

C Location-Based Services Data Analysis

Introduction

This memorandum describes key travel markets for Lynn, Massachusetts, with a focus on examining needs and opportunities for public transportation service as part of the Lynn Transit Action Plan. The travel market analysis is informed by a set of metrics drawn from the LOCUS Location-Based Services (LBS) data produced by Cambridge Systematics (CS), transit and auto routing data appended to the LOCUS dataset, and transit Origin-Destination-Transfer (ODX) data provided by the MBTA. The data represented in these findings present current trip making patterns, but do not represent desired trip making or potential future travel pattern adjustments based on future conditions.

Summary of Key Findings

Three key market types were identified as target markets for improvement:

- Travel within Lynn, especially from East Lynn and West Lynn to Central Lynn

- Both peak and off-peak travel within the North Shore to meet travel demand for work and other essential activities.
- Off-peak (including early morning) travel to and from medical centers and other employment destinations in Boston, including the Longwood Medical Area and Logan Airport.

The size of the travel markets within Lynn and to other North Shore destinations appears unlikely to be sufficient to support high-frequency fixed-route service. Alternative service and mobility improvements may need to be considered, such as microtransit targeting specific employment needs, shared mobility services, and walking and bicycling improvements. Additional fixed-route services to Boston destinations targeting the needs of employers, especially in the health care sector, might be given further consideration.

Existing Conditions

Located in the North Shore–MBTA service area (defined collectively as Lynn, Salem, Marblehead, Swampscott, Nahant, Saugus, Revere, Winthrop, Beverly, Danvers, and Peabody), Lynn stands out as a unique opportunity for transit service improvements for three reasons: high population density, a large proportion of disadvantaged communities, and high existing MBTA service utilization.

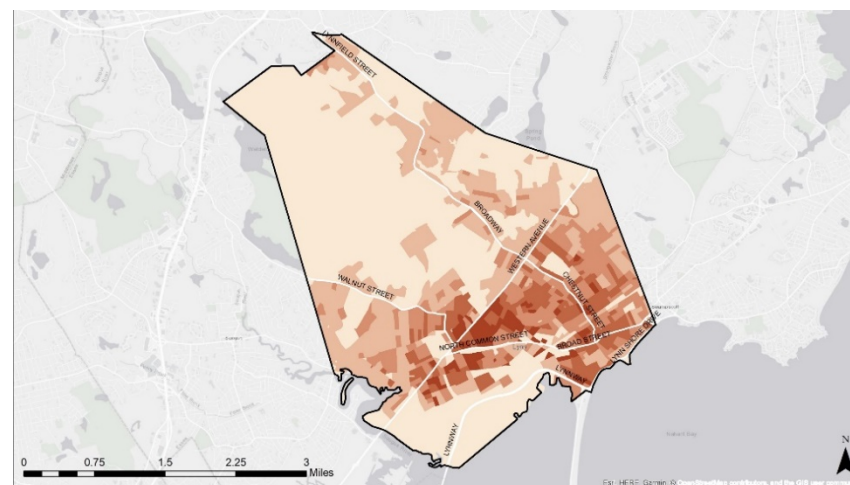
Demographics

Lynn has a median household income of \$54,600, compared to a median household income of \$85,500 in the Boston-Cambridge-Newton Metropolitan Statistical Area (Boston MSA) as a whole. While 17 percent of the block groups in the Boston MSA have an annual median income below \$50,000 (low-income block groups) and 28 percent have more

than one-third minority population (minority block groups), the proportions of population in low-income block groups and in minority block groups in Lynn are 48 percent and 80 percent respectively, with 43 percent of the population in both categories. Eighteen percent of Lynn residents work in the health care and social assistance industry and 13 percent work in the retail trade industry (2018 5-year ACS).

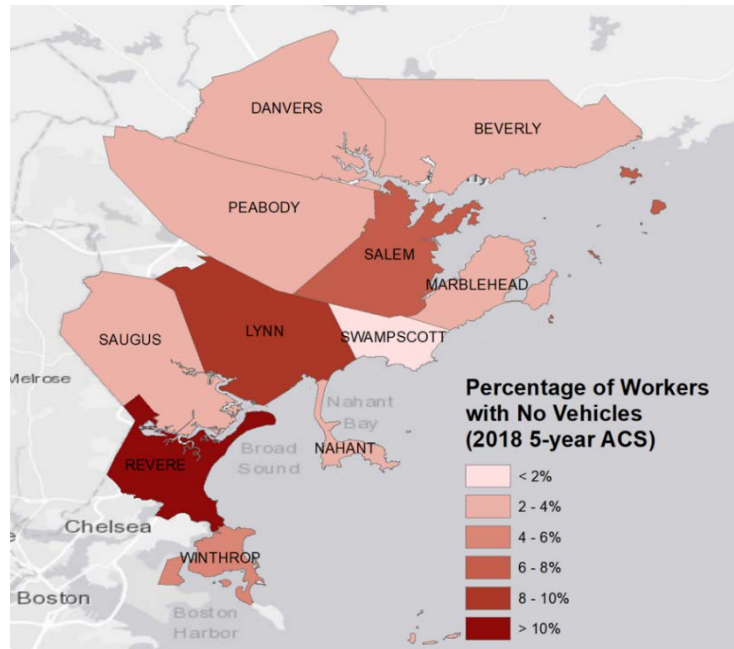
The average population density in Lynn is 8,100 persons per square mile, nearly double the average density in the North Shore MBTA service area of 4,200 persons per square mile.¹ However, density varies considerably by neighborhood, as shown in Figure C-1. Relative to most of its neighboring municipalities, Lynn also has a higher share of workers with no vehicles (nearly 10 percent), as shown in Figure C-2. These characteristics all suggest a relatively high propensity and need for transit service compared to neighboring North Shore communities, although most workers still have a vehicle available.

Figure C-1 Population Density in Lynn



¹ 2018 five-year American Community Survey

Figure C-2 Percentage of workers with no vehicles, cities and towns in the North Shore



Transit Service

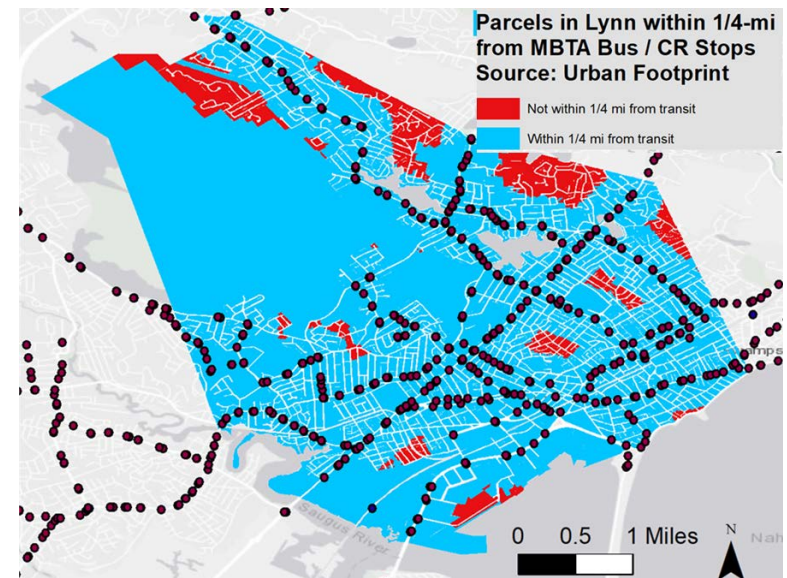
Lynn is relatively well-connected on with Boston by public transportation, with a combination of local and express bus service as well as less frequent commuter rail service.

- The Newburyport/Rockport Commuter Rail Line provides direct access from central Lynn to downtown Boston at North Station.
- The commuter rail runs approximately every 30 minutes in the AM peak inbound.

- Express bus routes 426 and 450 (roughly 30 minute headways) and 434 (one trip per weekday) serve downtown Boston, via Haymarket.
- Routes 424, 426W, 439, 441, 442, and 455 provide connections to the Wonderland Blue Line station in Revere, where passengers can take rapid transit into the core of Boston.
- Routes 426, 428, 429, 434, 435, and 436 provide local service to destinations in Lynn and other North Shore communities.

Based on a parcel-level analysis with parcel population retrieved from Urban Footprint, 93 percent of the population in Lynn lives within a quarter mile of an MBTA bus or commuter rail stop (Figure C-3).

