Regionwide Suburban Transit Opportunities Study

Phase III

Boston Region Metropolitan Planning Organization

Regionwide Suburban Transit Opportunities Study: Phase III

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Central Transportation Planning Staff

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INTRODUCTION

In January 2003, CTPS completed the first phase of the Suburban Transit Opportunities Study, which included a review of suburban transit operations in peer metropolitan areas, an assessment of existing services in the Boston metropolitan area, and the development of new guidelines for operating successful transit service in Boston's suburbs. The Boston Region Metropolitan Planning Organization (MPO) used these guidelines in evaluating applications for funding of new services that would improve mobility in suburban communities. In Phase II of the study, suburban communities and employment centers with the potential for supporting new fixed-route transit services were identified, irrespective of any funding considerations, and initial technical assistance was provided to the selected recipients of funding under the MPO's new suburban mobility funding program.

As part of the Regionwide Suburban Transit Opportunities Study, Phase III, MPO staff resources were reserved to help a limited number of communities assess their potential to support demand-responsive transit service. This type of service differs from traditional fixed-route transit service. Fixed-route service, such as an MBTA bus route, may have designated variations in routing or run at higher frequencies during the peak period, but the service is defined well in advance of any trip, usually on schedule cards that customers can reference. Demand-responsive service, as the name suggests, is more immediately responsive to demand. In this type of service, characteristics such as the routing or the schedule are more flexible and can be altered to more closely conform to actual demand at a given point in time. Customers may call in to a central operations center as early as a week in advance of a trip or, depending on the service, even while that trip is being run, to request a ride. If possible, the service will be altered to accommodate the customer.

There are several types of demand response. So-called route deviation usually runs on a fixed route but is permitted to deviate from that route up to a certain distance. Point deviation is another form of demand-responsive service that has two or more time points but deviates as necessary for passengers between those points. Feeder services serve one point on one end of the trip, often a fixed-route connector, and provide demand-responsive service to cover a defined geographic area on the other end. Pure demand-responsive service, more commonly known as "dial-a-ride," follows no schedule, but simply picks up and drops off passengers where and when they request. Demand-responsive service usually operates within a specified geographical area, and the vehicles used are generally smaller buses or vans. Different applications of demand-responsive service include rapid transit feeder services, commuter vanpools, subscription services, and community circulators.

The analysis of demand-responsive service necessitates the consideration of many of the same characteristics that are used to analyze fixed-route transit. These criteria are mainly demographic, focusing on the characteristics of the given population and the physical distribution of this population and its characteristics, but they also often consider the physical layout of an area, in terms of both its man-made and natural features. As directed by the work program, therefore, the MPO, in order to help communities think about the potential for transit, pulled together and analyzed information on land use, population and employment densities, travel patterns, and demographic characteristics. Along with the potential demand for transit in communities, the analyses also discussed the potential difficulties. Considering both these sides was intended to help the community to realistically consider the potential for demand-responsive transit.

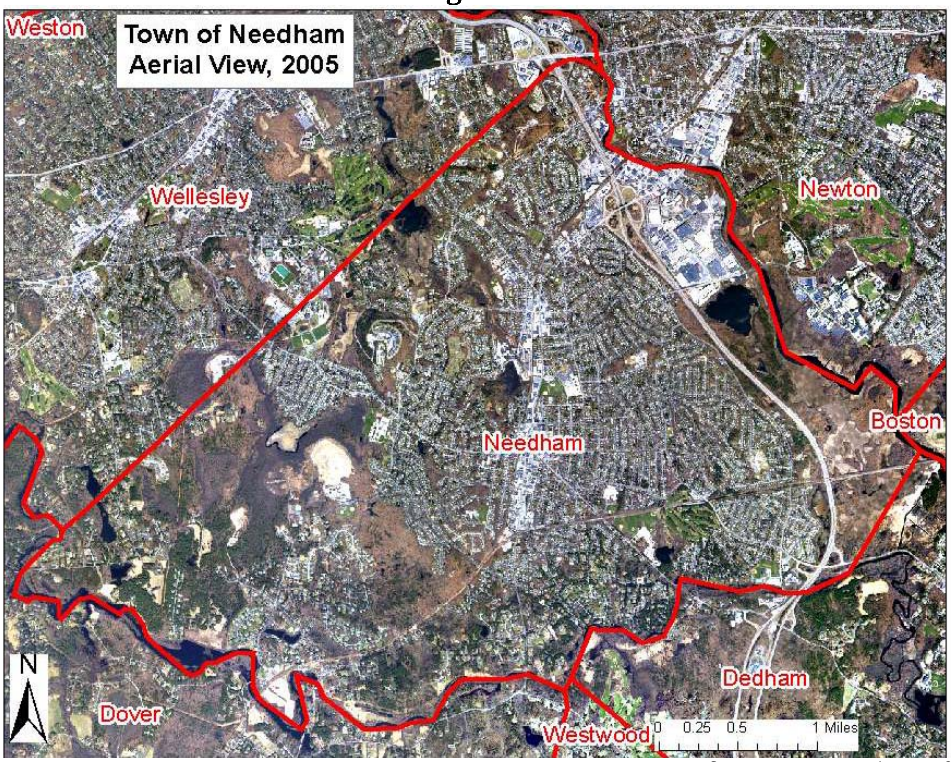
This report compiles the individual analyses for the towns of Needham, Acton, Carlisle, Bedford, Reading, and Lexington. Each of these towns, except for Needham, applied to, and received approval from, the Suburban Mobility/TDM Subcommittee to be included in the MPO analysis of the potential for demand-responsive service in the Boston metropolitan area. Needham was included as an example case study.

NEEDHAM

Physical Criteria

Figure 1 presents an aerial photograph of the town of Needham and the surrounding area from 2005. From this photograph, one can generally see three distinct areas of the town. The center of the town, lying to the west of Route 128, is mostly composed of residential areas, with commercial uses concentrated mainly along Highland Avenue, running through the center of town. To the northeast corner of the town, Highland Avenue continues through the Route 128 business complex, east of Route 128 towards southern Newton. Finally, while the southwestern corner of the town does contain some residential development, it is mostly devoted to open space and other environmental or recreational uses. Needham is bordered by Wellesley to the northwest, Newton to the northeast, Dedham to the southeast, and Dover to the southwest.

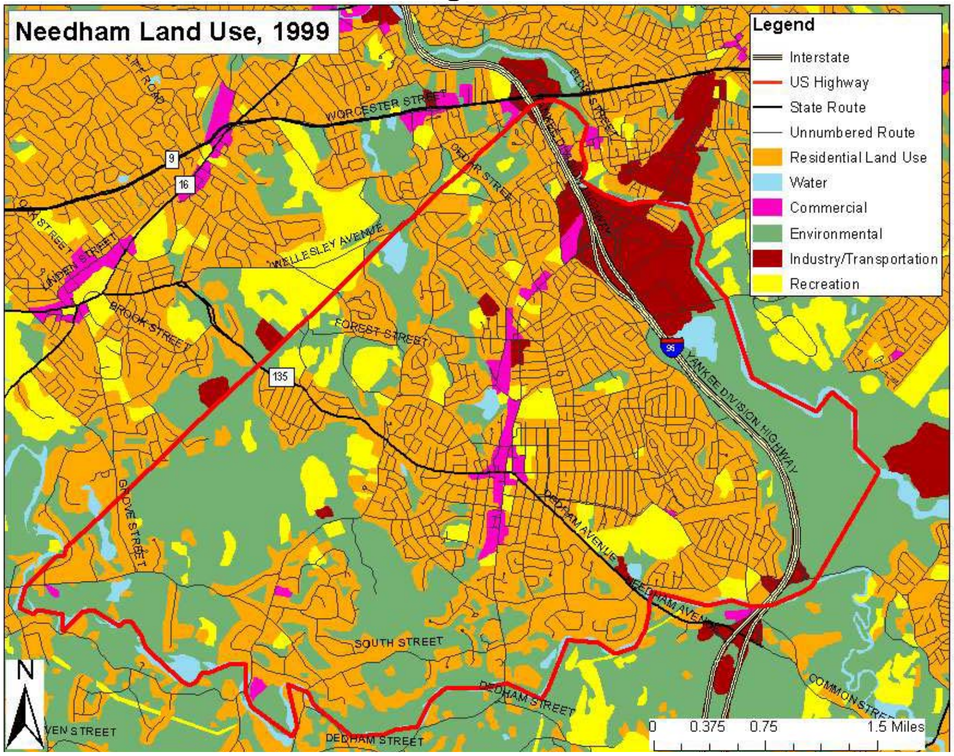
Figure 1



Source: Boston Region MPO

Figure 2 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston Region MPO region in 1999 and breaks down land uses into 21 categories. Figure 2 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen from the figure, the majority of land use in Needham is residential in nature.

Figure 2

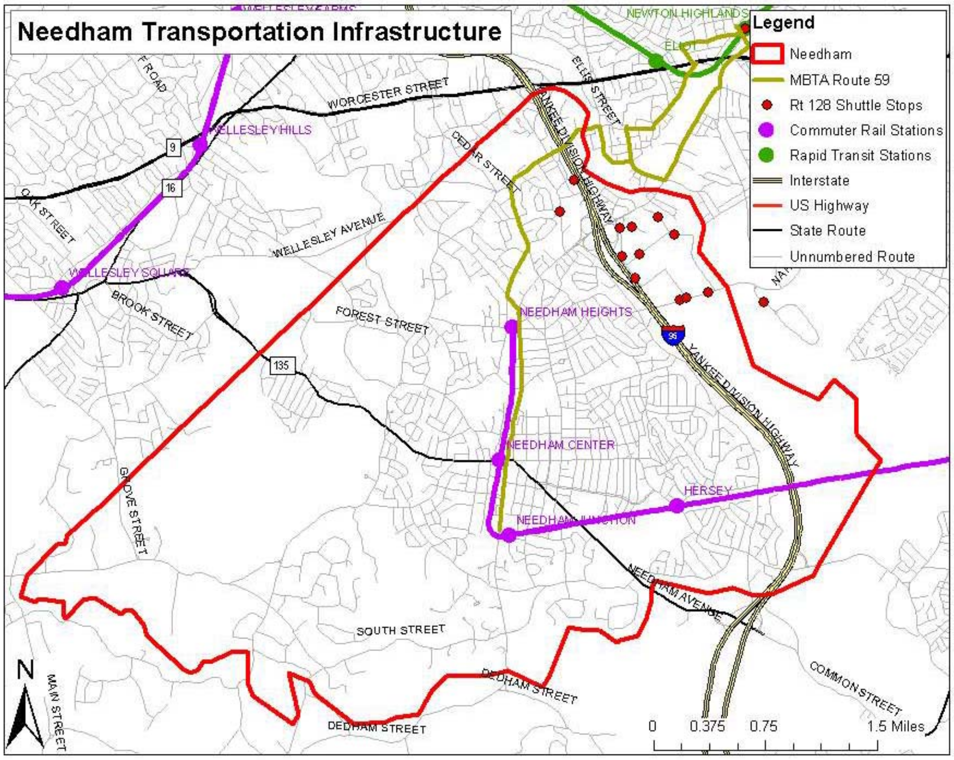


Source: MassGIS

Figure 3 depicts the transportation infrastructure in the town of Needham. Route 128 lies to the eastern side of the town, providing access to the Route 128 business complex and continuing north towards Newton and south towards Dedham. The Route 128 Business Council also runs a shuttle between the complex and the Newton Highlands station on the Green Line D branch. The shuttle has five morning runs between 6:30 AM and 9:10 AM and four evening runs between 4:13 PM and 6:30 PM. Drivers wishing to access the commercial center of Needham can exit Route 128 at Highland Avenue. MBTA bus route 59 and the Needham commuter rail line also serve Highland Avenue. The bus route runs north through Newton to Watertown while commuter rail runs through West Roxbury and Roslindale to South Station in downtown Boston. Route 135, running through Needham Center, acts as the major east-west corridor in the town between Dedham and Wellesley.

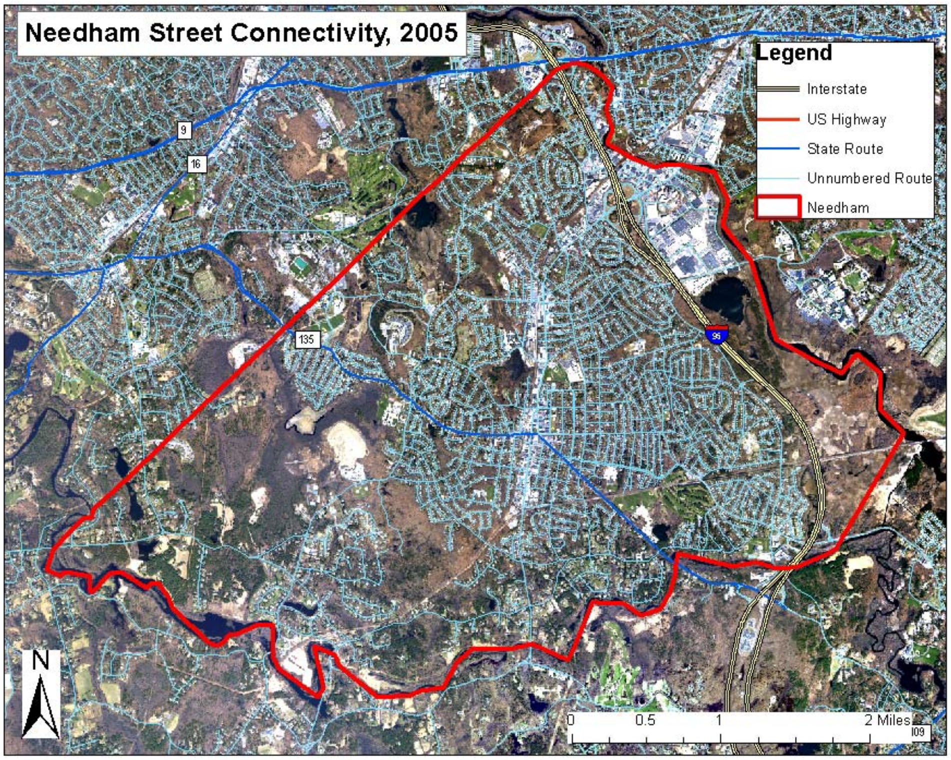
Figure 4 overlays the street network on top of the aerial photograph of Needham, highlighting the street connectivity in the town. As seen in the figure, cul-de-sacs and curvilinear roads characterize the low coverage of the street network in the northern corner of the town. This coverage is even lower in the western section of the town. The street grid coverage improves slightly, however, in the center, west of Highland Avenue and west of Route 128. The highest coverage, characterized by a comprehensive grid network with few cul-de-sacs and dead ends, lies just east of Highland Avenue.

Figure 3



Source: Boston Region MPO

Figure 4



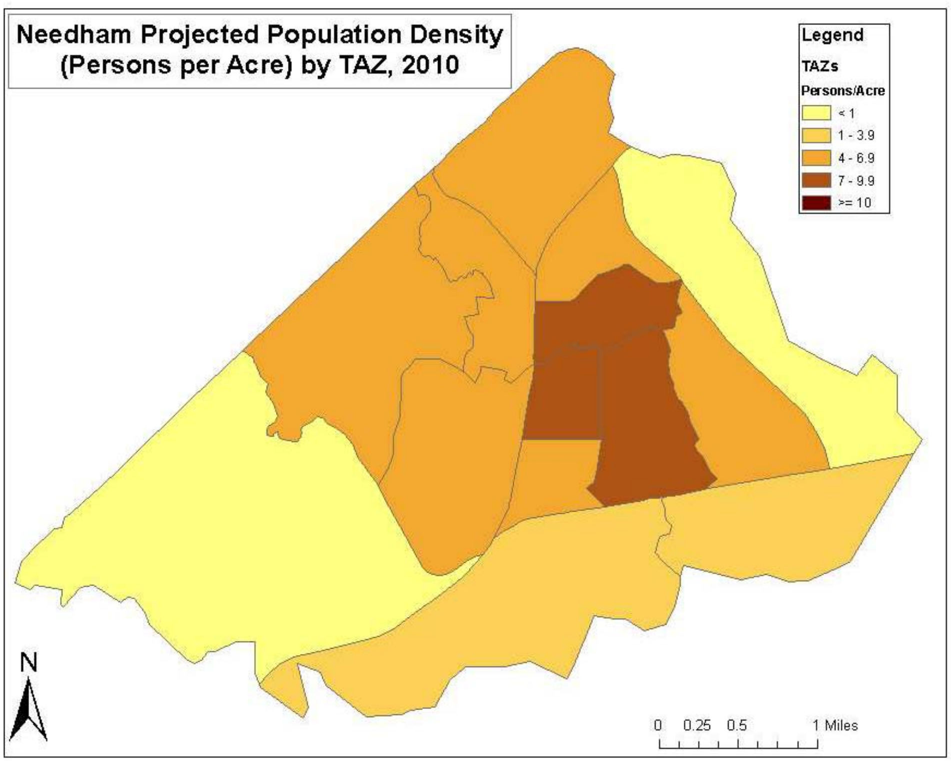
Source: Boston Region MPO

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips tends to be greater. Figure 5 shows the 2010 projections for population density by TAZ (Traffic Analysis Zone). As seen in the figure, the three TAZs with the highest population densities are concentrated in the center of the town. However, most of the town has densities above 4 persons per acre, and population density levels seem to generally match the level of street connectivity. Namely, the largest concentration of higher-density blocks lies east of Highland Avenue in the center of town where the street network is characterized by a grid pattern, with few cul-de-sacs or dead-ends. As the street network becomes less connected, population density also generally decreases.

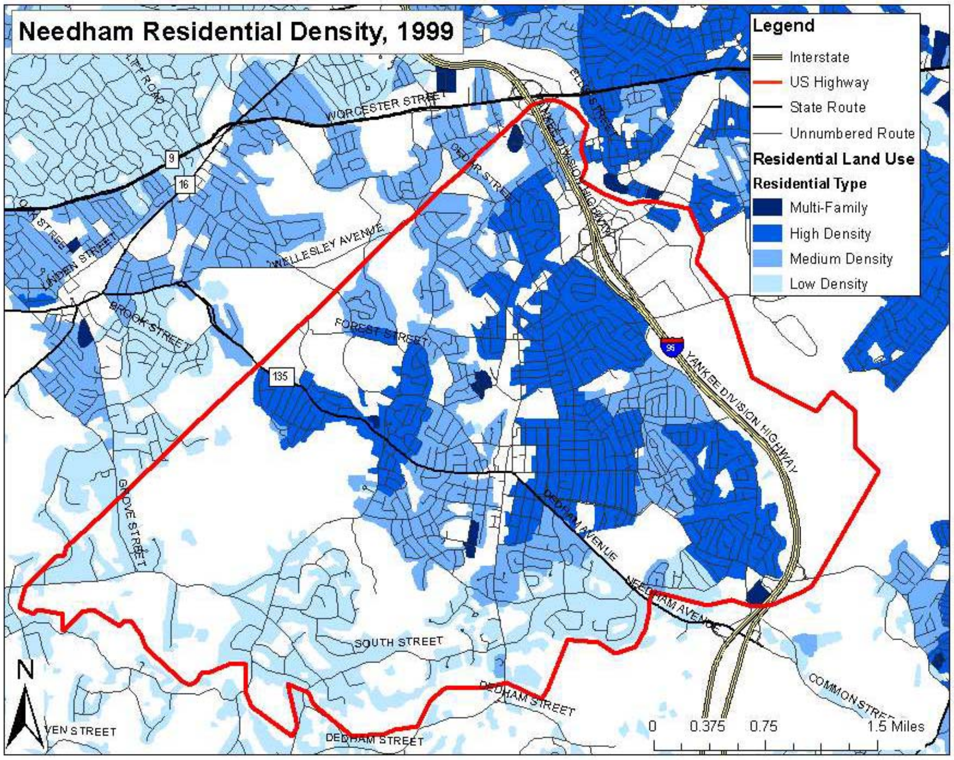
Figure 5



Source: Boston Region MPO

Figure 6 presents population densities in a slightly different way. In this figure, the residential areas of the town are explicitly shown and broken into various density categories, based on the MPO survey of land use in the Boston region. Areas with multi-family housing development represent perhaps the greatest potential for transit demand, owing to the greater concentrations of people and thus trip origins and destinations in one place. Transit is also potentially suitable in areas of high density, less so in medium-density locations, and difficult to justify in low-density locations. In Needham, however, most multi-family and high-density locations are relatively concentrated in the center part of town. Only in the southern and western parts of the town do residential densities fall to the "low density" designation.

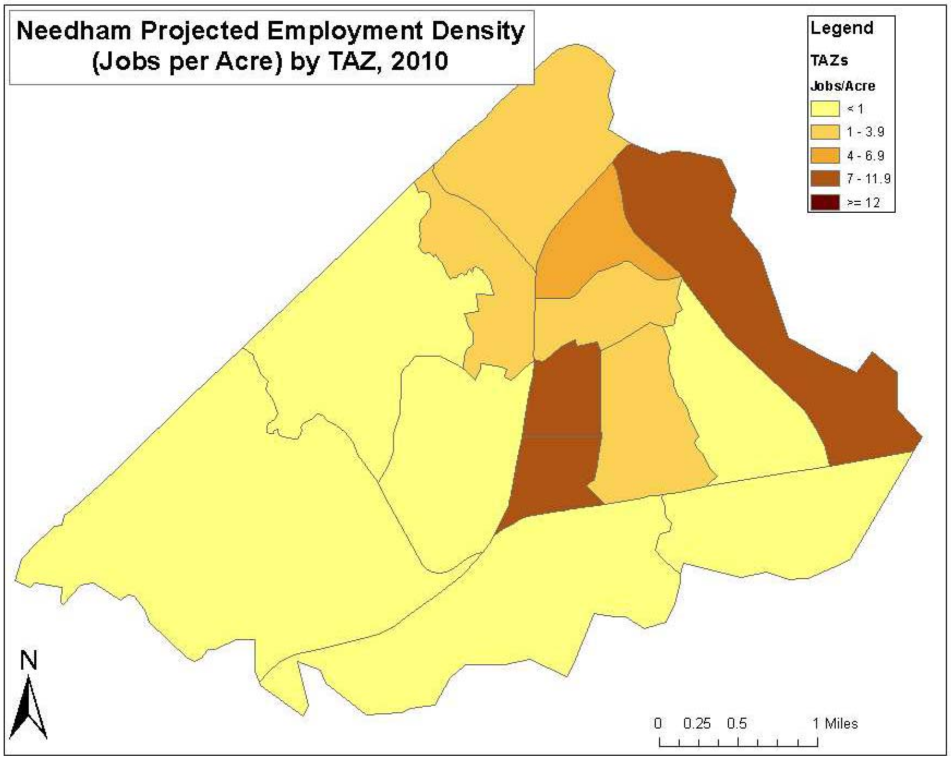
Figure 6



Source: MassGIS

The population and residential densities depicted in Figures 5 and 6 are important for determining the locations of potential origins and destinations of a transit service in Needham. Another significant origin/destination for travel within Needham exists at places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Indeed, transit has generally been most successful at serving commuting trips between work and home. In the town of Needham, Figure 7 depicts the employment density, measured as the number of jobs per acre, by TAZ. As could be expected from viewing the map of land uses, the highest employment densities lie along the commercial corridor of Highland Avenue and in the Route 128 business complex. Elsewhere in the town, where residential land uses predominate, employment densities generally fall below 1 job per acre.

Figure 7

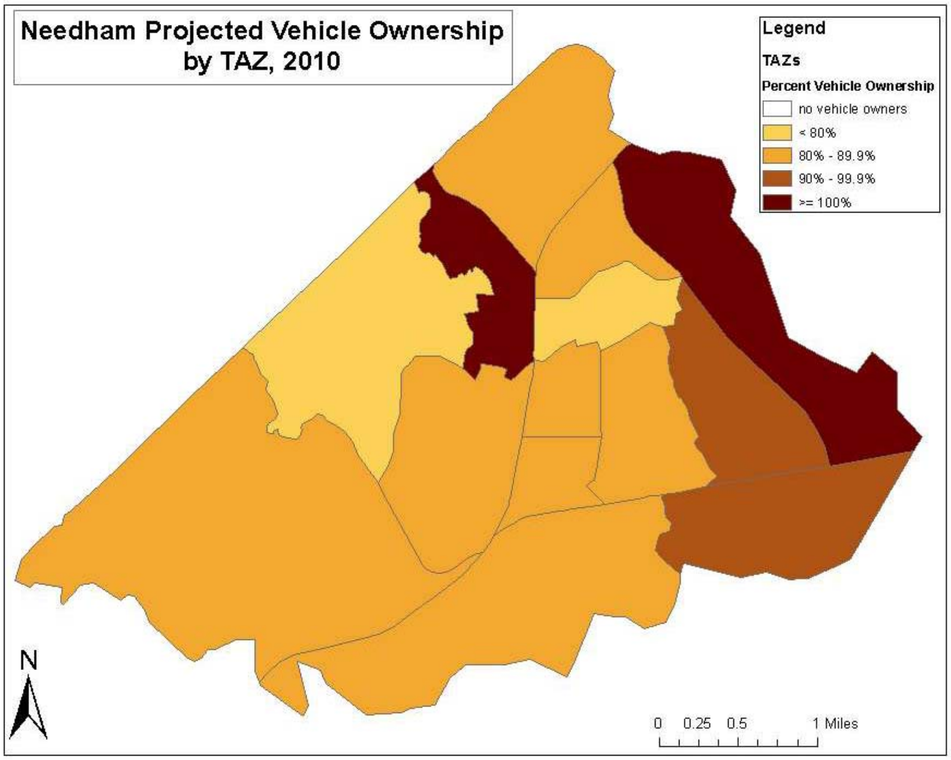


Source: Boston Region MPO

One factor that can influence the potential of transit in an area is the rate of vehicle ownership to population. Lower vehicle ownership percentages are a likely indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 8, vehicle ownership in Needham is generally quite high, even in the high-density areas identified above. Indeed, these areas seem to have some of the highest vehicle ownership percentages in the town. Of the two TAZs with rates below 80 percent, one lies along the Highland Avenue corridor and one lies on the western border of Needham, where Route 135 passes into Wellesley.

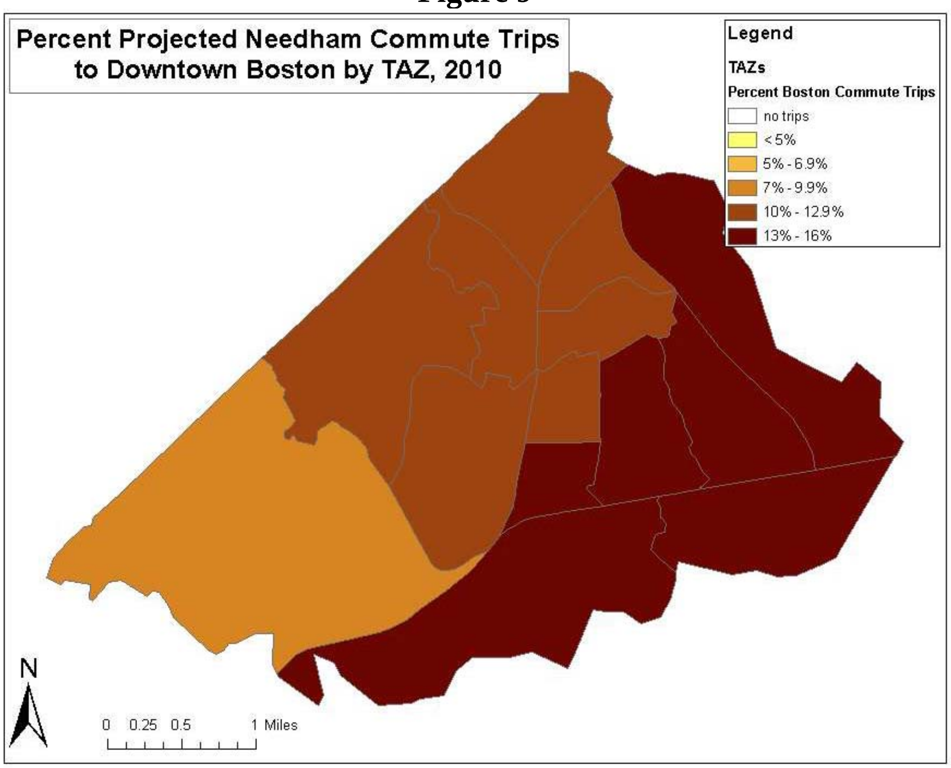
Given that work trips represent a significant portion of public transit usage, it is useful to know where residents are traveling to and from during their daily commute. Figure 9 presents the percentage of commute trips from Needham to downtown Boston and Figure 10 shows the percentage of intra-Needham commute trips. As seen in Figure 9, the percentage of workers who commute to downtown Boston for work is relatively consistent across nearly all block groups, only falling below 10 percent in one case and never rising above 16%. The highest rates of city commuting do lie in the eastern-central section of the town. The rate of intra-Needham commuting varies much more. However, the highest rates of intra-Needham commute trips are found along Highland Avenue. Moreover, at least 16 percent of all commute trips from Needham stay within the town in all but two TAZs. When the number of trips expands to include all types of trips (both peak and off-peak – Figure 11) the percentage of intra-Needham trips in all TAZs increases with central Needham having the highest rates of intra-town travel.

Figure 8



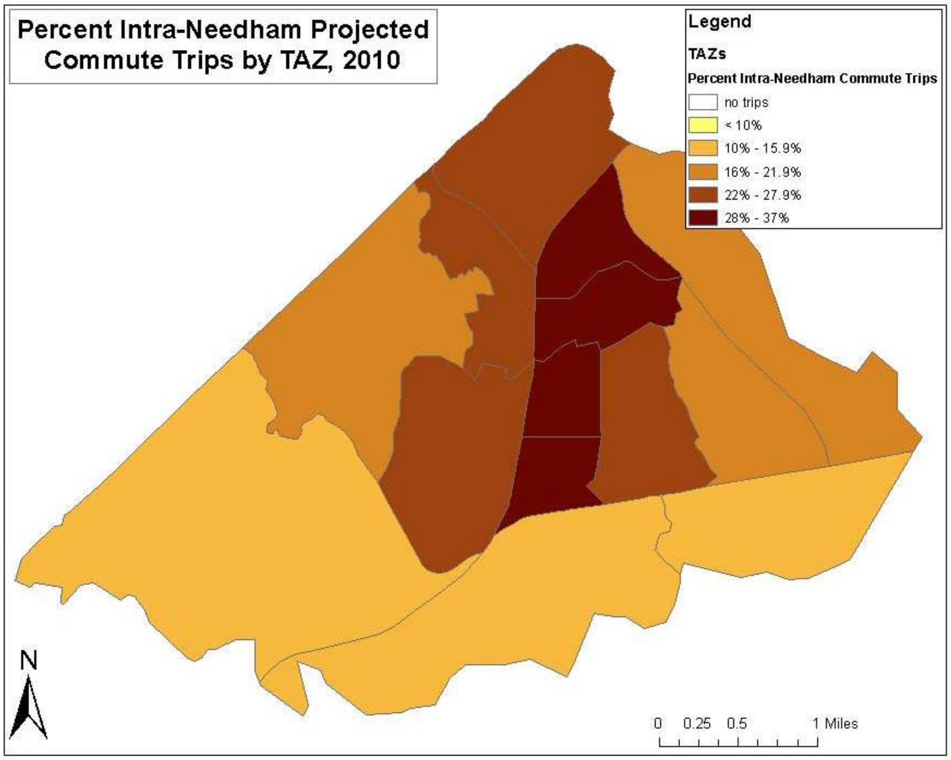
Source: Boston Region MPO

Figure 9



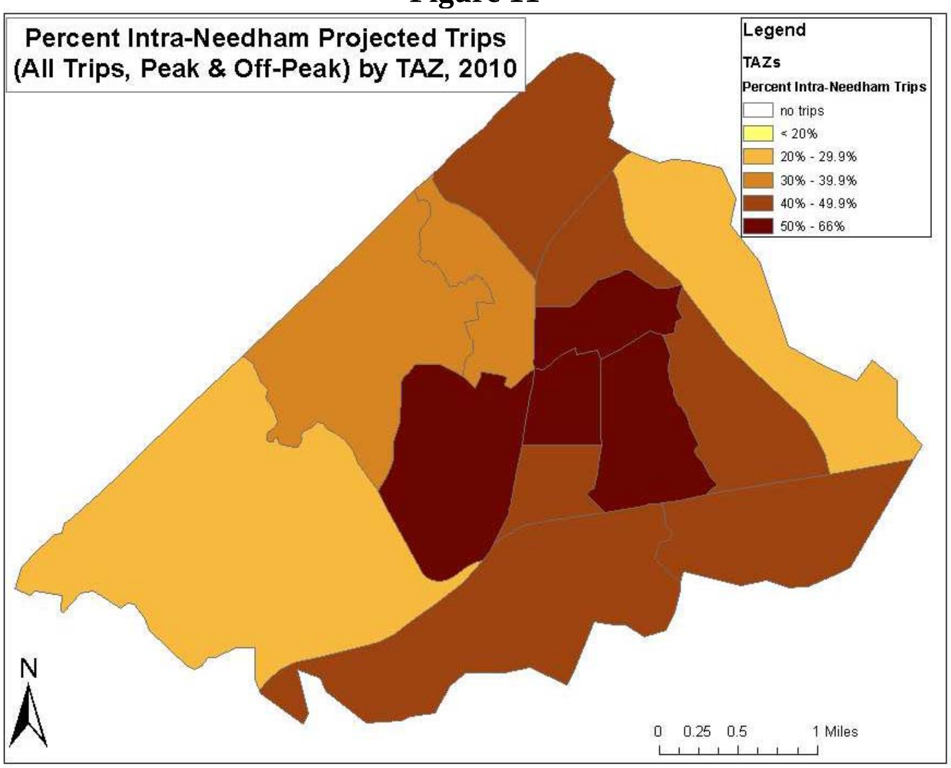
Source: Boston Region MPO

Figure 10



Source: Boston Region MPO

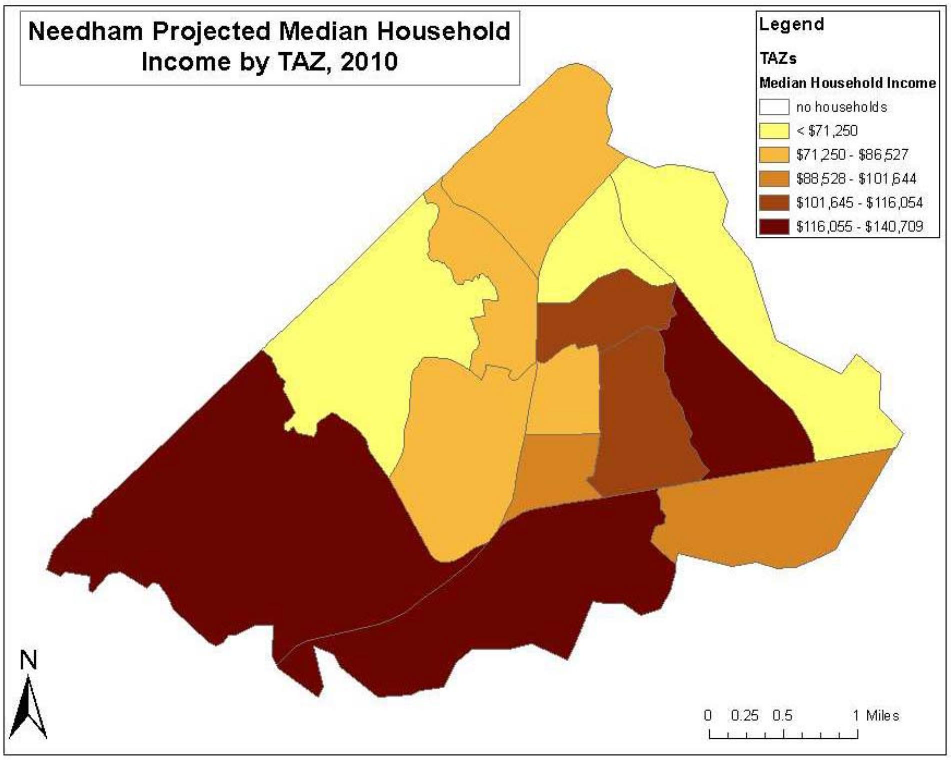
Figure 11



Source: Boston Region MPO

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 12, no TAZs in the town of Needham have a median household income below $41,850. However, many of the TAZs in northern and central Needham are characterized by much lower median household incomes than those in southwestern Needham.

