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5/9/24

Investigating the Boston Commuter Rail

Abstract:

How people move in and out of the city of Boston has long been a question for researchers to examine. By planes, trains, and automobiles, thousands of people commute in and out of Boston every day for work, school, and leisure and in recent years public transportation has continued to expand access for more people to easily get in and out of the metropolitan area. The MBTA Commuter Rail is one of the most rapidly growing forms of public transportation in the state with plans to get much larger in the future. It will be critical to data analytics and data science on past MBTA data and emerging cell phone data sources like SafeGraph to outline the ideal strategy for the upcoming expansion. Creating strong models and data visualizations now can provide the necessary insights for policymakers to create an efficient, sustainable, and accessible commuter rail for millions to use for years to come.

Introduction:

This project studies the MBTA Commuter Rail System and tries to track people moving in and out of Boston by train. The Commuter Rail has been a staple in Boston transportation since 1977 and has twelve lines available to most counties of eastern Massachusetts and parts of Rhode Island. Daily weekday commuter rail ridership in December of 2023 was self-reported at 93,854 riders via the MBTA Performance Metrics. The goal of the train system is to provide an alternative to commuters in and out of Boston that would limit car congestion on the major highways and deposit riders into the subway hubs of North Sation, South Station, and Back Bay Station. Massachusetts Governor Maura Healey promised over three hundred million dollars of

the state budget to the MBTA for 2024 with forty-five million earmarked for a system-wide reduced fair option for low-income riders. She has stated that she has a goal of a “true west-east and east-west passenger service from Pittsfield to Springfield to Worcester to Boston and back.” Healey has also created a task force intending to re-evaluate the state’s transportation system and create a long-term financial plan focused on sustainability. This goal matches the UN Sustainability Goal number nine, “Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.” The state of Massachusetts has a clear plan to work on the MBTA and commuter rail to meet these goals so we need to investigate how they might do that.

Literature Review:

Previous research on the Commuter Rail on the real-time information on rider movement was heavily looked into in 2012 by a group of college professors, Dr. Candace Brakewood, Dr. Francisca Rojas, Dr. P. Christopher Zegras, Dr. Kari Watkins, and Joshua Robin in a study titled “An Analysis of Commuter Rail Real-Time Information in Boston.” The study focused on passenger use of real-time data to plan their movement to try and decrease wait times and improve ridership. The researchers conducted on-board surveys of the riders on two lines of the Boston commuter tail and sought to understand how real-time information on digital platforms might help riders and transit managers be more efficient. The researchers concluded that this real-time data didn’t provide a tremendous impact on the commuter rail experience but that folding it into the same system with subway and bus real-time information would be beneficial as people could have a more seamless transition from one form of public transit to the other.

The second factor that has been researched in regards to the commuter rail is accessibility. In “An evaluation of the accessibility benefits of commuter rail in Eastern

Massachusetts using spatial hedonic price functions", Dr. Robert Armstrong and Dr. Daniel Rodriguez looked into how the Boston commuter rail was affecting housing prices around the stations in the area of the stations in 2006. The two found that houses within half a mile of commuter rail stations had an increase in value of 10.1% to similar homes outside of this so-called "buffer area" and towns with commuter rail stations had home values of 9.8% higher than towns without. There is a major advantage to having a commuter rail stop in your town as it creates easier accessibility to the train and thus to Boston. This study also makes us question whether the state has purposefully built commuter rail stations in wealthier areas to deny access to lower-income people who might not be able to afford other forms of transportation. Part of this project must examine this and determine where additional future stations could help assist commuters who need the rail the most.

Research Questions:

The research conducted in this project on the commuter rail is on the ridership and visitation of the rail at the present moment and how it may be improved in the future. It is clear that policymakers are making expansion of the MBTA a priority and determining the best path forward is a question that needs an answer. How many people have been riding the commuter rail over the past few years and what railways have they been taking? What does a day on the commuter rail look like and where are people getting on and off? Where are the rail stops and how far are people willing to go to get there?

Data:

The data used in this project should come from several sources. The first would be the MBTA itself on their ridership count data. Over the past decade, the MBTA has tracked how many riders have gotten on and off at each stop along the commuter rail. This information will

be critical in understanding what the day-to-day looks like at all the various stations and help determine which stations have the highest workload. The second data source would be the SafeGraph mobility data tracking cell phones and rider movement. In creating points of interest around each station, it is possible to track how people arrive and depart from the commuter rail.

Methods:

The plan for breaking down the data will be in two parts: building statistical models and building data visualizations. Using Tableau, the MBTA data was broken down for use in data visualization and data analysis. First, the long-term data set with all total boardings on each railway from June 2020 to February 2024 was broken down and analyzed. A visualization of monthly total boardings and daily total boardings was the first data analyzed and put into a line graph with projections for the future (Fig 1 and 2). Second, the smaller more detailed MBTA data from January 2018 was analyzed in Tableau. Two line graphs were made of the hourly "on and offs" of passengers on each MBTA line and the "ons and offs" for the stop sequence on each MBTA line (Fig 3 and 4). The third data analysis was done on the SafeGraph POI data and started in Python. Using the Latitude and Longitude of specific stations, little bubbles around certain stations were created to examine what was going on around the stations. With lots of different businesses in and around the stations, such as sandwich shops, small technology stores, and even a major sports stadium, using overall locations would be too tricky as it is difficult to determine whether these individuals were riding the train. However, the "naics_id" of 482111 is a code for rail stations and thus could be used to filter more directly to people there to ride trains. Taking the SafeGraph data from July 2019, August 2020, and August 2021 into Tableau, the next step was building spatial maps to demonstrate the raw visitors and distance traveled by visitors to each station (Figure 5-9).