Figure C-3 Parcels in Lynn within a quarter mile from MBTA bus and commuter rail stops



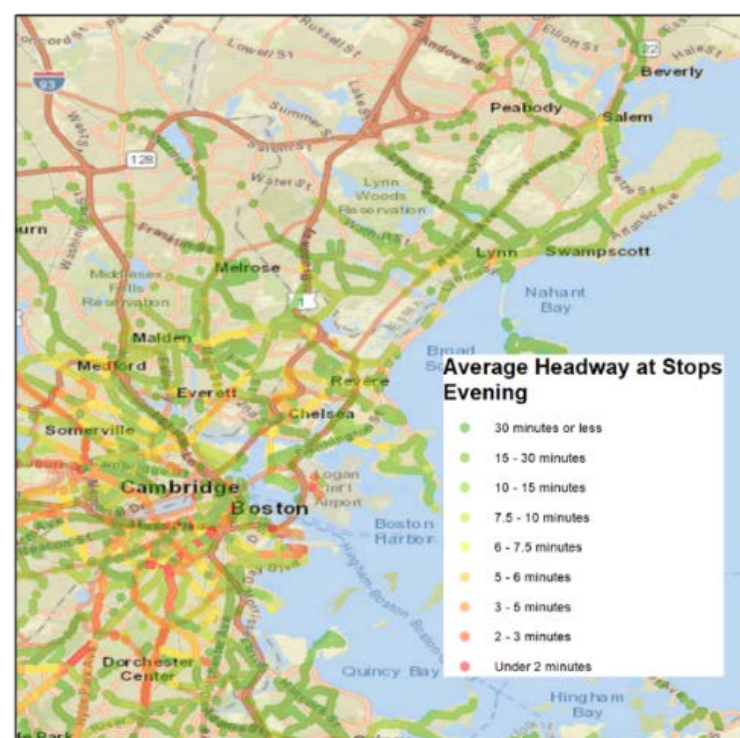
However, transit service in most of Lynn is much less frequent than in the urban core. A service frequency analysis based on MBTA's GTFS feed² is shown in Figures C-4 and C-5. During the weekday AM peak, the average interval between arrivals of transit vehicles on any route at MBTA stops is much longer in Lynn – and most of the North Shore – than in Boston, Cambridge, or Somerville.

Figure C-4 GTFS bus service frequency at MBTA stops – Weekday AM Peak



AM peak and PM peak frequencies are roughly similar in Boston, while the midday frequencies are lower than the peak periods but higher than in the evening. The disparity is reduced in the evening (except for certain bus and rapid transit services in Boston), when service frequencies in the North Shore remain closer to those during the AM peak. In other words, the service frequencies in the North Shore largely throughout the day resemble the off-peak service frequencies in the urban core.

Figure C-5 GTFS bus service frequency at MBTA stops – Weekday Evenings



² The version used for the analysis is dated August 9, 2018 and is consistent with the routing analysis.

Data Sources

Location-based Services (LBS) Trip Tables

LBS data are collected by global positioning systems (GPS) applications running either in the background or foreground on cellular devices, where the device user has opted to allow access to the app to import the device's geographic location. The data are anonymized so that information cannot be tracked to a particular mobile phone number, processed into trips based on a set of algorithms and criteria, and aggregated by block group in the Boston MSA and time periods defined by MassDOT. The LBS trip tables identify the origin and destination block group of each trip. Trips are classified as "home-based regular" (work or school), "home-based other", and "non-home based" considering their patterns of repetition. Since the LBS dataset only includes a sample of all trips made, the trips from this sample are factored to approximate total trip volumes. Expansion algorithms are applied to scale travel metrics so that they reflect the patterns of the total population in the region and normalize the metrics to a unit scale – in this case, average daily trips on weekdays, Saturdays, and Sundays. For this study, the focus was on trips starting and/or ending in Lynn.

MBTA Origin-Destination-Transfer (ODX) Data

The MBTA Origin-Destination-Transfer (ODX) data contains transit trips to or from the North Shore for the fall of 2018. Trip records are organized by origin/destination stops, routes taken at trip origins/destinations, days

of week, and time periods per MBTA definition (on weekdays only). The ODX data does not account for trips made on commuter rail.

The ODX trip records were converted to daily trip counts and geotagged by origin/destination stops based on MBTA's General Transit Feed Specification (GTFS) files in 2018. Some of the stops that appeared in the ODX data were not found in the GTFS files and could not be geotagged. The records were aggregated by origin and destination block groups, to be compared with the LBS data.

Routing Dataset

Trips in the LBS dataset were routed to the transportation network to provide insights regarding competitiveness by time-of-day, geography, travel purpose, and travel distance. The steps of the routing analysis included:

- Path-Building: LBS trip tables were processed through the OpenTripPlanner (OTP) engine based on GTFS, which returns in-vehicle travel times, access/waiting times, number of transfers, and walking access distance.
- Travel Time Measurements: Each transit trip was screened to determine if the path is feasible by transit based on total transit time, which includes walk access, wait, transit in-vehicle, transfer walk and wait time, and walk egress. This generated detailed transit and auto times for each LBS trip. Auto travel times were further adjusted by traffic using congestion factors obtained from Google Maps.³

³ Severe congestion can cause significant variation and uncertainty in drive times. In the routing dataset, the congestion factors are calculated with the most realistic assumption among three options in the routing algorithm (called

"best guess", between "optimistic" and "pessimistic"). During congested times, it is entirely possible to experience drive times between "best guess" and "pessimistic."

Analytical Framework

The travel market analysis uses multiple metrics to study and identify travel markets that could benefit from improved transit service. The methodology relies on LBS trip tables at the block group level for total travel demand, ODX data to document existing transit usage, and transit and auto routing data accompanying the LBS trip tables to understand transit competitiveness.

LBS Trip Intensity

The LBS trip tables capture multimodal travel demand by day of the week, time of day, and trip purpose for residents and non-residents of Lynn. While the trip count for a given O-D pair measures its aggregate market size, trip hourly intensity, defined as the trip count per hour normalized by the geographic area of the origin and/or destination block groups, allows for more standardized comparison across O-D pairs with disparate land areas. As transit service viability is often determined by land-use and trip-making density, this measure also assesses the potential resource effectiveness of improving transit service for a given O-D pair or along a corridor. In the analysis hereinafter, travel markets are ranked by the trip intensity as opposed to aggregate market size.

Trip intensity is computed differently for internal trips (those starting and ending in Lynn) and external trips (those with one end in Lynn, and one end in another community). For internal trips, it is calculated as the number of hourly LBS trips divided by both origin and destination neighborhood land areas. The numerator is simplified to daily LBS trips for daily travel market analysis. For external trip analysis where Lynn is considered as a whole, it is the number of hourly LBS trips divided by the land area of the external neighborhood or municipality. Finally, when exploring potential service from Lynn to certain hotspots in the North Shore, the metric is normalized by the land area of the origin block group in Lynn.

Transit vs. Auto Competitiveness

A number of factors affect the relative competitiveness of transit vs. automobile travel between any given O-D pair. Competitiveness factors include:

- The ratio of total travel times for transit vs. automobile (which is likely to vary by time of day). Total travel times include time spent walking to the transit vehicle or car, waiting for the transit to arrive, time traveling on the vehicle, time transferring (if needed), and time walking from the vehicle to the final destination.
- The relative amount of time spent out of the vehicle (walking and waiting) vs. in the vehicle. Time out of the vehicle is generally perceived as more of a burden by travelers than time in the vehicle.
- Number of transfers. Transfers are perceived as inconvenient and can deter transit usage, especially in areas where there is no timed transfer or where transit service frequency is relatively poor, as in many parts of Lynn and the rest of the North Shore.
- Cost considerations (fuel, parking, fares).
- Other less tangible considerations such as comfort and convenience.

In this study, general indicators are examined for travel time ratios, in-vehicle vs. out-of-vehicle time, and number of transfers between O-D pairs with at least one end in Lynn. Travel time ratios are not reported due to limitations of the data that make it difficult to develop precise estimates. Cost and other less tangible factors are not quantified or evaluated.

Existing transit mode shares are also examined as an overall indicator of competitiveness. Mode shares are considered for trips longer than 2 miles, since it is difficult for transit to compete with automobile travel for very short trips. The mode shares should only be used as a general indicator due to known limitations. One example is that the MBTA ODX data does not include commuter rail trips, which could lead to a systematic underreporting of transit mode shares.

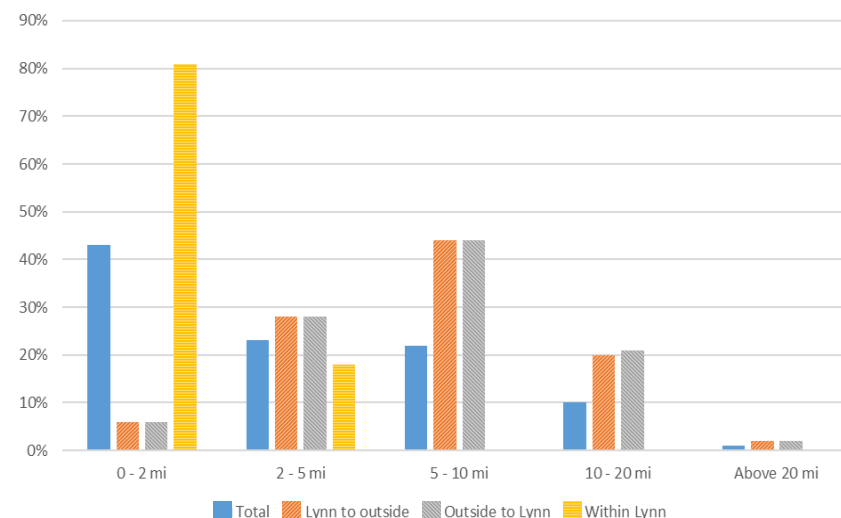
Market Research Findings

Regional Origin/Destination Patterns

Considering trips of any length, trips to destinations within the North Shore account for about 88 percent of all trips originating in Lynn throughout the week including weekdays, Saturdays, and Sundays. Boston is the largest trip destination outside the North Shore, accounting for 4 percent of the total trips on both weekdays and weekends, and about 10 percent of the home-based regular trips. Similar ratios are observed on weekdays and weekends, which might indicate a considerable proportion of Lynn residents who work outside regular business hours at the same locations identified as their weekday regular locations, as commonly seen in the service, retail, and healthcare industries. About one of every six weekday trips is a “regular” trip (most likely work or school); this ratio is lower on weekends. About one of every three weekday trips to Boston is a “regular” trip. Over two-thirds of trips started or ended at home.