Figure 12



Source: Boston Region MPO

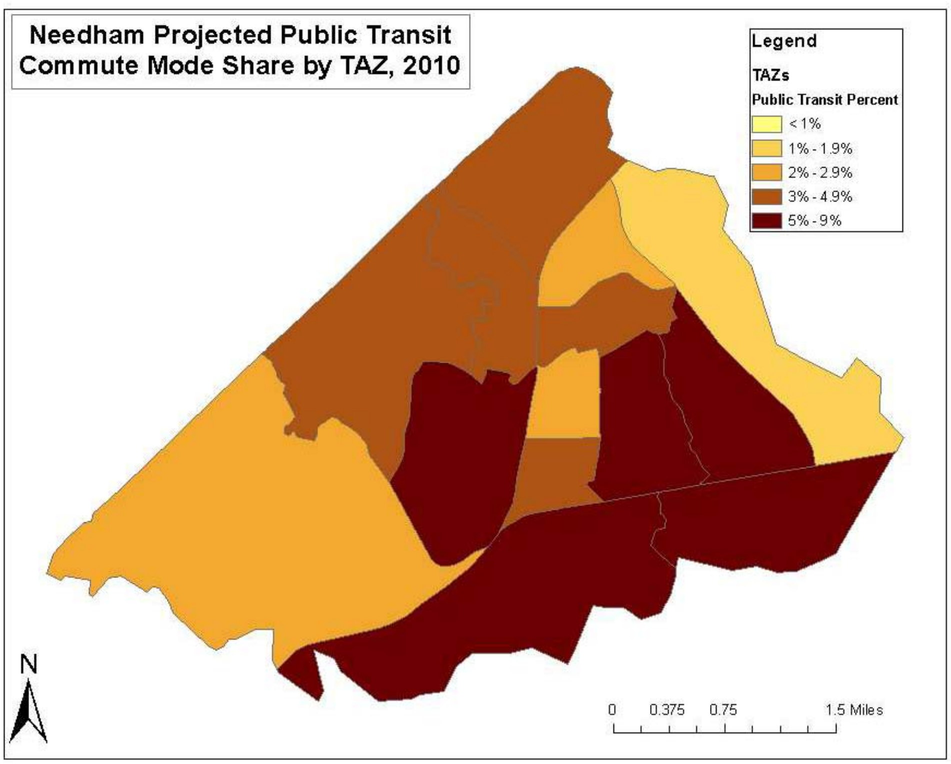
With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. The Boston Region Metropolitan Planning Organization (MPO) predicts that 13.3 percent of the population of the town of Needham will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, the MPO predicts that this population group will compose 18.5 percent of the total population in 2010. Thus, 31.8 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher.

Transit Demand Assessment

The town of Needham does seem to offer many of the characteristics that would make it suitable for public transportation. For a suburban community, the population, residential, and employment densities around Highland Avenue and the Route 128 business complex increase the likelihood that transit can offer a convenient and competitive alternative to driving with a private vehicle. This ability to compete is important given the high rate of vehicle ownership in many of the TAZs that also have high densities. Many of the trips for which public transit traditionally competes occur as part of the daily commute. Across Needham, a fairly significant and consistent percentage of residents commute to downtown Boston for work. For these trips, both the Needham commuter rail line and the Green Line D branch provide direct-to-Boston access. MBTA bus route 59 also links and provides access to these two services.

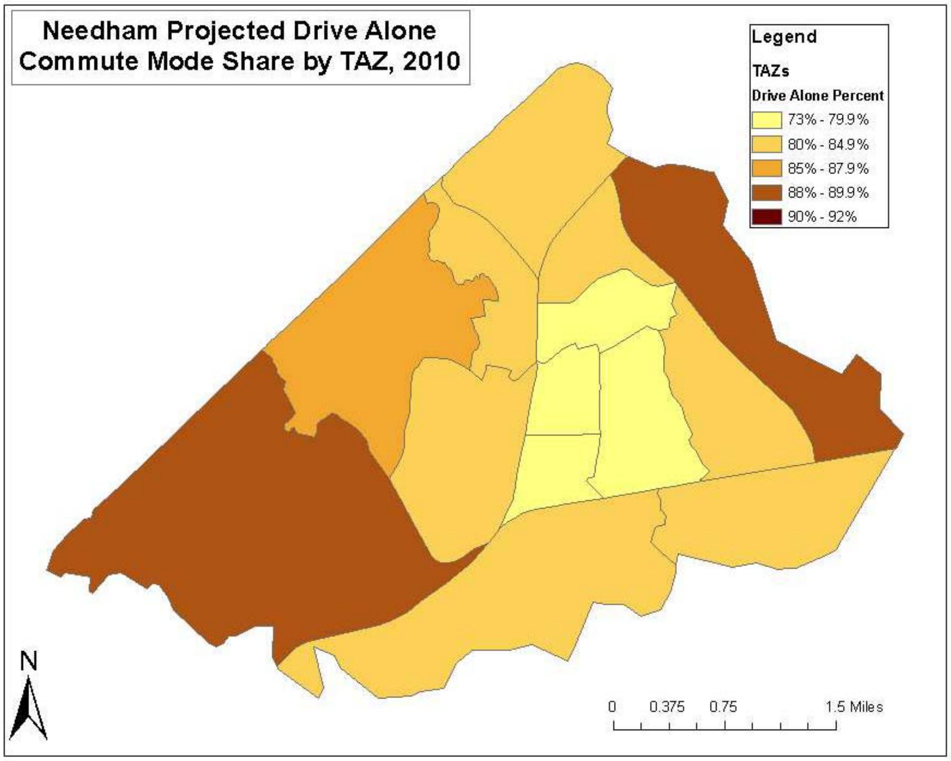
Indeed, Needham is already fairly well served by public transit between commuter rail, the Green Line D branch in Newton, local bus, and the Route 128 Business Council shuttle. As seen in Figure 13, most TAZs have transit commute mode shares greater than 3 percent and several have mode shares above 5 percent. Higher transit commute mode shares are generally balanced by lower drive alone percentages, as seen in Figure 14. From the two figures, it appears as though the central and southern sections of the town are the most likely to use public transportation for their commute. This is not surprising, given that the Needham commuter rail line runs adjacent to this area.

Figure 13



Source: Boston Region MPO

Figure 14

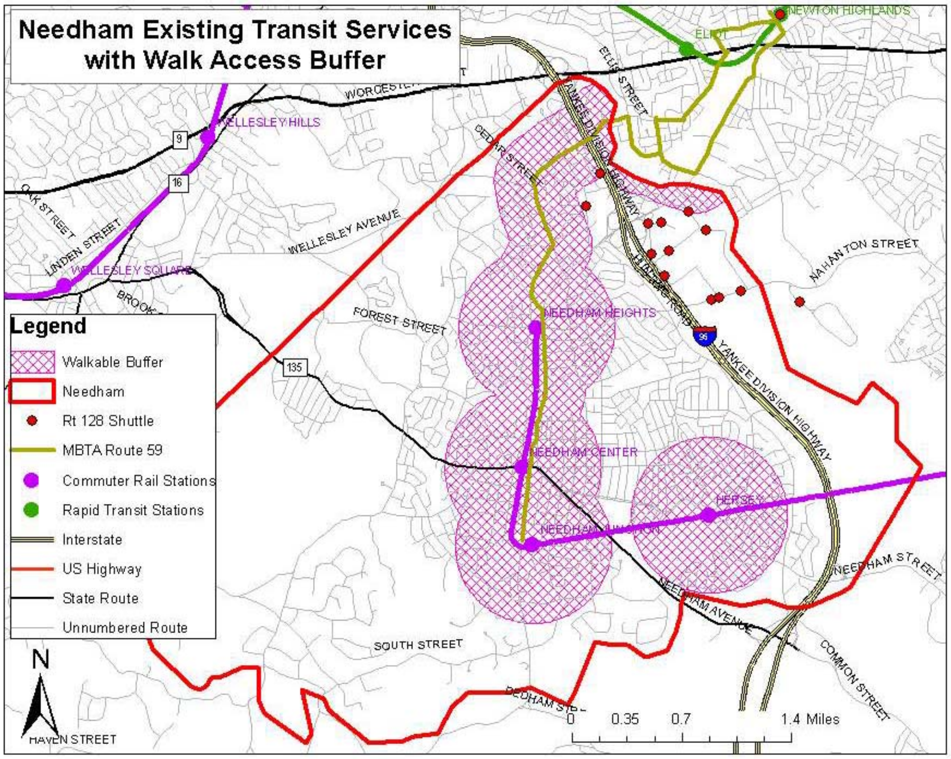


Source: Boston Region MPO

While city commuters are fairly well served by existing public transit services along the Highland Avenue corridor and in the Route 128 business complex, there may be some potential for a demand-responsive service to facilitate intra-Needham travel and provide better linkages to the existing fixed-route services for individuals without access to a private vehicle. Most TAZs have greater than 16 percent of their residents commuting locally and in the TAZs lying adjacent to the Highland Avenue corridor, the percentage falls within the range of 28 to 37 percent. The difference in median household incomes between the central and southwestern sections of town is another indicator of where the potential demand for transit may lie. Finally, with 31.8 percent of the population aged 10-19 or 65 and above, a large segment of Needham's population is in an age group that is traditionally limited with regard to mobility, and thus more likely to use public transit.

There are already some demand-responsive services in place to serve residents with limited mobility. The Council on Aging in Needham operates and subsidizes the costs of shuttle services to MBTA stations, area medical facilities, grocery stores, and other destinations. Needham is also part of the service area for The RIDE, a paratransit dial-a-ride service (door-to-door shuttle service where customers call ahead to reserve a time slot) provided by the MBTA. These operations thus serve some of the same markets as a potential new demand-responsive service, but are available only to certain segments of the population. Indeed, the extent to which Needham is already well-served by not only MBTA fixed-route services but also paratransit and private shuttles such as the one operated by the Route 128 Business Council is itself a possible obstacle for any new demand-responsive service in terms of attracting riders. Figure 15 demonstrates the coverage that existing fixed-route services in Needham currently provide. The buffer that is shown around commuter rail stations and MBTA Route 59 are 0.5 miles and 0.25 miles, respectively. These buffers are based on the maximum distance that a person is generally assumed to be willing to walk to different forms of public transportation. As seen in the figure, a large portion of the area in central and southern Needham is covered by existing services.

Figure 15



The greatest potential for demand-responsive service in Needham would seem to point to two markets among residents of central and southern Needham: the workers who are commuting to the commercial corridor along Highland Avenue or to the Route 128 business complex, and those individuals with limited access to a personal vehicle who may wish to travel to the Highland Avenue commercial corridor or connect to a commuter rail, rapid transit, or bus line. This area of Needham has the highest population and residential densities in the town, as well as several Census block groups with high local employment and Census blocks with high percentages of traditionally mobility-limited individuals. The commercial corridor along Highland Avenue is a likely destination for these individuals and both Highland Avenue and the Route 128 business complex are likely destinations for the intra-Needham commuters.

Potential New Service

Given the existing presence of several fixed-route transit services, the most feasible possibility for a demand-responsive service in the town of Needham appears to be a point-deviation service. Point deviation is most appropriate where several geographically confined service areas can be defined, but the location of trip origins and destinations within those areas may vary. In Needham, for example, while many trips may be made between the residential area in southern and central Needham and either the commercial corridor of Highland Avenue or the Route 128 business complex, all of these areas are quite large with multiple potential origins and destinations dispersed throughout them. While trips to the Route 128 business complex will likely follow the traditional commuting pattern, those to Highland Avenue are likely to be spread throughout the day. Moreover, trips to Highland Avenue are likely to be spatially dispersed through the commercial corridor, as are trips from any residential area. Point deviation allows for defined locations where passengers can be picked up and dropped off according to a schedule, but also for trips to areas within a buffer zone surrounding that time point.

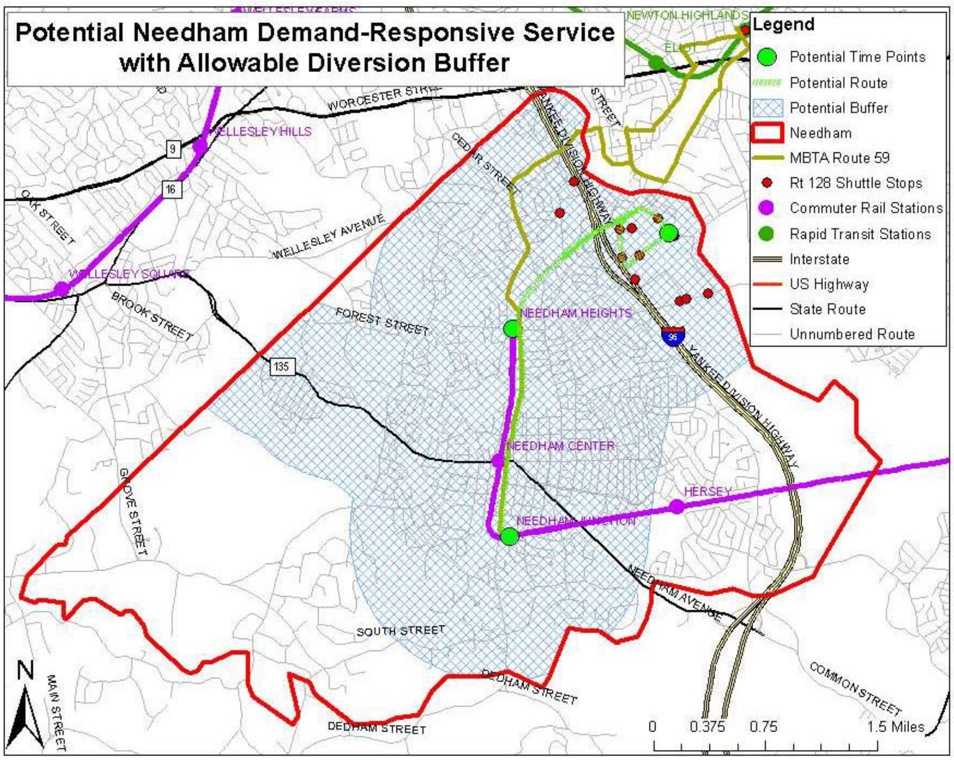
The most obvious location for a time point for a point-deviation service in Needham is along the commercial corridor on Highland Avenue, perhaps at the Needham Heights commuter rail station. Such a time point would not only locate passengers directly in the heart of the commercial corridor, but also provide for transfers to commuter rail. Another time point located at the Needham Junction commuter rail station could act as the southern terminus for the route and as a collection point for southern residents. Finally, a third time point located at the Route 128 business complex would also provide access for southern and central residents to the jobs in the complex. The potential points and general basic route that such a service might follow without deviations is depicted in Figure 16. The figure also shows a proposed service area extending approximately one mile from the basic route (with a half-mile buffer around Route 135 to the west added because of the ease of travel along this corridor) and allow for deviations to most of Needham.

While a more detailed travel demand analysis would need to be completed to determine optimum service levels, a point-deviation service such as the one proposed in Figure 16 could generally be operated with two small buses (capacity approximately 20 passengers) at 30-minute headways with a minimum of deviations. The basic route from Needham Junction to the Route 128 business complex is approximately 3 miles in distance. At an average speed of 15 miles per hour, the route with no deviations would have a running time of approximately 12 minutes. Assuming that each deviation would total up to 2 total miles (1 mile in each direction to and from the deviation) and take approximately 8 minutes to run per deviation, this schedule would allow for up to two deviations per trip, with a two minute minimum of lag time built in. With headways greater than 30 minutes, the number of scheduled deviations could increase. The extent to which deviations need to be scheduled will depend on the expected level of demand for such deviations. If an objective of the service were to facilitate transfers to the commuter rail network, it would be advisable to match headways with those of the commuter rail train at Needham Heights. In the AM peak period, trains depart Needham at a minimum headway of 28 minutes while in the PM peak period, trains arrive in Needham at headways ranging from

28 minutes to 40 minutes. Bus headways could be adjusted to allow for more time in one direction depending on travel demand.

As with service levels, more detailed fare and cost estimates would also be necessary beyond the general estimates presented here. However, services such as these generally tend to cost between $55.00-$65.00 per vehicle revenue-hour to operate, when including all costs. Under the most optimistic ridership forecasts of 10-12 passengers per vehicle revenue-hour, therefore, the cost per passenger is unlikely to fall below $5.00. Fares are unlikely to recover much of this cost. The fare level thus depends more on the type of service that communities wish to provide and how, if at all, they wish to price deviations versus non-deviations. For example, some services add a surcharge to any trip that deviates beyond the scheduled time points.

Figure 16



Conclusion

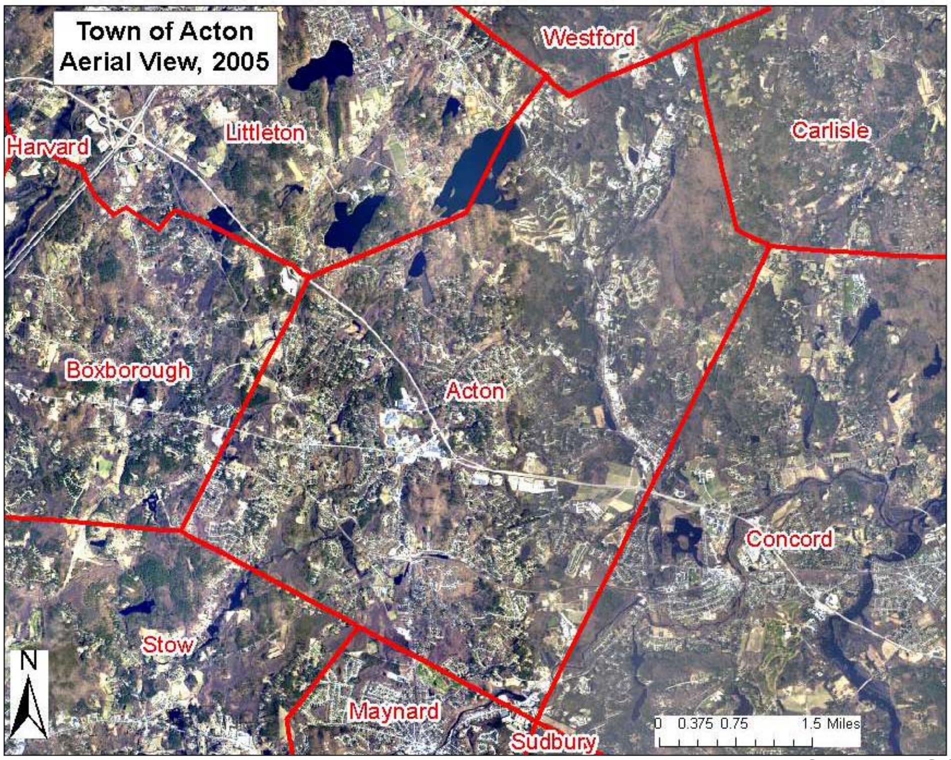
While Needham has many of the characteristics that make it amenable to public transportation, one of the greatest obstacles to a demand-responsive service is the fact that several public transit services – from fixed-route rail and bus services to business shuttles and paratransit – already exist. Undoubtedly, there are some individuals who are not well served by the existing transportation system and would benefit from and enjoy the flexibility that demand-responsive service would provide. Should Needham be interested in pursuing the concept of demand-responsive service further, a comprehensive market analysis should be performed with detailed schedule and cost plans for a potential service.

ACTON

Physical Criteria

Figure 17 presents an aerial photograph of the town of Acton and the surrounding area from 2005. From this photograph, one can generally make out two areas of the town. The majority of Acton's population lies in residential areas in the southern half of town. One can also see the concentration of development at the intersection at the center of town. Moving northward, the aerial photograph shows a decreasing density in development with larger tracts of open space compared to the south. Acton is bordered by Boxborough and Littleton to the northwest, Westford to the north, Carlisle to the northeast, Concord and Sudbury to the southeast, and Maynard and Stow to the southwest.

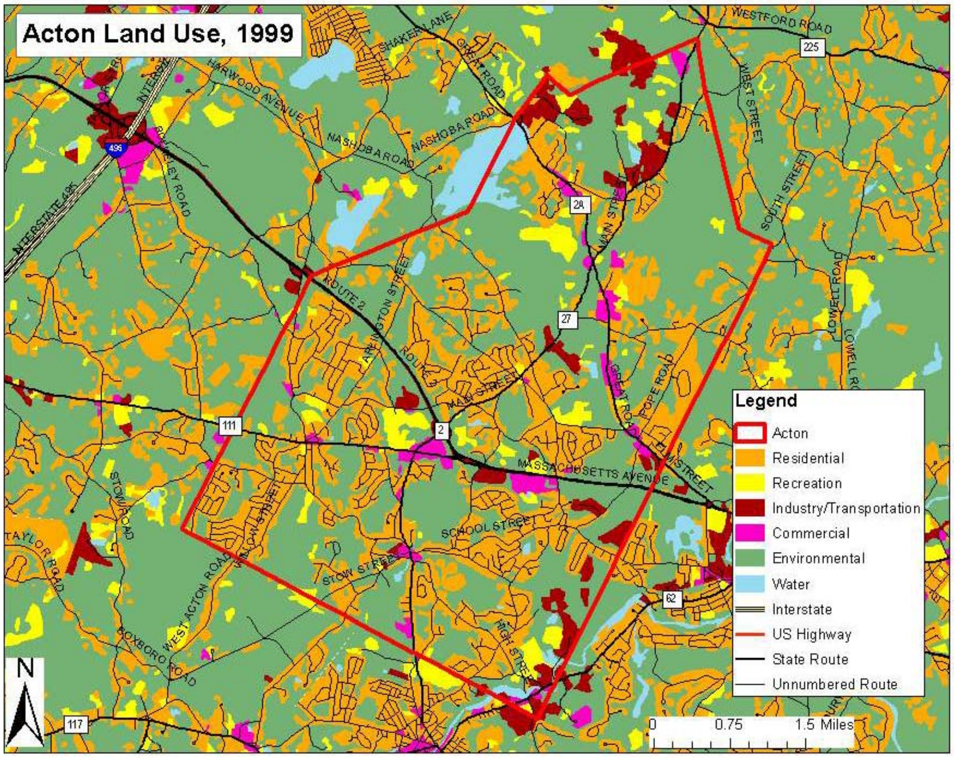
Figure 17



Source: MassGIS

Figure 18 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston Region MPO region in 1999 and breaks down land uses into 21 categories. Figure 18 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen in the figure, residential and environmental land uses predominate and mix together throughout the town, while commercial and industrial land uses generally lie adjacent to major roads.

Figure 18

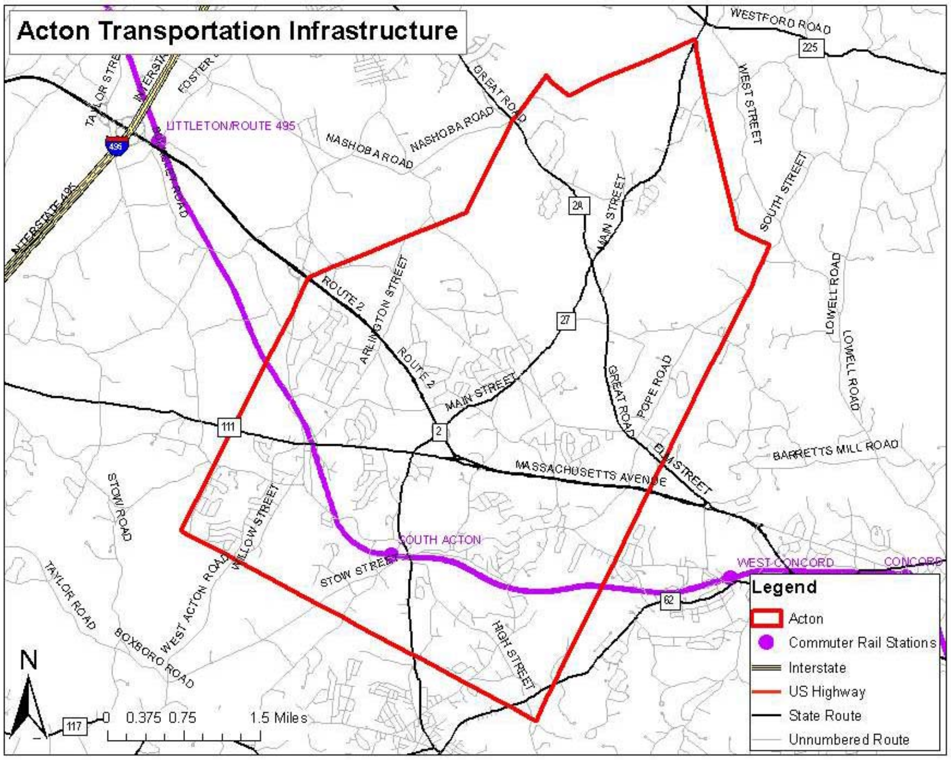


Source: MassGIS

Figure 19 depicts the transportation infrastructure in the town of Acton. Route 2 runs east-west and effectively cuts the town in half, with the majority of residential areas lying south of and surrounding Route 2. Three major roads (Routes 2 and 111 running east-west and Route 27 running north-south) meet in the center of town and route 27 intersects with the other major north-south corridor, Route 2A/119, in northern Acton. These roads provide access to all of the surrounding communities and, with Routes 2 and 2A, direct access to Route 128 and all points east towards Boston. The South Acton commuter rail station, along the Fitchburg commuter rail line, also provides direct-to-Boston access. This station is located in southern Acton, off of Route 27. There are 438 parking spaces available at the station, 156 of which are devoted to resident parking through a permit system. These 156 spaces reach capacity just after 7:00 A.M. The town owns and provides for free 218 parking spaces while the remaining 64 spaces are privately owned. All of these spaces are filled to capacity shortly after 8:00 A.M. Approximately 550 passengers use the South Acton commuter rail station during a weekday and the weekend ridership is about 110 passengers on both Saturday and Sunday.

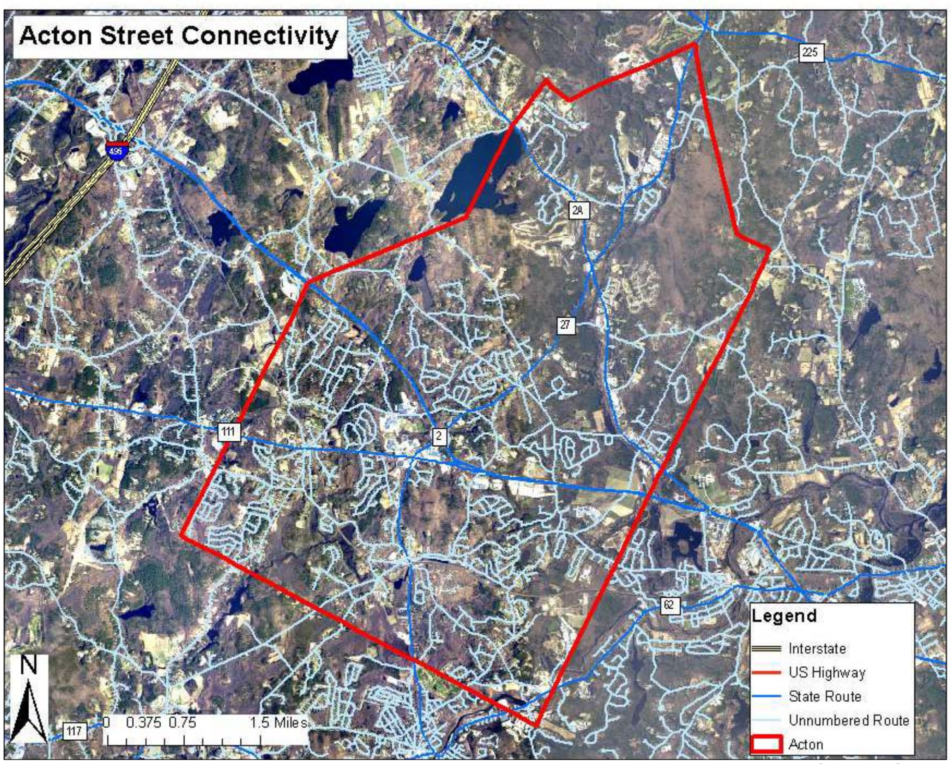
Figure 20 overlays the street network on top of the aerial photograph of Acton, highlighting the street connectivity in the town. As seen in the figure, cul-de-sacs and curvilinear roads characterize the low coverage and limited accessibility provided by the street network throughout the town. Despite the accessibility afforded by the large

Figure 19



Source: MassHighway and CTPS

Figure 20



Source: MassHighway and CTPS

number of major roads running through Acton, most neighborhoods have only one or two points of access to these roads.

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips tends to be greater. Figure 21 shows the 2010 projections for population density by residential acre. As seen in the figure, the majority of residential acres fall into the range of 4-6 persons per acre, with the range of 0-3 persons per acre characterizing most of the remaining residential acres. Only scattered acres have higher population densities, with the greatest concentration of high-density residential development located along Route 2A north of Route 27. The relatively consistent densities across town are indicative of similar development patterns throughout Acton; that is, curvilinear streets and cul-de-sacs with a lack of grid street patterns where density is generally higher. Areas with multi-family development represent perhaps the greatest potential for transit demand, owing to the greater concentrations of people and thus trip origins and destinations in one place. Transit is also potentially suitable in areas of high density, less so in medium-density locations, and difficult to justify in low-density locations.

The residential densities depicted in Figure 21 are important for determining the locations of potential origins and destinations of a transit service in Acton. Another significant origin/destination for travel within Acton lies at places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Commute trips between work and home generally make up an important segment of transit ridership. In the town of Acton, Figure 22 depicts the employment density, measured as the number of employees per developed commercial acre. As seen in the figure, places of employment are spread throughout Acton, though most are located near and with direct access to a major road such as Routes 2, 2A, and 108. The center of town has one of the highest employment densities in town due to its concentration of commercial land uses while the Nagog Park complex in northern Acton contributes to that area's higher employment density.