Results:

The general results from the study show a steady increase in ridership from the very poor numbers during the COVID-19 Pandemic across all rail lines. The Providence and Worcester lines are the most popular lines throughout the 4 year span in the MBTA Data maxing out at 536,723 and 346,923 Monthly Boardings. The Newburyport/Rockport line has more seasonal ridership with massive spikes every October due to the massive Halloween festivities in Salem which is right in the middle of the line. The future projections made for each rail line can be seen in Figure 1 and each line should maintain steady growth for the next two years. By December 2025, the Providence line is predicted to have over 755,000 monthly riders, a massive increase from the 8,000 monthly riders in June 2020 during the height of the COVID-19 Pandemic. The Fairmount Line has the lowest ridership and is projected to grow from 81,000 riders in January 2024 to 115,000 riders by December 2025. All of the other rail lines have projected ridership between those two levels and accounts for the annual massive ridership spike in October on the Newburyport/Rockport Line. In looking at the Daily Boarding visualization, Figure 2, the Halloween spike on that line usually gets close to 20,000 riders on that line before returning to more normal levels over the next month so accounting for that in the projection is crucial. The same can be said for Marathon Monday on the Worcester line which has the highest single-day total with 29,455 riders on April 17, 2023. This serves as an outlier as that line rarely gets over 15,000 daily riders. The visualizations produced in Figures 3 and 4 regarding the hourly “ons and offs” and the “ons and offs” at each stop provide the opportunity to examine what a day looks like on the commuter rail. There are steady increases in ridership throughout the morning peaking at noon before a long lull in the afternoon before a similar rise and fall in the evening peaking at 10 PM. People getting on the train and then getting off the train are correlated by

about one hour which demonstrates that the longest train rides are about an hour. In looking at Figure 4, the stop sequences show that most people get on the train at the beginning of the respective line and most get off towards the end of the line. This demonstrates that most riders come from farther away to get on the commuter rail and the expansion of the line outward away from Boston could make it easier for people to access the system.

The spatial data from SafeGraph is not quite as complete and robust a sample as the MBTA data but there are still insights to be gained. The maps built in Figures 5-9 illustrate which stations are being visited the most and how far from home the visitors are traveling to get to those stops. The main stops at the end of the line in Boston have the highest numbers of visitors and the greatest distance from home traveled by their visitors. There are several other stations that have similar patterns such as the Providence, Rhode Island station, the Foxborough station, and the Lowell station. These are all end-of-the-line stops and the potential expansion of the line outwards is supported by this data. The spatial visualizations show how far apart the stations are and where the trains are going and stopping which is crucial for future proposals.

Study Impact and Policy Implications:

Governor Healey's plans for the expansion of the commuter rail system across the state are supported by the study. The end-of-the-line stops draw the most people from the farthest distance and building new stops closer to their homes will improve overall sustainability in the system. Improved technology in high-speed trains would probably be necessary to maintain the hour-long commute held by most commuter rail riders. The train schedules generally run one train every hour and lengthening the line would force that schedule to change. Either more trains would need to run or there would need to be an adjustment to an hour and a half or even two-hour schedule if the same kind of locomotive was used. A high-speed rail system could keep

the hour-long schedule intact. With growing overall ridership, a high-speed system might be necessary to accommodate new riders as trains might be more likely to be fully booked. Faster trains could run more often and handle a larger and growing ridership. This study helps riders as it will allow policy makers to make the proper investment in expansion of the rail system to reach more people more efficiently.

Reference

Candace Brakewood, Francisca Rojas, P. Christopher Zegras, Kari Watkins, Joshua Robin, An Analysis of Commuter Rail Real-Time Information in Boston, Journal of Public Transportation, Volume 18, Issue 1, 2015, Pages 1-20, ISSN 1077-291X, https://doi.org/10.5038/2375-0901.18.1.1.

Armstrong, R.J., Rodríguez, D.A. An Evaluation of the Accessibility Benefits of Commuter Rail in Eastern Massachusetts using Spatial Hedonic Price Functions. *Transportation* **33**, 21–43 (2006). https://doi.org/10.1007/s11116-005-0949-x

MBTA ridership data https://www.mbta.com/performance-metrics/ridership-the-t

Expansive Station by Station MBTA Data https://mbta-massdot.opendata.arcgis.com/datasets/3b93de20570f462ea27219dfb7e75347_0/explore

Opinion Article on Commuter Rail https://www.americancityandcounty.com/2023/06/07/bostons-commuter-rail-system-is-outdated-and-needs-an-overhaul-according-to-advocacy-report/

TransitMatters Brief on Transit https://static1.squarespace.com/static/533b9a24e4b01d79d0ae4376/t/6478dd971efd1f75dcd3e293/1685642650655/TransitMatters+-+Turning+Vision+Into+Reality.pdf