The distribution of trips within, to, and from Lynn by length is shown in Figure C-6. Most trips are short; over 40 percent of all trips are less than 2 miles, and two-thirds of all trips are less than 5 miles.

Figure C-6 LBS weekday trip length distribution by trip direction

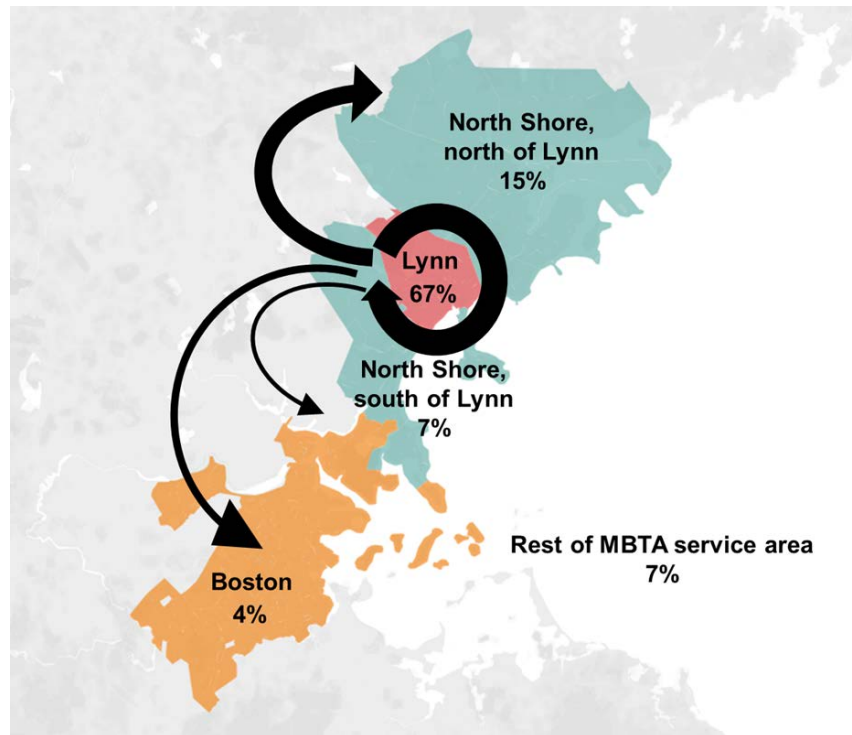


Detailed breakdowns by trip purpose and destination are listed in Table C-1. Figure C-7 shows the percentage distribution of trips from Lynn on weekdays; travel patterns on the weekend and in the opposite direction (travel to Lynn) are similar.

Table C-1 LBS trips from Lynn by destination locations and trip purpose

		Total Trips					Percentage of Total			
		Total	Within Lynn	To the North Shore	To Boston	To Other Locations	Within Lynn	To the North Shore	To Boston	To Other Locations
Weekday	Total	295,900	197,600	63,700	12,100	22,500	67%	22%	4%	8%
	Home-based regular	48,600	27,200	11,400	4,000	6,000	56%	23%	8%	12%
	Home-based other	158,100	109,000	32,800	5,400	10,900	69%	21%	3%	7%
	Non-home based	89,200	61,400	19,500	2,700	5,600	69%	22%	3%	6%
Saturday	Total	232,700	144,600	59,000	9,600	19,500	62%	25%	4%	8%
	Home-based regular	18,000	8,900	5,300	1,500	2,300	49%	29%	8%	13%
	Home-based other	147,900	93,300	36,300	5,800	12,500	63%	25%	4%	8%
	Non-home based	66,900	42,500	17,300	2,300	4,800	64%	26%	3%	7%
Sunday	Total	203,800	129,200	49,900	8,000	6,700	63%	24%	4%	8%
	Home-based regular	13,200	6,400	4,100	1,200	1,500	48%	31%	9%	11%
	Home-based other	137,300	88,600	32,700	5,000	11,000	65%	24%	4%	8%
	Non-home based	53,300	34,200	13,100	1,800	4,200	64%	25%	3%	8%

Figure C-7 Percentage of weekday trips from Lynn to Other Travel Markets



The temporal pattern of trips is also examined. Figure C-8 shows the distribution of trips by Lynn residents by start time and Figure C-9 shows the distribution of trips by non-residents traveling to Lynn. While the start times are not all the same length, this figure does illustrate the large number of trips occurring during “off-peak” time periods, including the midday, evening, and late night and early morning. Many of these off-peak trips are “regular” (typically commuting or school) trips. The travel needs of Lynn residents and visitors throughout the day, not just for peak period commuting, need be considered.

Figure C-10 shows the origin of trips to Lynn (from outside of Lynn) by municipality and trip purpose. The largest trip origins are the City of Boston and other North Shore municipalities. The distribution of destinations of trips from Lynn to other communities looks similar.