Figure 21

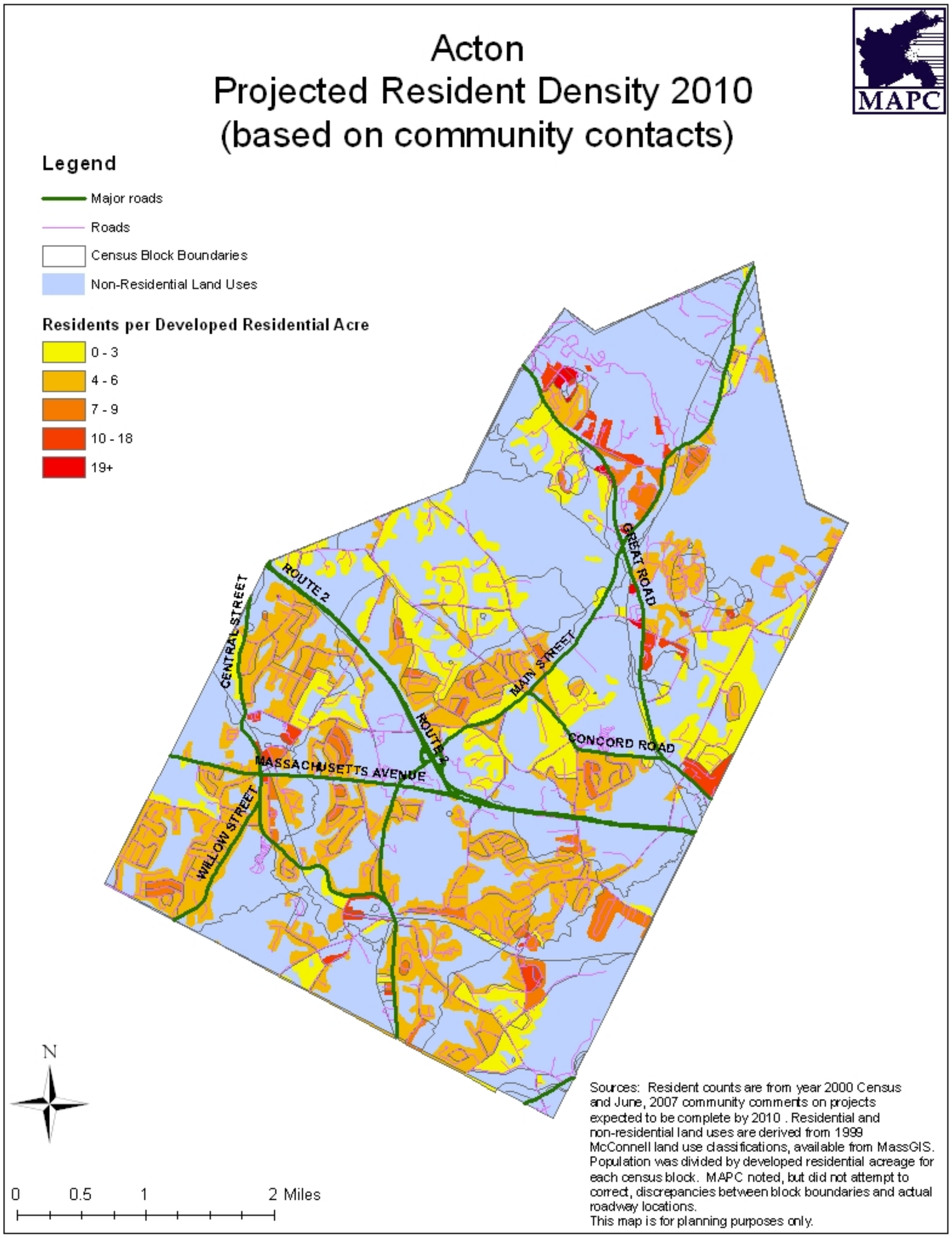
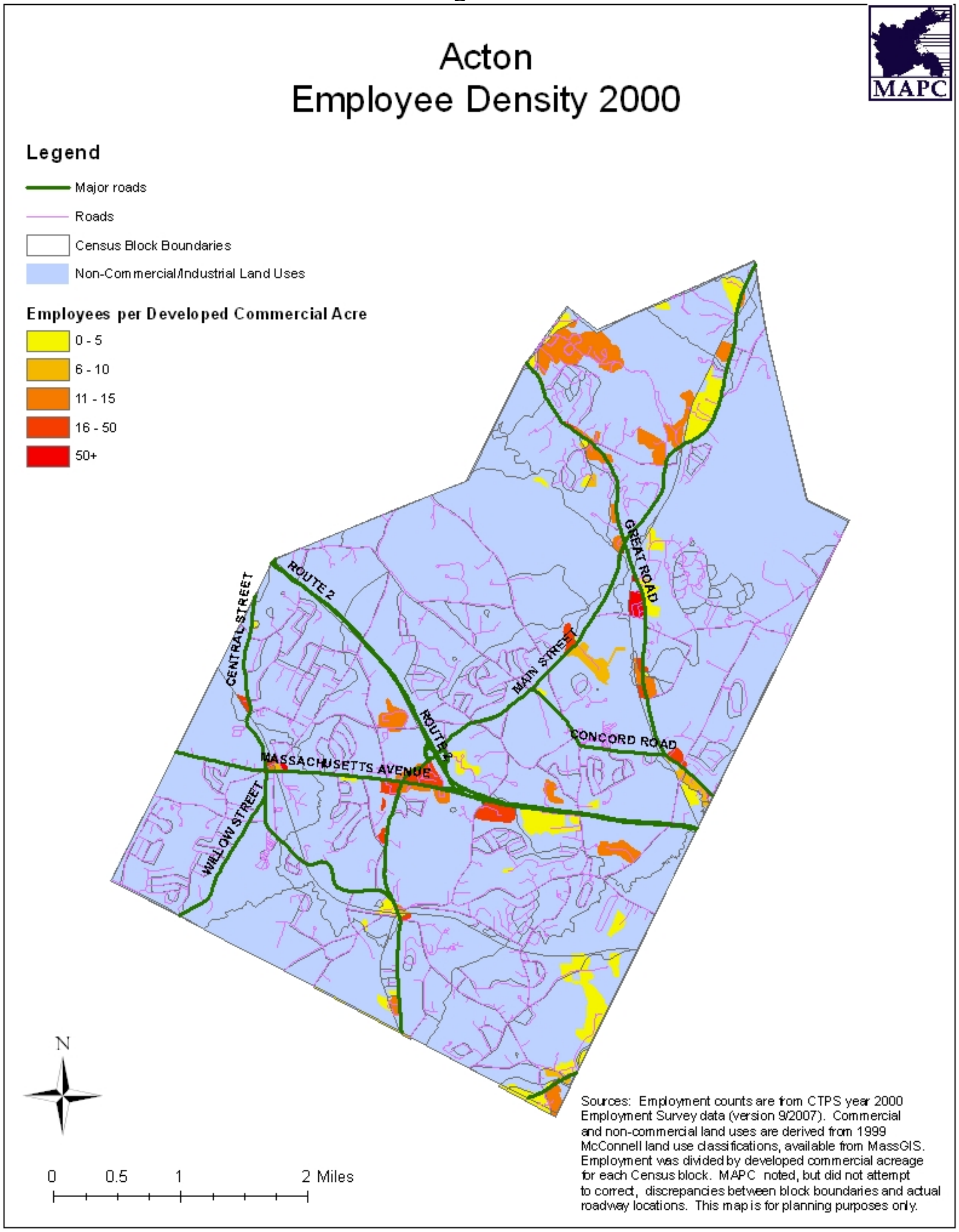

Acton
Projected Resident Density 2010
(based on community contacts)
MAPC
Legend
Major roads
Roads
Census Block Boundaries
Non-Residential Land Uses
Residents per Developed Residential Acre
0 - 3
4 - 6
7 - 9
10 - 18
19+
ROUTE 2
CENTRAL STREET
GREAT ROAD
MAIN STREET
ROUTE 2
CONCORD ROAD
MASSACHUSETTS AVENUE
WILLOW STREET
N
0
0.5
1
2 Miles
Sources: Resident counts are from year 2000 Census and June, 2007 community comments on projects expected to be complete by 2010 . Residential and non-residential land uses are derived from 1999 McConnell land use classifications, available from MassGIS. Population was divided by developed residential acreage for each census block. MAPC noted, but did not attempt to correct, discrepancies between block boundaries and actual roadway locations.
This map is for planning purposes only.

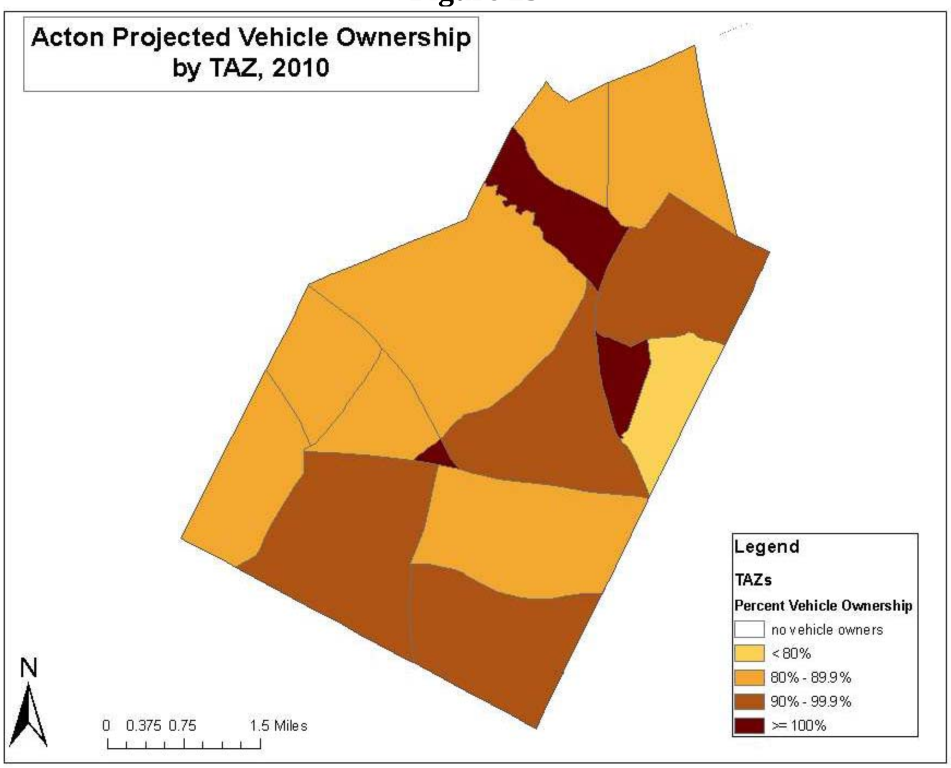
Figure 22



One factor that can influence the potential of transit in an area is the ratio of vehicle ownership to population. Lower vehicle ownership percentages are a likely indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 23, vehicle ownership in Acton is generally quite high, with only one TAZ having a rate below 80 percent. Several TAZs have vehicle ownership rates above 100 percent.

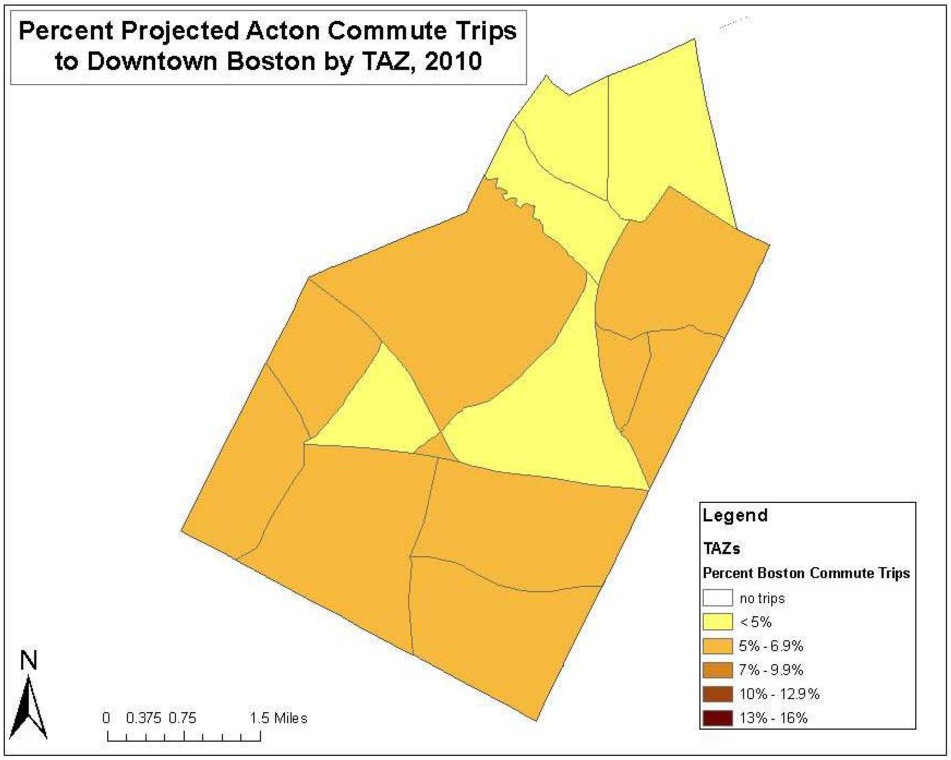
Given that work trips represent a significant portion of public transit usage, it is useful to know where residents are traveling to and from during their daily commute. Figure 24 presents the percentage of commute trips from Acton to downtown Boston and Figure 25 shows the percentage of intra-Acton commute trips. As seen in Figure 24, the percentage of workers who commute to downtown Boston is below 7 percent and, in several TAZs, is less than 5 percent. A greater percentage of Acton commute trips stay within the town of Acton, with no less than 16 percent of these trips remaining within the town border. When added to Boston commute trips, however, the combined intra-Acton and Boston categories account for 26 percent of all Acton's home-based work trips. Therefore, nearly three-fourths of Acton's commute trips are headed beyond the town to areas outside of downtown Boston. The probable suburban destinations of many of these commute trips are more likely to necessitate private vehicle travel. When the number of trips expands to include all types of trips (both peak and off-peak – Figure 26), however, the percentage of intra-Acton trips increases in all TAZs with no TAZ having a percentage below 30 percent and several having rates above 50 percent.

Figure 23



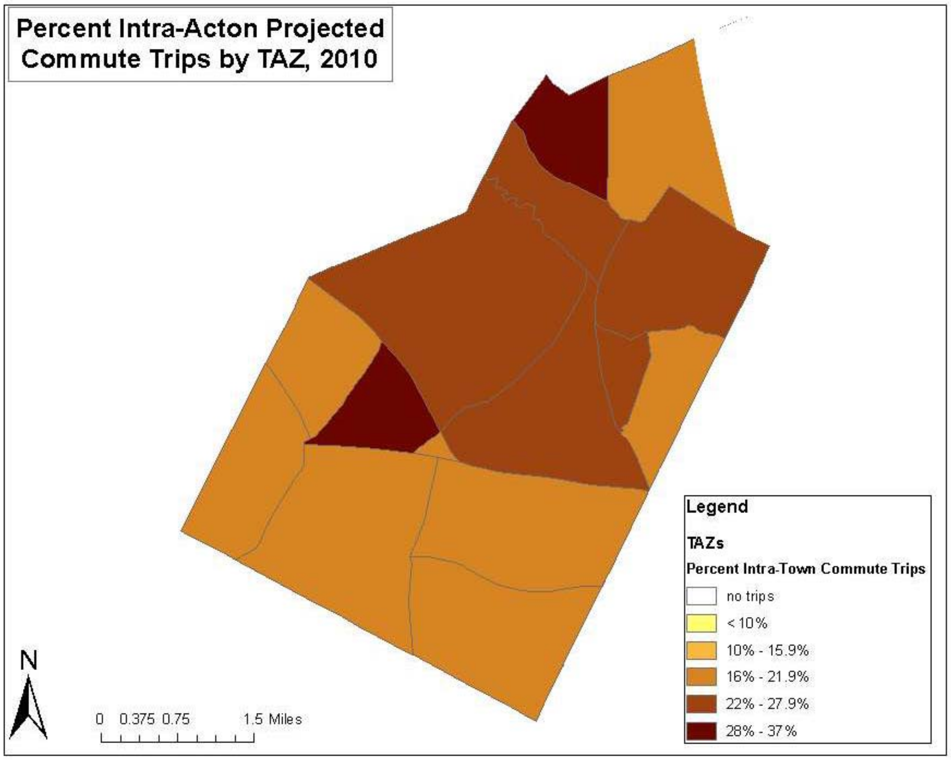
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 24



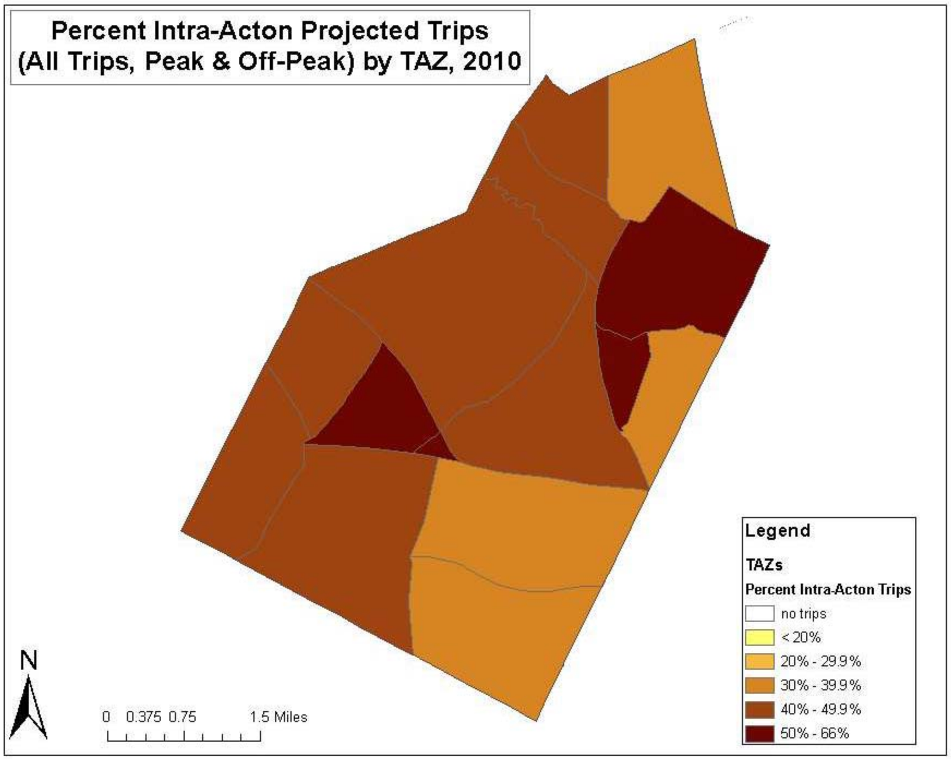
Source: CTPS Regional Model Smart Growth+ Projections

Figure 25



Source: CTPS Regional Model Smart Growth+ Projections

Figure 26

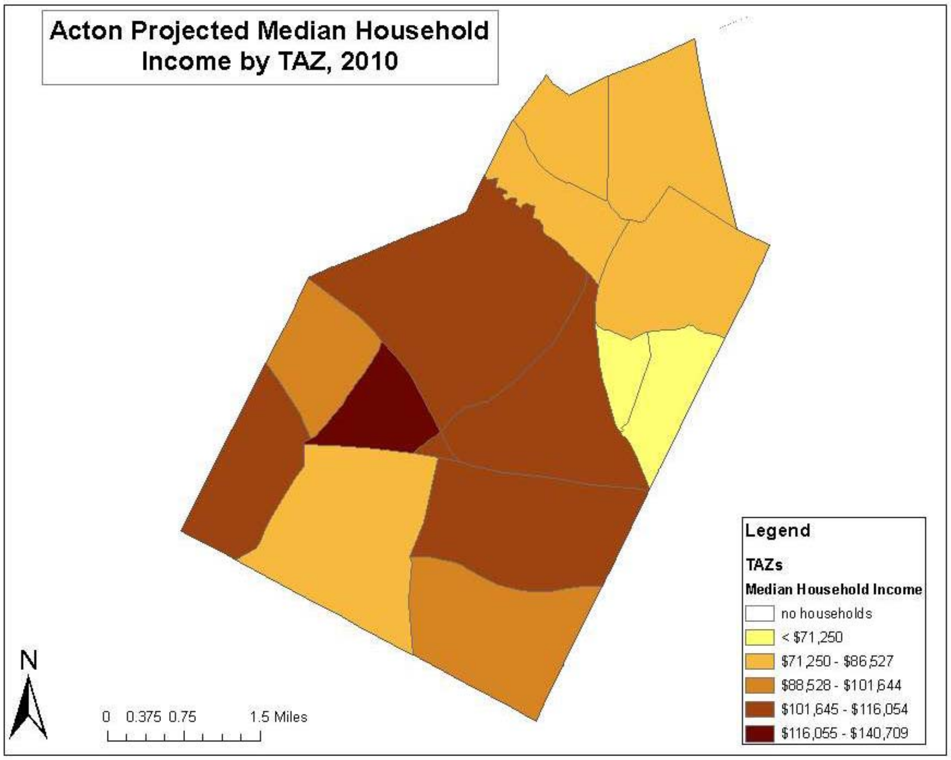


Source: CTPS Regional Model Smart Growth+ Projections

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 27, no TAZs in the town of Acton have a median household income below $41,850. However, Acton is characterized by a range in household incomes across TAZs. The highest incomes tend to be located in central Acton, while the median household incomes of several TAZs outside the center, particularly in the northern section of town, fall into the lower income brackets.

With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. According to the Metropolitan Area Planning Council (MAPC), approximately 14.6 percent of the population of the town of Acton will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, MAPC predicts that this population group will compose 9.3 percent of the total population in 2010. Thus, 23.9 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher.

Figure 27



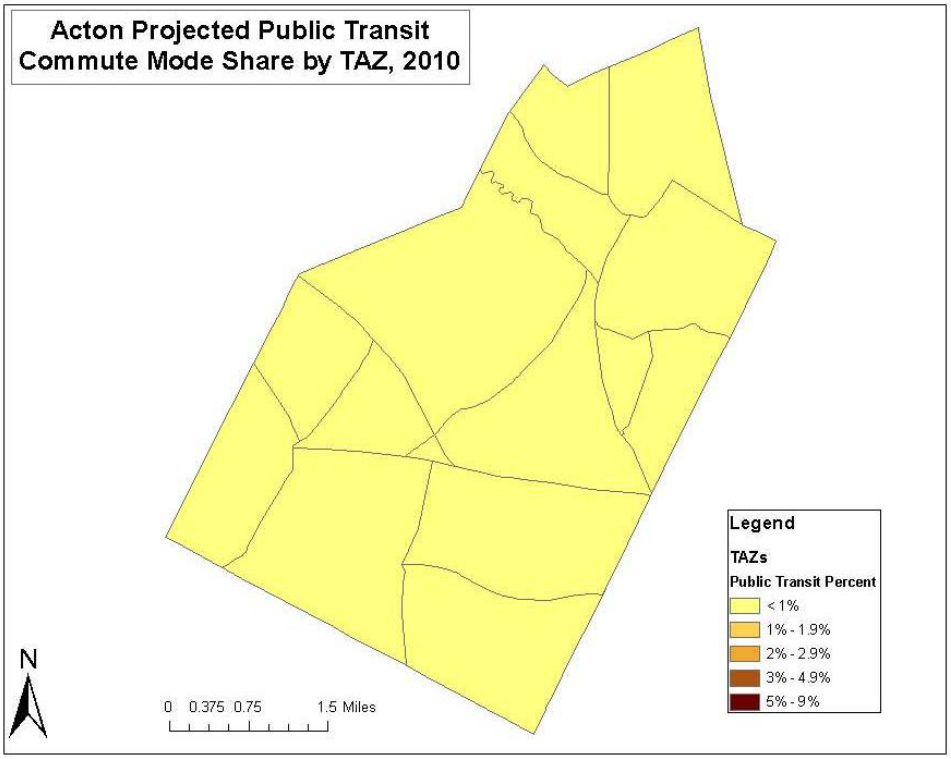
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Transit Demand Assessment

Given its low density of development, disconnected nature of the street network, high vehicle ownership and income levels, and few choices to using a private vehicle for most trips, it is not surprising that public transit usage in Acton is low. As seen in Figure 28, no TAZ has a public transit commute mode share greater than 1 percent. Even in the TAZs surrounding and adjacent to Acton's commuter rail station, public transit fails to capture more than a marginal percentage of commute trips.

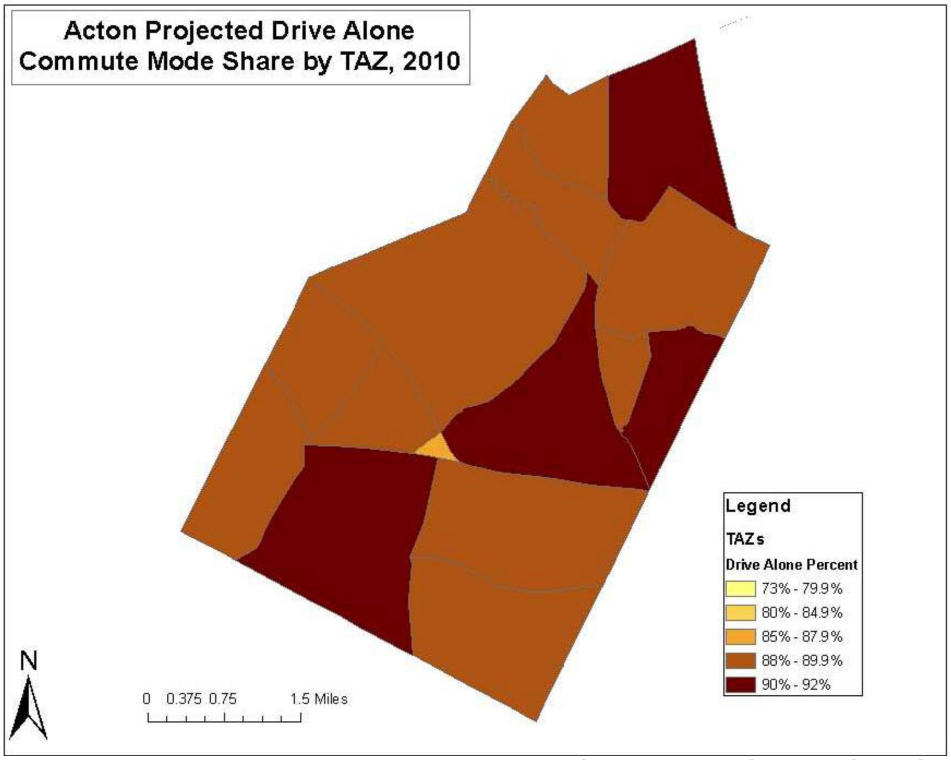
Each of these factors also makes the feasibility of a potential new transit service more difficult. In areas of low-density residential development, trip origins and destinations are more likely to be dispersed, increasing the cost per passenger for transit. The large number of cul-de-sacs and the disconnected nature of the street network also increase this cost. In such a street network, it is often necessary to enter and exit a neighborhood through the same road. When combined with the winding, non-direct nature of many of these roads, the distance and time, and therefore cost, devoted to each trip increases. As the cost per passenger incurred by the transit agency increases, so too does the cost incurred by the passenger in terms of their time. With most residents having access to a private vehicle, due in large part to Acton's relatively high household incomes, it becomes difficult for transit to compete. As seen in Figure 29, only one TAZ, in the very center of town, does not have a drive alone commute mode share greater than 88 percent.

Figure 28



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 29



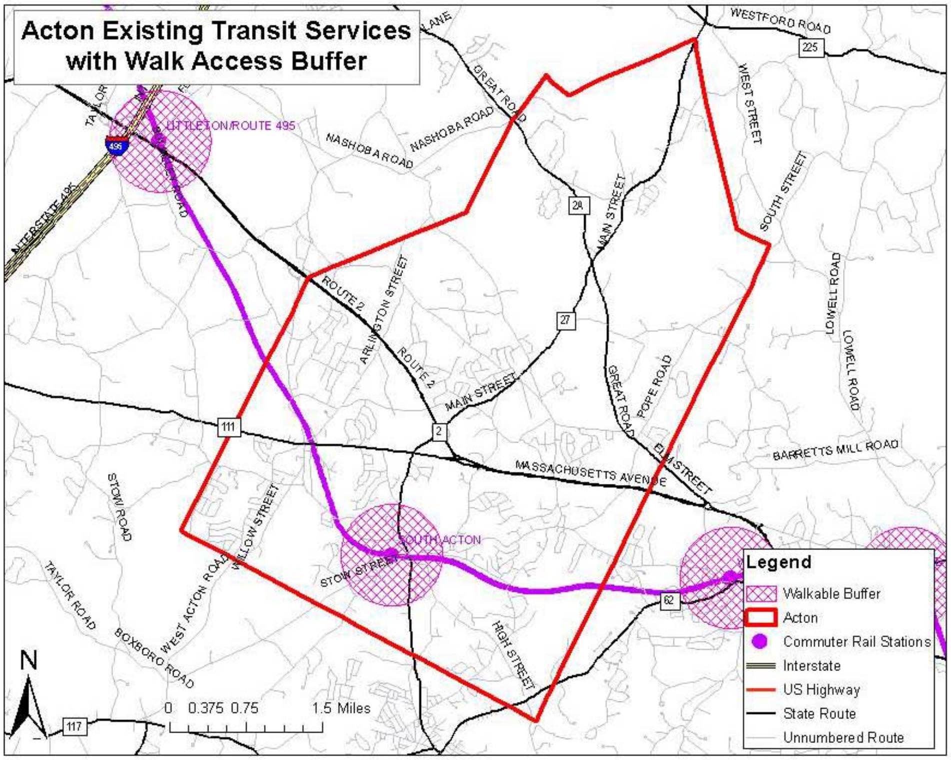
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Given the parking limitations at the commuter rail station in southern Acton, there may be an opportunity for demand-responsive service to provide a linkage between the station and the town's residential neighborhoods. Such a service could also be combined with one that facilitates other intra-Acton travel, given that more than 44 percent of all trips started in Acton also end in Acton. There are several multi-family developments in northern Acton along Route 2A/119 where, given their higher population density, there may be a demand for transit. Nagog Square, where the Acton Mall is located, is also found in this area and is a potential trip attractor. The historic district, extending from western Acton to the intersection of Routes 27 and 111, also has the residential densities as well as the commercial development to potentially warrant transit. Route 2 runs directly through Acton, and while it does link the town to areas north and south, it also serves to divide eastern Acton in half, making travel between the sides north and south of Route 2 difficult.

There are already some demand-responsive services in place to serve residents with limited mobility. The Council on Aging in Acton operates and subsidizes the costs of a shuttle service to the commuter rail station, area medical facilities, grocery stores, and other destinations. Acton is also part of the service area for the Roadrunner, the dial-a-ride paratransit service (door-to-door shuttle service where mobility-limited customers call ahead to reserve a time slot) operated by the Lowell Regional Transit Authority (LRTA). These operations thus serve some of the same markets as a potential new demand-responsive service, but are available only to certain segments of the population. And while these services cover all of Acton, Figure 30 demonstrates how little of the town is within walking distance of the South Acton commuter rail station. The half-mile buffers depicted are based on the maximum distance that a person is generally assumed to be willing to walk to public transportation. As seen in the figure, most of Acton's neighborhoods lie quite a distance from a commuter rail station.

Many of Acton's residential areas are located in neighborhoods with low levels of street connectivity and often only one way to access a main road. This type of development is traditionally difficult for fixed-route transit to serve, given the distance that residents must often walk to access a transit stop on the main road and the barrier to using transit that this presents. Demand-responsive service is, in many cases, intended to divert from the main corridor and enter the neighborhoods where fixed-route service cannot; however, low levels of street connectivity make it more difficult for the transit vehicle to enter and exit the neighborhood quickly. For example, if a bus were to serve many of the residential areas in Acton, it would usually need to use the same road both to enter and exit the neighborhood. Unlike with a grid street network, where there are multiple connection points and various ways that a transit vehicle could weave its way through a neighborhood, the cul-de-sacs and low connectivity of many Acton neighborhoods make diversions to those areas very costly in terms of time. This cost is only heightened by the low-density of many Acton neighborhoods, making it difficult to group diversions and efficiently serve several destinations on one trip.

Figure 30

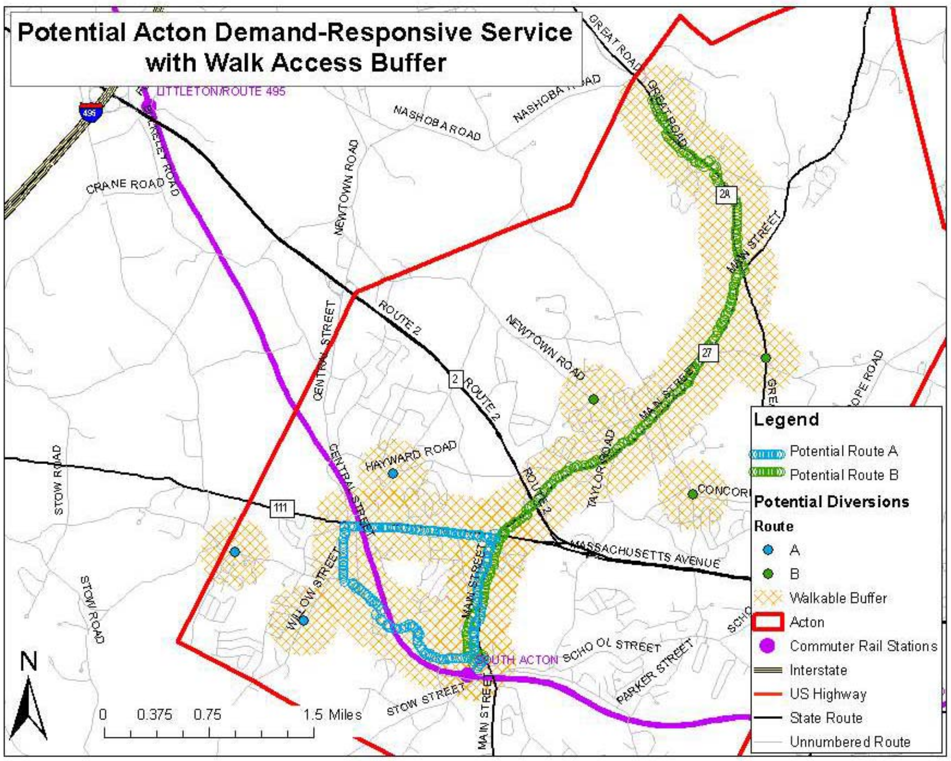


Potential New Services

Despite these difficulties, two potential choices for transit in Acton exist. The first would be a pure on-demand service, or "dial-a-ride." Two or three small vans would serve all of Acton, providing door-to-door service for which individuals would need to call ahead and make a reservation. Similar services generally require customers to call anywhere from one day to one hour in advance of their trip to schedule a reservation. Trips would be grouped where possible. This alternative would provide the highest level of accessibility and probably the highest cost per passenger, on the order of $25.00-$35.00 per trip provided. This cost is due in large part to the fact that such a service would be dedicated to Acton residents at all times, unlike a taxi service that could offer a lower cost per trip but would be unlikely to provide the same level of accessibility. Even with the high level of accessibility afforded by on-demand service, it would likely serve only a low level of demand, perhaps one or two passengers per hour, with obstacles to any growth in demand resulting from the lack of a defined schedule or routing.