Boston Globe article on Commuter Rail ridership increases in summer 2023

https://www.bostonglobe.com/2023/06/07/metro/mbta-commuter-rail-ridership/

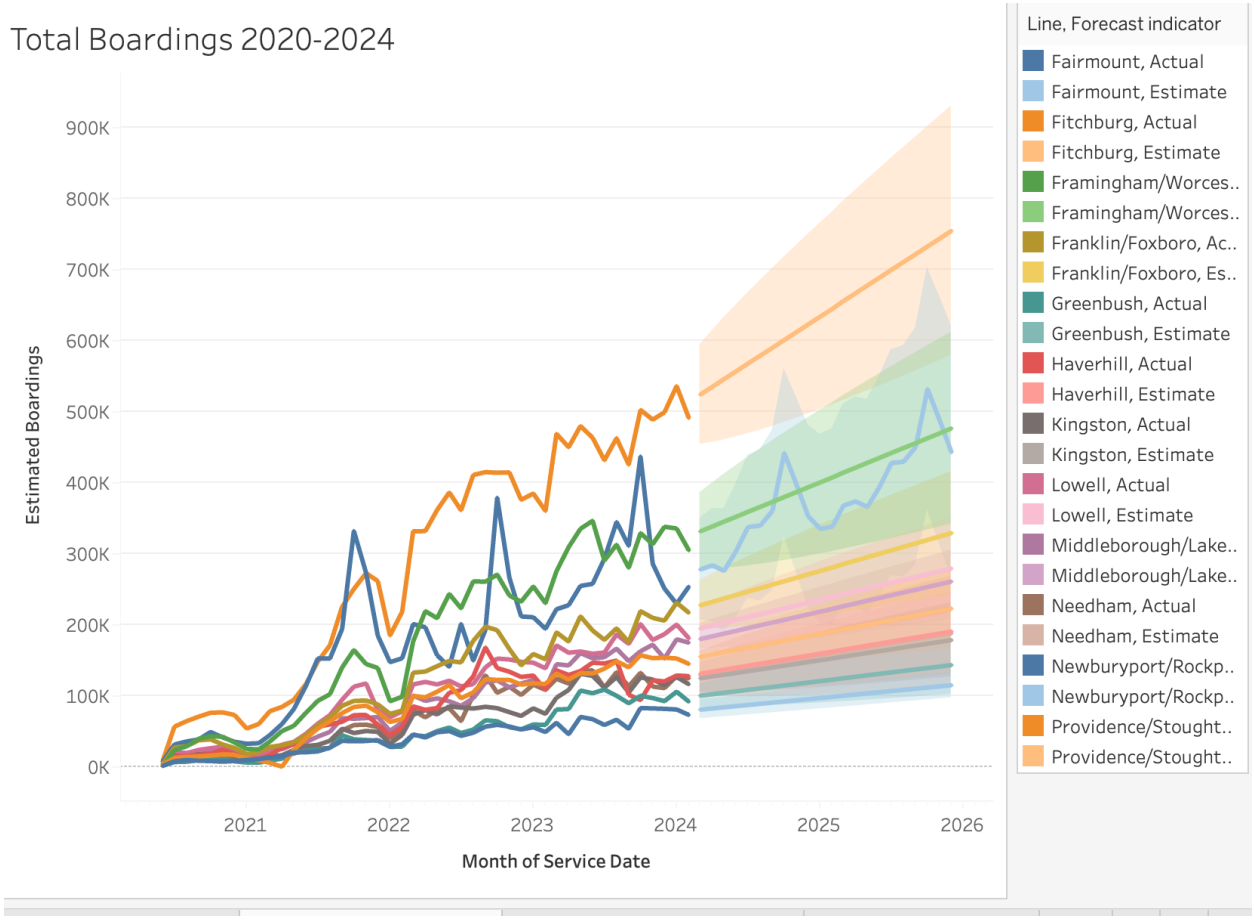
Maura Healey Recent Budget Proposals from Spectrum News

https://spectrumnews1.com/ma/worcester/news/2024/02/13/gov--healey-touts-investments-in-mbta--east-west-rail

Appendix

Task Allocation Statement: All work done on this project was done by me, Jackson Reydel.

Figures:

1. 

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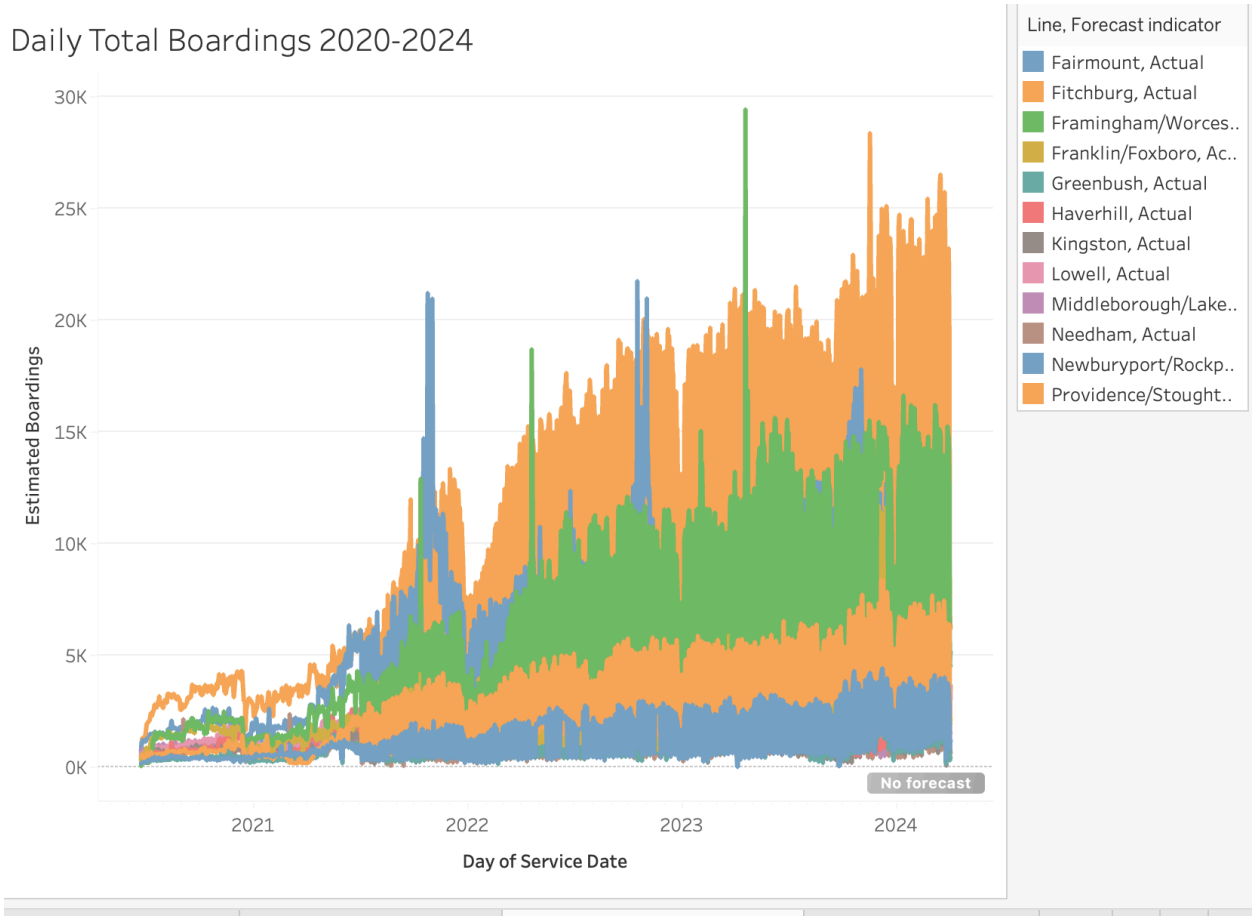
Daily Total Boardings 2020-2024
Estimated Boardings
30K
25K
20K
15K
10K
5K
0K
No forecast
2021
2022
2023
2024
Day of Service Date
Line, Forecast indicator
Fairmount, Actual
Fitchburg, Actual
Framingham/Worces..
Franklin/Foxboro, Ac..
Greenbush, Actual
Haverhill, Actual
Kingston, Actual
Lowell, Actual
Middleborough/Lake..
Needham, Actual
Newburyport/Rockp..
Providence/Stought..