Figure C-8 Trips by Lynn residents by time of day and purpose

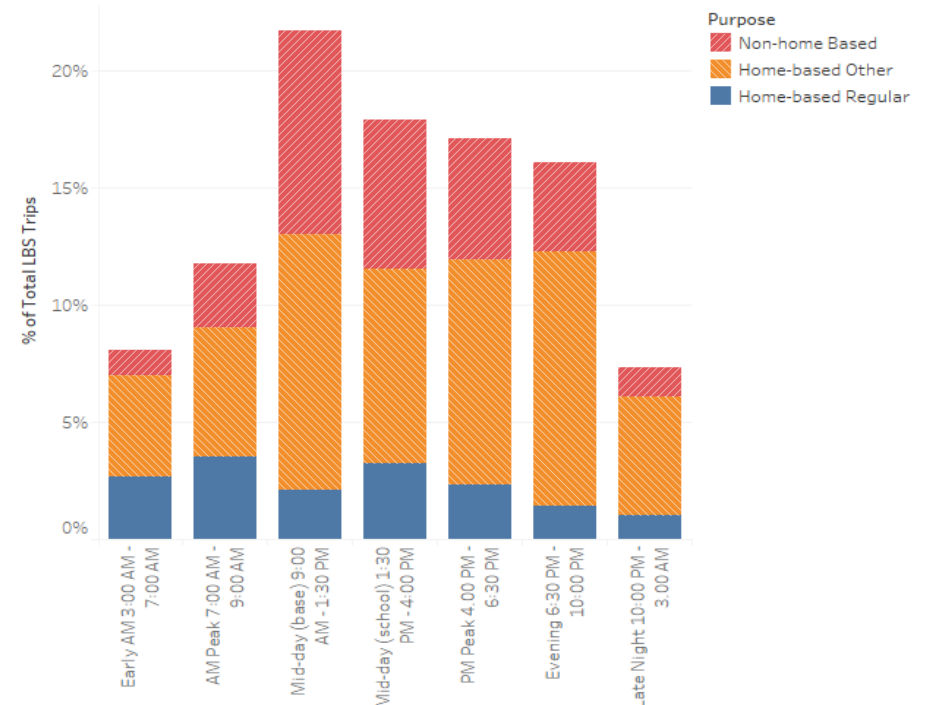


Figure C-9 Trips to Lynn by non-residents by time of day and purpose

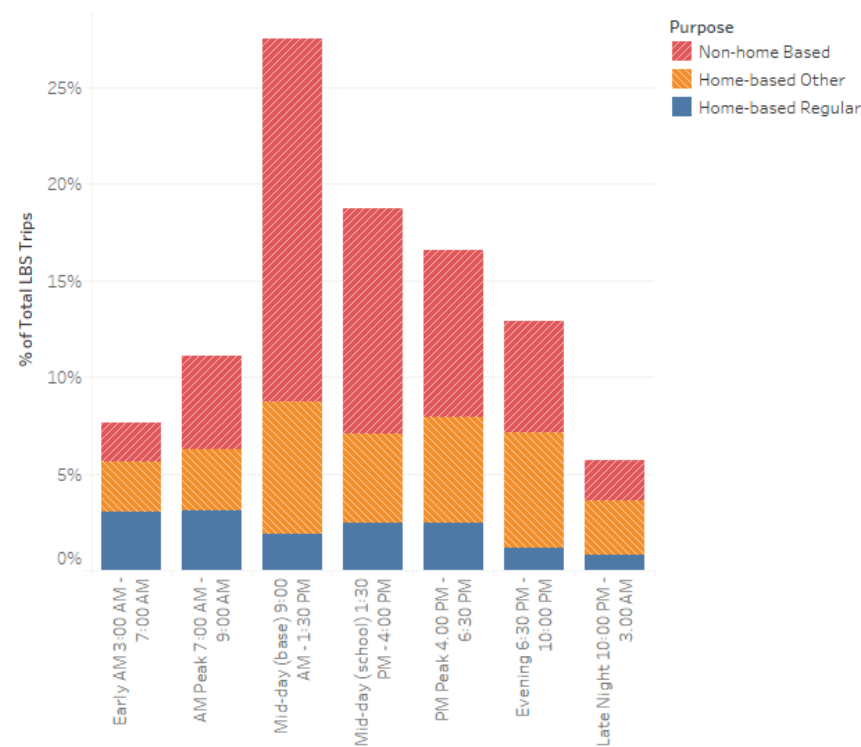
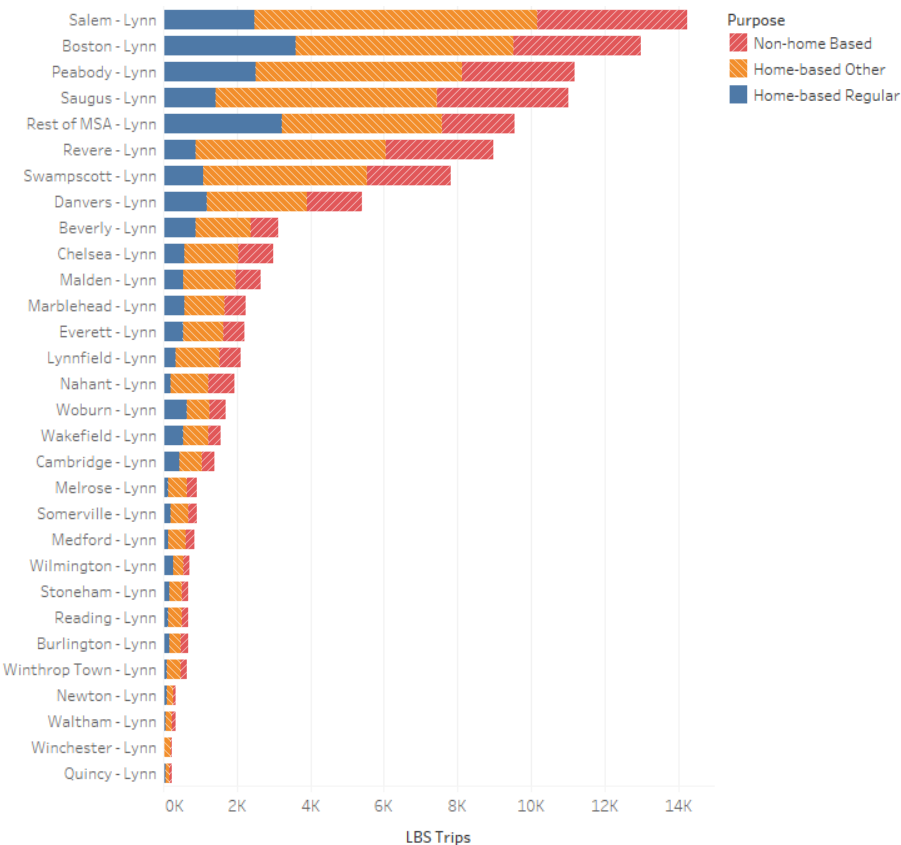


Figure C-10 Community of origin of trips to Lynn by purpose



Ratios of Out-of-Vehicle Travel Time to In-Vehicle Travel Time

All transit travel time is not equal. The Federal Transit Administration considers time spent outside a transit vehicle (OVTT), which includes walk time, wait time, and transfers, twice as burdensome as the time spent inside a vehicle (IVTT). Travel mode choice models often apply a higher value-of-time factor on OVTT than on IVTT to account for disparate effects on travel behaviors. Therefore, understanding the breakdown of the transit leg of the journey into IVTT and OVTT components is critical for transit network design. A higher OVTT-IVTT ratio often diminishes the competitive edge of transit service over driving, if any, and indicates a mix of long access/egress, infrequent service, and/or inconvenient transfers.⁴

OVTT-IVTT ratios are computed for trips above 2 miles (Table C-2). A ratio of 2.0 (for example) means for every 15 minutes spent on a transit vehicle, the traveler spends 30 minutes walking or waiting. These values show large gaps between off-peak and peak services, as well as weekday and weekend services. Despite being the major travel market, trips within Lynn have consistently higher OVTT-IVTT ratios than external trips. This suggests that current service design has not been focused on internal circulation within Lynn but rather on connectivity across municipality boundaries.

⁴ Note that in this analysis, the OVTT estimates assume random start times, which could overestimate actual OVTT compared to a traveler who is able to adjust their trip start time to match a transit schedule.

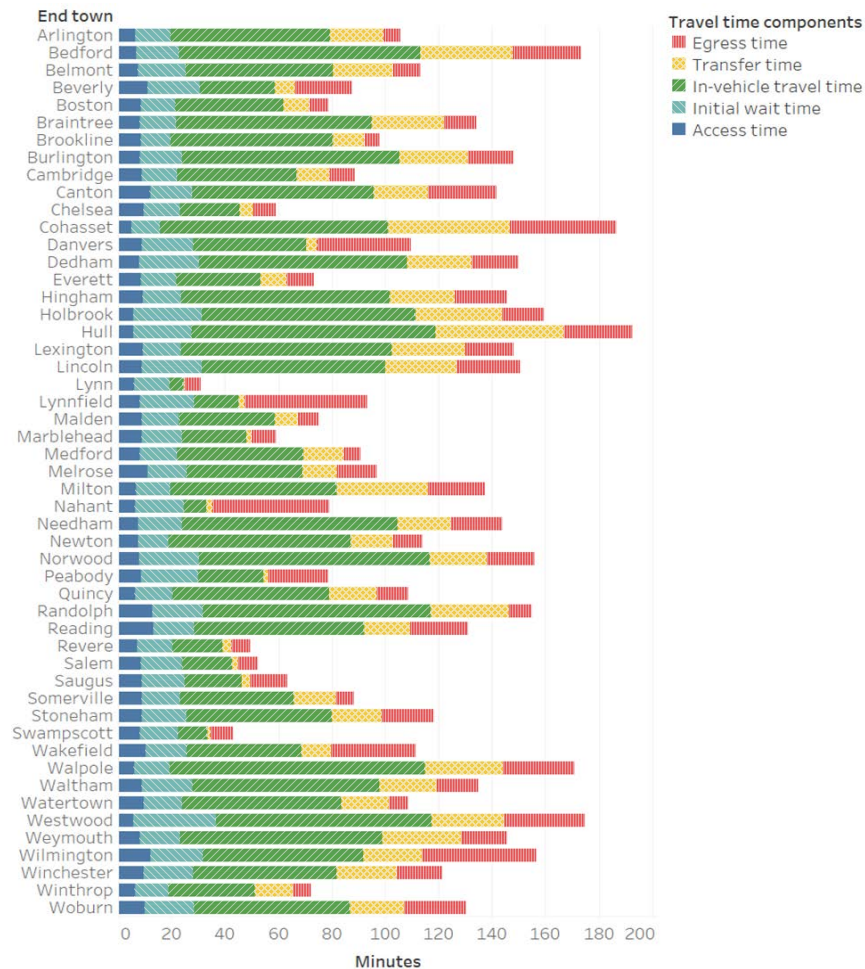
Table C-2 OVTT-IVTT ratio matrix by time period and trip distance (for trips above 2 miles)

Time period	Weekday			Saturday			Sunday		
	From Lynn	To Lynn	Within Lynn	From Lynn	To Lynn	Within Lynn	From Lynn	To Lynn	Within Lynn
Early AM	1.4	1.8	3.1	2.0	2.9	5.4	3.2	3.8	11.0
AM Peak	1.3	1.5	2.1	1.8	2.0	2.9	2.6	3.1	7.4
Midday Base	1.5	1.5	2.7	1.7	1.7	2.8	2.4	2.4	5.7
Midday School	1.5	1.3	2.2	1.8	1.6	2.8	2.4	2.2	5.1
PM Peak	1.5	1.3	2.2	1.8	1.7	3.3	2.5	2.3	5.4
Evening	2.3	2.0	4.1	2.4	2.1	4.5	2.9	2.5	6.8
Late Night	3.3	2.8	7.9	3.6	2.7	8.0	4.4	2.8	10.8

Time periods are defined as: Early AM: 3:00 AM - 7:00 AM; AM Peak: 7:00 AM - 9:00 AM; Mid-day (base): 9:00 AM - 1:30 PM; Mid-day (school): 1:30 PM - 4:00 PM; PM Peak: 4:00 PM - 6:30 PM; Evening: 6:30 PM - 10:00 PM; Late Night: 10:00 PM - 3:00 AM

Looking at the components of travel time in detail illustrates the reasons for high OVTT-IVTT ratios. Figure C-11 shows the average transit travel time by five components: access time (walking to the transit stop); initial wait time; in-vehicle travel time; transfer time; and egress time (walking from the transit stop to the destination), for trips starting in Lynn. (These are based on total trips to anywhere in the destination communities where transit exists and are not weighted by actual transit trips taken.) Trips to Lynn and nearby communities tend to have shorter in-vehicle travel times, but access and wait times remain relatively constant, leading to higher OVTT-IVTT ratios. More distant communities that do not have direct service show both longer in-vehicle times and transfer times. Lower-density communities show higher egress times, since destinations are less likely to be within a short walk of the transit stop.