A more conventional form of transit, bordering on fixed-route service with pre-defined diversion points, is shown in Figure 31. This service could have two basic routes, one a loop service running along Route 111 to Central Street to the South Acton commuter rail station and then up Route 27. The second route would run from the Acton Mall at Nagog Square down Routes 2A/119, and then turn onto Route 27 and head towards the South Acton commuter rail station. These routes would operate on a set schedule and passengers would not need to make a reservation to board or alight anywhere along the basic route. However, each route would have three allowed diversion points, each intended to serve a separate residential area. Riders would collect at these points from the surrounding neighborhood and would need to call ahead and make a reservation alerting the driver to stop at the diversion point. If allowable time to pick up or drop off passengers closer to their home is available on a trip-by-trip basis, then the passenger would be alerted and the driver could make this diversion. In this way, the schedule for every trip, in terms of the number and location of allowable diversions, would be made before the trip's departure. Customers would be required to make any reservations before the trip departure. These customers would then receive a call before the trip departure informing them as to where the bus would pick them up and the expected pick-up time.

Figure 31



A deviation service such as the one proposed in Figure 31 could generally be operated with three small buses (one for Route "A" and two for Route "B", each about 20 passengers in capacity) with headways and running times set to match the commuter rail schedule at South Acton station (approximately 30 minutes between trains in the peak hours). The basic Route A distance is almost four miles. At an average travel speed of 15 miles per hour, the route with no deviations would have a running time of approximately 16 minutes. The three Route A diversions are each about one mile in distance to and from the basic route, each adding about four minutes in travel time to the route. Thus, if time is available on a trip-by-trip basis, perhaps because one or two of the diversion points need not be served, this would allow the bus to divert further into the neighborhood. Similarly, the basic Route B distance is about 5.25 miles one-way, for an approximate running time of 21 minutes. As with Route A, the three diversions are each about one mile in distance to and from the basic route. Since travel along this corridor is likely to be heavier in the southern direction in the AM peak and heavier in the northern direction in the PM peak, buses could leave from Acton Mall 39 minutes before the desired arrival time at the South Acton station. This would allow enough time to serve each of the three diversions as well as additional time to divert beyond these points if time is available. The reverse trip would not divert from the basic route, such that the round-trip running time of Route B would be one hour.

As with service levels, more detailed fare and cost estimates would also be necessary beyond the general estimates presented here. However, services such as these generally tend to cost between $55.00-$65.00 per vehicle revenue-hour to operate, when including all costs. Some of the more successful and mature services in other metropolitan areas have achieved ridership levels of up to 10-12 passengers per vehicle revenue-hour. This ridership figure thus corresponds to a cost per passenger of approximately $5.00-$6.00. Like all other public transit services, fares are unlikely to recover much of this cost. The fare level thus depends more on the type of service that communities wish to provide and how, if at all, they wish to add a premium to any trip that deviates beyond the basic route. The extent to which public or private sources subsidize the service can also affect fare levels.

This potential service obviously has much less coverage than a town-wide on-demand service. Indeed, the entire southern area of Acton east of the commuter rail station and much of the areas in eastern and western Acton surrounding Route 2 lie beyond the service area that could be realistically provided. Not only are these neighborhoods located several miles from the basic routes presented in Figure 31, they are even further isolated and disconnected from the rest of Acton by the presence of the limited-access lanes of Route 2. Within Acton, there are only four ways to cross Route 2, and all of these roads are located in the relative center of town. Along the eastern and western edges of Route 2 in Acton, this road effectively divides the town in half, preventing direct travel from one side of the town to the other. This presents a particular obstacle to transit and is partly the reason why the service proposed in Figure 31 does not serve these neighborhoods. This would be less an obstacle to an on-demand, “dial-a-ride” service, as there is neither a schedule to maintain nor a route to serve.

Conclusion

There are many challenges to providing new transit service in Acton. The town’s low residential densities, poor level of street connectivity, high median household income levels, and high vehicle ownership rates are a few of the major difficulties that any potential new transit service in Acton would face when trying to attract ridership. However, there are certainly some individuals in Acton for whom a transit service, either as the primary mode of transportation or as an alternative to private vehicle travel, could prove useful. Acton’s development patterns make it difficult for either a point- or route-deviation with door-to-door service to operate efficiently. Either a completely flexible on-demand service or a less flexible form of route-deviation service would appear to be the most suitable.

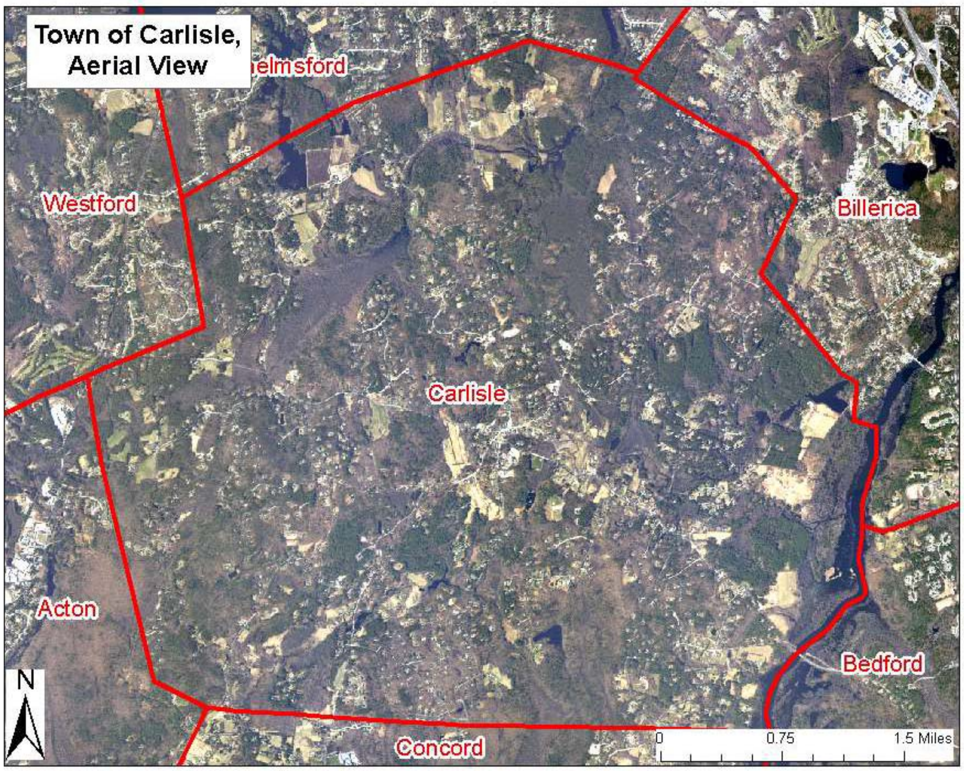
Should Acton be interested in pursuing either of these or other concepts further, it is encouraged to prepare an application, with the assistance of CTPS, to the Suburban Mobility Program. While not prohibitive, the amount of personnel resources required to complete the application is not insignificant. The application is intended to demonstrate that the community has given thorough consideration to fiscal, operational, and marketing considerations. As such, travel demand reviews, market research, and financial plans are all necessary components of a community's application. CTPS is available to provide data and analytical advice upon direction of the MPO's Suburban Mobility/TDM Subcommittee. This document is intended to assist Acton in determining whether to prepare an application and whether or not demand-responsive transit service is viable given the potential costs and demand.

CARLISLE

Physical Criteria

Figure 32 presents an aerial photograph of the town of Carlisle and the surrounding area from 2005 taken by the Metropolitan Area Planning Council (MAPC). From this photograph, one can generally see that development is scattered throughout the town with few areas of concentration aside from the center of town. There are large areas of the town with no development whatsoever. The town is small, with approximately 25 percent of its 9,856 acres protected as conservation land and a further 9 percent owned by the Commonwealth. Carlisle is bordered by Westford to the northwest, Chelmsford to the north, Billerica to the northeast, Bedford to the southeast, Concord to the south, and Acton to the southwest.

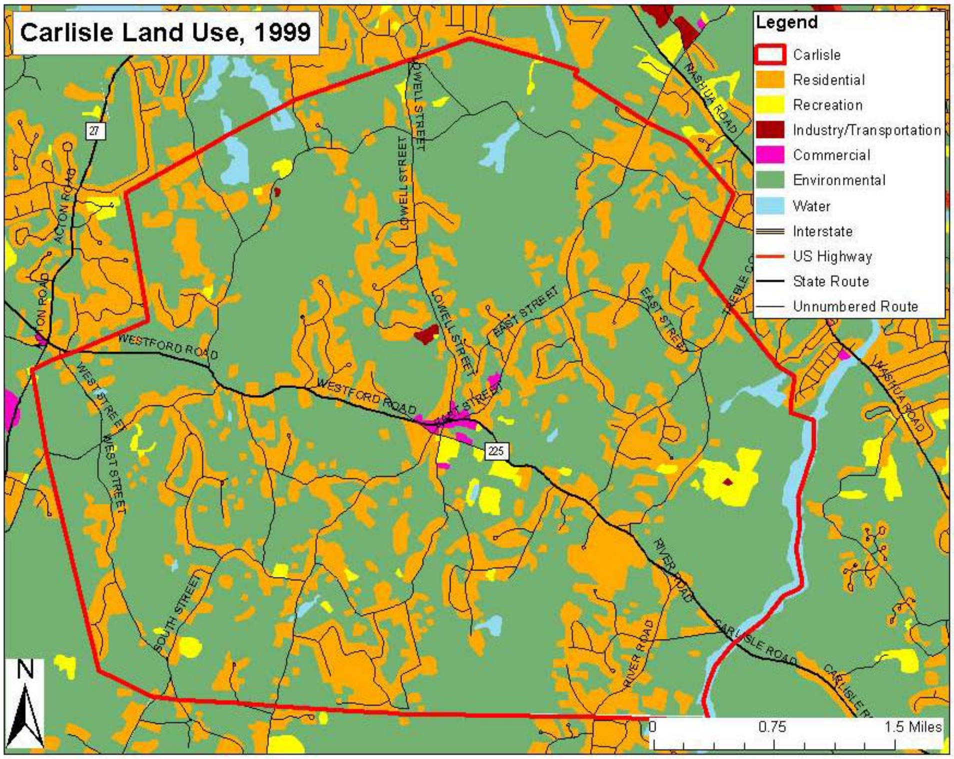
Figure 32



Source: MassGIS

Figure 33 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston MPO region in 1999 and breaks down land uses into 21 categories. Figure 33 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen in the figure, residential and environmental land uses predominate and mix together throughout the town. All of Carlisle's commercial land uses are located in roughly the geographic center of town, and there are only a few industrial land uses. Several recreational areas are dispersed throughout the town among residential and environmental land uses.

Figure 33

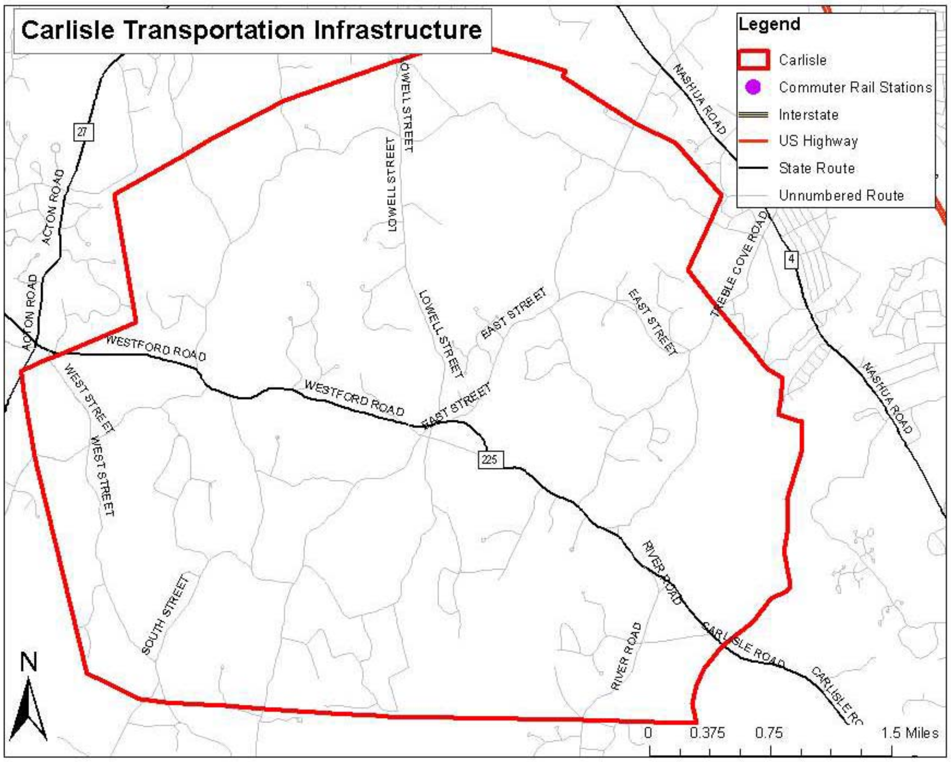


Source: MassGIS

Figure 34 depicts the major and local roads in Carlisle. Route 225 runs east-west and effectively cuts the town in half, with local roads serving the remainder of the town to the north and south of Route 225. Just west of town, Route 27 runs north-south through Westford and Acton and to the east of town, Route 4 runs through Billerica and Bedford. Route 225 intersects with both of these north-south routes just outside of the town borders. While there is no direct fixed-route transit service to Carlisle, the town does lie approximately halfway between two commuter rail lines to Lowell and Fitchburg with stations in Concord and Billerica.

The Council on Aging (COA) provides the only public transit service in Carlisle. The service is composed of one van, donated by an anonymous citizen, and a group of "Friendly Drivers" who volunteer to provide rides using their own private vehicle. Service is typically available Monday through Friday, 7:30 A.M. to 5:00 P.M.; however, arrangements have been made in the past to provide Saturday service using the volunteer Friendly Drivers. Riders needing transportation leave a message on the service phone line. Messages are checked two to three times per day Sunday through Friday and riders are requested to give a minimum of 24-hours notice. A part-time transportation coordinator then generally decides the best way to fulfill the request using either the van or the volunteer Friendly Drivers. The van is generally reserved for transporting more than three people and/or days when multiple rides are needed. Between one-half to two-thirds of all rides are provided by the Friendly Drivers. The COA funds the van and uses it for group trips, and the town employs three part-time van drivers as well as the transportation coordinator. Rides are provided to destinations in Concord, Acton, Lexington, Burlington and other nearby communities. Given that essentially no retail business exists within Carlisle, the only in-town service provided is to the polls and the monthly COA luncheon.

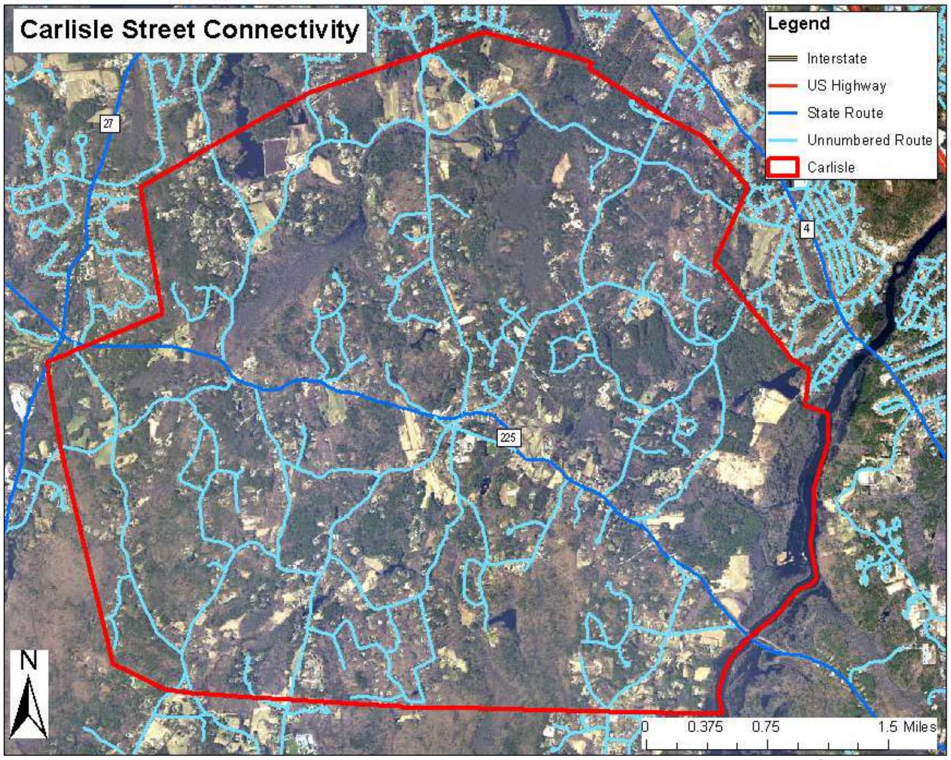
Figure 34



Source: MassHighway and CTPS

Figure 35 overlays the street network on top of the aerial photograph of Carlisle, highlighting the street connectivity in the town. As seen in the figure, cul-de-sacs and curvilinear roads characterize the low coverage of the street network throughout the town. There are several points of access to Route 225 by local roads running north-south and while there are several cul-de-sacs, the local road network generally does provide multiple connections throughout the town, meaning that there are usually more than one or two potential paths from any point in town to another point. Given the distance between these paths, however, it is unlikely that many are or could be used as alternates to another.

Figure 35



Source: MassHighway and CTPS

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips tends to be greater. Figure 36 shows the 2010 projections for population density by residential acre. As seen in the figure, the population density of developed residential areas lies almost uniformly in the range of 0-3 persons per acre, with only a few areas having a higher density. This is partly the result of the town's 2-acre minimum lot size requirement. It is apparent from this and previous figures that the residential development that does exist in Carlisle is spread throughout the town with most housing distributed along curvilinear local roads. Several multi-family units and higher-density areas are located just outside of the town borders in several surrounding communities.

The residential densities depicted in Figure 36 are important for determining the feasibility of transit in Carlisle to serve potential origins and destinations. Another traditional area of analysis for transit feasibility concerns travel to and from places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Commute trips between work and home generally make up an important segment of transit ridership. In the town of Carlise, Figure 37 depicts the employment density, measured as the number of employees per developed commercial acre. Carlisle has few commercial or industrial land uses that attract employment. As such, the employment density within the town is low, though the highest concentration of jobs does appear to be located at the center of town, with convenient access to the major north-south and east-west corridors that intersect Carlisle.

Figure 36

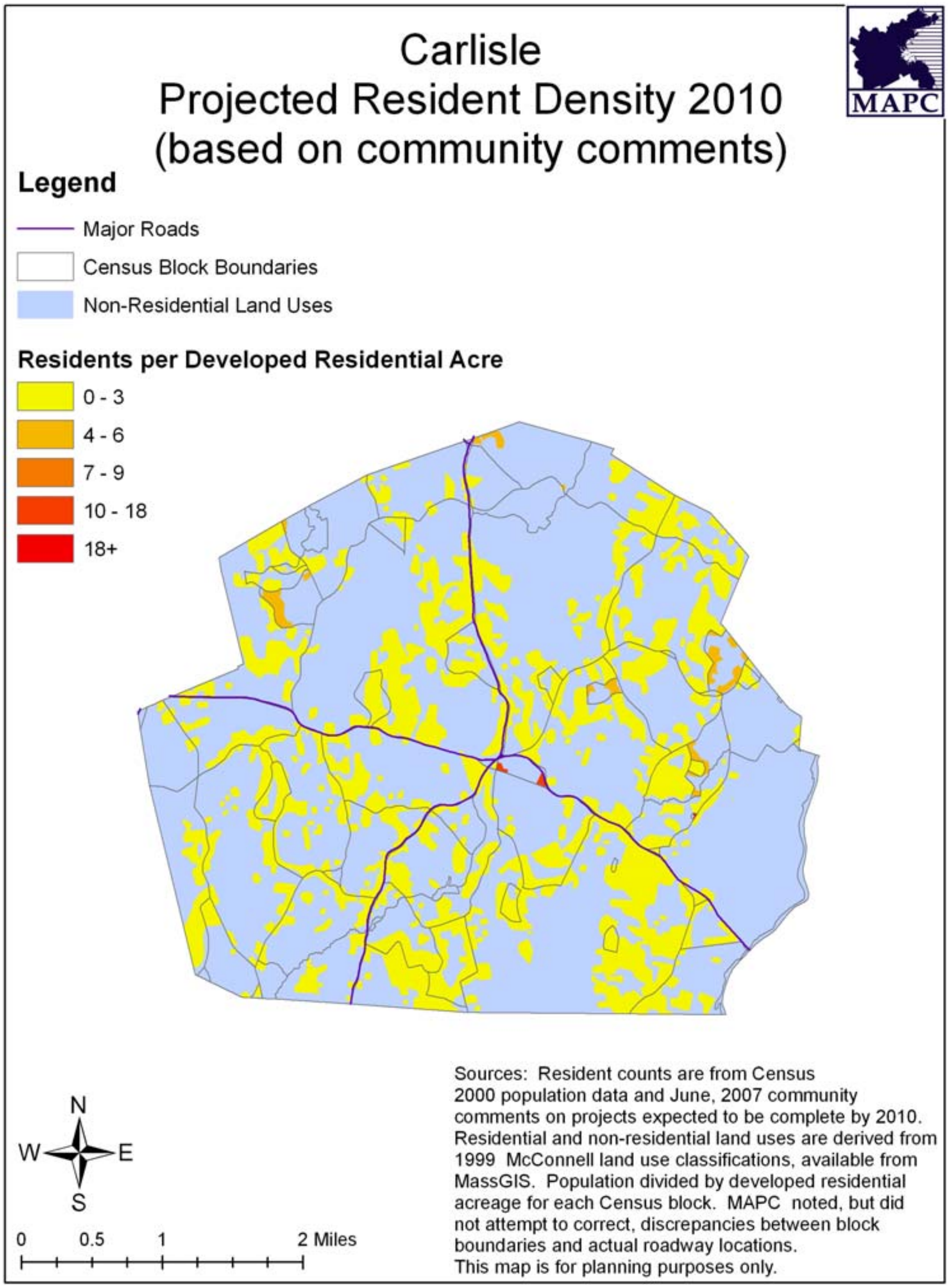
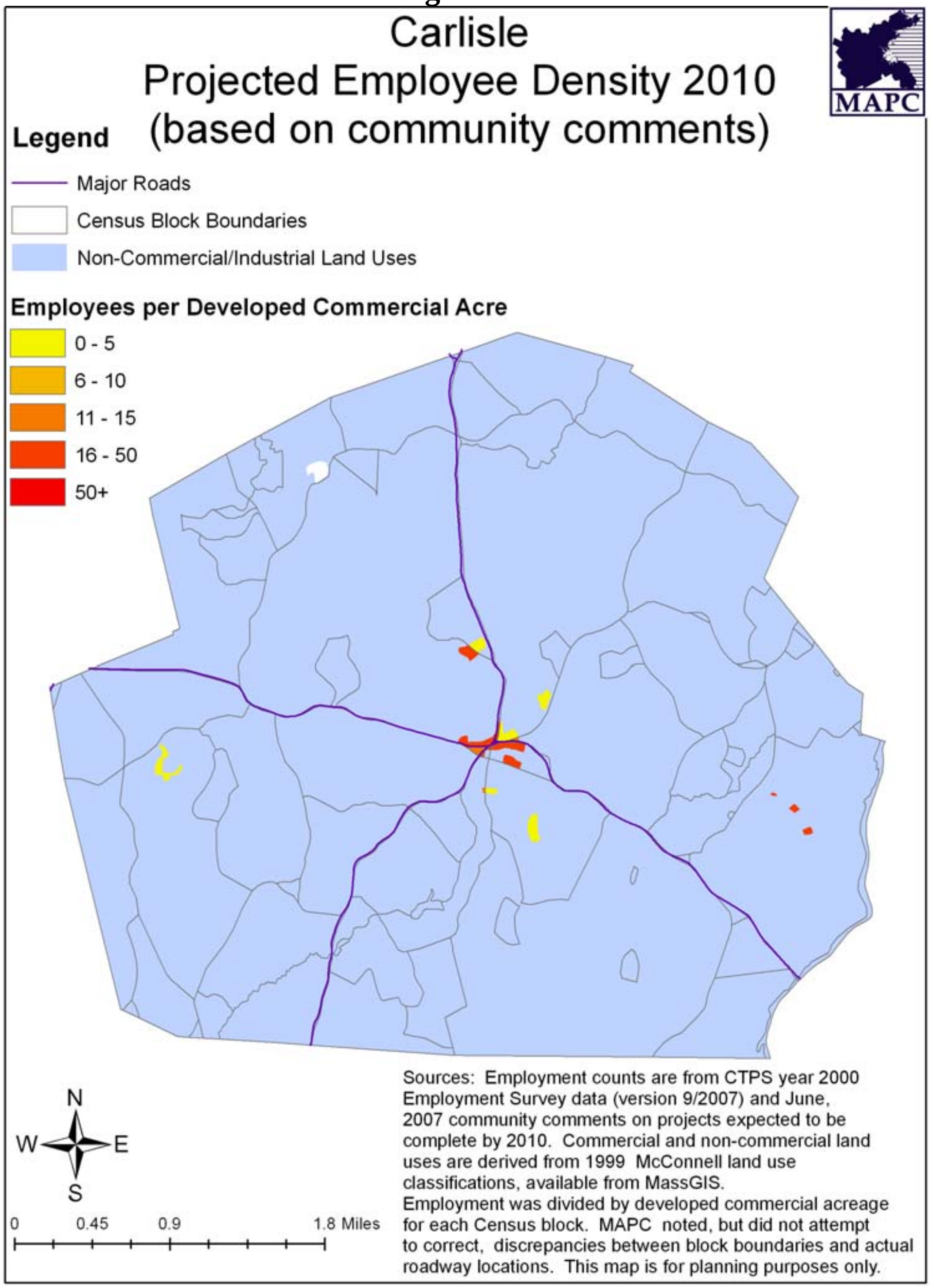
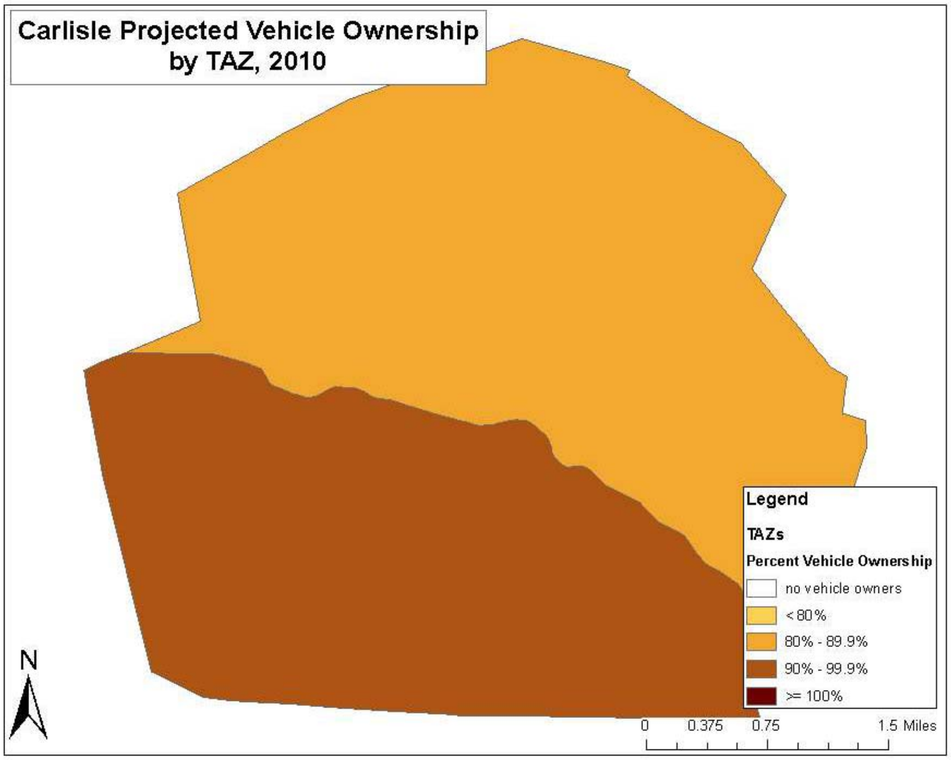


Figure 37



One factor that can influence the potential of transit in an area is the rate of vehicle ownership to population. Lower vehicle ownership percentages are a likely indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 38, vehicle ownership in Carlisle is generally quite high, with one TAZ having a rate between 80 and 89 percent and the other having a rate between 90 and 99 percent.

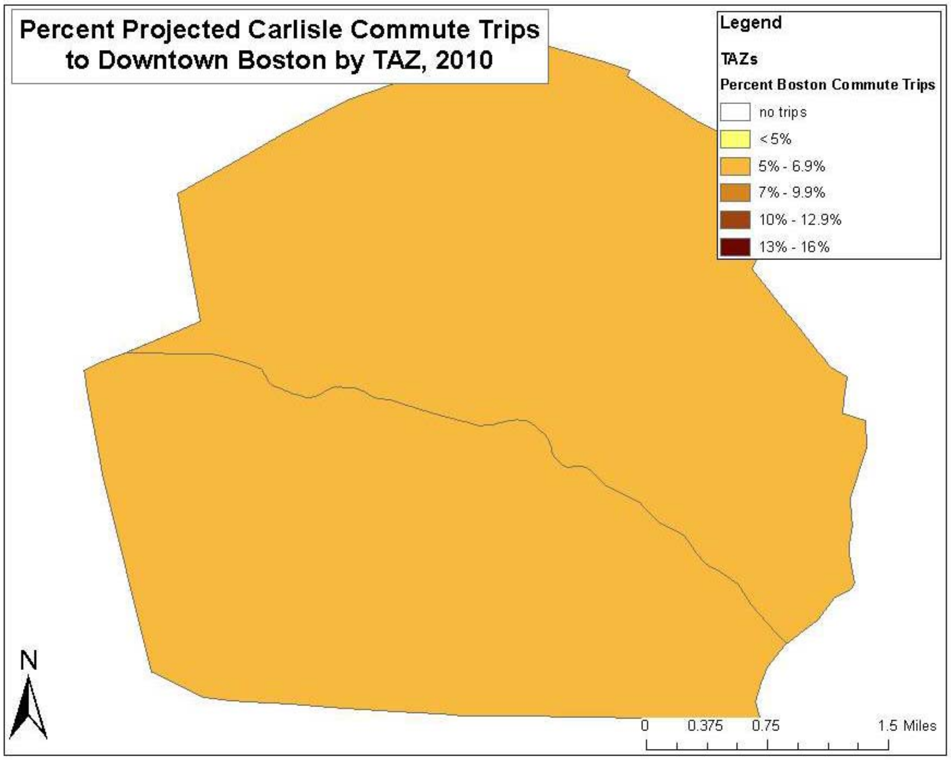
Figure 38



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

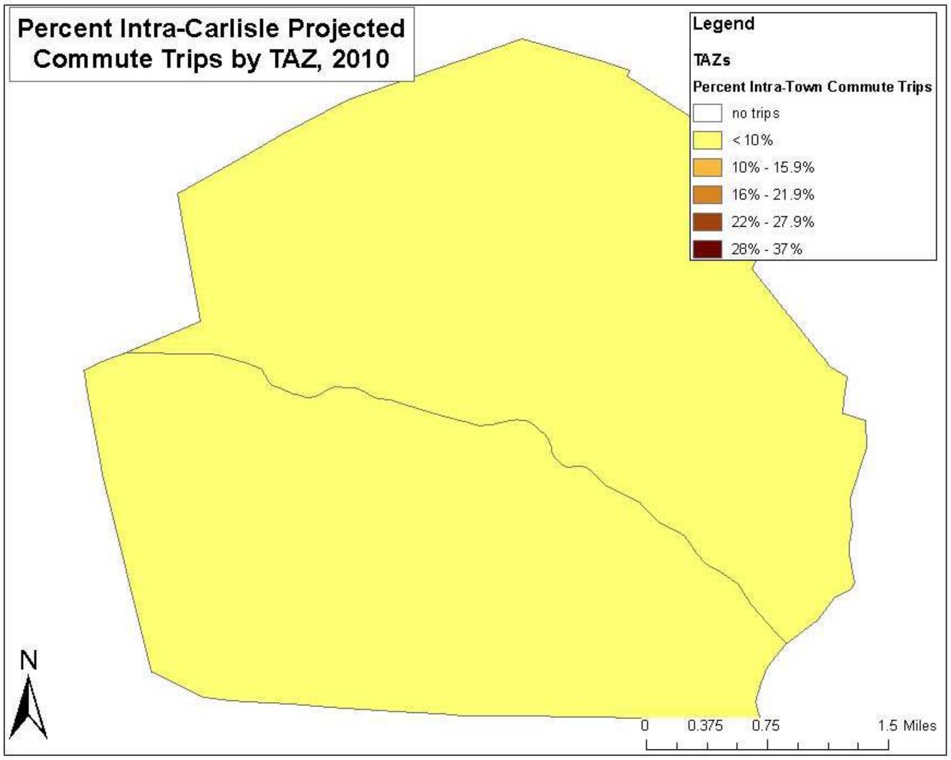
Given that work trips represent a significant portion of public transit usage, it is useful to know where workers are traveling to and from during their daily commute. Figure 39 presents the percentage of commute trips from Carlisle to downtown Boston and Figure 40 shows the percentage of intra-Carlisle commute trips. As seen in Figure 39, the percentage of workers who commute to downtown Boston is between 5 and 7 percent. When added together, the combined total of intra-Carlisle and Boston commute trips accounts for less than 9 percent of all home-based work trips trips. As could be expected given the town's low employment density, few commute trips both originate and end within Carlisle. Indeed, even when considering all trips originating from Carlisle, as seen in Figure 41, less than 20 percent have a destination within the town borders.