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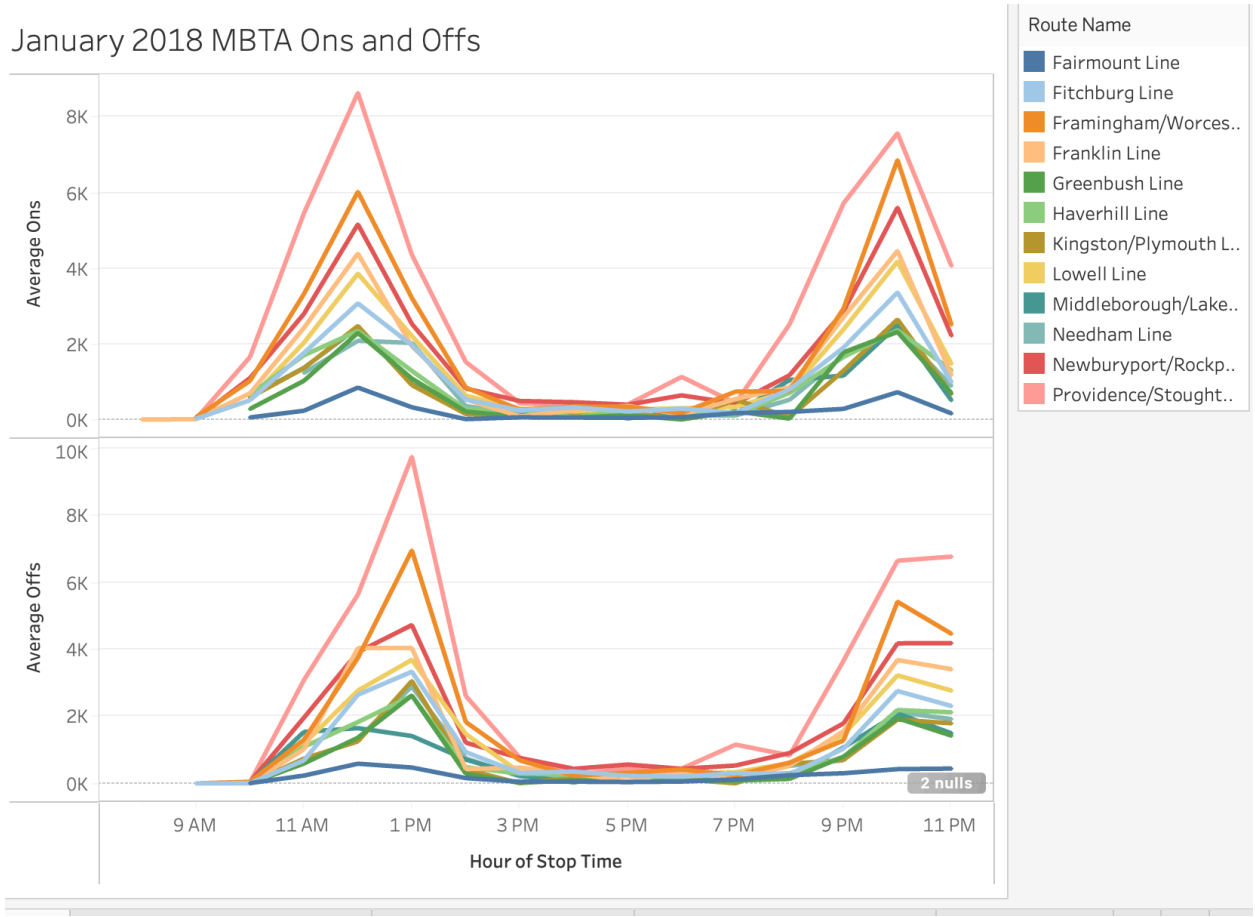