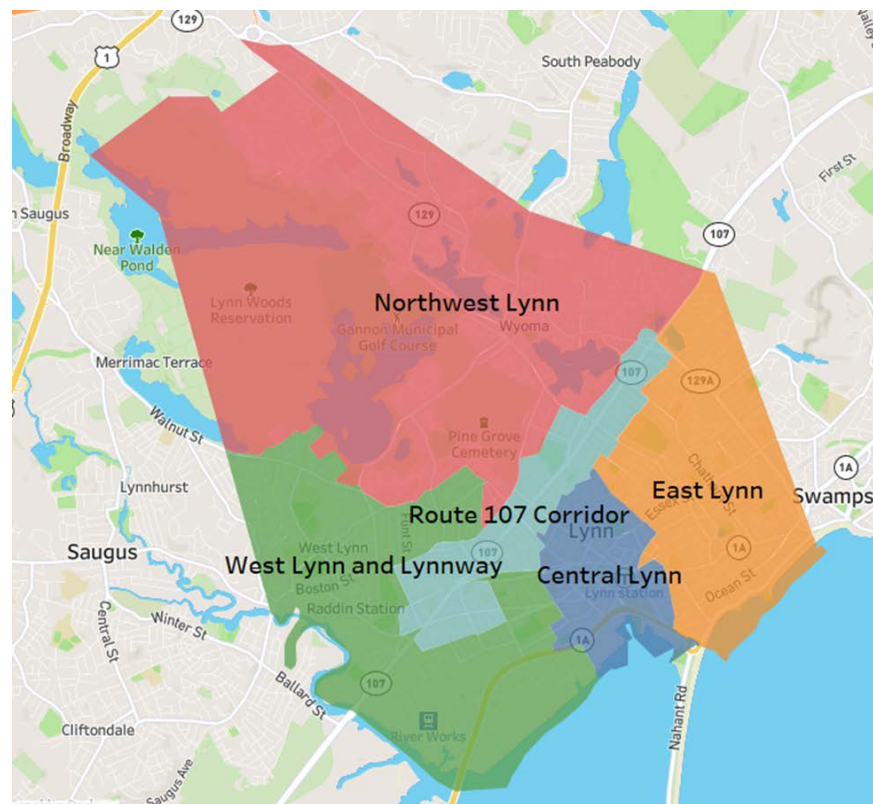
Figure C-11 Average transit travel time components by destination municipality



Trips Within Lynn

For this analysis, Lynn is divided into five neighborhoods (Figure C-12). The characteristics of the five neighborhoods are as follows:

- *Central Lynn* is the employment center and transit hub for Lynn. It is home to the Lynn Commuter Rail station, the North Shore Community College, four high schools, and Lynn Vocational Technical Institute.
- *East Lynn* is primarily moderate-density residential, with some neighborhood serving commercial uses and Lynn English High School.
- *West Lynn and Lynnway* is primarily lower- to moderate-density residential but has considerable industrial and commercial uses adjacent to the Lynnway.
- *Route 107 Corridor* includes land along Route 107 (also known as Western Avenue), a commercial street with low-rise mixed-use development that connects West Lynn and East Lynn.
- *Northwest Lynn* is largely covered by natural landscape and low-density residential development with higher vehicle ownership and household income than the rest of Lynn.

Figure C-12 Neighborhoods in Lynn for market analysis

On a daily basis, about 80 percent of the trips within Lynn are less than 2 miles. As discussed above, travelers are unlikely to use transit for short trips, unless transit is very frequent (which it is not in Lynn). As a result, bus transit market share for trips starting and/or ending in Lynn is less than 1 percent.

When only considering trips above 2 miles, the overall transit market share within Lynn reaches 2 percent on weekdays and around 1 percent

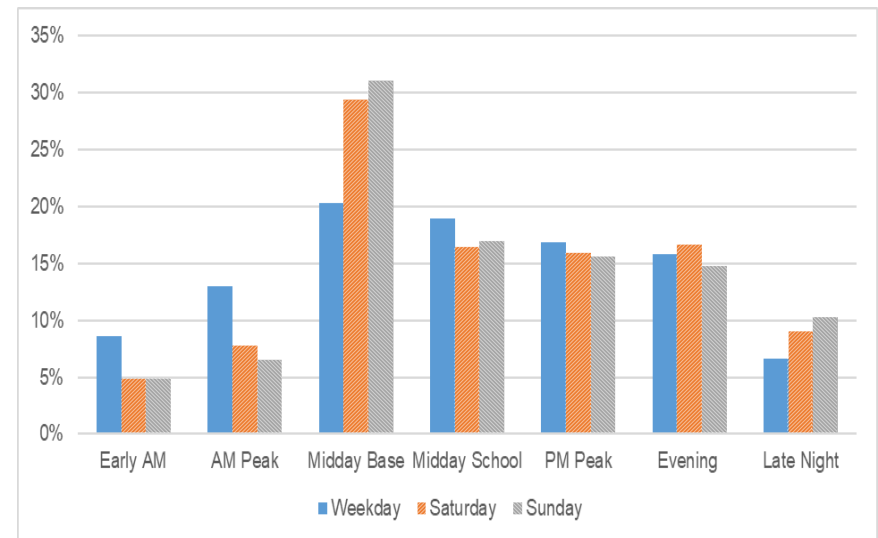
on weekends. When only considering block group pairs with observed transit trips (a proxy for where transit service might be available at all), the transit market share is significantly higher, ranging between 7 and 10 percent depending on the day of the week. The top 10 travel markets (based on trip intensity) within Lynn are listed in Table C-3 through Table C-5, for weekdays, Saturdays, and Sundays, respectively. These tables also show the transit market share (which may reflect trip intensities, transit competitiveness, and demographics) as well as the ratio of transit to auto travel time. Observations include:

- The top travel markets in Lynn are fairly similar on weekdays and weekends with a limited number of minor differences.
- Complementary O-D pairs (same origin/destination pair in opposite directions) often have comparable trip flows, transit competitiveness, and transit market shares.
- The top three O-D pairs (and their complementary pairs) based on trip intensity on all days of the week are identical, namely Route 107 Corridor \rightleftharpoons East Lynn, West Lynn and Lynnway \rightleftharpoons East Lynn, and Central Lynn \rightleftharpoons West Lynn and Lynnway.
- High trip intensities are observed on weekdays from the Route 107 Corridor and Northwest Lynn to Central Lynn possibly for commuting purposes, but not on weekends.
- In the top travel market pairs, transit mode shares hover in the 1-2 percent range, but there are some high performers that could be worth looking into as benchmarks.
 - Route 107 Corridor \rightleftharpoons Central Lynn has the highest transit market share (16-17 percent); however, the total number of trips in this market is relatively small.
 - Central Lynn \rightleftharpoons West Lynn and Lynnway also has relatively high transit mode shares, around 10 percent. This travel market is the most competitive as compared

to auto across all major travel markets within Lynn on weekdays and Saturdays and third best on Sundays – demonstrating the effect of better transit service on ridership.

- Overall, Northwest Lynn is not among the top travel markets and does not have high transit market shares despite having even higher competitiveness than some of the low-performing, high-flow markets. This could be a result of the density, demographics, and travel options particular to this neighborhood.
- About 30 percent of the weekday trips above 2 miles within Lynn are occurring during the AM peak and PM peak, while the majority of the trips occur during off-peak hours. On weekends, trips are occurring more often in the midday and hours defined as “late night”. As a result of the temporal dispersal of trips (shown in Figure C-13), service may need to be oriented towards all-day travel.
- The daily total trip counts in individual travel markets within Lynn are typically in the range of 1,000 to 2,000 trips (one-way), with the highest being up to 4,000 trips. If high-frequency transit service were provided sufficient to attract a 10 percent mode share, and the entire land area of the neighborhood were served by the route, the daily ridership would be a maximum of 200 to 400 trips in any given market. Assuming 15-minute service frequency for 12 hours of the day, there would be an average of four to eight riders per trip, likely not enough to be viable unless the route could be designed to also serve other travel markets. This suggests that other travel options – such as demand-responsive service, microtransit or shared mobility options, and walking and biking improvements – might be needed to better serve local mobility needs.

Figure C-13 Trips above 2 miles within Lynn by time of day



Early AM = 3:00 AM - 7:00 AM; AM Peak = 7:00 AM - 9:00 AM; Midday base = 9:00 AM - 1:30 PM; Midday school = 1:30 PM - 4:00 PM; PM Peak = 4:00 PM - 6:30 PM; Evening = 6:30 PM - 10:00 PM; Late Night = 10:00 PM - 3:00 AM.

Table C-3 OVTT-IVTT ratio matrix by time period and trip distance (for trips above 2 miles)

O-D pair	Trip intensity rank	Daily Trips (LBS)	Transit trips (ODX)	Transit market share
Route 107 Corridor - East Lynn	1	2,190	20	1%
East Lynn - Route 107 Corridor	2	1,750	20	1%
West Lynn and Lynnway - Central Lynn	3	1,700	170	10%
West Lynn and Lynnway - East Lynn	4	3,940	30	1%
East Lynn - West Lynn and Lynnway	5	3,920	30	1%
Central Lynn - West Lynn and Lynnway	6	1,510	170	11%
East Lynn - Central Lynn	7	900	30	4%
Central Lynn - East Lynn	8	820	20	2%
Route 107 Corridor - Central Lynn	9	310	50	17%
Northwest Lynn - Central Lynn	10	1,710	40	2%

Note: colors indicate complementary O-D pairs. Uncolored O-D pairs do not have their complementary O-D pairs listed in the table.