Figure 39



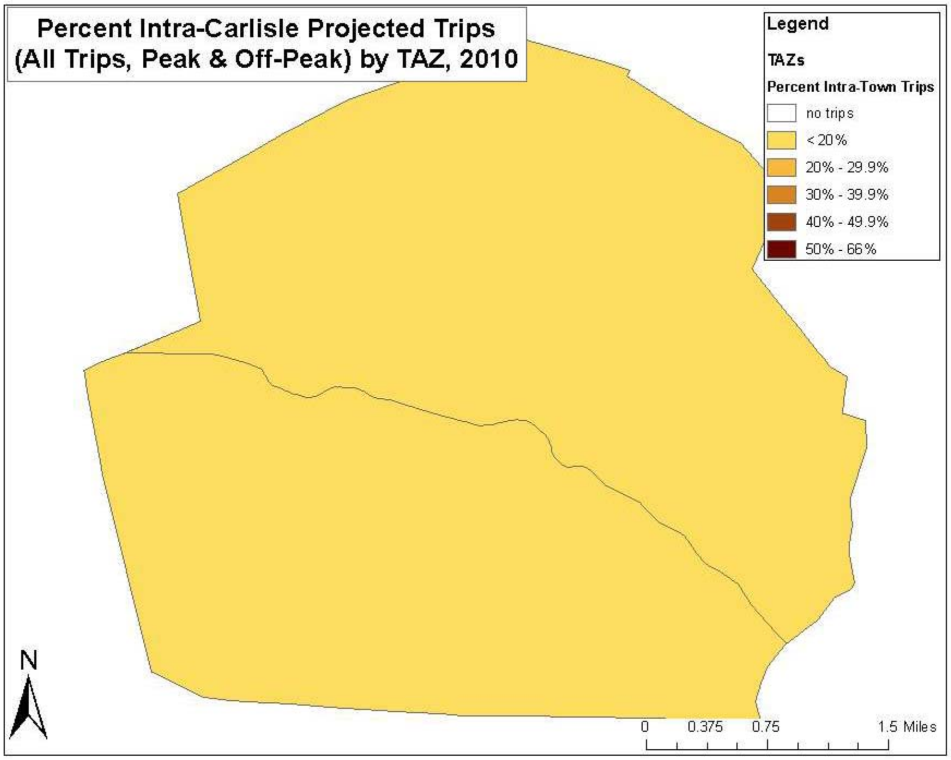
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 40



Source: CTPS Regional Model Smart Growth+ Projections

Figure 41

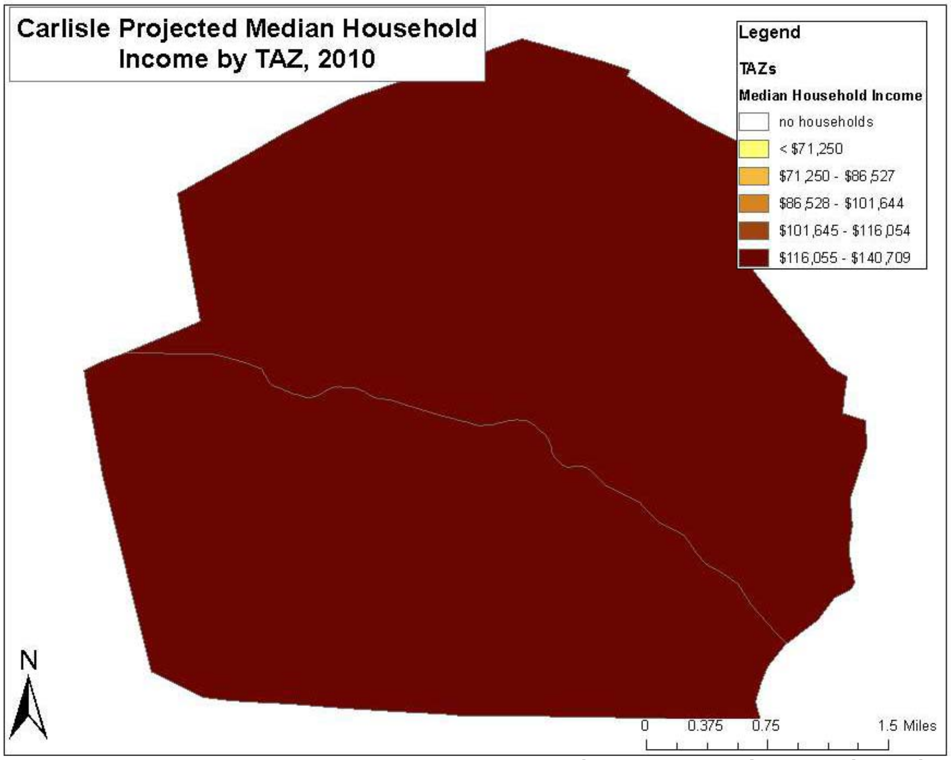


Source: CTPS Regional Model Smart Growth+ Projections

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (particularly those below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 42, Carlisle is a relatively wealthy community, when considering the median household income. Both TAZs are in the highest income bracket.

With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. MAPC predicts that 15.3 percent of the population of the town of Carlisle will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, MAPC predicts that this population group will make up 10.6 percent of the total population in 2010, with those in the 60-65-age range composing an additional 11 percent. Thus, 25.9 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher. This percentage generally coincides with the vehicle ownership rates presented above that show up to 20 percent of the population without access to a private vehicle. Many of these individuals are likely to fall into these two mobility-limited age groups.

Figure 42



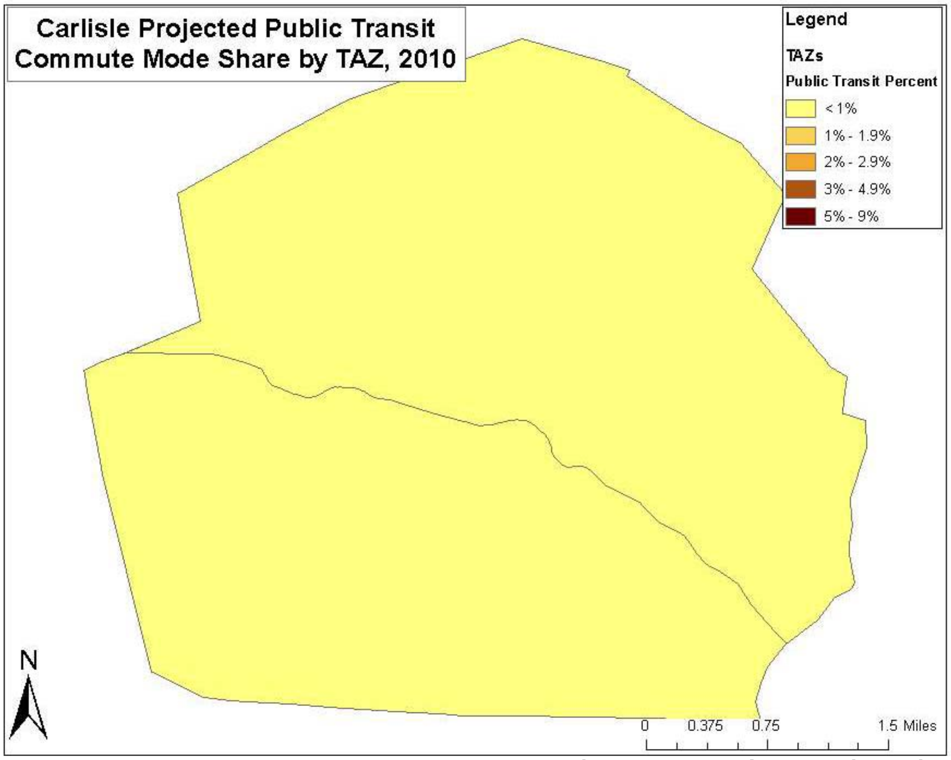
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Transit Demand Assessment

While Carlisle does lie between two commuter rail lines, with stations in Concord and Billerica, no direct public transit service currently exists, leaving few choices to using a private vehicle for most trips. Given its low density of development, disconnected nature of the street network, and high vehicle ownership and income levels, it is not surprising, therefore, that public transit usage in Carlisle is low. As seen in Figure 43, no TAZ has a public transit commute mode share greater than 1 percent.

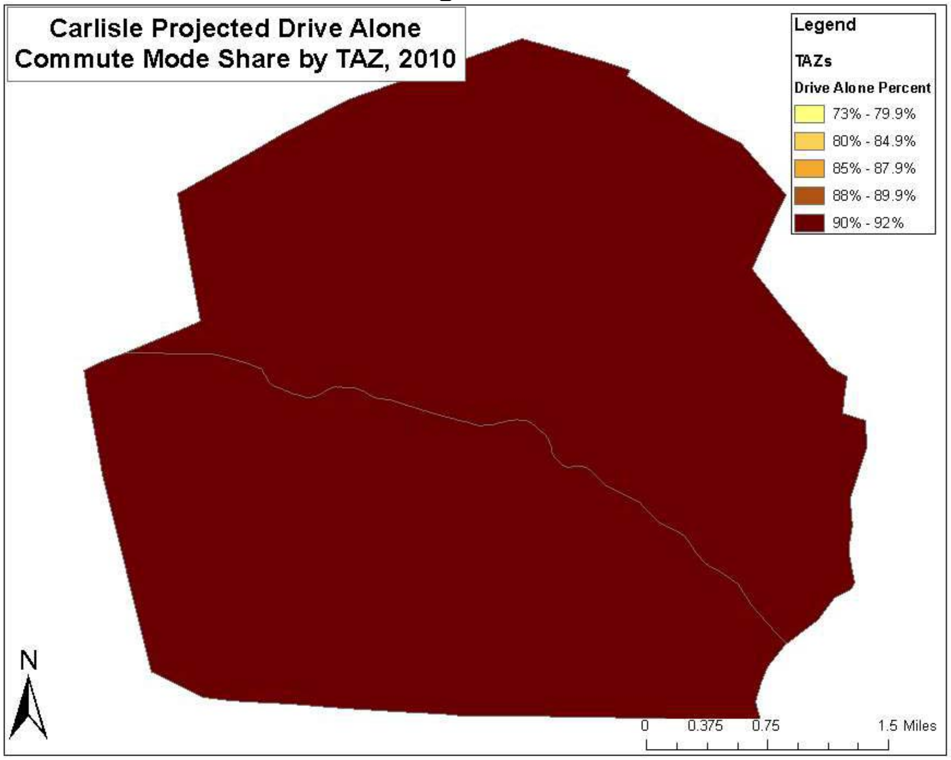
Each of these factors also makes the feasibility of a potential new transit service more difficult. In areas of low-density residential development, trip origins and destinations are more likely to be dispersed, increasing the cost per passenger for transit. As the cost per passenger incurred by the transit provider increases, so too does the cost incurred by the passenger in terms of their time. While Carlisle does have several cul-de-sacs, the relatively well-connected nature of the road network, despite its curvilinear nature and long distances, does facilitate travel around and between different areas of town. However, with most trips, commute or otherwise, destined for outside of the town and most residents having access to a private vehicle, due in large part to Carlisle's relatively high median household income, it becomes difficult for transit to compete. As seen in Figure 44, 90 to 92 percent of trips made in Carlisle are projected in 2010 to be drive-alone trips.

Figure 43



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 44



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

It is therefore difficult to see much demand for public transit in Carlisle coming from those with the means to use a private vehicle for transportation. However, this situation undoubtedly disadvantages any individual with limited mobility, either as a result of a lack of financial resources or an inability to drive. Children and the elderly for whom a driver does not exist are most likely to fall into this category. Given the difficulty of transit attracting few if any of the trips currently being made by private vehicle, it therefore seems reasonable to focus any potential service on those who most need it.

Potential New Services

Given the geographic and demographic realities faced in Carlisle, a potential public transit service in the town would need to be extremely flexible in order to meet the varied sources of demand. Large distances and few direct routes between any two points in the town make it difficult to offer and maintain any set schedule. Similarly, limited but potentially geographically dispersed demand further reduces the suitability of pre-determined routes. In sum, given the need for flexibility in terms of meeting demand, a pure on-demand service would appear to be the most suitable of any potential transit option in Carlisle. This type of service, also commonly known as “dial-a-ride,” could be operated with one or two small vans to cover all of Carlisle as well as specified destinations outside of town. Vans provide door-to-door service for which individuals would need to call ahead and make a reservation. Similar services generally require customers to call anywhere from one day to one hour in advance of their trip to schedule a reservation. Trips would be grouped where possible.

Given the open nature of any service funded by the Boston Region MPO Suburban Mobility Funding Program, in which service cannot be limited to any particular segment of the population, it seems reasonable to investigate opportunities to combine resources with already existing services. The Council on Aging (COA) in Carlisle does operate and subsidize payment for an on-demand transportation service for its senior residents. The experience developed in operating this service could be very useful in expanding the service to all town residents. In addition, should Carlisle decide that a community-wide demand-responsive service is not a feasible choice for the community, the town could join the Lowell RTA and receive service from the RTA’s Road Runner paratransit service. Carlisle does not currently receive any service from its MBTA assessment, and by subtracting this assessment from the RTA fee, this alternative, while limited to serving the elderly and those with disabilities, would result in improved accessibility for more Carlisle residents beyond those that the COA shuttle is currently serving.

As with service levels, more detailed fare and cost estimates would also be necessary beyond the general estimates presented here. However, the high accessibility offered by services such as these generally tends to increase the cost per vehicle revenue-hour of operation to between $55.00-$65.00, when including all costs. This cost is due in large part to the fact that such a service would be dedicated to Carlisle residents at all times, unlike a taxi service that could offer a lower cost per trip but would be unlikely to provide the same level of accessibility. Such suburban taxi services generally charge around $3.00 per mile, though no such services currently exist in Carlisle and most services in the area only offer inter-town trips with flat, per-trip rates. Even with the high level of accessibility afforded by on-demand service, it would likely serve only a low level of demand, perhaps one or two passengers per hour, with obstacles to any growth in demand resulting from the lack of a defined schedule or routing. Such levels of ridership would translate to a cost per passenger between $25.00-$35.00 per trip.

Fares are unlikely to recover much of this cost. The fare level thus depends more on the type of service that communities wish to provide and how, if at all, they may wish to set the price relative to distance traveled. For example, some services add a surcharge to any trip that goes beyond a certain border. A Carlisle on-demand service might charge a flat fare for any travel within the town or to frequent destinations, but add a surcharge for travel to other less-frequent destinations beyond the town borders. Given the difficulties that transit faces in a community such as Carlisle, however, most users of such a service are likely to be those with limited mobility options, often stemming from limited financial means. Thus, any fare structure should also consider the equity implications of its prices and who is generally expected to pay those prices.

Conclusion

There are many obstacles to transit in Carlisle. The town's low residential densities, long travel distances, high median household income levels, and high vehicle ownership rates are a few of the major difficulties that any potential new transit service in Carlisle would face when trying to attract ridership. However, there are certainly some individuals in Carlisle for whom a transit service, either as the primary mode of transportation or as an alternative to private vehicle travel, could prove useful. Carlisle's development patterns make it difficult for any sort of route- or point-deviation service to operate efficiently. As a result, a completely flexible on-demand service would appear to be the most suitable. The shuttle service currently operated by the Carlisle COA represents an existing model of how to potentially run such a service. Expanding service availability to more than the town's senior residents may require some changes and modifications to service, but one of the primary goals should be to maintain the level of service currently enjoyed by the town's senior shuttle users.

Should Carlisle be interested in pursuing either of these or other concepts further, it is encouraged to prepare an application, with the assistance of CTPS, to the Suburban Mobility Funding Program. While not prohibitive, the amount of personnel resources required to complete the application is not insignificant. The application is intended to demonstrate that the community has given thorough consideration to fiscal, operational, and marketing considerations. The application must also demonstrate, in order to receive the CMAQ (Congestion, Mitigation, and Air Quality) funding upon which the Suburban Mobility Funding Program is based, that the proposal decreases local air pollutant emissions. As such, travel demand reviews, market research, and financial plans are all necessary components of a community's application. CTPS is available to provide data and analytical advice upon direction of the MPO's Suburban Mobility/TDM Subcommittee. CTPS can assist communities with the preparation and analysis of surveys and the estimation of predicted ridership and emissions as well as provide examples and review drafts of fiscal, operational, and marketing plans. Communities may obtain additional information on suburban transportation by consulting the first Suburban Transit Opportunities Study prepared by CTPS as well as the Transportation Research Board's TCRP Report 116: Guidebook for Evaluating, Selecting, and

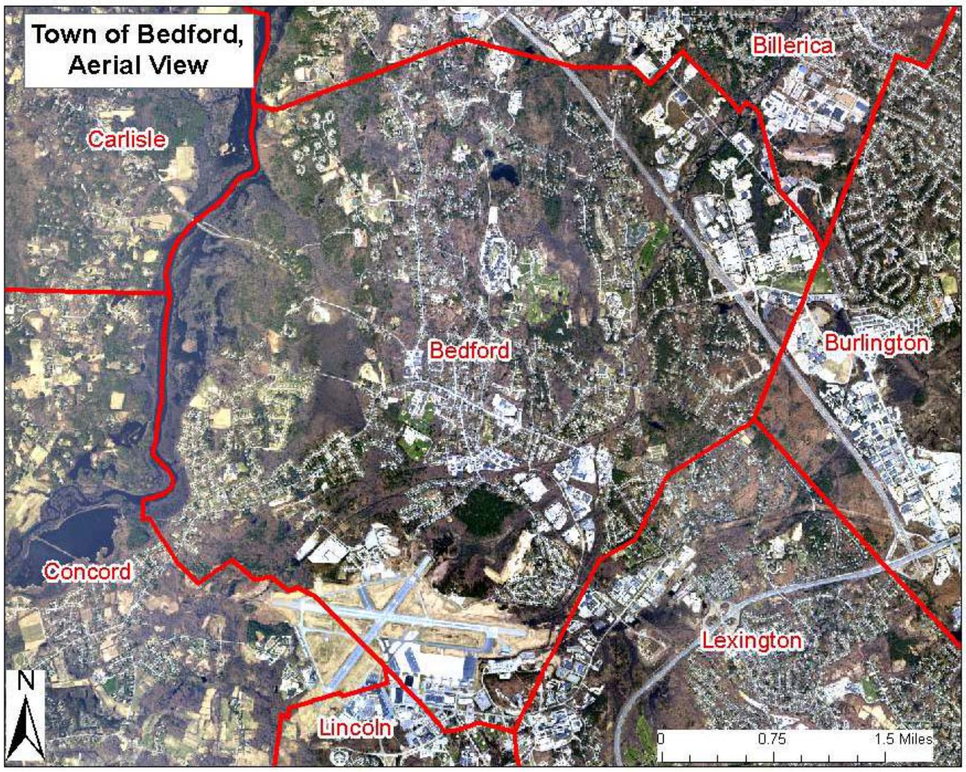
Implementing Suburban Transit Services. Both reports are available on the respective organizations' websites. The information provided in this Carlisle Transit Analysis is intended to assist Carlisle in determining whether to prepare an application and whether or not demand-responsive transit service is viable given the potential costs and demand.

BEDFORD

Physical Criteria

Figure 45 presents an aerial photograph of the town of Bedford and the surrounding area from 2005. From this photograph, one can see the extent to which development is dispersed throughout town. Hanscom Field and its related facilities are located in the south of town and a large industrial complex lies in the northeast corner of town, separated from the remainder of town by Route 3. Other than these large industrial concentrations of development, most other development in Bedford appears fairly scattered. There are also several tracts of open space located throughout the town. Bedford is bordered by Billerica to the north, Burlington to the east, Lexington to the southeast, Lincoln to the south, Concord to the southwest, and Carlisle to the northwest.

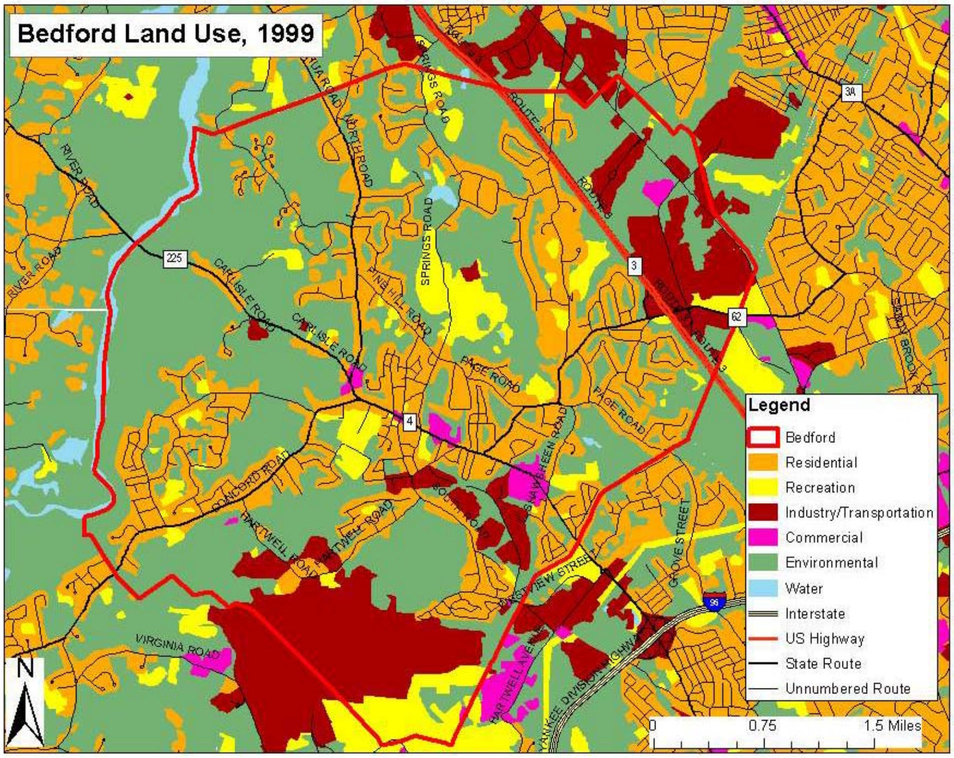
Figure 45



Source: MassGIS

Figure 46 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston Region MPO region in 1999 and breaks down land uses into 21 categories. Figure 46 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen in the figure, residential and environmental land uses predominate and mix together throughout the town, while industrial and office development is concentrated in the south and northeast sections. What little retail commercial development exists in Bedford is located primarily along Route 4.

Figure 46

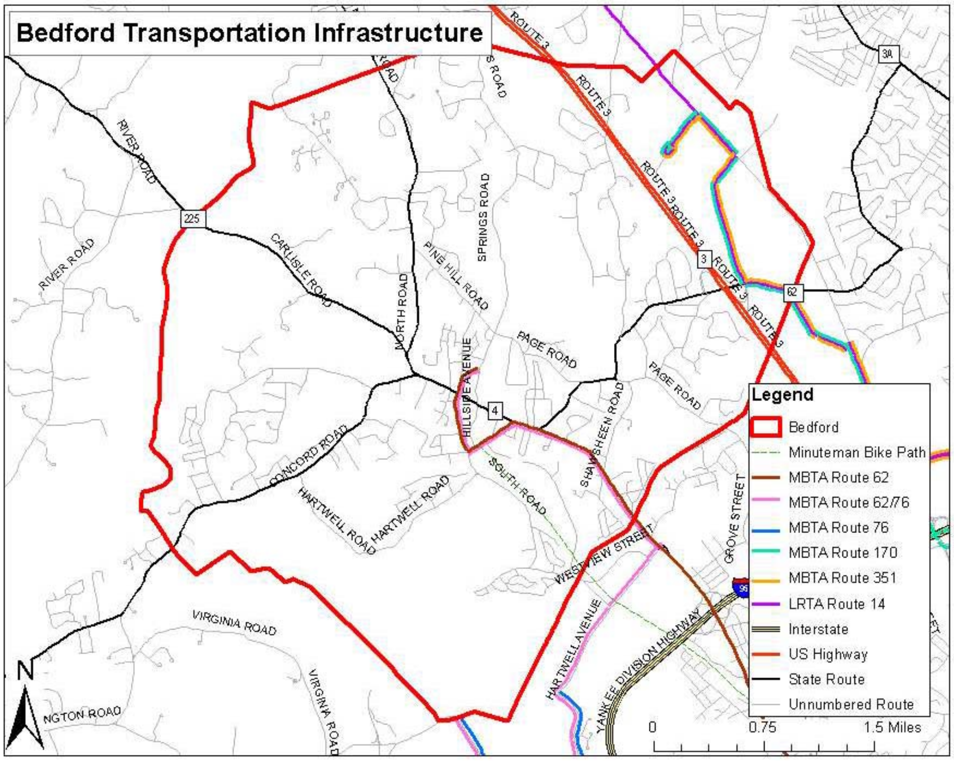


Source: MassGIS

Figure 47 depicts the transportation infrastructure in the town of Bedford, including major and local roads, MBTA bus routes, and additional modal corridors. Lying just north of Route 128, Bedford is traversed by several major arterials. Route 3 is a limited-access highway and terminates at Route 128 while Route 4 provides local access and passes through the center of town on its way to Route 128 and points south in Lexington. Other arterials include Route 62, which runs east-west through Bedford between Burlington and Concord, and Route 225, which follows Route 4 from Route 128 until just north of the center of town when it splits east towards Carlisle while Route 4 continues north to Billerica. While Bedford is not served by commuter rail, it does lie approximately halfway between two commuter rail lines with stations in Woburn and Concord. MBTA bus Route #62 provides local stops along Great Road (Routes 4 and 225) into the center of town with a headway of 30 minutes during the peak periods and as much as one hour during the off-peak. Bus Route #76 serves Lincoln Laboratories to the south and the weekend combination of these two routes, bus Route #62/76, has headways throughout the day of 60 or 70 minutes. Several routes also serve Bedford Woods and Oak Park Drive in the northeastern corner of town. MBTA bus Routes #170 and #351 are both reverse-commute services, running outbound towards Bedford in the morning and inbound to Dudley and Alewife Stations, respectively, in the evening. The Lowell Regional Transit Authority also runs a service between Lowell and the Lahey Clinic in

Burlington that passes through Bedford north of Route 3. Bedford is the terminus of the Minuteman Bike Path, which also passes through Arlington and Lexington.

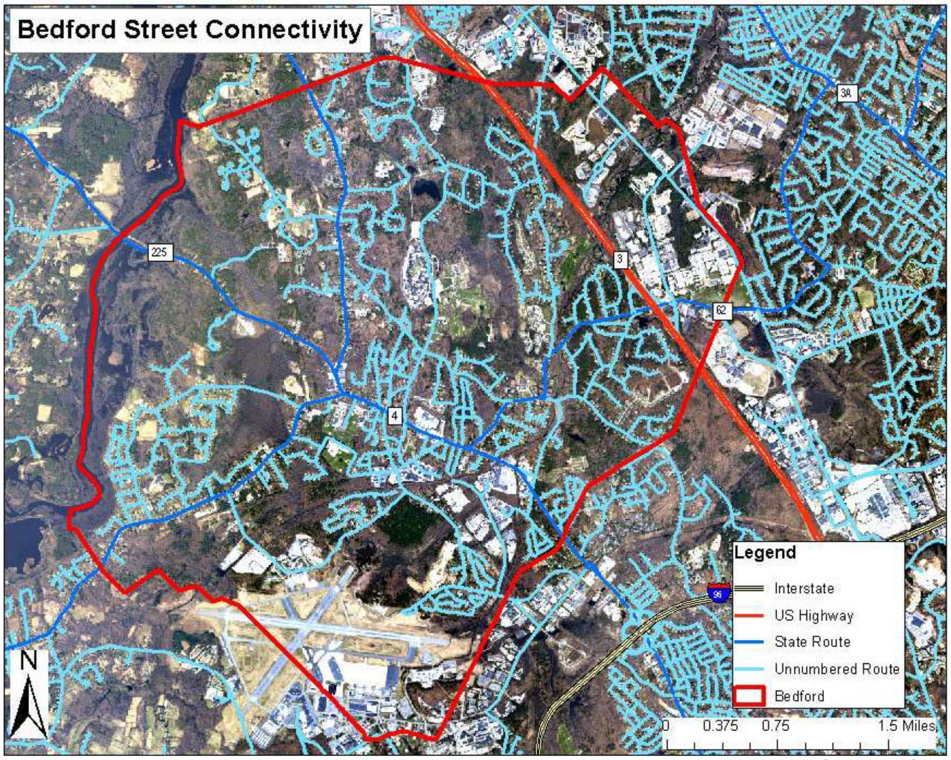
Figure 47



Source: MassHighway and CTPS

Figure 48 overlays the street network on top of the aerial photograph of Bedford, highlighting the street connectivity in the town. As seen in the figure, cul-de-sacs and curvilinear roads characterize the low coverage and limited accessibility provided by the street network throughout the town. Despite the accessibility afforded by the large number of major roads running through Bedford, many neighborhoods are limited in their points of access to these roads.