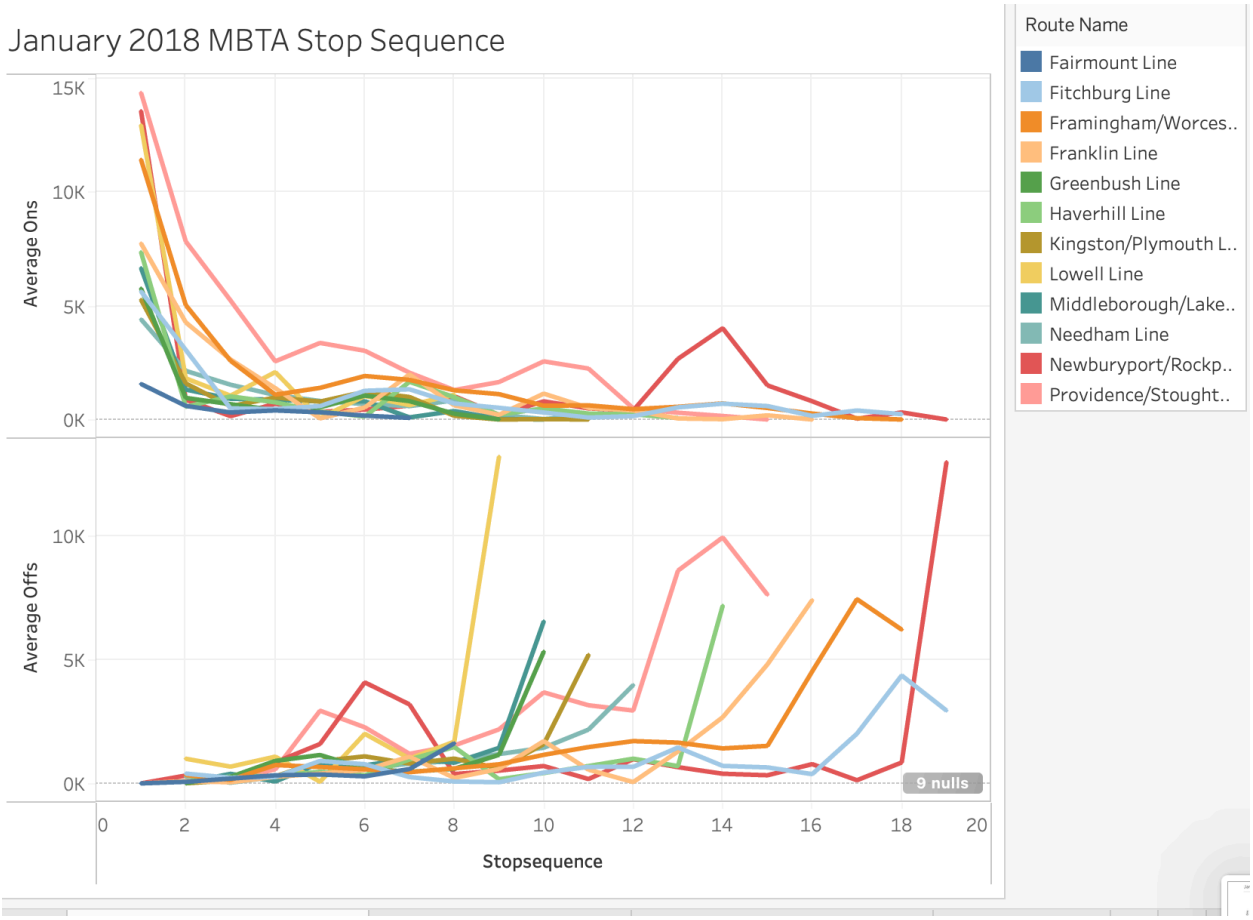
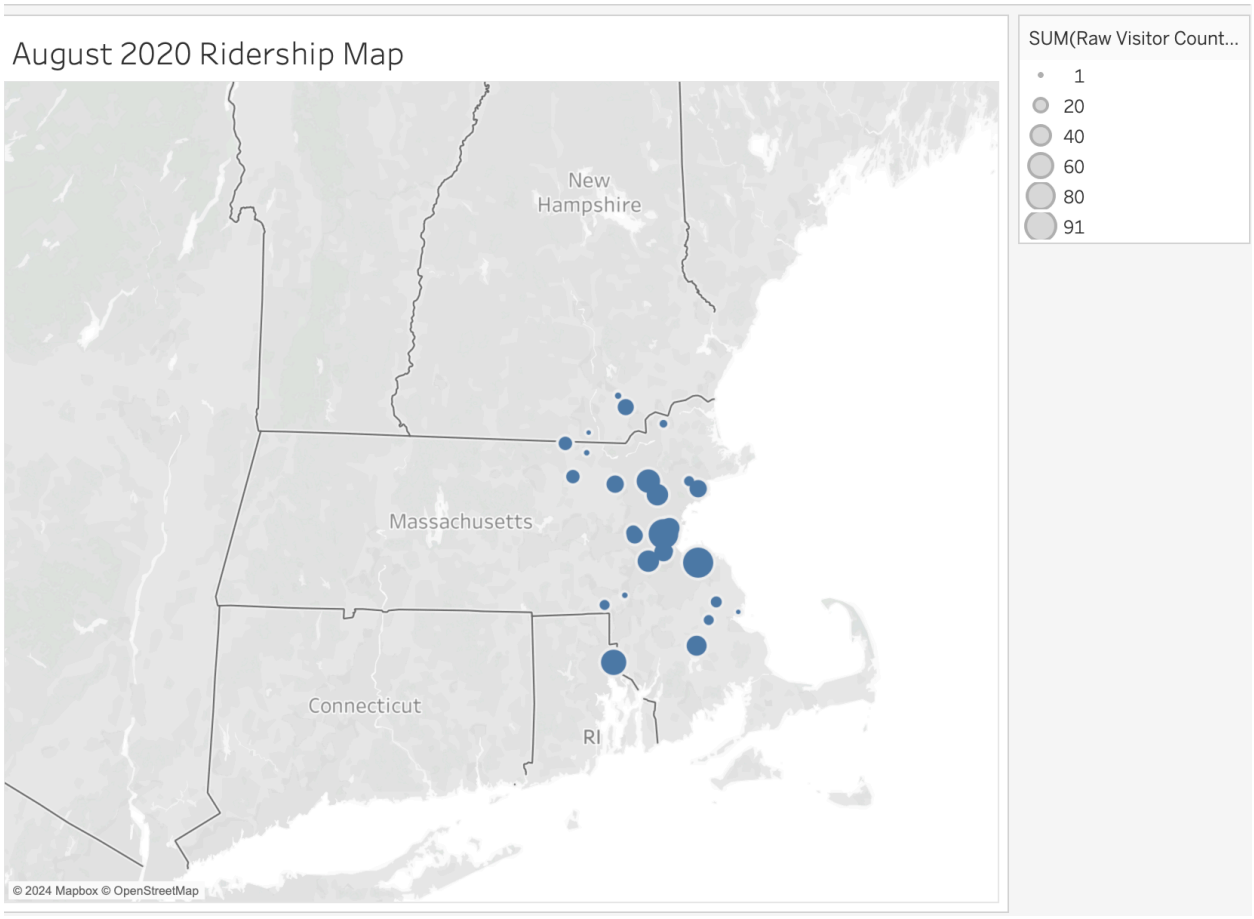
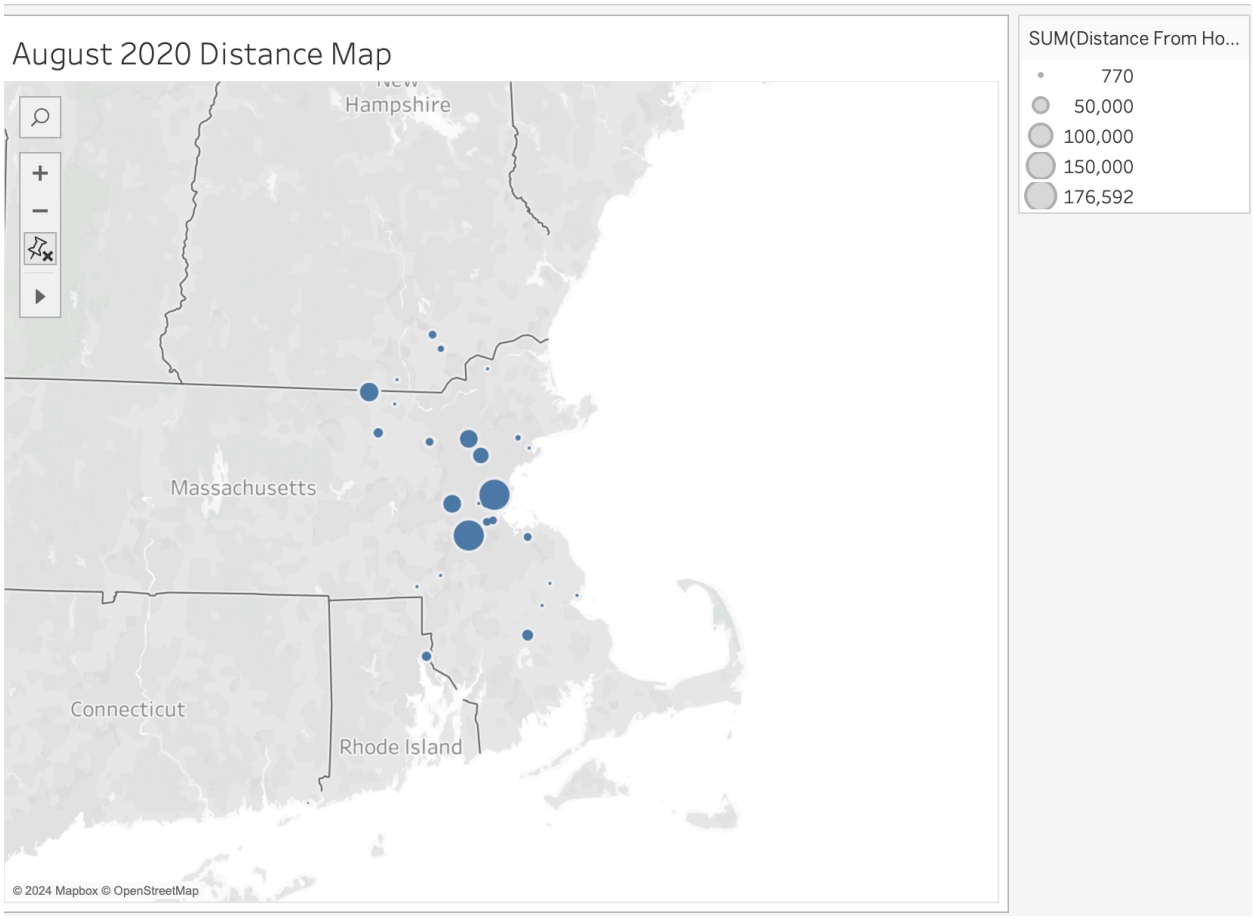

