can be selected as the "first/last-mile" mode for transit trips. If walking is chosen, a walking speed is required.

- **Date and time of day.** Date and time settings determine public transit trip schedules from GTFS. While it is not required, if impedances are used analysts should choose a day and time for the driving trips to select the correct impedance. For example, when analyzing access to jobs, we selected the weekday morning peak period since that is when traffic is greatest.

- **Decay.** A decay function indicates whether and how destinations that are closer are weighted higher than destinations that are further away.

- **Level of Stress (LTS).** OSM tags are used to generate LTS on links on the bicycle network. Conveyal has assigned LTS tags (1 through 4) on bicycle network segments, which is based on road speed and the type of bicycle facility present. In this study, trips were routed onto rights-of-way that have a LTS of one or two. An LTS of one or two will route bicycle trips onto rights-of-way that
    - do not allow cars, or
    - are tagged as residential roads, or
    - have a maximum speed less than 25 mph and four or fewer lanes, or
    - are connector roads and have a bicycle lane in the direction of the traffic.

- **Maximum walk or drive time.** Users can set the maximum walking or driving time for access and egress for public transit trips.

- **Time percentile.** This setting indicates how likely public transit riders are to adjust their departure time based on published schedules. Higher time percentiles are used for frequent service (such as rapid transit) and lower percentiles for service where riders show up to catch a particular scheduled service (such as commuter rail).

- **Transfers.** Users can select the maximum number of transfers that will be permitted in each public transit trip. Transfer time is considered in the travel time calculation.

- **Travel time threshold.** These thresholds determine the travel-time limit for reaching destinations. Any destination that takes longer than the threshold to reach is considered not accessible.

- **Walking and bicycling speed.** Users can set the speed for walking and bicycling trips.

A.4 OTHER ANALYSIS CONSIDERATIONS

GEOGRAPHY

Destination access analyses require defining an analysis area, as well as selecting a geography for origins. When selecting the geography, the smallest reliable geography is preferable. If conducting an analysis of access for all people in the analysis area (as opposed to discrete demographic groups), population (or other aggregate variable) data can be attached to the origins to allow for analysis of access within the Conveyal interface.

POST-PROCESSING FOR DEMOGRAPHIC ANALYSES

The output for Conveyal is a raster grid that shows the number of destinations that can be accessed from each origin grid cell. The output can be downloaded and processed for a variety of custom indicators, including access for different demographic groups.

Conveyal runs produced the number of destinations accessible for the entire population in the Boston region and in each Community Type. Once these runs were completed, we downloaded the outputs to analyze the number of destinations accessible to each equity and non-equity population. The Conveyal output is a raster grid—each cell acts as an origin, containing the number of destinations that can be accessed throughout the region from that starting point. Since demographic data is available as polygon vector data, we used binary *dasymetric interpolation* to allocate the demographic data to the grid cells based on two filters: residential road and land cover classification. We then determined the total number of destinations accessible to each equity and non-equity population in each CT and in the Boston region by multiplying the total number of accessible opportunities by the percent of each equity and non-equity population estimated to live within that grid cell and summing the results across all grid cells. The final step was to calculate the average number of destinations accessible per person so that we could determine whether equity populations have access to fewer destinations than their non-equity counterparts.

APPENDIX B

STATE OF THE CURRENT PRACTICE

In undertaking this study, MPO staff wanted to ensure that efforts were duplicative among other agencies and organizations in the Boston region and complemented their efforts where possible. In addition, many MPOs across the country have pursued similar initiatives to address transportation equity and improve outcomes among marginalized and underserved populations in their region. To better understand types and scope of metrics that could be used for this study, staff reviewed similar work done by MPOs across the country. This section summarizes the findings.

B.1 BOSTON REGION

- **Metropolitan Area Planning Council (MAPC):** In 2011, MAPC released the report The State of Equity in Metro Boston. The report identified several equity-related cross-sectorial indicators both in transportation and other planning areas. In 2017, MAPC produced an *update*, using new data and adding additional indicators. Of particular interest to this study, the report examined several metrics related to transportation, including average travel-time disparities between people of color and their white counterparts. The report also documents other indicators that are not directly related to transportation but for which transportation is a factor in their outcomes. This includes health outcomes, income disparity, racial segregation, and employment indicators.