Figure 48



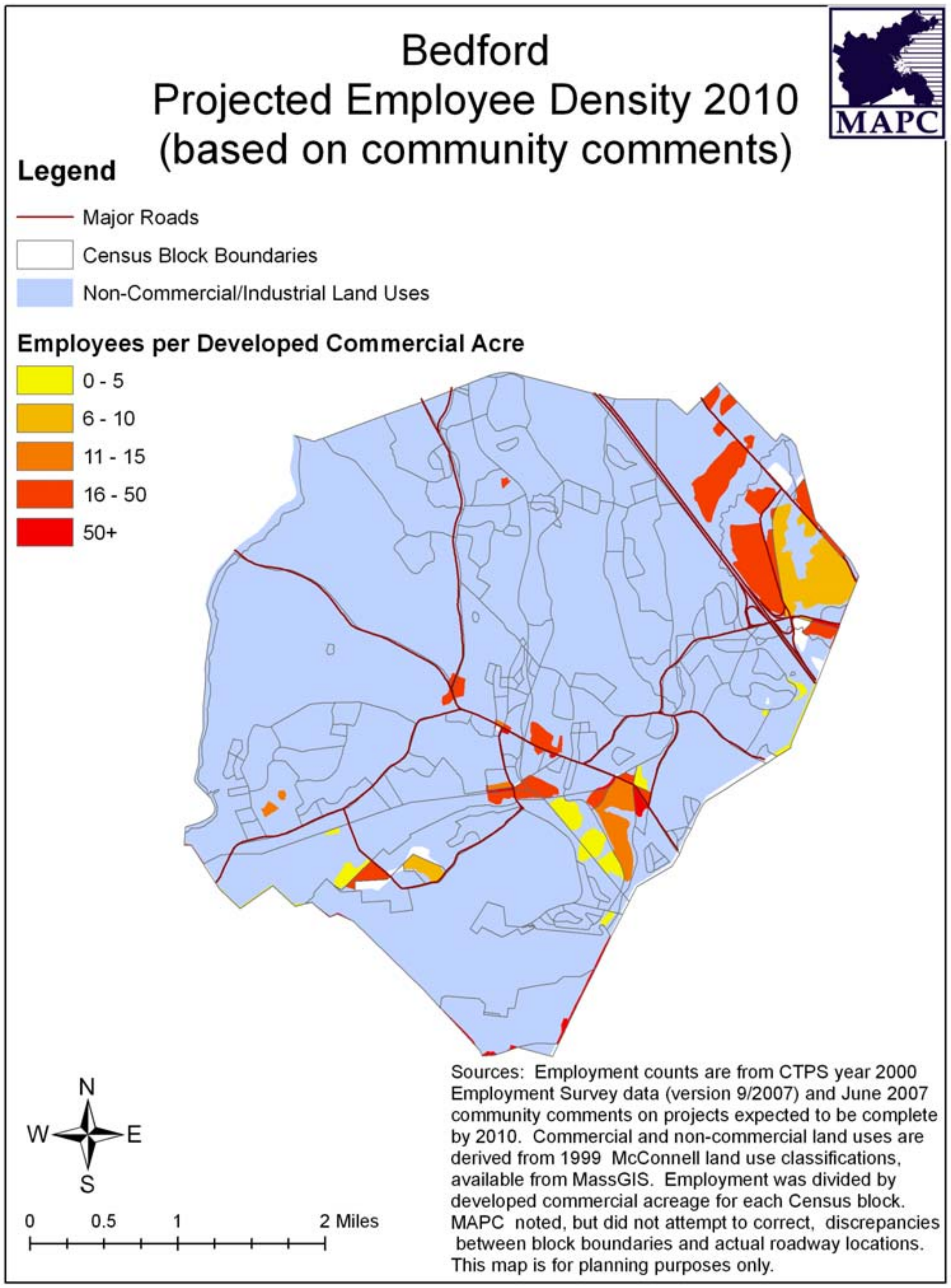
Source: MassGIS and MassHighway

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

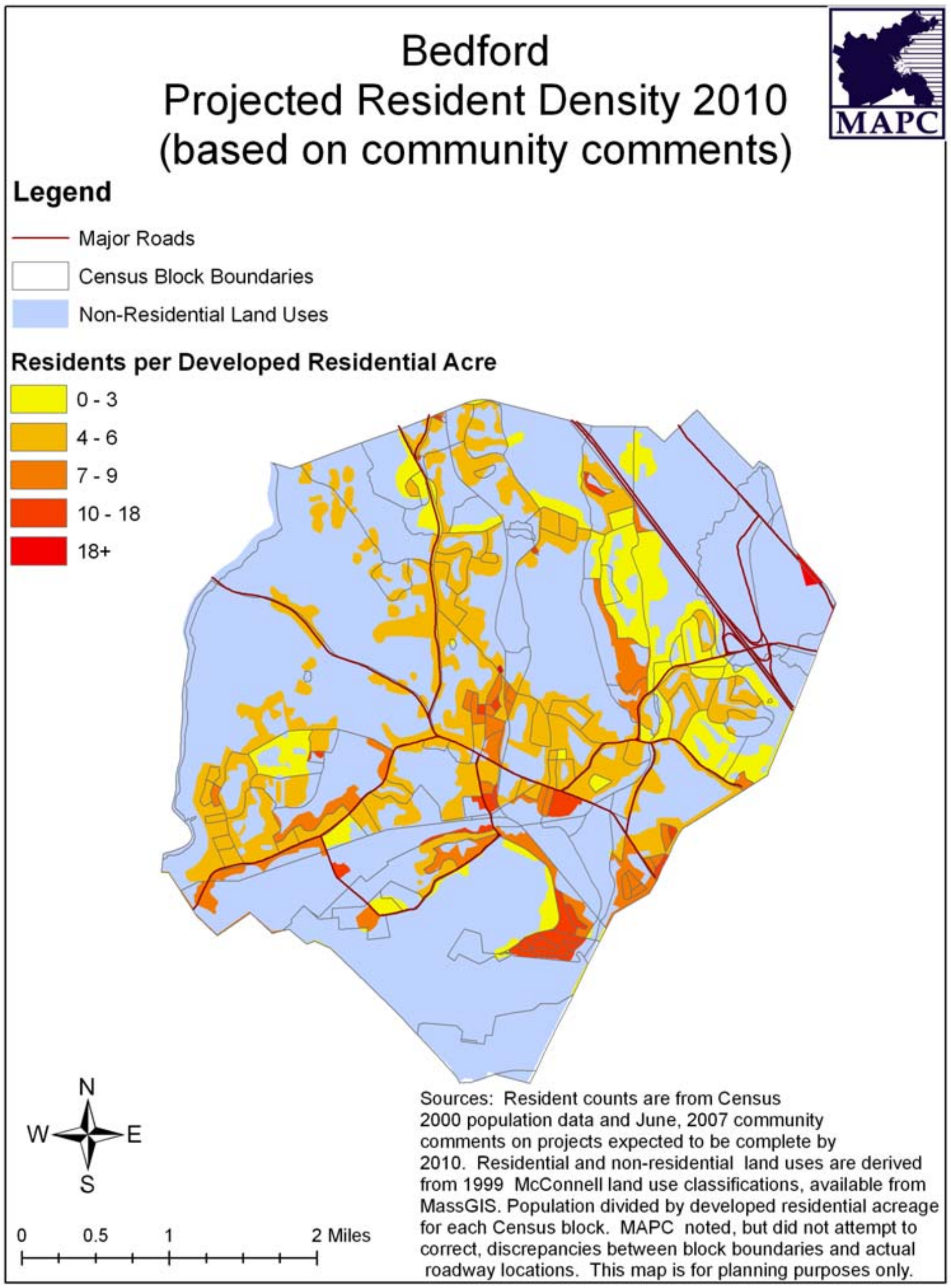
As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips tends to be greater. Figure 49 shows the 2010 projections for population density by residential acre. As seen in the figure, there is a wide range of residential densities throughout Bedford. Several areas, particularly in the southern portion of town, have residential densities in the range of 10-18 persons per acre, while the lowest density category, 0-3 persons per acre, is primarily located in the northeastern corner of town. These varying residential densities across town are indicative of the different development patterns throughout Bedford. The central and southern portions of town, due in large part to the industrial and commercial land uses located there, generally have more concentrated street patterns with better accessibility and higher residential density. Other residential development throughout town, however, is mostly characterized by the traditional curvilinear street pattern and cul-de-sacs often found in suburban communities. Transit is generally assumed to be most suitable in areas of high density, less so in medium-density locations, and difficult to justify in low-density locations due to the concentration of trip origins and destinations and the ability of public transit to provide convenient service to these locations.

Figure 49



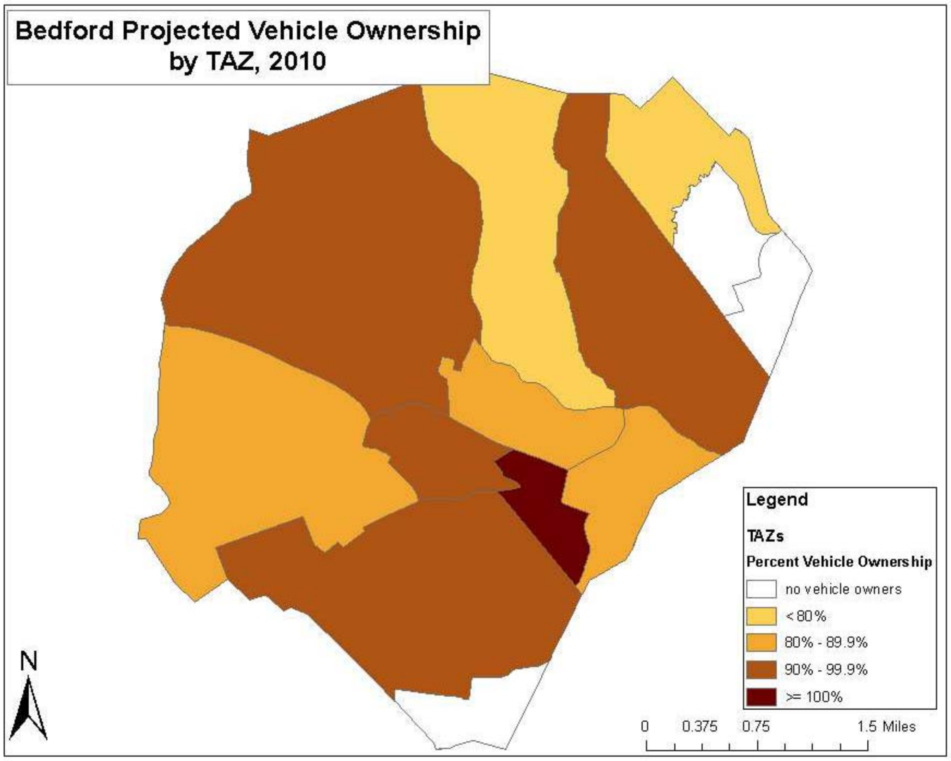
The residential densities depicted in Figure 49 are therefore important for determining the locations of potential origins and destinations of transit users and the type of service that would be most appropriate in Bedford. Another significant origin/destination for travel within Bedford lies at places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Commute trips between work and home generally make up an important segment of transit ridership. In the town of Bedford, Figure 50 depicts the employment density, measured as the number of employees per developed commercial acre. As seen in the figure, there are roughly two general locations for employment in the town. The northeastern corner of Bedford is characterized by a high number of jobs located in one central location. By comparison, employment in the southern portion of town is concentrated into relatively smaller developments that are distributed primarily along and adjacent to the Route 4 corridor.

Figure 50



One factor that can influence the potential of transit in an area is the ratio of vehicle ownership to population. Lower vehicle ownership percentages are a likely indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 51, vehicle ownership in Bedford is generally quite high, with only two TAZs (Traffic Analysis Zones) having rates below 80 percent. One TAZ has a vehicle ownership rate above 100 percent and half of the TAZs have rates greater than 90 percent.

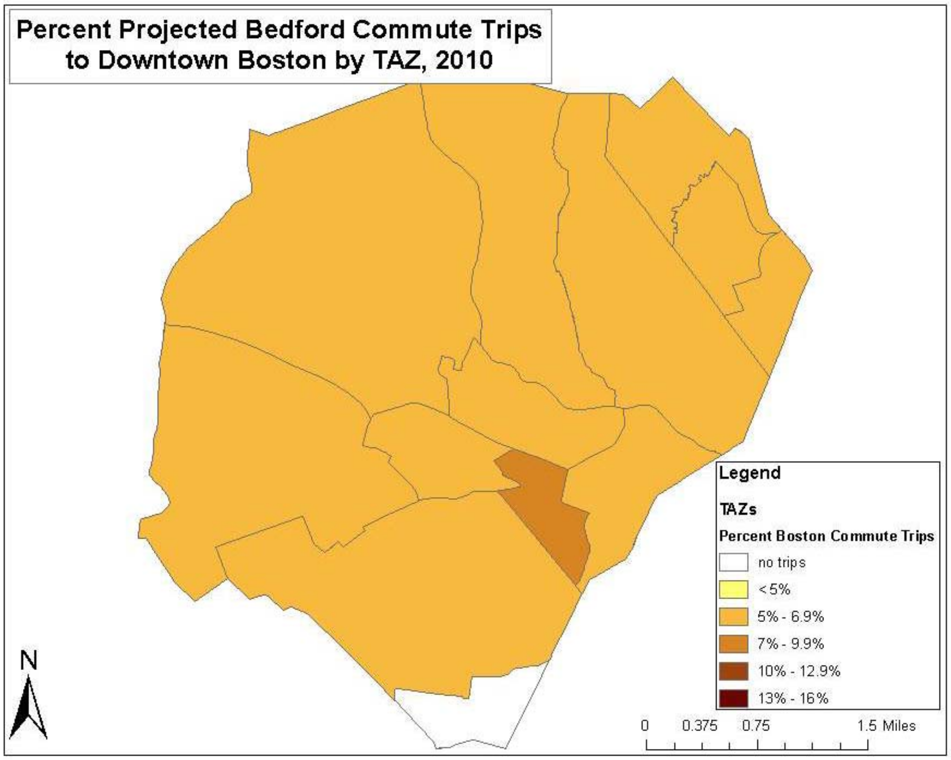
Figure 51



Source: CTPS Regional Model Smart Growth+ Projections

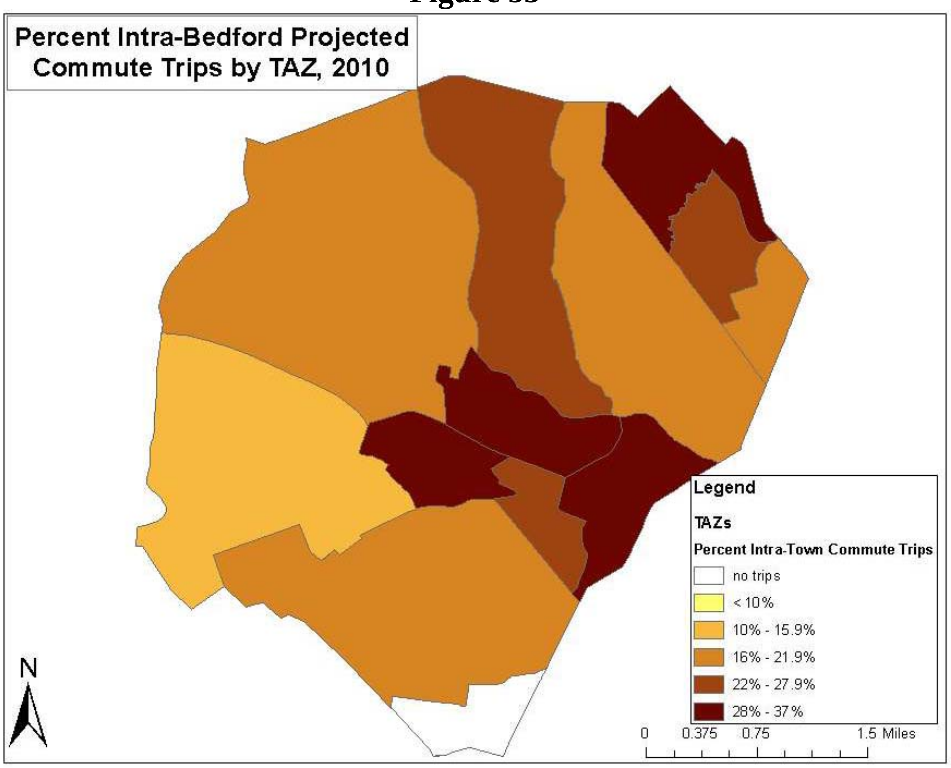
Given that work trips represent a significant portion of public transit usage, it is useful to know where residents are traveling to and from during their daily commute. Figure 52 presents the percentage of commute trips from Bedford to downtown Boston and Figure 53 shows the percentage of intra-Bedford commute trips. As seen in Figure 52, the percentage of workers who commute to downtown Boston is between 5 percent and 7 percent in all but one TAZ in the center of town, where the rate falls between 7 percent and 10 percent. A greater percentage of Bedford commute trips stay within the town borders, with only one TAZ having a rate of less than 16 percent and several TAZs having rates between 26 percent and 37 percent. When added to Boston commute trips, however, the combined intra-Bedford and Boston categories account for almost 30 percent of all Bedford's home-based work trips. An additional 4.5 percent of Bedford commute trips are destined for the western portion of Burlington along Middlesex Turnpike towards the Burlington Mall. Therefore, slightly more than 65 percent of Bedford's commute trips are headed beyond the town to areas outside of downtown Boston and western Burlington. The probable suburban destinations of many of these commute trips are more likely to necessitate private vehicle travel. When the number of

Figure 52



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

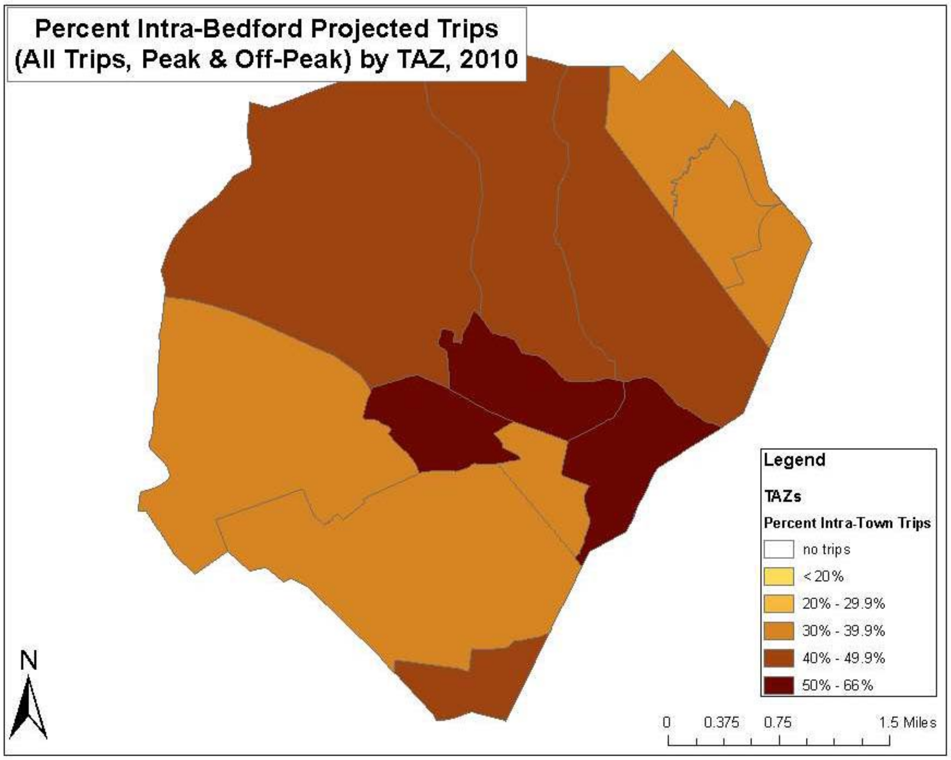
Figure 53



Source: CTPS Regional Model Smart Growth+ Projections

trips expands to include all types of trips (both peak and off-peak – Figure 54), however, the percentage of intra-Bedford trips increases in all TAZs to 44 percent on average with no TAZ having a percentage below 30 percent and several having rates above 50 percent.

Figure 54

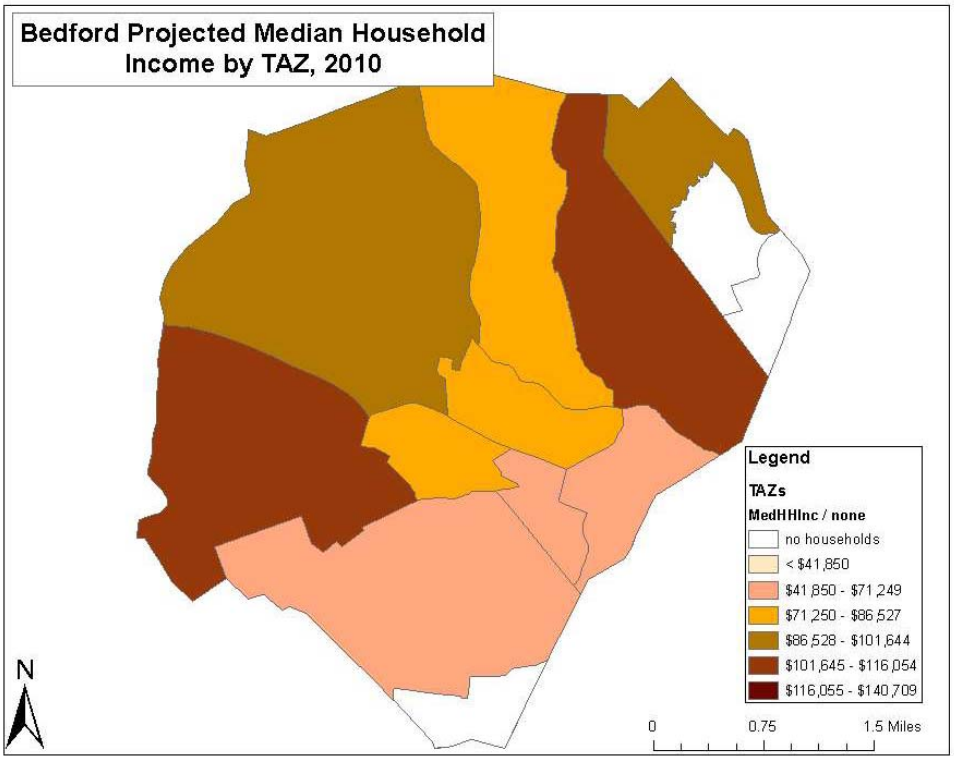


Source: CTPS Regional Model Smart Growth+ Projections

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 55, no TAZs in the town of Bedford have a median household income below $41,850. However, Bedford is characterized by a range in household incomes across TAZs. The highest incomes tend to be located along the eastern and western edges of town near the neighboring municipalities of Carlisle, Billerica, and Burlington, while the median household incomes of several TAZs in the south and through the center of town fall into comparatively lower income brackets.

With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. According to MAPC, approximately 12.4 percent of the population of the town of Bedford will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, MAPC predicts that this population group will compose 18.6 percent of the total population in 2010. Thus, 31 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher.

Figure 55



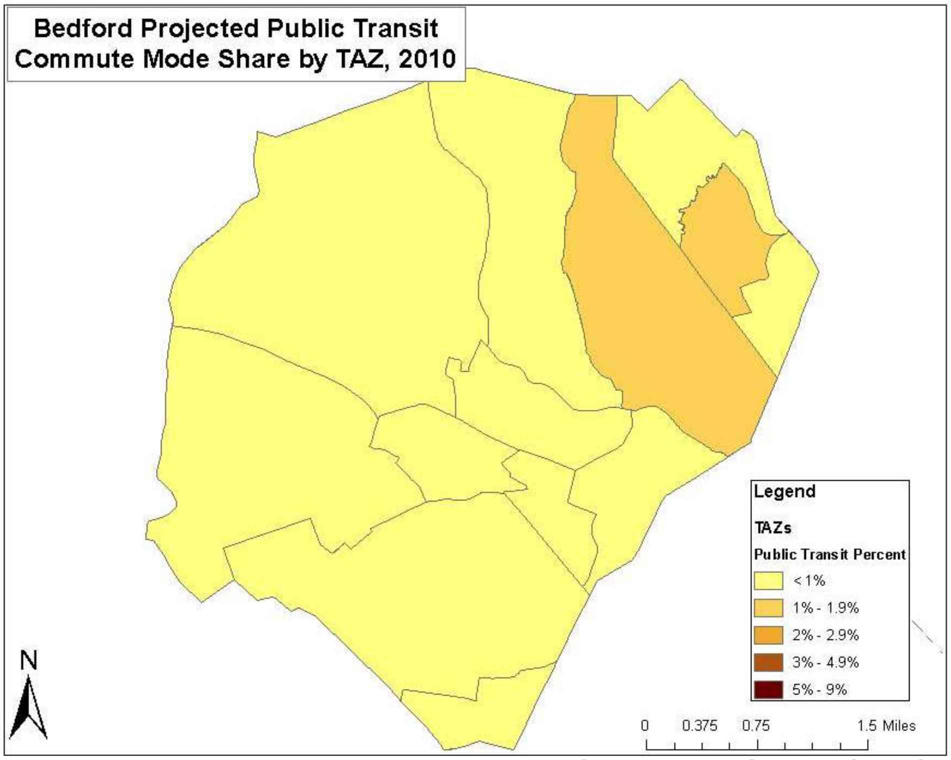
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Transit Demand Assessment

Given its relatively low density of development, disconnected nature of the street network, high vehicle ownership and income levels, and few choices to using a private vehicle for most trips, it is not surprising that existing public transit usage in Bedford is low. As seen in Figure 56, no TAZ has a public transit commute mode share greater than 2 percent and most TAZs do not have a mode share greater than 1 percent. Even in the TAZs through which bus Routes #62 and #62/76 pass, transit fails to capture more than a marginal percentage of commute trips.

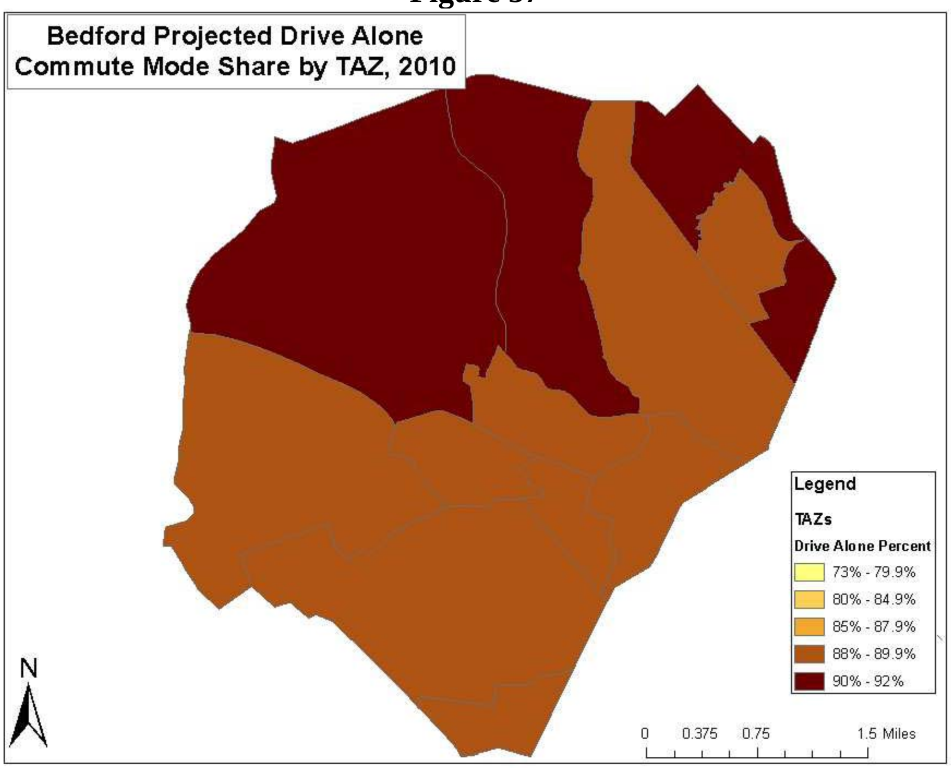
Each of these factors also makes the feasibility of a potential new transit service more difficult. In areas of low-density residential development, trip origins and destinations are more likely to be dispersed, increasing the cost per passenger for transit. The large number of cul-de-sacs and the disconnected nature of the street network also increase this cost. In such a street network, it is often necessary to enter and exit a neighborhood through the same road. When combined with the winding, non-direct nature of many of these roads, the distance and time, and therefore cost, devoted to each trip increases. As the cost per passenger incurred by the transit agency increases, so too does the cost incurred by the passenger in terms of their time. With most residents having access to a private vehicle, it becomes difficult for transit to compete. As seen in Figure 57, no TAZ has a drive alone commute mode share less than 88 percent.

Figure 56



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 57



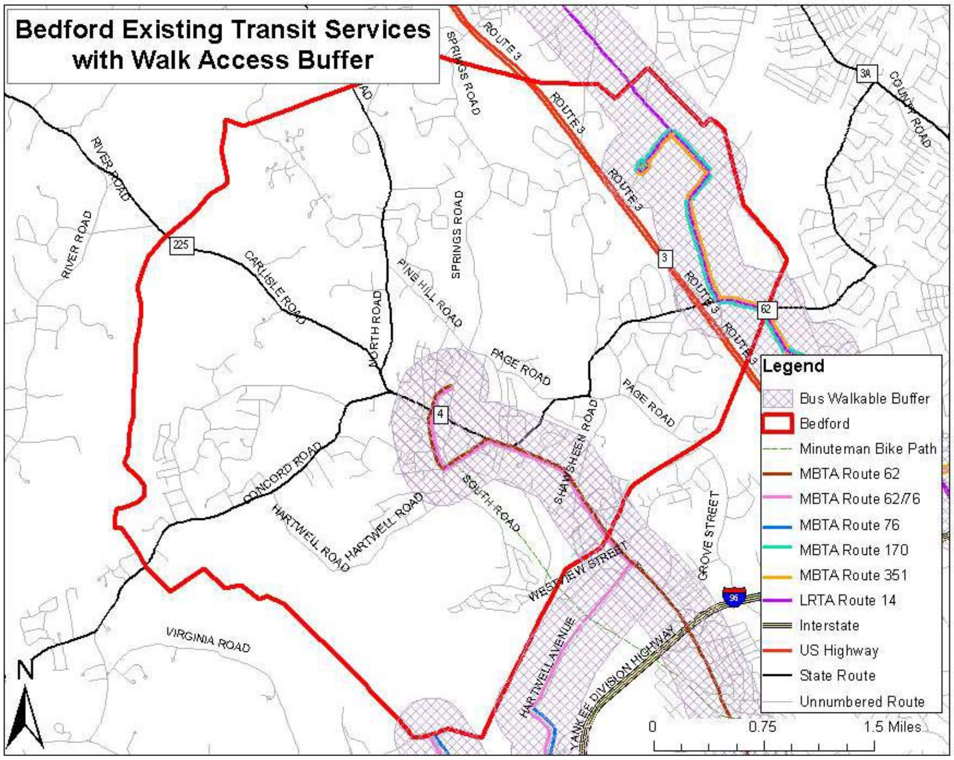
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

There are already some demand-responsive services in place to serve residents with limited mobility. The Council on Aging (COA) in Bedford provides transportation for town residents aged 60 and above to medical appointments and on group trips to historical and cultural destinations. Bedford is also part of the service area for The RIDE, a paratransit dial-a-ride service (door-to-door shuttle service where customers call ahead to reserve a time slot) administered by the MBTA that provides access to the entire Boston metropolitan region served by The RIDE. Finally, Bedford Local Transit provides service without eligibility criteria for in-town, door-to-door travel Monday through Friday from 9:10 a.m. to 11:55 a.m. and from 12:45 p.m. to 2:55 p.m. as well as two midday round trips between the Bedford Town Hall and the Burlington Mall, stopping at the town Whole Foods and Stop & Shop on Route 4. The fares for local travel are $0.50 for adults and children and $0.25 for seniors and persons with disabilities while the fares for travel to the Burlington Mall are $0.75 and $0.35, respectively, and all buses are handicapped-accessible. Reservations are taken Monday through Friday between 8:00 a.m. and 9:00 a.m. During Federal Fiscal Year 2007 (July 2006 through June 2007), Bedford Local Transit carried 6,566 riders. These operations thus serve some of the same markets as a potential new demand-responsive service, and while COA trips and The RIDE are available only to certain segments of the population, Bedford Local Transit imposes no such eligibility criteria for service.

Figure 58 demonstrates how little of the town is within walking distance of MBTA bus service along Routes 4 and 225 into the center of town. The quarter-mile buffer depicted are based on the maximum distance that a person is generally assumed to be willing to walk to fixed-route bus service. As seen in the figure, most of Bedford's neighborhoods lie quite a distance from the MBTA bus routes. Therefore, for travel to these routes or within town for these neighborhoods via public transportation, residents must use Bedford Local Transit or one of the paratransit services if they are eligible.

The greatest potential for demand-responsive service in Bedford would seem to point to two markets. One population that could be interested in using intra-town public transit would be residents who work either in southern or northeastern Bedford. These potential riders are likely to be so-called "choice" riders in that they tend to have access to a private vehicle and their use of public transit therefore depends largely on the cost, reliability, and convenience of the service. Another population might be individuals with limited mobility, such as students, seniors, and those who do not own a private vehicle and for whom the existing schedule of Bedford Local Transit is not convenient. These potential riders have much less choice with regard to their transportation options. They may be finding ways to travel using a combination of carpooling, taxis, bicycling, walking, and various public transit modes, and would greatly benefit from an affordable, convenient, and accessible public transit service on which they could rely. Low- and medium-density residential housing is spread throughout the town and riders traveling between their homes and their destinations in Bedford would make up most of the demand for both choice and non-choice trips. Travel to places of employment is likely to follow the traditional commuting pattern with the majority of trips in the AM and PM Peak periods. Conversely, travel to commercial and educational destinations is more likely to be spread throughout the day.

Figure 58



Many of Bedford's residential areas are located in neighborhoods with low levels of street connectivity and often only one way to access a main road. This type of development is traditionally difficult for fixed-route transit to serve, given the distance that residents must often walk to access a transit stop on the main road and the barrier to using transit that this presents. Demand-responsive service is, in many cases, intended to divert from the main corridor and enter the neighborhoods where fixed-route service cannot; however, low levels of street connectivity make it more difficult for the transit vehicle to enter and exit the neighborhood quickly. For example, if a bus were to serve many of the residential areas in Bedford, it would usually need to use the same road both to enter and exit the neighborhood. Unlike with a grid street network, where there are multiple connection points and various ways that a transit vehicle could weave its way through a neighborhood, the cul-de-sacs and low connectivity of many Bedford neighborhoods make diversions to those areas very costly in terms of time. This cost is heightened by extent to which low-density neighborhoods characterize a town, making it difficult to group diversions and efficiently serve several destinations on one trip. Fortunately, while Bedford does have several low-density residential neighborhoods, most neighborhoods are medium-density and several multi-family developments are also scattered throughout town.

Potential New Services

Given its mix of existing services, there are several potential choices and opportunities for new demand-responsive transit services in Bedford. One possible option would be to grow Bedford Local Transit on-demand service. Bedford Local Transit is already established in the community. The town could therefore take advantage of the service's existing operational structure, funding resources, and marketing strategy without having to create an entirely new service. Growing Bedford Local Transit would most likely mean extending its dial-a-ride service into the evening beyond its current ending time of 2:55 P.M. and operating service on the weekends. This, in turn, would generate the cost of paying the driver for this additional time, or perhaps hiring another driver. As the driver is also in charge of taking reservations and scheduling trips, it might be advisable to schedule an additional hour of non-service time (like the 8:00 A.M. hour in the morning) in the afternoon for passengers to call and make reservations.