January 2018 MBTA Ons and Offs
Average Ons
8K
6K
4K
2K
0K
Average Offs
10K
8K
6K
4K
2K
0K
2 nulls
9 AM
11 AM
1 PM
3 PM
5 PM
7 PM
9 PM
11 PM
Hour of Stop Time
Route Name
Fairmount Line
Fitchburg Line
Framingham/Worces..
Franklin Line
Greenbush Line
Haverhill Line
Kingston/Plymouth L..
Lowell Line
Middleborough/Lake..
Needham Line
Newburyport/Rockp..
Providence/Stought..

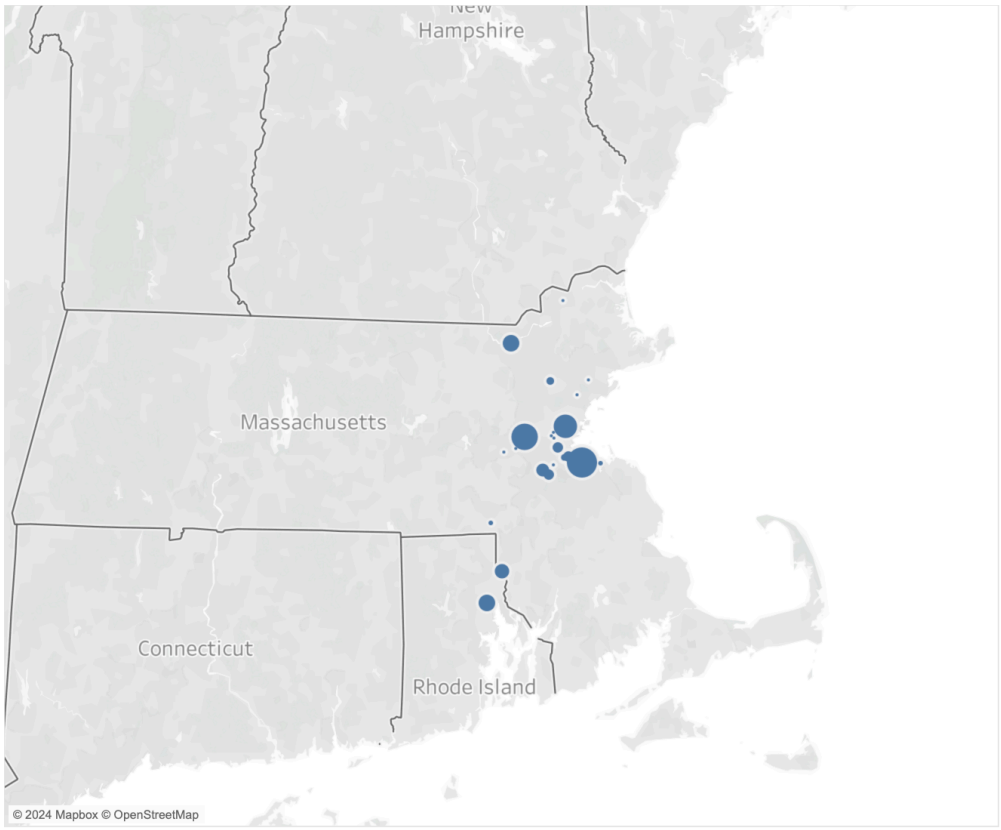
4.


January 2018 MBTA Stop Sequence
Average Ons
15K
10K
5K
0K
Average Offs
10K
5K
0K
9 nulls
0
2
4
6
8
10
12
14
16
18
20
Stopsequence
Route Name
Fairmount Line
Fitchburg Line
Framingham/Worces..
Franklin Line
Greenbush Line
Haverhill Line
Kingston/Plymouth L..
Lowell Line
Middleborough/Lake..
Needham Line
Newburyport/Rockp..
Providence/Stought..