Table C-4 Saturday top ten travel markets within Lynn (trips above 2 miles)

O-D pair	Trip intensity rank	Daily Trips (LBS)	Transit trips (ODX)	Transit market share
Route 107 Corridor - East Lynn	1	2,050	10	0%
East Lynn - Route 107 Corridor	2	1,770	10	1%
West Lynn and Lynnway - East Lynn	3	3,690	30	1%
East Lynn - West Lynn and Lynnway	4	3,480	40	1%
Central Lynn - West Lynn and Lynnway	5	1,230	110	9%
West Lynn and Lynnway - Central Lynn	6	1,200	70	6%
Central Lynn - East Lynn	7	610	20	3%
East Lynn - Central Lynn	8	560	20	4%
West Lynn and Lynnway - Route 107 Corridor	9	920	10	1%
Route 107 Corridor - West Lynn and Lynnway	10	850	10	1%

Note: colors indicate complementary O-D pairs.

Table C-5 Sunday top ten travel markets within Lynn (trips above 2 miles)

O-D pair	Trip intensity rank	Daily Trips (LBS)	Transit trips (ODX)	Transit market share
Route 107 Corridor - East Lynn	1	2,210	10	0%
East Lynn - Route 107 Corridor	2	1,950	10	0%
East Lynn - West Lynn and Lynnway	3	3,270	20	1%
West Lynn and Lynnway - East Lynn	4	3,220	20	1%
Central Lynn - West Lynn and Lynnway	5	1,020	80	8%
West Lynn and Lynnway - Central Lynn	6	920	60	7%
Route 107 Corridor - West Lynn and Lynnway	7	880	0	0%
Central Lynn - East Lynn	8	480	10	1%
East Lynn - Central Lynn	9	450	10	2%
West Lynn and Lynnway - Route 107 Corridor	10	810	0	0%

Note: colors indicate complementary O-D pairs.

The disparity between peak period and off-peak and weekend transit competitiveness within Lynn is also worth noting. For example, the OVTT-IVTT ratios (Tables C-3 - C-5) show that if all trips were to be made on transit, travelers would spend a larger proportion of travel time outside the vehicle on weekends than on weekdays.

External Trips

For any given time period, trips within Lynn are the largest share of travel from or to Lynn; therefore, trips with one end outside Lynn are analyzed independently in this section. Travel locations by Lynn residents are indicative of employment patterns and other daily activities, and are therefore used to help identify opportunities for transit improvements.

In this analysis, municipalities in the North Shore have been further divided into smaller units of analysis (no smaller than block groups) where there are potential hotspots for travel. Other locations were catalogued by municipality. Hotspots including malls, post-secondary schools, medical centers, and central business districts) have been

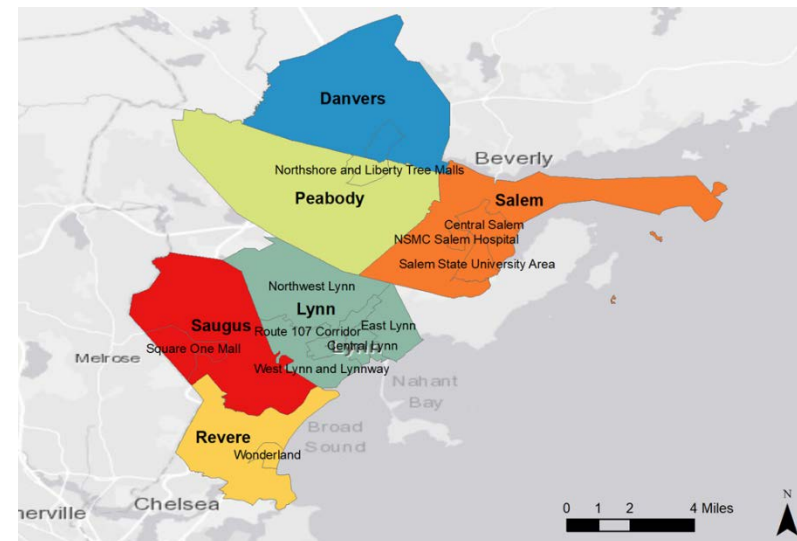
identified in Danvers, Peabody, Salem, Saugus, and Revere (Figure C-14). The points of interest are briefly introduced below.

- Danvers and Peabody:
 - Northshore and Liberty Tree Malls: refers to contiguous block groups containing the Northshore Mall in Peabody and the Liberty Tree Mall in Danvers. These malls are currently served by Route 436 with roughly hourly headways from Central Square.
- Salem:
 - Central Salem: contains the Salem commuter rail station and most of the retail and office space in Salem. In addition to commuter rail, this area is currently served by Routes 450, 455, and 456 with frequency of roughly 30 minutes in peak periods (450 and 455) and 40 to 80 minutes at other times.
 - NSMC Salem Hospital: headquarters of the North Shore Medical Center, a general hospital that operates a 24-7 emergency department; currently served by Routes 450 and 456.
 - Salem State University Area, currently served by Route 455.
- Saugus:
 - Square One Mall, currently served by Route 429 with 35 (AM) to 60 (PM) minute peak service frequencies and 75 minute midday frequencies.

- Revere:
 - Wonderland: contains the Wonderland and Revere Beach T stations, the Revere Registry of Motor Vehicles office, and a section along the Revere Beach Boulevard. Served by a number of routes, mainly with the purpose of providing connections to the Blue Line.

Travel market characteristics for the top travel markets are provided in the tables below; similar data for all travel markets is provided.

Figure C-14 Subdivisions in selected municipalities in the North Shore



The City of Boston is also analyzed based on its neighborhoods, with one exception for the Logan Airport, which is part of the East Boston neighborhood but analyzed separately as a standalone activity center. The resulting subdivisions are illustrated in Figure C-15.

For the City of Cambridge, East Cambridge comprising Kendall Square, the Massachusetts Institute of Technology campus, the CambridgeSide Galleria Mall, and North Point has been identified as a possible hotspot for travel (Figure C-16). Except for the five North Shore communities, Boston, and Cambridge, trips are reported at a municipal level.

Key findings for external travel markets are as follows:

- As in the case of internal travel, the top 10 travel markets for Lynn residents by direction (combinations of location and time period) are listed in Tables C-6, C-8, and C-10 for weekdays, Saturdays, and Sundays, respectively.
- The top daily travel destinations ranked by trip intensity are listed in Tables C-7, C-9, and C-11 along with the daily transit mode share for the destination. Since ODX trips could not be further classified by traveler residence location, the daily transit mode shares are calculated using all LBS trips beginning in Lynn (not limited to residents). Note that commuter rail trips are not in the ODX data, and none of the existing data source about commuter rail trips could provide origin-destination information. Therefore, transit market shares calculated with ODX data are likely to be underestimates.
- Besides employment at NSMC Salem Hospital and the Logan Airport, travel patterns on weekends seem to be largely driven by non-work activities such as shopping, personal business, and recreation; trips to the Northshore, Liberty Tree, and Square One Malls in the midday are major travel markets, along with certain neighborhoods in Boston such as Chinatown and Downtown (Tables C-9, C-11).
- The top travel markets by direction were examined specifically for residents in low-income block groups and minority block groups. The top travel markets for these groups were very similar to the top travel markets for all residents of Lynn.

Figure C-15 Subdivisions in the City of Boston

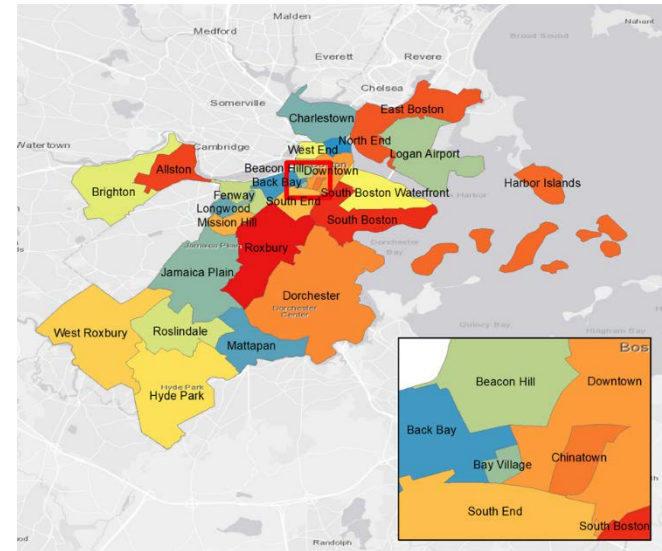


Figure C-16 Subdivision in the City of Cambridge



Travel to/from Medical Center Areas and the Airport

External travel markets were examined in greater detail specifically to medical center areas on the North Shore and within the City of Boston, as well as to Logan Airport. These areas appear to be significant destinations for work trips and potentially non-work trips (for health care) for Lynn residents.