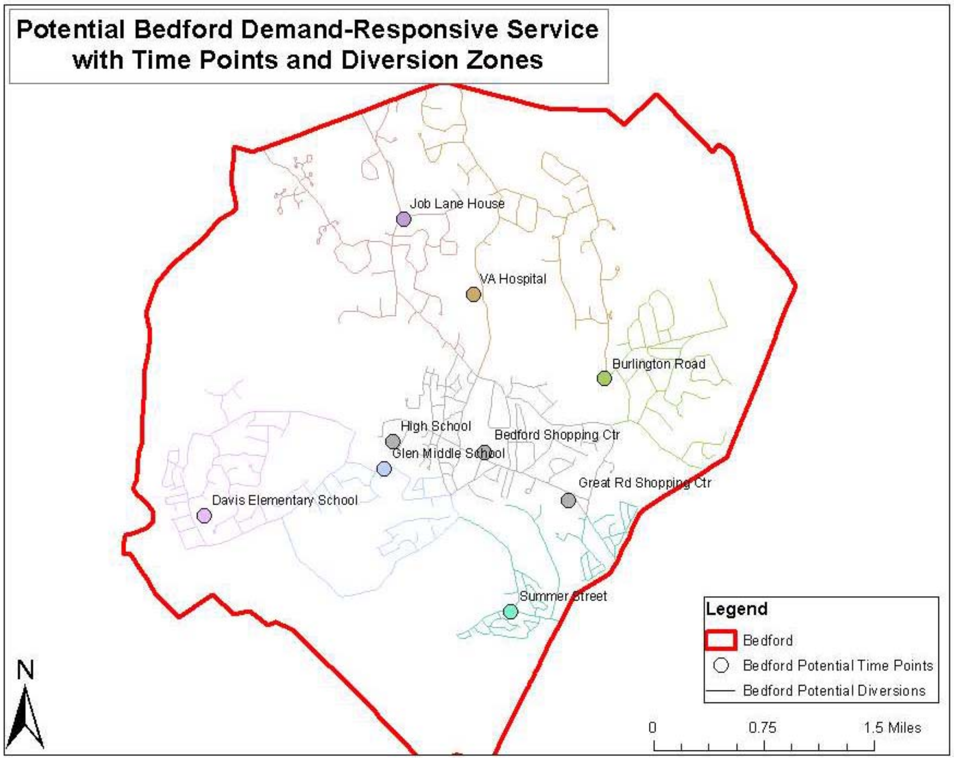
This alternative would provide the highest level of accessibility and probably the highest cost per vehicle revenue-hour of operation, somewhere between $55.00-$65.00, when including all costs. This cost is due in large part to the fact that such a service would be dedicated to Bedford residents at all times, unlike a taxi service that could offer a lower cost per trip but would be unlikely to provide the same level of accessibility. Even with the high level of accessibility afforded by on-demand service, it would likely serve only a low level of demand. In fiscal year 2007, Bedford Local Transit carried approximately 3.8 passengers per service hour and any expansion in service would likely transport three or four passengers per hour, with obstacles to any growth in demand resulting from the lack of a defined schedule or routing. Such levels of ridership would translate to a cost per passenger between $12.00-$22.00 per trip. Suburban Mobility funding could be provided for an extension in on-demand service, as it would represent "new" service in a time period that is not currently being served. Such a growth would likely require some changes in operational and capital management, but the development of such plans would be facilitated by the fact that Bedford already has experience running an on-demand service.

Another choice would be a service with characteristics somewhere between the MBTA bus routes and Bedford Local Transit. Traditional MBTA bus routes provide fixed-route service throughout the day with accessibility limited to approximately 0.25 miles from the route. Bedford Local Transit operates a few fixed-stop trips to the Burlington Mall from the town center as well as a door-to-door service to any area in town during the morning and afternoon. A point-deviation service, such as the one depicted in Figure 59, would provide greater accessibility than a fixed-route bus route as well as a clearer and more reliable schedule than a door-to-door demand-responsive service. Such a service would have several fixed stops throughout the town, as well as a fixed schedule for serving each stop. However, as shown by the diversion zones around the potential stops, door-to-door service would be provided within a certain area of the stop, with time built into the schedule to allow for such diversions.

Figure 59 presents two potential routes – one serving southern Bedford and the other serving northern Bedford. Each route would serve the three proposed central Bedford stops at the Great Road Shopping Center, the Bedford Shopping Center, and the town

High School and surrounding area along Route 4 as well as three other stops. For the southern route, the service would stop at the Davis Elementary School, the Glen Middle School, and the intersection of Summer Street and South Road. The northern route would stop at the Job Lane House, the VA Hospital, and the intersection of Burlington Road and Billerica Road. These stops were selected as central locations within the respective diversion zone as well as potential destinations for trips where possible. As mentioned above, the proposed service would stop at each of the time points according to a set schedule while passengers wishing to board or alight at another location within the diversion zone would be required to make a reservation.

Figure 59

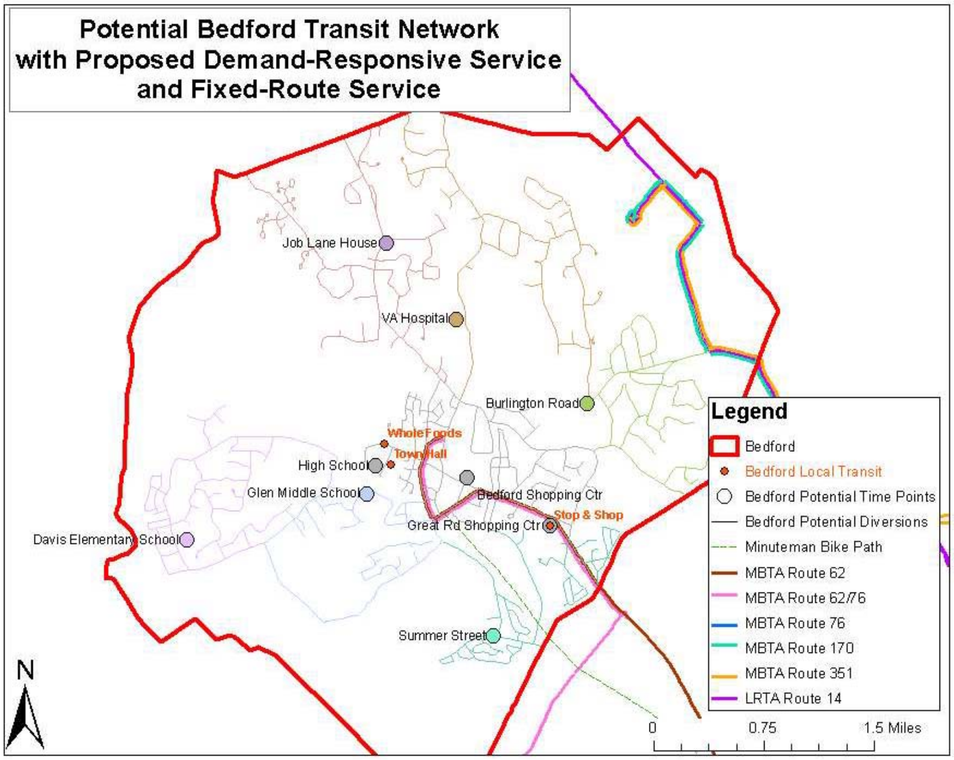


A point-deviation service such as the one proposed in Figure 59 could generally be operated with two small buses or shuttles (one for northern Bedford and one for southern Bedford, designed for efficient boarding and alighting in the context of residential neighborhoods). A reasonable headway and running time for each of the routes of the proposed service would be about one hour. This would allow perhaps 15 total minutes to serve the three central stops and surrounding location and 15 minutes to serve each of the three southern and northern stops and surrounding areas. With both shuttles having headways of one hour and serving all three central point locations, passengers should also be able to use these points to transfer between shuttles with minimal waiting time.

Figure 60 demonstrates the potential transit network that would exist in Bedford with the proposed point-deviation service. As seen in the figure, under the proposal, most areas of Bedford would be accessible by transit, with multiple connection points between services. Travel between the northern and southern sections of town would be made with the point-deviation service. A trip starting from the northern border of Bedford on Route

4, for example, would fall into the diversion zone of the northern route and its timepoint at Job Lane House. The point-deviation service would then allow the passenger to transfer to the southern route at any of the three common timepoints. Riders could also use the point-deviation service to transfer to Bedford Local Transit or LRTA Route #14 for travel towards the Burlington Mall.

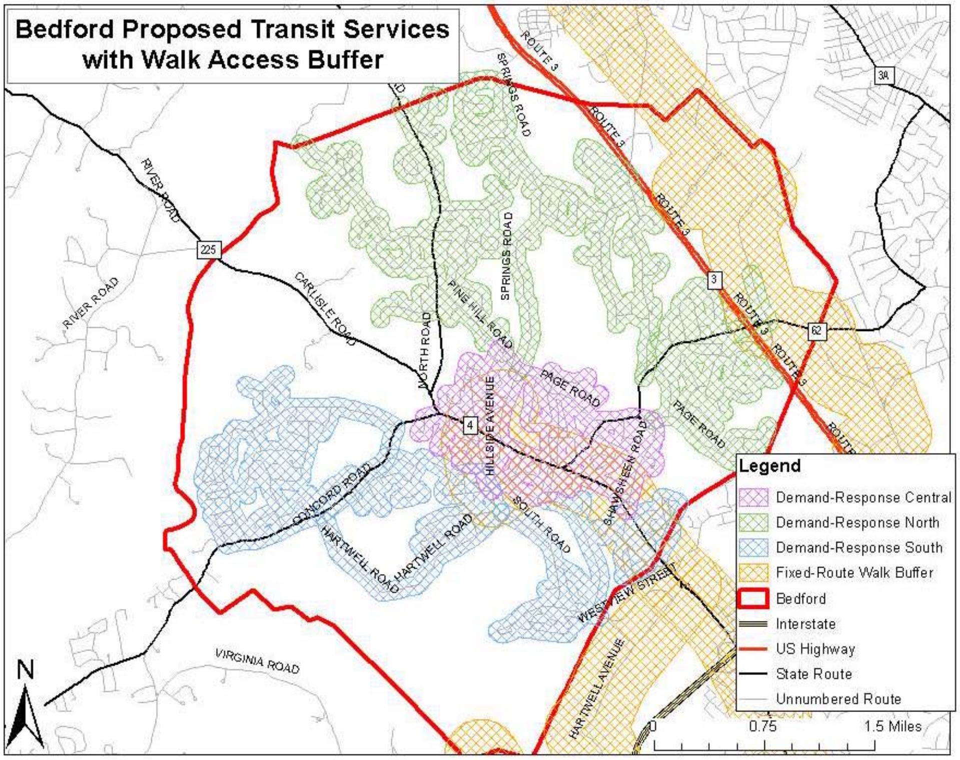
Figure 60



As with service levels, more detailed fare and cost estimates would also be necessary beyond the general estimates presented here. However, services such as these generally tend to cost between $55.00-$65.00 per vehicle revenue-hour to operate, when including all costs. Some of the more successful and mature services in other metropolitan areas have achieved ridership levels of up to 10-12 passengers per vehicle revenue-hour. This ridership figure thus corresponds to a cost per passenger of approximately $5.00-$6.00. Like all other public transit services, fares are unlikely to recover much of this cost. The fare level thus depends more on the type of service that communities wish to provide and how, if at all, they wish to add a premium to any trip that deviates beyond the scheduled time points. The extent to which public or private sources subsidize the service can also affect fare levels.

This potential service offers nearly as much accessibility as a town-wide on-demand service. The accessibility of the proposed service, superimposed on the existing accessibility provided by fixed-route MBTA bus service, is shown in Figure 61. There are only a few areas, notably along Carlisle Road and northern Billerica Road, where diversions would not be permitted. Upon a more exact review of running times and possible routings, further areas may need to be cut from the allowable diversion buffers in order to maintain a desired running time. If such a service is intended to supplant Bedford Local Transit, on the other hand, the goal may be to provide as much accessibility as possible. Indeed, running both a point-deviation and on-demand service in Bedford would not be advisable, as it would pit the two services against each other in terms of attracting limited ridership.

Figure 61



Conclusion

There are many challenges to providing new transit service in Bedford. The town's low residential densities, high median household income levels, and high vehicle ownership rates, and the extent to which existing on-demand services are already in place are a few of the major difficulties that any potential new transit service in Bedford would face when trying to attract ridership. However, there are certainly some individuals in Bedford for whom a transit service, either as the primary mode of transportation or as an alternative to private vehicle travel, could prove useful. Bedford's development patterns make it difficult for fixed-route service to operate efficiently. Either a form of point-deviation service with door-to-door accessibility or an extension of the existing Bedford Local Transit on-demand service into the evening hours would appear to be the most suitable.

Should Bedford be interested in pursuing either of these or other concepts further, it is encouraged to prepare an application, with the assistance of CTPS, to the Suburban Mobility Funding Program. While not prohibitive, the amount of personnel resources required to complete the application is not insignificant. The application is intended to demonstrate that the community has given thorough consideration to fiscal, operational, and marketing considerations. The application must also demonstrate, in order to receive the CMAQ (Congestion, Mitigation, and Air Quality) funding upon which the Suburban Mobility Funding Program is based, that the proposal decreases local air pollutant emissions. As such, travel demand reviews, market research, and financial plans are all necessary components of a community's application. CTPS is available to provide data and analytical advice upon direction of the MPO's Suburban Mobility/TDM Subcommittee. CTPS can assist communities with the preparation and analysis of surveys and the estimation of predicted ridership and emissions as well as provide examples and review drafts of fiscal, operational, and marketing plans. Communities may obtain additional information on suburban transportation by consulting the first Suburban Transit Opportunities Study prepared by CTPS as well as the Transportation Research Board's TCRP Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services. Both reports are available on the respective organizations' websites. The information provided in this Bedford Transit Analysis is intended to assist Bedford in determining whether to prepare an application and whether or not demand-responsive transit service is viable given the potential costs and demand.

READING

Physical Criteria

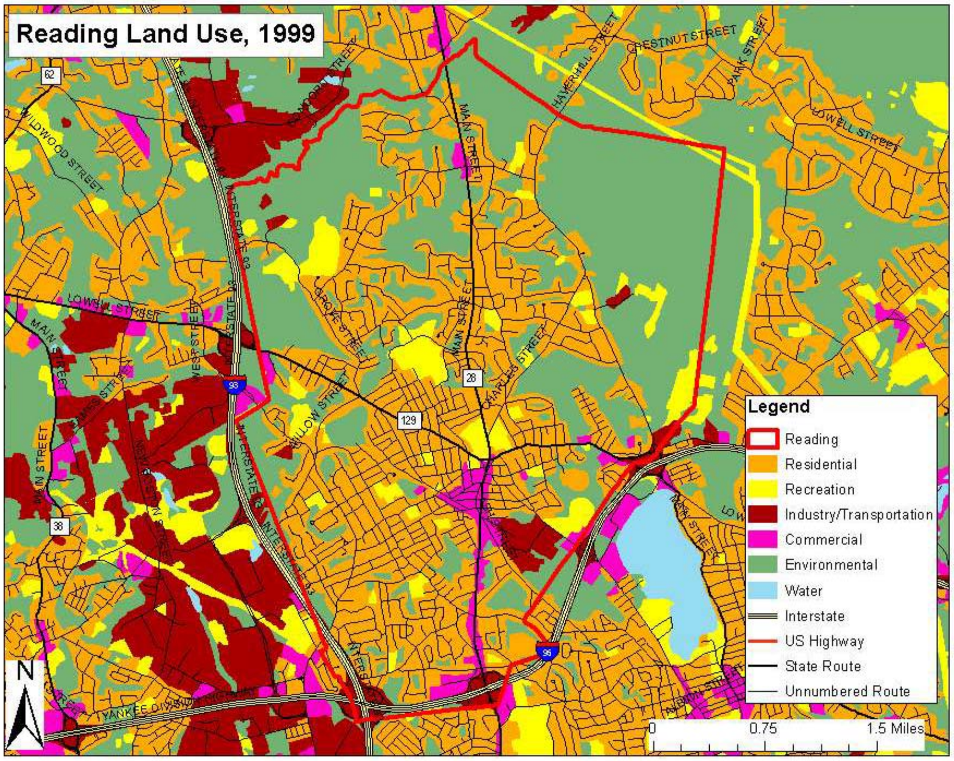
Figure 62 presents an aerial photograph of the town of Reading and the surrounding area from 2005. From this photograph, one can make out three general areas of the town. The majority of Reading's population lies in residential areas in the southern half of town. One can also see the concentration of development in the south along the main commercial corridor of Route 28. Moving northward, the aerial photograph shows a decreasing density in development and the absence of the concentrated, grid-like street pattern seen in the south. Finally, large tracts of open space lie to the northeastern and northwestern corners of the town. Reading is bordered by North Reading to the north, Lynnfield and Wakefield to the east, Stoneham to the south, and Wilmington and Woburn to the west.

Figure 62

Source: MassGIS

Figure 63 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston Region MPO region in 1999 and breaks down land uses into 21 categories. Figure 63 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen in the figure, residential land uses predominate, with environmental land uses mostly located in the northern half of town and commercial land uses located along Route 28. While Reading does have an industrial development just between Routes 28 and 128, most industrial development in the area is located to the west in the town of Woburn.

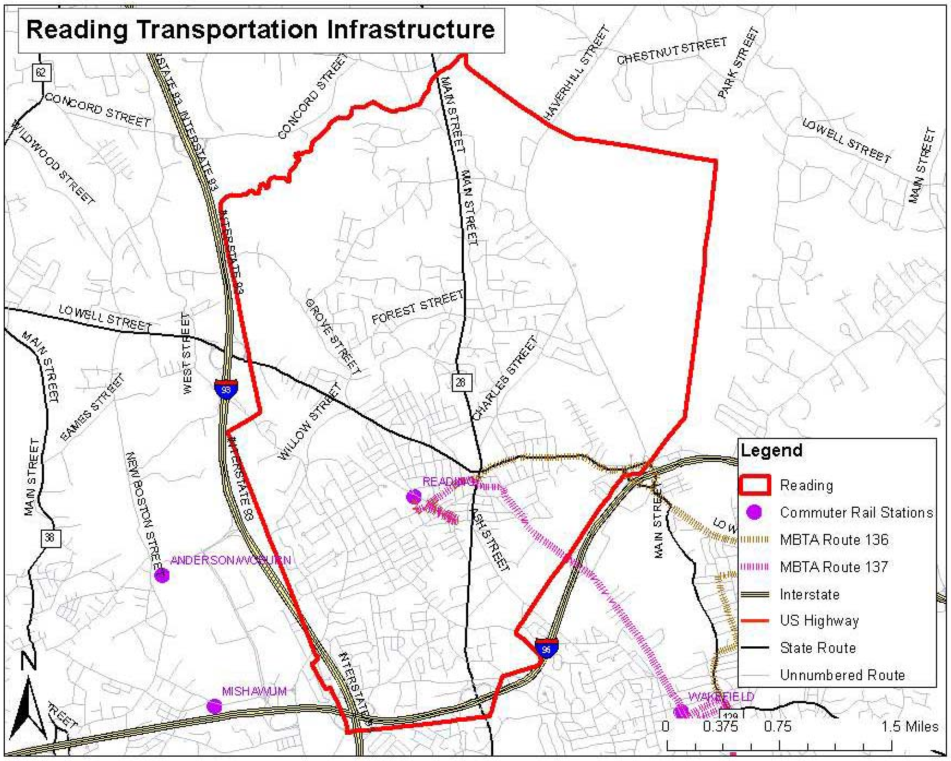
Figure 63



Source: MassGIS

Figure 64 depicts the transportation infrastructure in the town of Reading. Two major roads effectively divide Reading into four quadrants. Route 28 runs north-south from Route 128 towards North Reading and Route 129 runs east-west between Route 128 and Interstate 93. The fact that Reading lies at the intersection of these two expressways means that the town has significant accessibility to the larger Boston metropolitan region. The Reading commuter rail station, along the Haverhill commuter rail line, also affords access to downtown Boston and points northward. The station is located just west of the town center. Nine trips per weekday in each direction start or end at Reading, meaning that this station often acts as a collection point for commuter rail passengers living beyond the immediate area. Morning trains serving Reading between 7:00 A.M. and 9:00 A.M. depart at 7:40 A.M., 8:02 A.M., and 8:36 A.M., with parking capacity generally mirroring these times. 36 resident on-street parking spaces, reserved for those holding permits, reach capacity at 7:38 A.M. 113 spaces, owned by the MBTA with a $2.00 parking charge, and 266 resident permit spaces generally reach capacity at 8:00 A.M. Finally, the town also offers 42 spaces with a $2.00 rate that reach capacity shortly after 8:30 A.M. Two MBTA bus routes, Route #136 and Route #137, also serve the Reading commuter rail station and points east. As seen in Figure 64, the routes take two different paths through eastern Reading and northern Wakefield, later joining at Wakefield Square and connecting with the Orange Line at Oak Grove and Malden Stations.

Figure 64

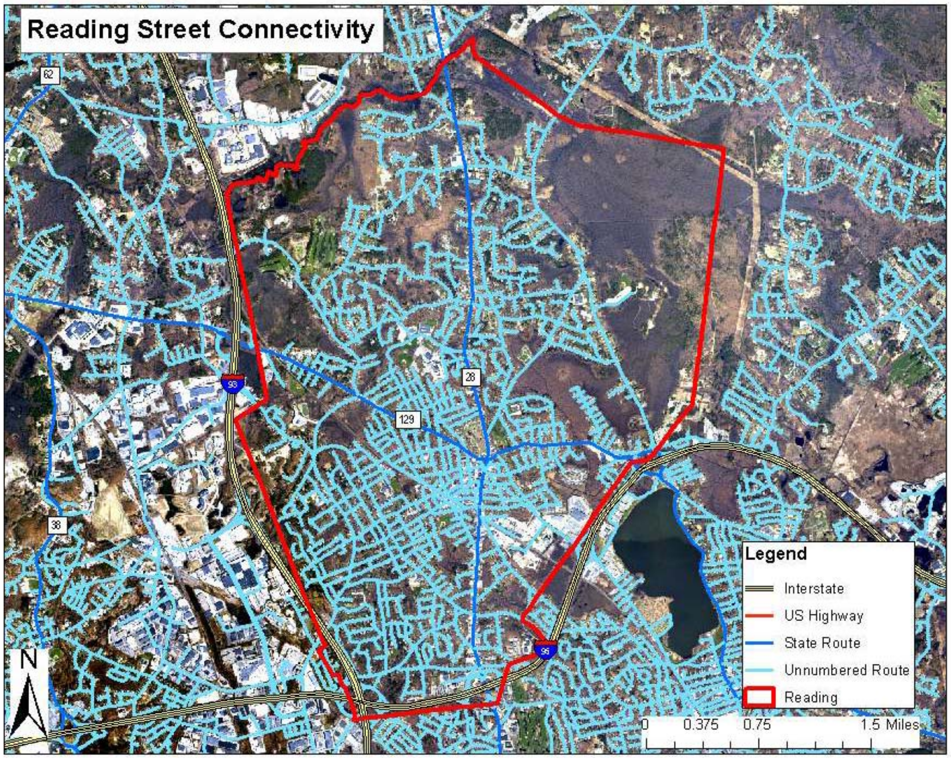


Source: MassHighway and CTPS

There are several shuttle services offered in the town of Reading to assist seniors and persons with disabilities with transportation. The Reading Response Medical Transportation program provides any Reading resident meeting income criteria with in-town and out-of-town medical rides. Medical escort volunteers and Mystic Valley Elder Services are also available to help residents reach their medical appointments. Reading is also part of the service area for The RIDE, a paratransit dial-a-ride service (door-to-door shuttle service where customers call ahead to reserve a time slot) provided by the MBTA that offers transportation throughout the region. Finally, the Reading Council on Aging (COA) also has one van, funded in large part by a state grant. Service is available Monday through Thursday 8:30 A.M. to 4:00 P.M. and Friday 8:30 A.M. to 1:30 P.M. Riders needing transportation are requested to leave a message at the senior center two days in advance of their desired trip and service is limited to seniors aged 60 and above and the disabled. The van driver, hired to provide the full 32.5 hours of service, then decides the best way to schedule the various requests. Rides are provided to the senior center and for various errands such as shopping, in-town medical trips, hairdresser, etc. One trip per month is provided to North Reading for shopping and breakfast, but all other trips are limited to Reading town borders. Service expenses such as maintenance, fuel, and driver salary are funded out of the town budget. Demand for the service often exceeds its capacity, and medical trips in particular often face delays.

Figure 65 overlays the street network on top of the aerial photograph of Reading, highlighting the street connectivity in the town. As seen in the figure, several areas of town, particularly in the south, have a grid street pattern. This pattern offers the highest level of accessibility given the high number of connections it provides. The rest of southern Reading where a grid street pattern does not exist still has a generally high level of connectivity. That level decreases in the northern part of town, as the number of cul-de-sacs and curvilinear roads with few connections increases.

Figure 65



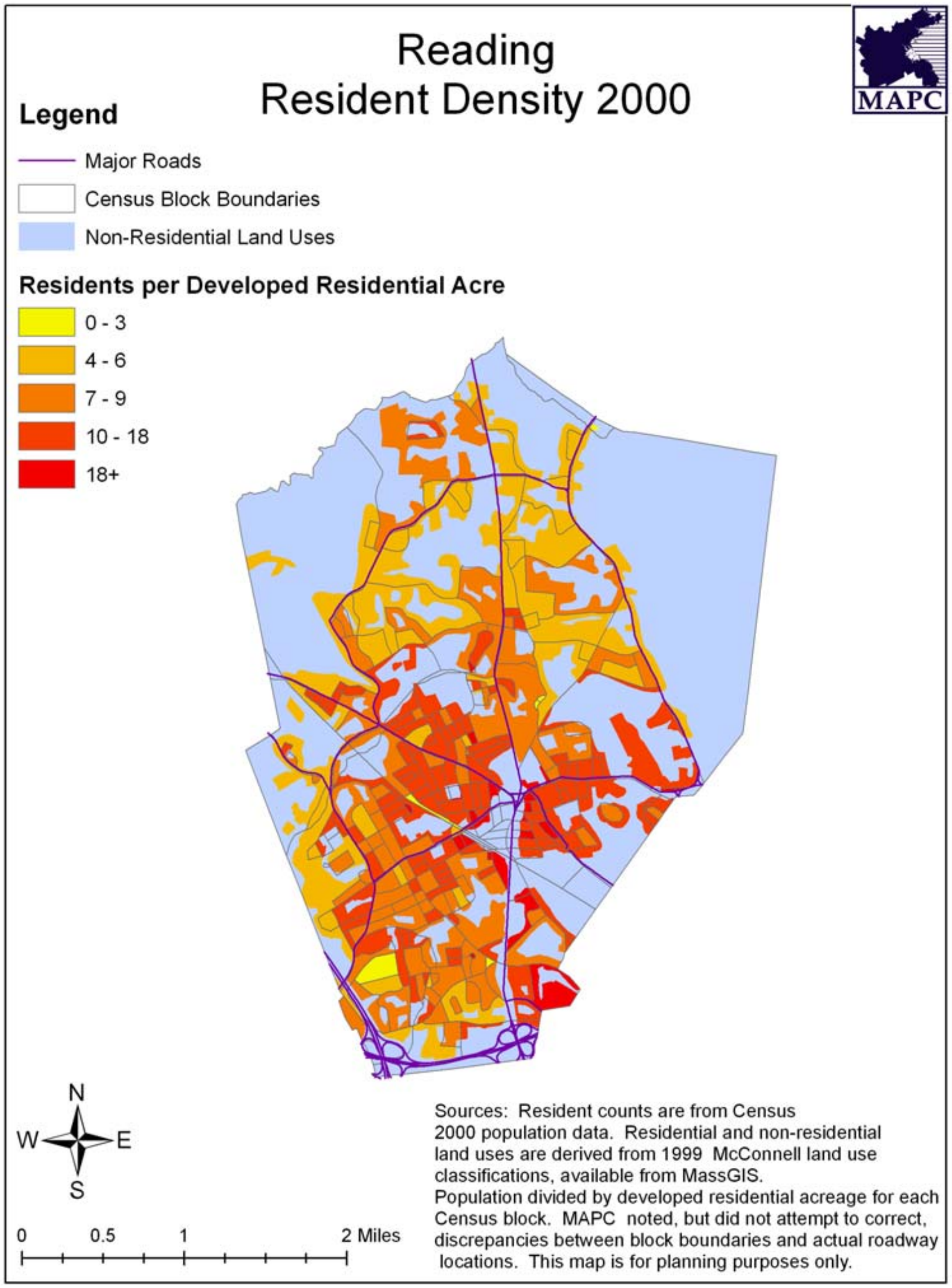
Source: MassGIS and MassHighway

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

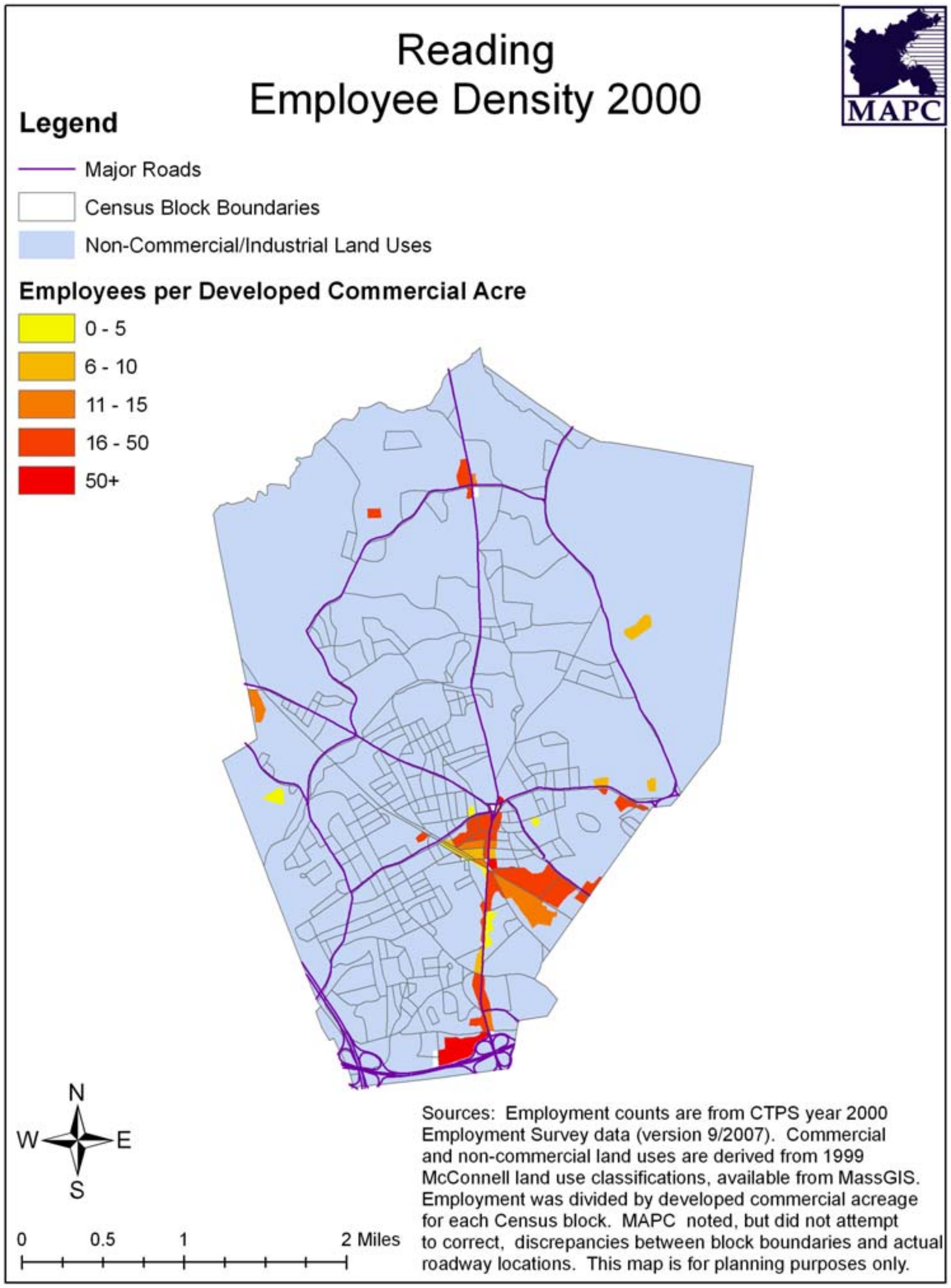
As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips tends to be greater. Figure 66 shows the 2010 projections for population density by residential acre. As seen in the figure, the area devoted to a residential land use as well as the population density are both greater in the central and southern portions of town. Almost all of these residential acres have population densities greater than 7 persons per acre. While a smaller percentage of the area in the northern section of town is devoted to a residential land use, the population densities found in these residential acres are also generally high for a suburban community, never falling below 4 persons per acre. These population densities generally reflect the level of street connectivity and land use patterns shown above, with the more concentrated street patterns and better accessibility of the southern and central neighborhoods correlated with higher population densities. Transit is generally assumed to be most suitable in areas of high density, less so in medium-density locations, and more difficult to justify in low-density locations due to the concentration of trip origins and destinations and the ability of public transit to provide convenient service to these locations.