- **Boston Indicators Project:** A research center at the Boston Foundation, the Boston Indicators Project (BIP), periodically produces equity indicators related to transportation, including access to public transit and commute lengths in Boston and other neighborhoods in the inner core, ridership on essential bus services during the pandemic, and changes in bicycle use in the Boston region before and during the pandemic. The BIP also produced a summary report of key findings from two years of their COVID

Community Data lab, which charts changes over the course of the pandemic with eight key indicators, which include public transit ridership by mode and line and Bluebikes ridership.

- **Massachusetts Department of Transportation (MassDOT):** MassDOT has created a destination access dashboard, which specifically displays access to jobs by various travel modes and at different times of day, and travel times from each census block group in Massachusetts. The dashboard does not compare results across demographic groups, but the block group-level data can be downloaded for use in additional analyses.

Of note, MassDOT is currently developing a new Statewide Long-Range Transportation Plan (SLRTP), *Beyond Mobility*. As part of Beyond Mobility, an existing conditions analysis will be produced, which will identify the transportation needs in Massachusetts, both statewide and locally, based on public input and data analyses. The data analysis portion will include several equity-related analyses. During the study, MPO staff coordinated with MassDOT staff to ensure their respective work efforts support and complement each other.

B.2 EQUITY METRICS AT OTHER MPOS

Many MPOs have developed metrics that assess impacts to equity populations. Many metrics are associated with the TIP and LRTP project selection analyses and EJ analyses, but some are independent of these efforts. Several of these metrics are described below.

- **Racial Equity Baseline Report, Southern California Association of Governments:** This report covers a wide range of racial equity indicators, in transportation and other sectors. Those related to transportation include access to jobs or open space, travel time to work, access to a vehicle, and bicycle and pedestrian crashes. Most of the results are reported as a percentage of each race or ethnicity in the region that meets the metric definition.

- **Walk-Access Screening Tool, Madison County Council of Governments (MCCOG):** As part of a health impact analysis conducted for the Madison County MPO region, the MCCOG developed a network-based buffer tool to estimate the percentage of population that has access to various destinations, including parks, government services, grocery stores, schools, bus stops, and medical services within various travel times.

- **Access to Core Services Report, Southeast Michigan Council of Governments (SEMCOG)**: This report includes the percentage of the population with access to destinations across several modes and travel times and includes equity populations.

- **Concept 3, Atlanta Regional Council (ARC):** For scoring transit projects, ARC considers the change in access to jobs due to a new transit project but does not directly consider change in access for equity populations.

- **Plan Bay Area 2040 Equity Analysis Report, Metropolitan Transportation Commission (MTC):** MTC analyses are across several topic areas, including health outcomes (PM2.5 exposure, safety, access to parks); access to jobs; access to opportunities (resource rich areas); access to public transit; and housing costs and transportation affordability, among others.

B.3 THINK TANK METRICS

Some think tanks also have developed metrics that assess impacts to equity populations:

- **Tracking Transit Equity in US Cities, Transit Center:** This metric assesses travel times to various destinations for different demographics, number of jobs accessible within a travel time for different demographics, number of transit trips available within an hour, transit fares, and on-time performance.

- **Access Across America, University of Minnesota's Accessibility Observatory:** Access Across America measures access by different travel modes—public transit, driving, biking, and walking—across major metropolitan areas.

B.4 FEDERAL GOVERNMENT

Other analytical tools have emerged recently at the federal level as a result of the Biden administration's *Executive Order 14008*, also known as *Justice40*. Justice40 sets the goal for 40 percent of government benefits to be distributed to disadvantaged communities. As part of this effort, several online tools have been created to identify these communities and the disproportionate impacts that they bear. The ones described here contain metrics that relate directly to transportation and/or are outcomes that result in part from transportation.

The Climate and Economic Justice Screening Tool (CEJST) was developed by the Council on Environmental Quality to identify disadvantaged communities that are overburdened by pollution by using nationally available datasets. The CEJST provides a variety of climate, socioeconomic, and climate information for each community, including metrics related to health burdens, sustainable housing, and clean transit. The tool uses the official federal designation of "disadvantaged communities" to allow consistency between federal agencies.

For several years, the Environmental Protection Agency (EPA) has maintained the tool *EJScreen*, an EJ mapping tool that uses a nationally consistent dataset and approach for combining environmental and demographic indicators across communities in the US. Many of the metrics used in the CEJST are derived from the EJScreen dataset. EJScreen metrics include particulate matter, traffic proximity, and climate impacts.