- On weekdays, six out of the top 10 travel markets from Lynn (by time period) include NSMC Salem Hospital, the Longwood Medical Area, the West End in Boston, where the Massachusetts General Hospital is located (Table C-7). Chinatown, where the Tufts Medical Center is located, is also a top daily destination (Table C-8).
- NSMC Salem Hospital is the top travel destination on weekdays and Sundays and takes the second place on Saturdays, implying weekend employment at the facility (Tables C-7, C-9, and C-11).
- The transit mode shares vary largely depending on the travel location. They are usually higher for locations in Boston, but are less than 10 percent for nearly all destinations except for Downtown Boston (and Wonderland, which mainly reflects transfers to the Blue Line). Central Salem and shopping centers also tend to have higher transit mode shares (between 5 and 10 percent). However, NSMC Salem Hospital and Longwood are not among these locations and have very low transit mode shares, less than 5 percent (Tables C-8, C-10, and C-12).
- Trips to the medical areas are evenly split between home-based regular and home-based other on a daily basis; early AM and AM peak trips to these medical areas are predominantly home-based regular (Table C-19).

Possible New Service Opportunities

To explore the possibility of fixed-route services to the hotspots in the North Shore, trip intensity by origin block group in Lynn on different days of week are visualized in Figures C-17, C-18, and C-19. A number of block groups are identified with high trip intensity, located along Western Avenue, Broadway, and Walnut Street, making this area the most likely candidate for more fixed route service between these areas and other major North Shore destinations.

- As an example, there are an estimated 187 AM peak trips from Lynn to NSMC Salem Hospital and 468 trips from Lynn to Central Salem, two of the top North Shore destinations ranked by trip intensity. These destinations are near each other and are served by the same routes. If 15-minute peak period service was provided on existing Routes 455 and 456 for this 2-hour period, optimistically capturing a 10 percent market share and geographically serving half of the total Lynn trip market, there would be about two added riders to each bus trip $((187 + 468) * 0.5 \text{ coverage} * 10\% \text{ mode share} / 8 \text{ trips} / 2 \text{ routes} = 2.0 \text{ passengers})$. This probably would not be enough ridership to justify the additional service costs.
- Another example can be provided by looking at service to the Northshore and Liberty Tree malls. Over the course of the day from the AM peak to the PM peak (7:00 – 6:30, or 11.5 hours), there are a total of 1,718 estimated LBS trips to this destination from anywhere in Lynn. If service on Route 436 was increased to 15 minutes over this entire period, if the route was extended to serve one-third of Lynn's population, and a mode share of 10 percent was attained, there would be an additional one to two passengers on each bus $(1,718 * 0.33 \text{ coverage} * 10\% \text{ mode share} / (4 * 11.5 = 50 \text{ bus trips}) = 1.1 \text{ passengers})$.

- More direct services focused on major medical and employment centers in Boston (e.g., Longwood Medical Area, Logan Airport) might also be investigated. These centers typically have higher levels of roadway congestion and high parking costs which would support a higher transit mode share than observed to North Shore destinations. For example, MASCO provides shuttle services between off-site parking and remote offices and the Longwood medical area, but services are not provided to Lynn or the North Shore. The market in the early AM from Lynn to the Longwood area is around 50 trips per hour. At the average transit mode share for Longwood area employees of 48 percent,⁵ this could potentially justify a small bus service departing every 30 minutes. The return trips are more spread out throughout the rest of the day, however.

Recommendations

Specific Areas for Service Improvement

Three types of travel markets are identified as priority markets given their high trip intensity and volume compared with relatively low existing transit market shares and competitiveness indicators:

- Travel within Lynn, especially from East Lynn and West Lynn and Lynnway to Central Lynn.

These neighborhood pairs dominate the travel market in Lynn and suggest that more services on the weekend as well as equal transit level of service throughout the day on weekdays may be considered. The same strategy could apply to other high-flow neighborhood pairs in Lynn, none of which have high transit market shares and competitive service.

However, the analysis here suggests that trip intensities between Lynn neighborhoods may not be high enough to support the high-frequency service needed to attract choice riders. Infrastructure and safety improvements for walking and bicycling may also be an effective way of improving local mobility, given the prevalence of short trips. Local trips might also be served more cost-effectively with shared mobility services than with fixed-route transit.

- Both peak and off-peak travel within the North Shore to meet travel demand for work and other essential activities, especially on weekends.

Travel to NSMC Salem Hospital has high demand and is very possibly driven by employment, while the transit mode shares are low regardless of time period. As hospital shifts are not limited to regular business hours on weekdays, service may need to be modified to accommodate these travelers. Central Salem, Northshore Mall, Liberty Tree Mall, and Square One Mall are high-flow hotspots with limited transit competitiveness; improved service levels could benefit Lynn residents commuting to and accessing essential services in these locations. Again, however, preliminary analysis suggests that market sizes may not be large enough to justify high-frequency fixed-route service. Microtransit services focused on specific temporal markets (e.g., shift changes, mall openings and closings) with high concentrations of travelers should be investigated, with shared mobility services considered for lower-intensity travel markets.

- Off-peak travel to/from the Longwood Medical Area and Logan Airport.

These employment locations might warrant improved commuter options outside of regular business hours on weekdays, and given the cost of

⁵ <https://www.masco.org/moving-around-the-lma>

parking and higher levels of congestion in these areas, the markets might be large enough to support some fixed-route service, especially if targeted towards peak commuting times, such as the early morning period.

Examination of Additional Markets for Improved Service

In addition to these specific recommendations, the LBS data on travel markets by origin/destination and time period can be used to assess the viability of potential new or expanded transit service within Lynn and to other communities in the region. As a general procedure this may be done by:

- From the LBS data, identifying the total number of trips per hour for a given high-intensity origin-destination market.
- Identifying potential transit routes on which to enhance or introduce new service for this market.
- Factoring that market by the fraction of the market area that would be within walking distance of transit stops on a proposed improved service.
- Examining the competitiveness of transit service (e.g., travel time ratios) under existing conditions, and how that might change with a proposed future service.
- Applying estimated transit modes shares to the total trip market, based on observed transit mode shares for markets with similar competitiveness and demographics.⁶

⁶ For example, average transit commute mode shares for the Boston MSA, based on 2018 5-year ACS data, are 11 percent for workers in the retail industry and 13 percent for workers in the educational services, and health care and social assistance industries. These could be used as starting points for

mode share estimates to destinations outside of the core of Boston. Mode shares could also be taken from markets with similar transit-auto travel time ratios to the proposed service improvement.

Table C-6 Time period specific top 10 travel markets for Lynn residents ranked by trip intensity on Weekdays

	Intensity rank	Time period	Daily trips
Destinations - from Lynn			
Boston: West End	1	AM Peak	221
Salem: NSMC Salem Hospital	2	AM Peak	187
Salem: Central Salem	3	AM Peak	468
Salem: NSMC Salem Hospital	4	Midday School	204
Boston: Downtown	5	AM Peak	394
Revere: Wonderland	6	AM Peak	104
Salem: NSMC Salem Hospital	7	Early AM	231
Boston: Longwood	8	Early AM	187
Boston: Back Bay	9	AM Peak	204
Salem: NSMC Salem Hospital	10	Midday Base	212
Origins - to Lynn			
Boston: West End	1	PM Peak	284
Revere: Wonderland	2	PM Peak	219
Salem: NSMC Salem Hospital	3	Midday School	218
Salem: NSMC Salem Hospital	4	PM Peak	194
Revere: Wonderland	5	Midday School	131
Revere: Wonderland	6	Evening	173
Salem: NSMC Salem Hospital	7	Evening	206
Boston: Downtown	8	PM Peak	348
Boston: West End	9	Midday School	129
Salem: Central Salem	10	PM Peak	346

Table C-7 Top ten daily travel destinations for Lynn residents ranked by trip intensity – full weekday

Destination	Intensity rank	Daily trips	Transit mode share
Salem: NSMC Salem Hospital	1	1,074	3%
Boston: West End	2	664	4%
Revere: Wonderland	3	545	47%
Salem: Central Salem	4	1,713	8%
Northshore and Liberty Tree Malls	5	2,063	8%
Boston: Downtown	6	1,162	37%
Boston: Longwood	7	357	0%
Boston: Chinatown	8	93	0%
Swampscott	9	3,934	1%
Boston: Logan Airport	10	987	9%

Table C-8 Time period specific top 10 travel markets for Lynn residents ranked by trip intensity on Saturdays

	Intensity rank	Time period	Daily trips
Destinations - from Lynn			
Northshore and Liberty Tree Malls	1	Midday Base	1178
Northshore and Liberty Tree Malls	2	Midday School	566
Salem: NSMC Salem Hospital	3	Midday School	117
Northshore and Liberty Tree Malls	4	PM Peak	480
Salem: NSMC Salem Hospital	5	AM Peak	86
Saugus: Square One Mall	6	Midday School	454
Revere: Wonderland	7	Early AM	109
Revere: Wonderland	8	Midday Base	123
Salem: Central Salem	9	Midday Base	409
Saugus: Square One Mall	10	Midday Base	715
Origins - to Lynn			
Revere: Wonderland	1	PM Peak	139
Northshore and Liberty Tree Malls	2	PM Peak	742
Northshore and Liberty Tree Malls	3	Midday School	681
Northshore and Liberty Tree Malls	4	Evening	887
Salem: NSMC Salem Hospital	5	Midday School	123
Boston: Chinatown	6	Evening	37
Saugus: Square One Mall	7	PM Peak	577
Salem: NSMC Salem Hospital	8	Evening	158
Revere: Wonderland	9	Midday School	87
Revere: Wonderland	10	Evening	121