5. 
August 2020 Ridership Map
New Hampshire
Massachusetts
Connecticut
RI
© 2024 Mapbox © OpenStreetMap
SUM(Raw Visitor Count...
1
20
40
60
80
91

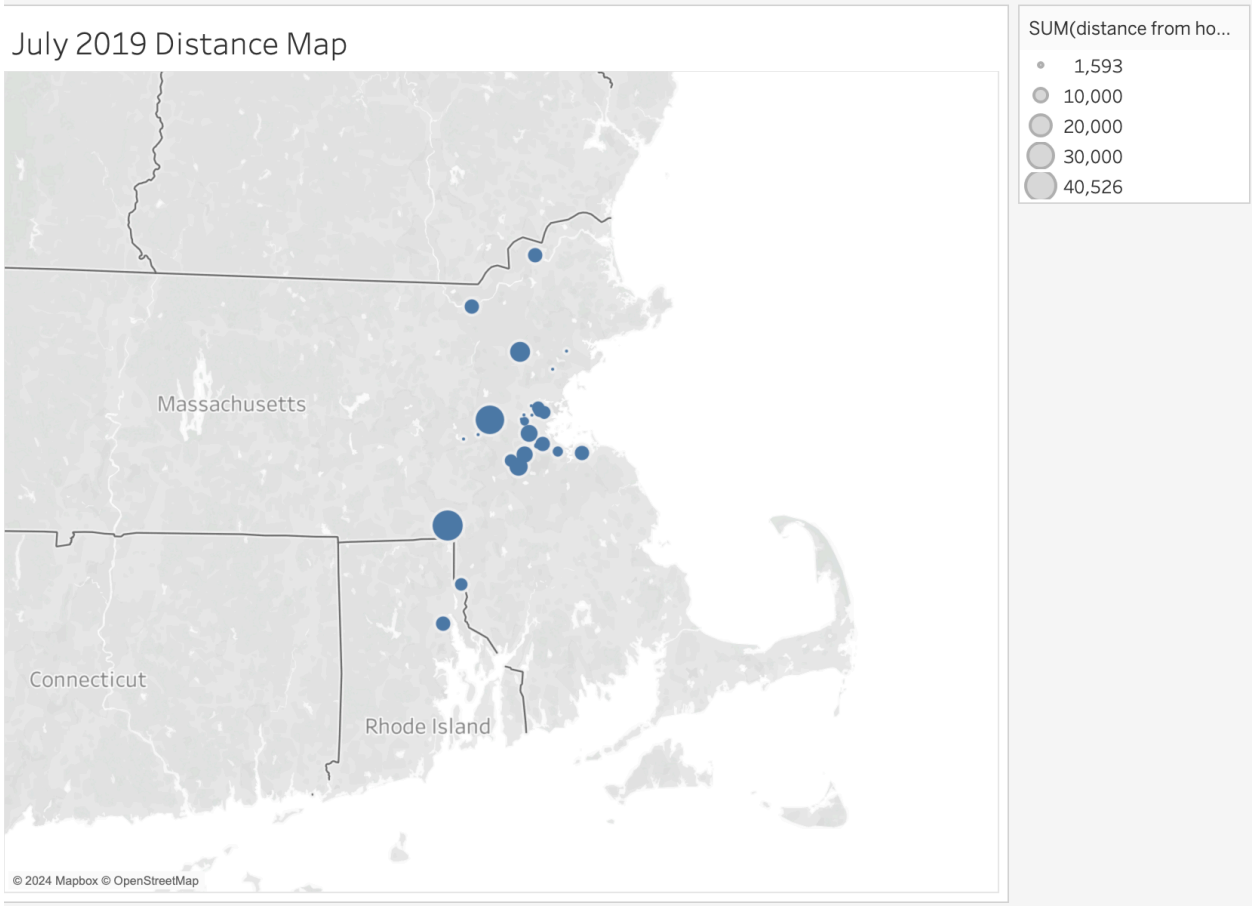
6. 
August 2020 Distance Map
Hampshire
Massachusetts
Connecticut
Rhode Island
© 2024 Mapbox © OpenStreetMap
SUM(Distance From Ho...
770
50,000
100,000
150,000
176,592