Table C-9 Daily top ten travel destinations for Lynn residents ranked by trip intensity – full Saturday

Destination	Intensity rank	Daily trips	Transit mode share
Northshore and Liberty Tree Malls	1	2,876	7%
Salem: NSMC Salem Hospital	2	592	1%
Revere: Wonderland	3	775	19%
Salem: Central Salem	4	1,244	7%
Saugus: Square One Mall	5	1,790	6%
Swampscott	6	3,532	1%
Boston: Chinatown	7	69	0%
Boston: West End	8	280	2%
Boston: Downtown	9	613	24%
Salem: Other	10	5,334	1%

Table C-10 Time period specific top 10 travel markets for Lynn residents ranked by trip intensity on Sundays

Destination	Intensity rank	Time period	Daily trips
Destination – from Lynn			
Salem: NSMC Salem Hospital	1	Midday School	140
Salem: NSMC Salem Hospital	2	Midday Base	233
Northshore and Liberty Tree Malls	3	Midday Base	878
Northshore and Liberty Tree Malls	4	Midday School	443
Salem: NSMC Salem Hospital	5	AM Peak	72
Salem: NSMC Salem Hospital	6	PM Peak	90
Salem: NSMC Salem Hospital	7	Early AM	131
Salem: Central Salem	8	AM Peak	175
Salem: Central Salem	9	Midday Base	376
Saugus: Square One Mall	10	Midday School	339
Origin – to Lynn			
Salem: NSMC Salem Hospital	1	Midday School	179
Revere: Wonderland	2	PM Peak	119
Boston: Chinatown	3	Evening	42
Northshore and Liberty Tree Malls	4	PM Peak	498
Revere: Wonderland	5	Late Night	177
Northshore and Liberty Tree Malls	6	Midday School	479
Salem: NSMC Salem Hospital	7	Evening	143
Salem: NSMC Salem Hospital	8	PM Peak	101
Revere: Wonderland	9	Evening	109
Salem: NSMC Salem Hospital	10	Late Night	190

Table C-11 Top ten daily travel destinations for Lynn residents ranked by trip intensity – full Sunday

Destination	Intensity rank	Daily trips	Transit mode share
Salem: NSMC Salem Hospital	1	776	1%
Northshore and Liberty Tree Malls	2	1,862	5%
Salem: Central Salem	3	1,081	6%
Revere: Wonderland	4	253	50%
Swampscott	5	3,072	1%
Saugus: Square One Mall	6	1,214	5%
Boston: Logan Airport	7	686	13%
Boston: Chinatown	8	46	0%
Salem: Other	9	4,517	1%
Boston: West End	10	189	1%

Table C-12 Weekday trips to medical areas, percentages by trip purpose

Destination	Time period	Home-based regular	Home-based other	Non-home-based
Boston: Chinatown	Early AM	70%	8%	22%
	AM Peak	52%	35%	13%
Boston: Longwood	Early AM	69%	28%	3%
	AM Peak	43%	45%	12%
Boston: West End	Early AM	60%	34%	5%
	AM Peak	44%	31%	24%
Salem: NSMC Salem Hospital	Early AM	73%	23%	4%
	AM Peak	46%	47%	7%

Figure C-17 Weekday daily trip intensity to North Shore hotspots

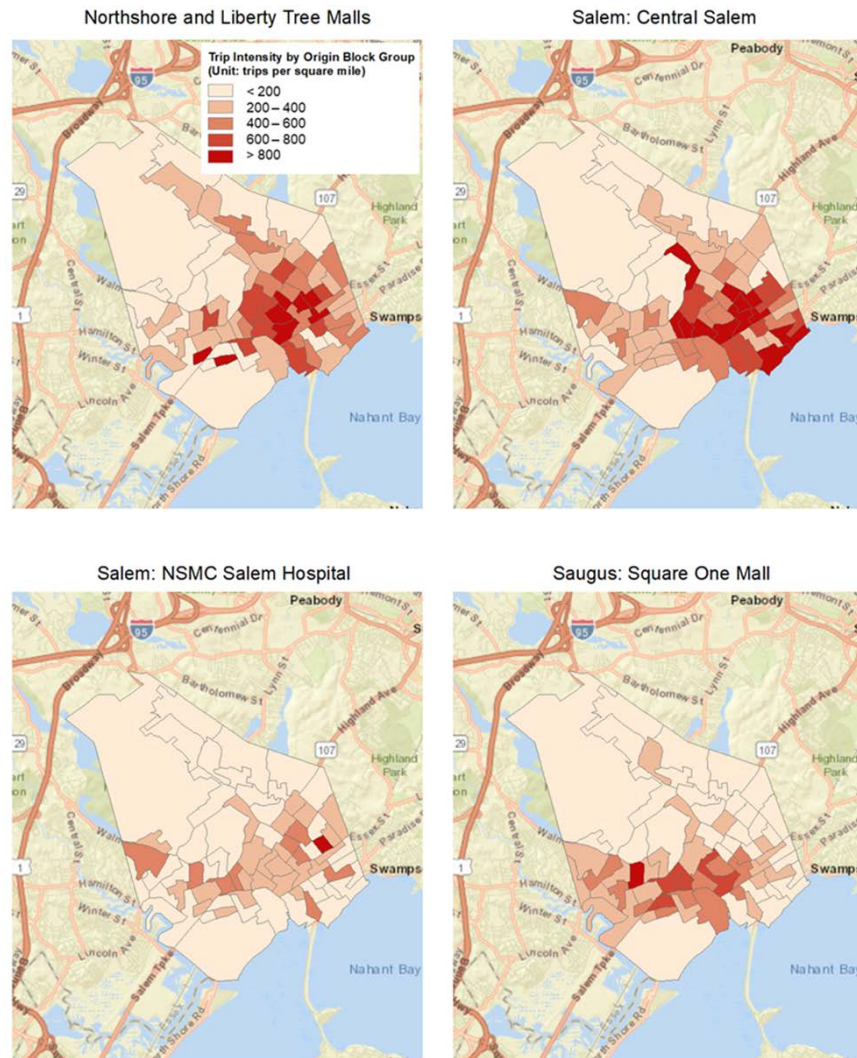


Figure C-18 Saturday daily trip intensity to North Shore hotspots

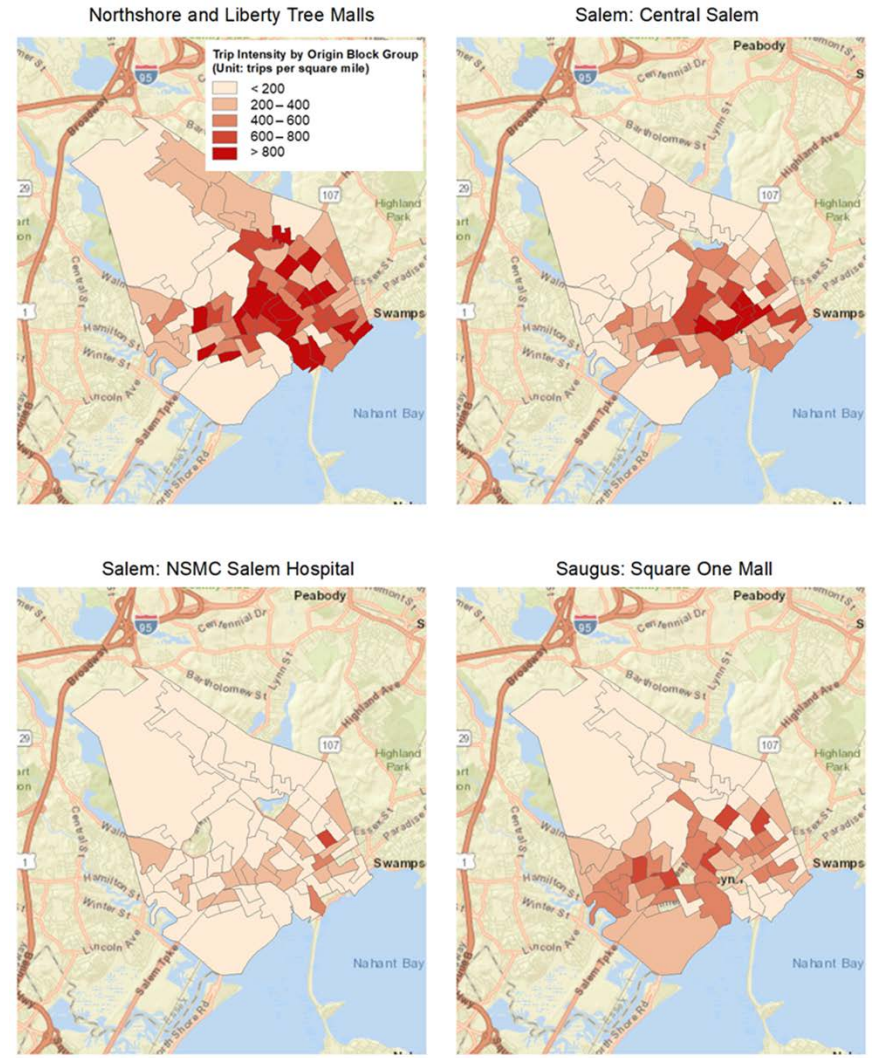


Figure C-19 **Sunday daily trip intensity to North Shore hotspots**