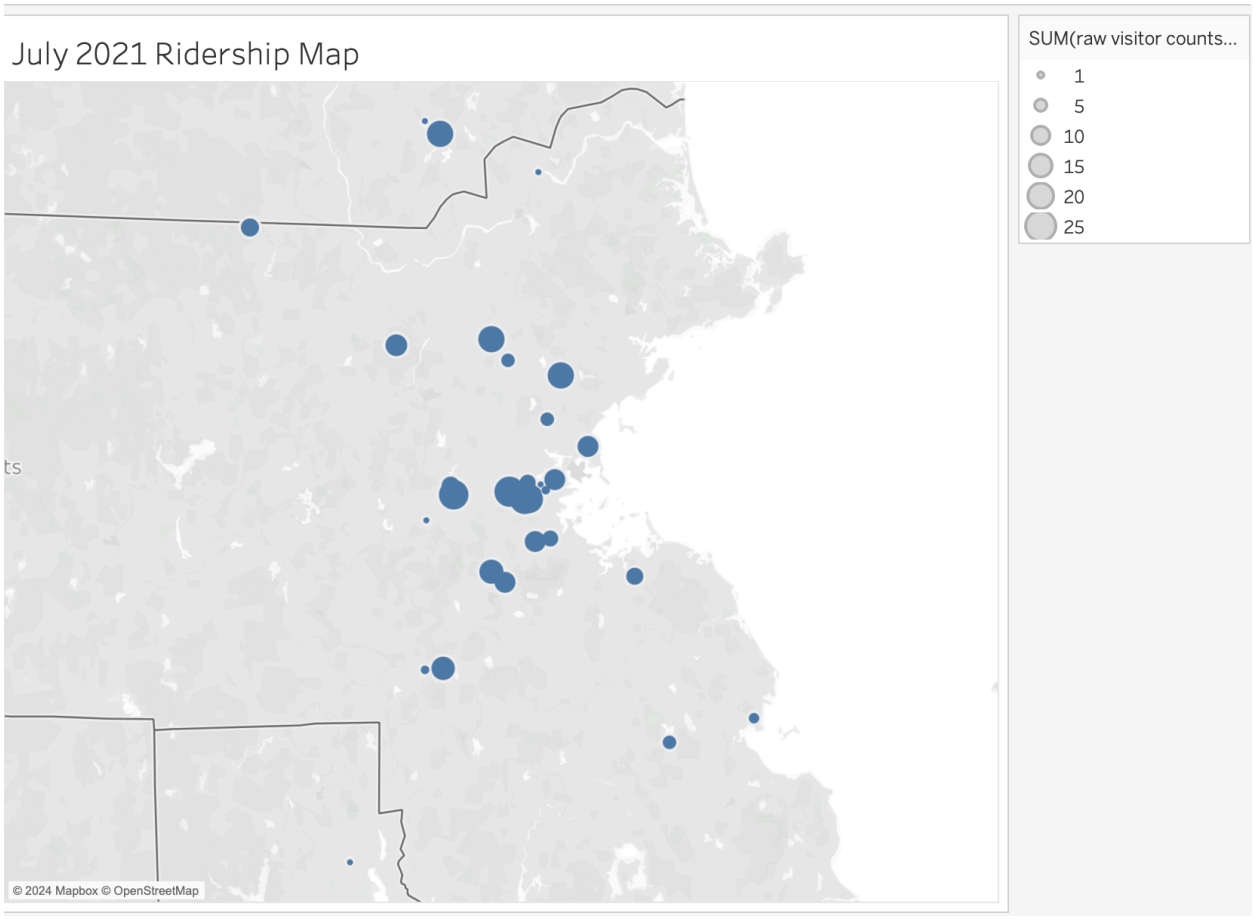
July 2019 Ridership Map

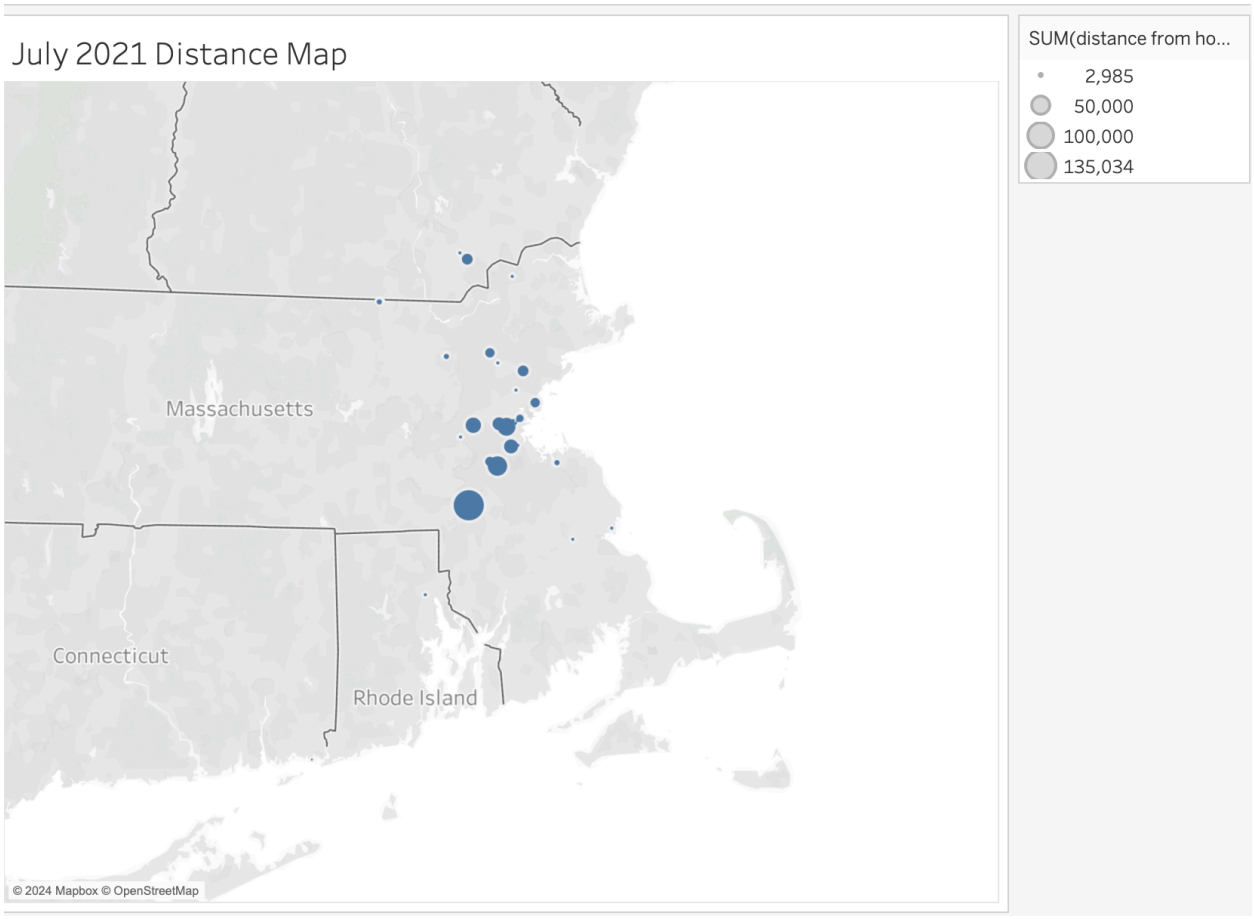


SUM(raw visitor counts...
1
100
200
300
394

7.


July 2019 Distance Map
Massachusetts
Connecticut
Rhode Island
© 2024 Mapbox © OpenStreetMap
SUM(distance from ho...
1,593
10,000
20,000
30,000
40,526

8. 
July 2021 Ridership Map
SUM(raw visitor counts...
1
5
10
15
20
25
© 2024 Mapbox © OpenStreetMap

9. 
July 2021 Distance Map
Massachusetts
Connecticut
Rhode Island
© 2024 Mapbox © OpenStreetMap
SUM(distance from ho...
2,985
50,000
100,000
135,034