Figure 66



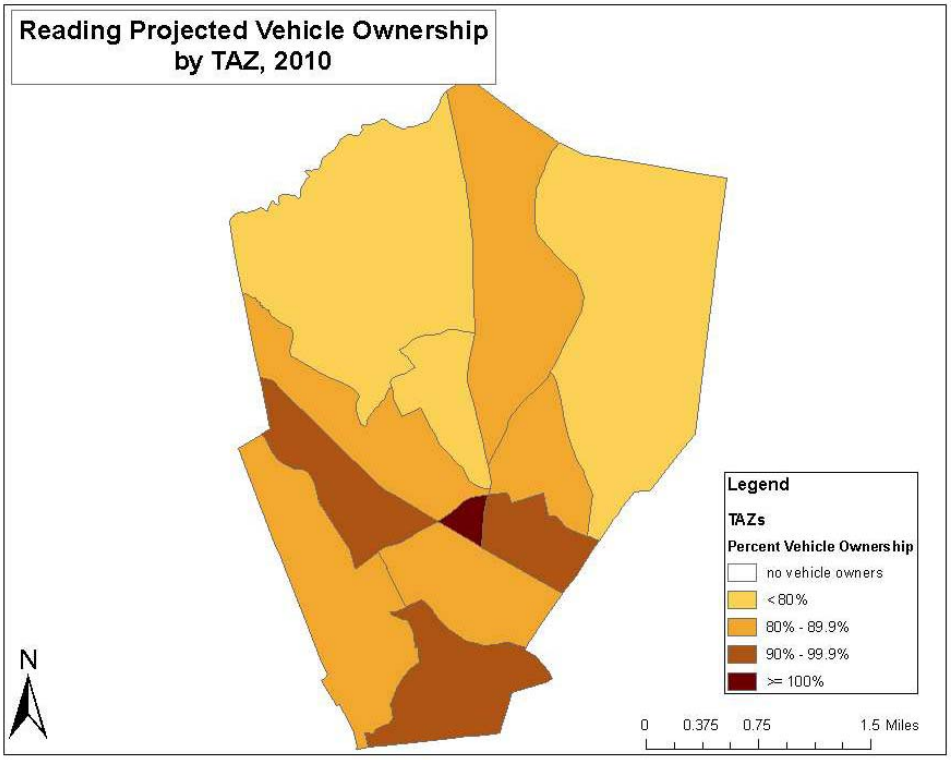
The residential densities depicted in Figure 66 are therefore important for determining the locations of potential origins and destinations of a transit service and the type of service that would be most appropriate in Reading. Another significant origin/destination for travel within Reading lies at places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Commute trips between work and home generally make up an important segment of transit ridership. In the town of Reading, Figure 67 depicts the employment density, measured as the number of employees per developed commercial acre. As seen in the figure, employment in Reading is for the most part concentrated along Route 28 between Route 129 and Interstate 95. Employment in Reading is generally highly concentrated, with most commercial acres characterized by 16-to-50 employees per acre.

Figure 67



One factor that can influence the potential of transit in an area is the ratio of vehicle ownership to population. Lower vehicle ownership percentages are a potential indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 68, the lowest vehicle ownership rates in Reading are located in the northern TAZs (Traffic Analysis Zones). The remaining TAZs all have rates above 80 percent, with several TAZs having rates above 90 percent.

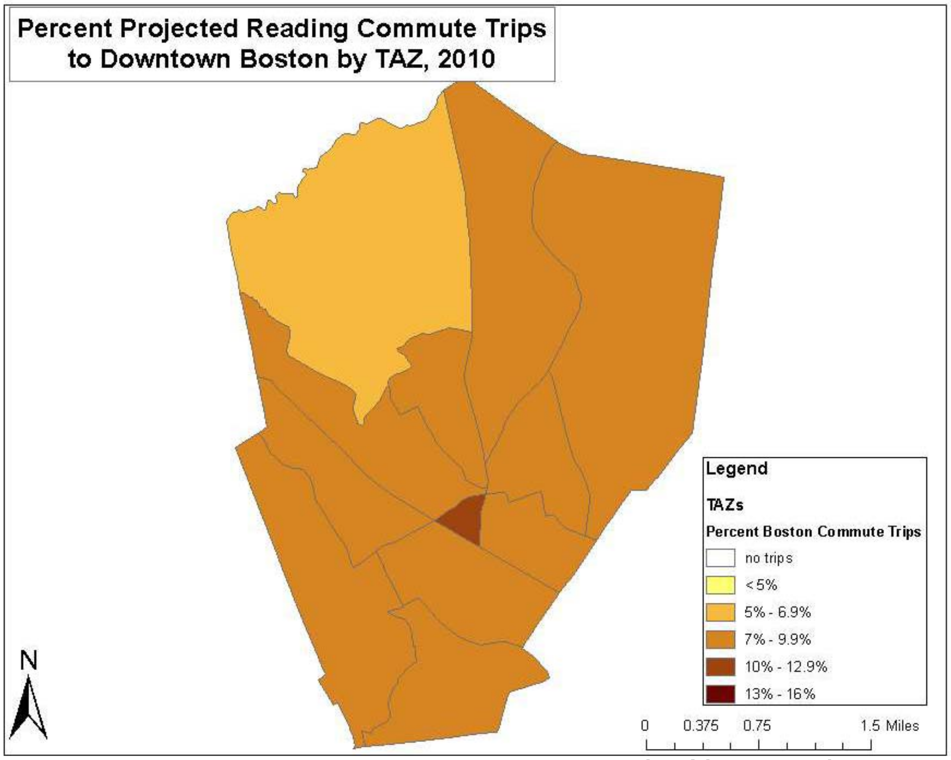
Figure 68



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

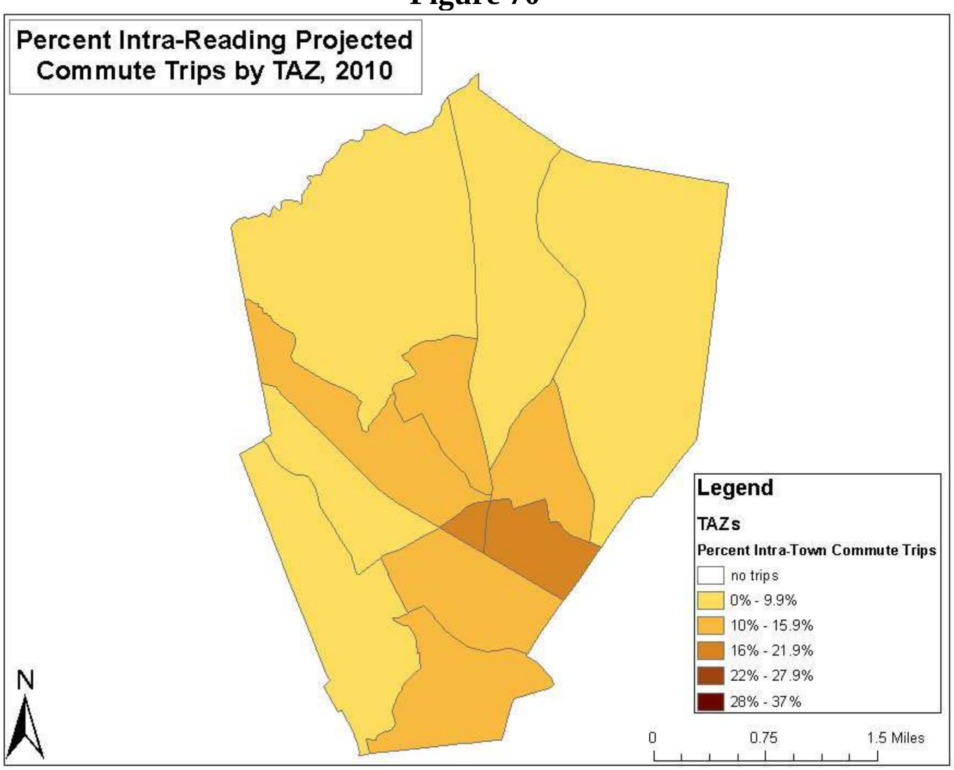
Given that work trips represent a significant portion of public transit usage, it is useful to know where residents are traveling to and from during their daily commute. Figure 69 presents the percentage of commute trips from Reading to downtown Boston and Figure 70 shows the percentage of intra-Acton commute trips. As seen in Figure 69, the percentage of workers who commute to downtown Boston is, in all but two TAZs, between 7 and 10 percent. The percentage of Reading commute trips staying within the town of Reading is more geographically dispersed, and, on average, is only slightly higher than the percentage of Boston commute trips. The combined intra-Reading and Boston categories account for 18.5 percent of all Reading's home-based work trips. Therefore, more than four-fifths of Reading's commute trips are headed beyond the town to areas outside of downtown Boston. The probable suburban destinations of many of these commute trips are more likely to necessitate private vehicle travel. When the number of trips expands to include all types of trips (both peak and off-peak – Figure 71), the percentage of intra-Reading trips does not climb above 50 percent for any TAZ and lies, for several TAZs, in the 20-30 percent range. On average, approximately 33 percent of all Reading home-based trips have a destination within the town, leaving two-thirds of trips with destinations outside of Reading.

Figure 69



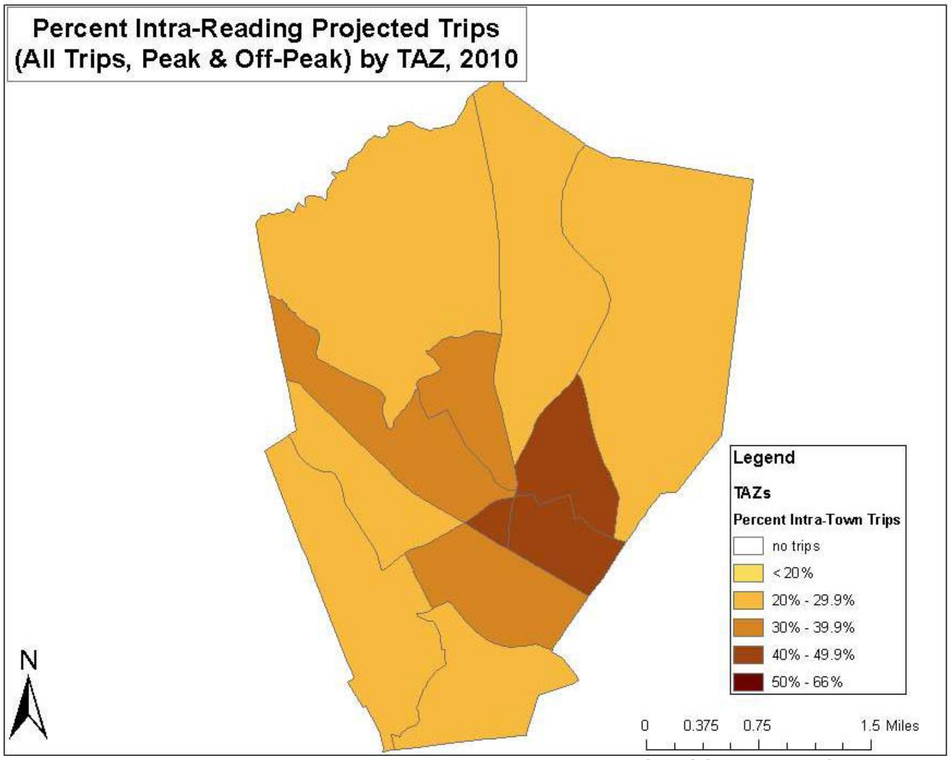
Source: CTPS Regional Model Smart Growth+ Projections

Figure 70



Source: CTPS Regional Model Smart Growth+ Projections

Figure 71

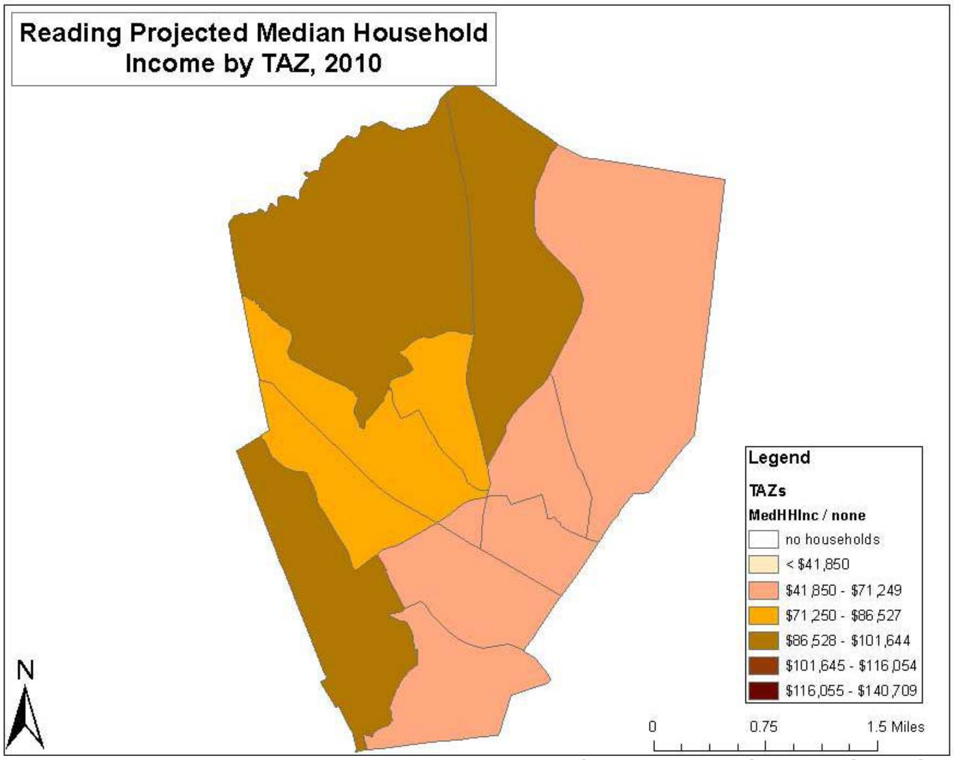


Source: CTPS Regional Model Smart Growth+ Projections

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 72, several TAZs in the town of Reading, particularly in the eastern half of town, have a median household income below $71,250 though none have an income below $41,850. No TAZ has a median household income above $101,644.

With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. According to MAPC, approximately13.6 percent of the population of the town of Reading will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, MAPC predicts that this population group will compose 14.7 percent of the total population in 2010. Thus, 28.3 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher.

Figure 72

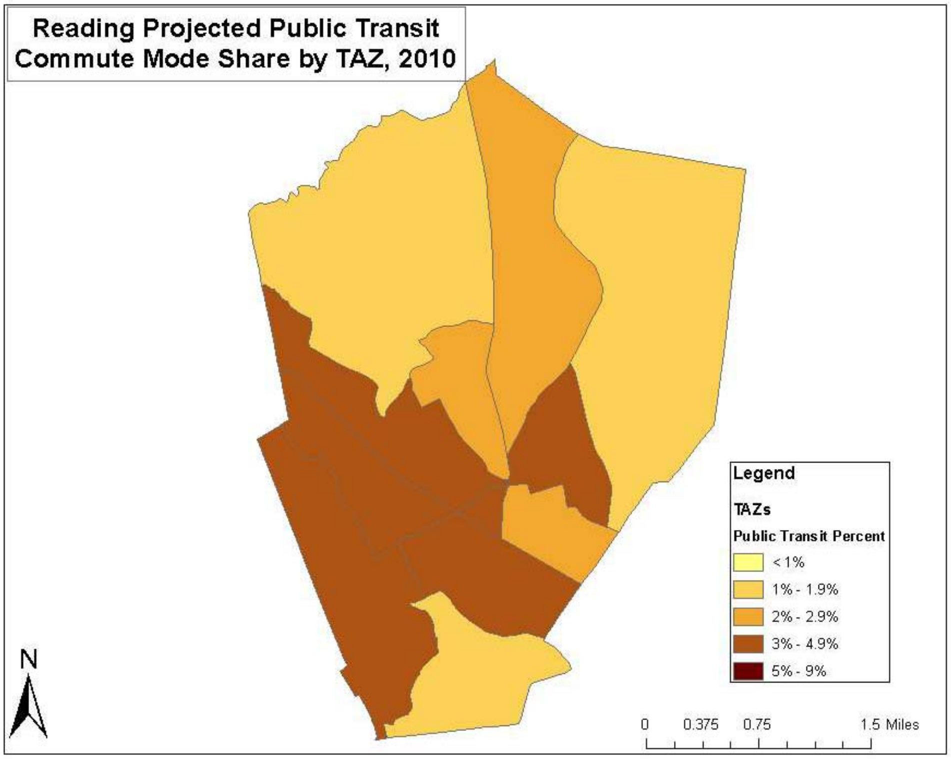


Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Transit Demand Assessment

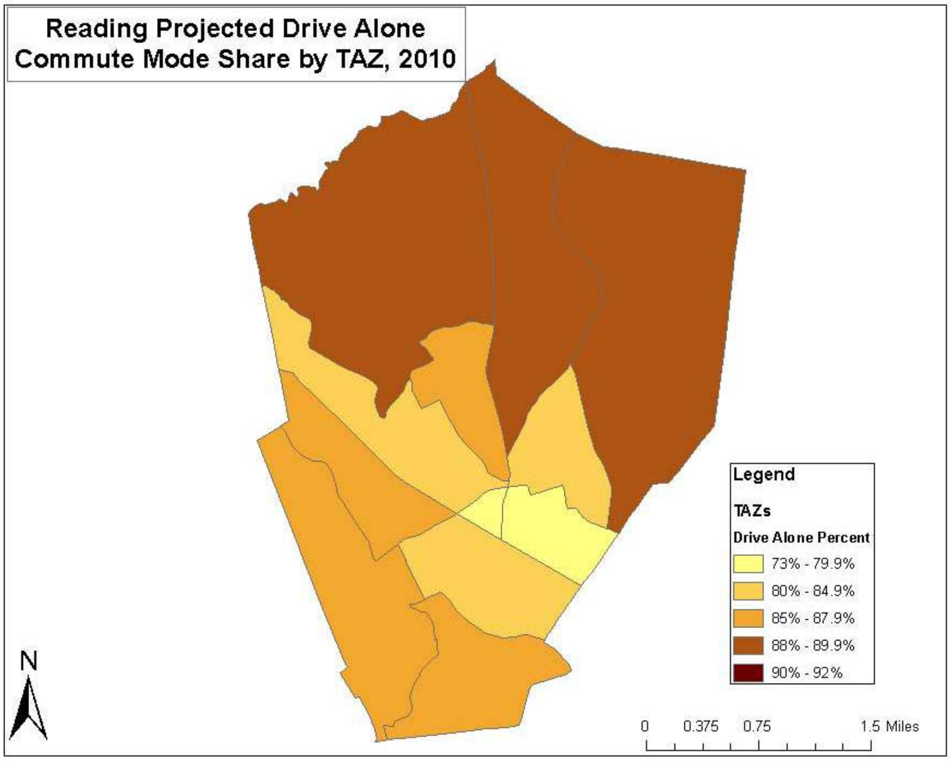
Compared to many suburban communities, Reading has higher population and employment densities and a greater level of street connectivity. When added to the fact that Reading is served by commuter rail and two MBTA bus routes, it is not surprising that the town has lower rates of vehicle ownership and a greater percentage of people using public transit. As seen in Figure 73, half the TAZs have public transit commute mode shares between 3 and 5 percent. Transit usage declines in the northern part of town and in the very southernmost TAZ surrounding Route 28. These transit commute trips can generally be assumed to be those destined for areas outside of Reading, most likely to Boston via the commuter rail. Despite the relatively higher public transit use, the vast majority of commute trips in Reading are made using a private vehicle. As seen in Figure 74, the high drive alone commute shares basically mirror the low public transit commute mode shares shown in Figure 73. The highest rates of drive alone commutes occur in the northernmost TAZs, though most TAZs have rates above 80 percent.

Figure 73



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

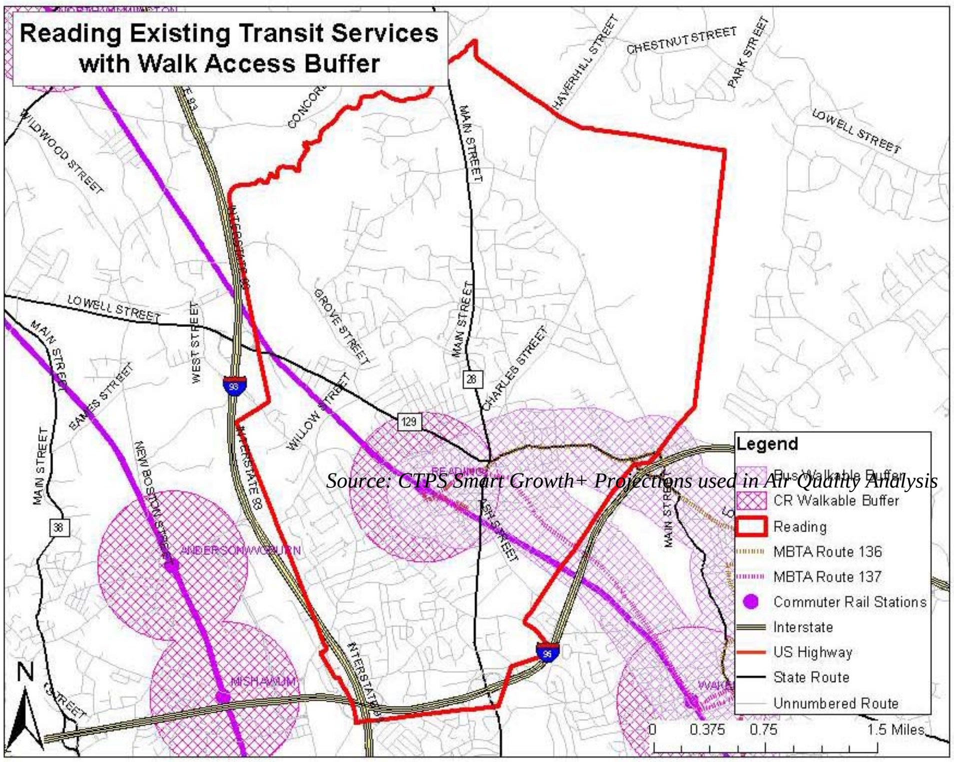
Figure 74



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Despite much of Reading's relatively high public transit mode share, Figure 75 demonstrates how little of the town is actually within walking distance of the town's fixed-route transit services. The half-mile buffer around the commuter rail station and the quarter-mile buffer around MBTA bus routes are based on the maximum distance that a person is generally assumed to be willing to walk to public transportation. As seen in the figure, a large portion of the southwest quarter of Reading lies beyond the walking buffer surround the Reading commuter rail station while virtually the entire town north of Route 129 lies beyond walking distance to either commuter rail or bus.

Figure 75



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Given the parking limitations at the commuter rail station in Reading, there may be an opportunity for demand-responsive service to provide a linkage between the station and the town's residential neighborhoods. Such a service could also be combined with one that facilitates other intra-Reading travel, given that more than 30 percent of all trips started in Reading also end in Reading. Travel to school, the Reading Senior Center, and the commercial corridors along Routes 28 and 129 undoubtedly compose a large portion of this intra-town travel. In each of these cases, one trip end is concentrated at a specific location or general area while the other trip end is dispersed, likely among the various medium-density neighborhoods in Reading. A transit service that collects riders from a large service area and delivers them at or close to their destination within town could therefore match up well with some of the intra-town travel patterns.

There are already some demand-responsive services in place to serve residents with limited mobility. As mentioned above, there are several services that help low-income and elderly residents travel to medical appointments. Many of these trips travel to areas outside of Reading. Similarly, The RIDE, a paratransit service operated by the MBTA, provides access to locations throughout the Boston metropolitan area. These types of services, characterized by the type of passenger they typically serve (limited to seniors and low-income residents) and their service area (beyond Reading town borders), are not consistent with the goals of an open intra-town demand responsive service. However, the shuttle service operated by the Reading Council on Aging stays primarily within town borders and the types of trips it generally serves, such as for shopping or other errands, are those that many different types of people take. Any potential new demand-responsive service in Reading should therefore consider the possibility and reasons for merging it with the COA shuttle and offering service to all Reading residents. The COA van could either be used for the new service or dedicated to providing medical-related trips for elderly residents. Hopefully, in addition to providing service to many people that currently do not qualify due to age, physical ability, or income criteria, the new service would also provide a higher level of service to elderly residents by having a more consistent schedule in which riders would no longer need to make a reservation two days in advance.

The greatest potential for demand-responsive service in Reading would seem to point to three demographic markets. One population that could potentially be interested in using public transit would be residents who use the Reading commuter rail station and currently must compete with other drivers for the ability to park at the station before the resident parking lot reaches capacity at 7:38 A.M. A second demographic group might be high school and middle school students who do not have access to a private vehicle and need to travel to their school or the town's commercial areas. Finally, the town already has a demonstrated demand for senior and disabled transportation. In each of these cases, while trips may be destined for the commuter rail station, the local high school, or the Route 28 commercial corridor, the trip origins are likely to come from many different places, given the relatively moderate density of most Reading neighborhoods. Trips to the Reading commuter rail station are likely to follow the traditional commuting pattern with the majority of trips in the AM and PM Peak periods. Conversely, trips to the commercial, educational, and residential areas in Reading are more likely to be dispersed throughout the day.

Many of Reading's residential areas are located in neighborhoods with relatively high levels of street connectivity. The grid-like street pattern allows for multiple paths through which to traverse a neighborhood and relatively few areas in Reading are characterized by cul-de-sacs and curvilinear roads. Reading also has two major corridors that both run through the center of town. Demand-responsive service is, in many cases, intended to divert from a main corridor and enter a neighborhood where fixed-route service does not traditionally operate. Higher levels of street connectivity make it easier for the transit vehicle to enter and exit the neighborhood quickly. For example, if a bus were to serve the residential area in southwest Reading, it would have multiple potential paths that it could traverse to get from one point to another. However, any bus serving the northern part of town would usually need to use the same road both to enter and exit the neighborhood, traveling on long, curvilinear roads. Such characteristics make diversions to northern Reading compared to southern Reading more costly in terms of time.

Potential New Services

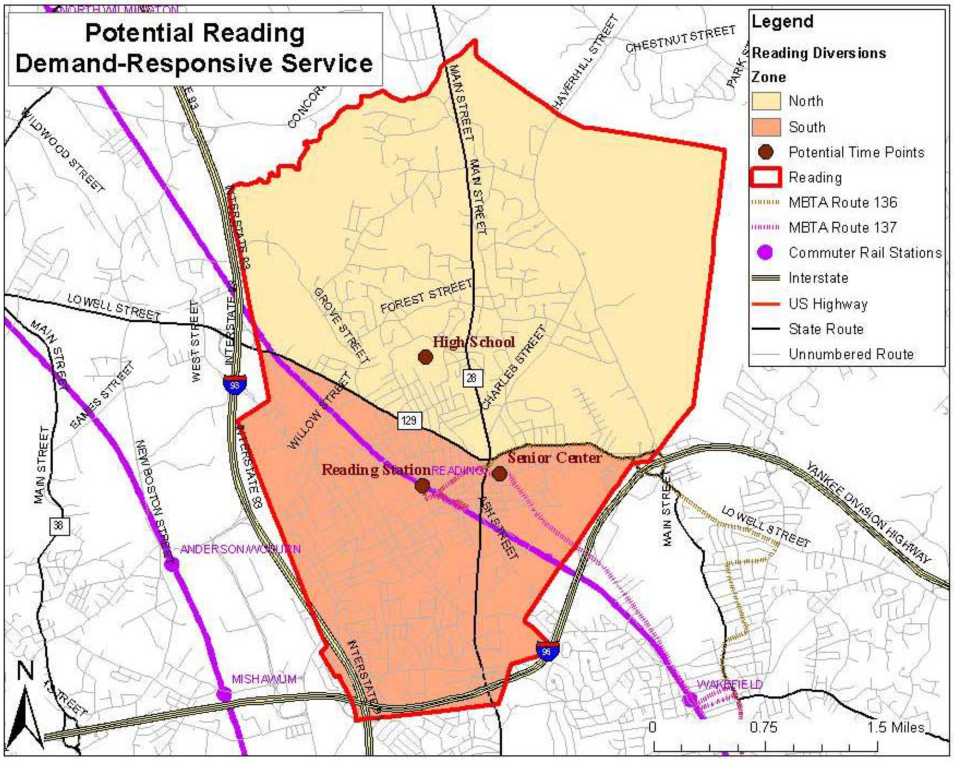
There are several types of demand-responsive service. Pure on-demand, or what is more commonly called "dial-a-ride", is already available in Reading for specific demographic groups such as seniors, the disabled, and low-income residents. The combination of medical shuttles, COA services, and regional paratransit operators already serves much of the existing demand for travel of traditionally mobility-limited populations. However, there does remain some demand that is not being met, particularly for trips with a medical purpose. Moreover, in limiting service to certain segments of the population, there undoubtedly remain individuals in Reading who do not meet the eligibility criteria for these services but still face mobility limitations or wish to use public transit. An additional on-demand shuttle that is open to any resident is thus a potential choice for Reading.

Any additional on-demand service in Reading would be similar to those that already exist. One or two small vans would serve the entire town, providing door-to-door service for which individuals would need to call ahead and make a reservation. Similar services generally require customers to call anywhere from one day to one hour in advance of their trip to schedule a reservation. Trips would be grouped where possible. This type of service provides a high level of accessibility and as well as a high cost per passenger, on the order of $25.00-$35.00 per trip provided. This cost is due in large part to the fact that such a service would be dedicated to Reading residents at all times, unlike a taxi service that could offer a lower cost per trip but would be unlikely to provide the same level of accessibility. Even with the high level of accessibility afforded by on-demand service, it would likely serve only a low level of demand, perhaps one or two passengers per hour, with obstacles to any growth in demand resulting from the lack of a defined schedule or routing. Given the existence of the COA shuttle, moreover, these two services would, in some respect, compete for many of the same passengers unless they were combined and the age eligibility requirement was removed.

Given the existence of several forms of on-demand service in Reading, for any new service to attract demand beyond the senior and low-income populations already served, a different type of service, with elements of more conventional transit such as fixed schedules, routing, or stops, is needed. However, any new service would also need to provide a high level of accessibility in the suburban context. The characteristics of the town include several areas of medium-density residential housing, two corridors of commercial development, and a few central locations to which many intra-town trips are destined. These locations, which tend to serve different population groups with different travel characteristics, include the Reading commuter rail station, the senior center, and Reading High School.

A potential point-deviation, demand-responsive transit service is shown in Figure 76. Under this scenario, the town of Reading would be divided into two general zones – north and south, with Route 129 acting as the dividing line – and a shuttle would serve each area. Both shuttles would serve the three centrally located points on a pre-defined schedule and pick-up or drop-off passengers within their respective service zone according to a reservation schedule. Passengers would not need, therefore, to make a reservation to board and alight at any of these three points. However, all other trips would be limited to travel to or from these points and would require a reservation. Such reservations would need to be made before the trip departure, though residents who have a weekly schedule, for example, could make their reservation on a weekly basis. Staff resources would need to be devoted to develop the most efficient routing for scheduled reservations.

Figure 76



A point-deviation service such as the one proposed in Figure 76 could generally be operated with two small buses or shuttles (one for the north zone and one for the south zone, each about 20 passengers in capacity). A reasonable frequency for the proposed service would be about one hour. The commuter rail departs from Reading station approximately every half-hour, but the proposed service could be matched up with the frequency of trains that originate or terminate at Reading. This frequency is about one hour in the AM and PM peak periods. Such a schedule would also allow for convenient transfers to MBTA bus Routes #136 and #137. With both shuttles having frequencies of one hour and serving all three central point locations, passengers should also be able to use these points to transfer between shuttles with minimal waiting time.

As with service levels, more detailed fare and cost estimates would also be necessary beyond the general estimates presented here. However, services such as these generally tend to cost between $55.00-$65.00 per vehicle revenue-hour to operate, when including all costs. Some of the more successful and mature services in other metropolitan areas have achieved ridership levels of up to 10-12 passengers per vehicle revenue-hour. This ridership figure thus corresponds to a cost per passenger of approximately $5.00-$6.00. Like all other public transit services, fares are unlikely to recover much of this cost. The fare level thus depends more on the type of service that communities wish to provide and how, if at all, they wish to price a premium for any specific type of trip. The extent to which public or private sources subsidize the service can also affect fare levels.

This potential service provides the same level of accessibility as a town-wide on-demand service with elements such as the fixed headway and central point locations that may make it desirable to a larger passenger base. The ease of using such a service would only be heightened by the extent to which it can incorporate the schedules of passengers traveling every weekday to and from the commuter rail station, or students with a set after-school schedule, or seniors with a weekly list of errands without requiring them to make a daily reservation. Providing a pass or other financial incentive for passengers to set up weekly or monthly pick-up and drop-off schedules would also help to develop a defined passenger base, which would assist not only with scheduling but also with maintaining a consistent revenue stream. Finally, given the need for additional medical transportation in Reading, it may be advisable to use the COA shuttle to focus on this population. By serving the senior center, the proposed service provides access to any area in Reading. It would make little sense to have the COA shuttle continuing to serve shopping trips and other non-medical errands when a large segment of the potential ridership of the proposed service is likely to be the senior population. These two services should not compete against each other, particularly when there exists a need for additional transportation to area medical facilities.

Conclusion

Unlike many suburban communities in which low residential densities, poor levels of street connectivity, high median household income levels, and high vehicle ownership rates reduce the potential for transit service, Reading has several characteristics that can potentially make transit feasible. Indeed, the extent to which Reading is already served by several different modes of transit – commuter rail, fixed-route bus, on-demand shuttles, and paratransit – is indicative of this potential. The current suite of services in Reading does, however, fail to provide a transit option for intra-town travel for those who do not meet age, disability, or income eligibility criteria. A point-deviation demand-responsive service such as the one described above could serve such trips to the commuter rail station, schools, senior center, and the Route 28 commercial corridor, and then back to peoples' homes, mostly in medium-density residential development. Not only could such a service assist those with limited mobility to whom a private vehicle is not available, but it could also potentially improve the parking situation at the Reading commuter rail station and reduce private automobile traffic and vehicle emissions of greenhouse gases and local pollutants.

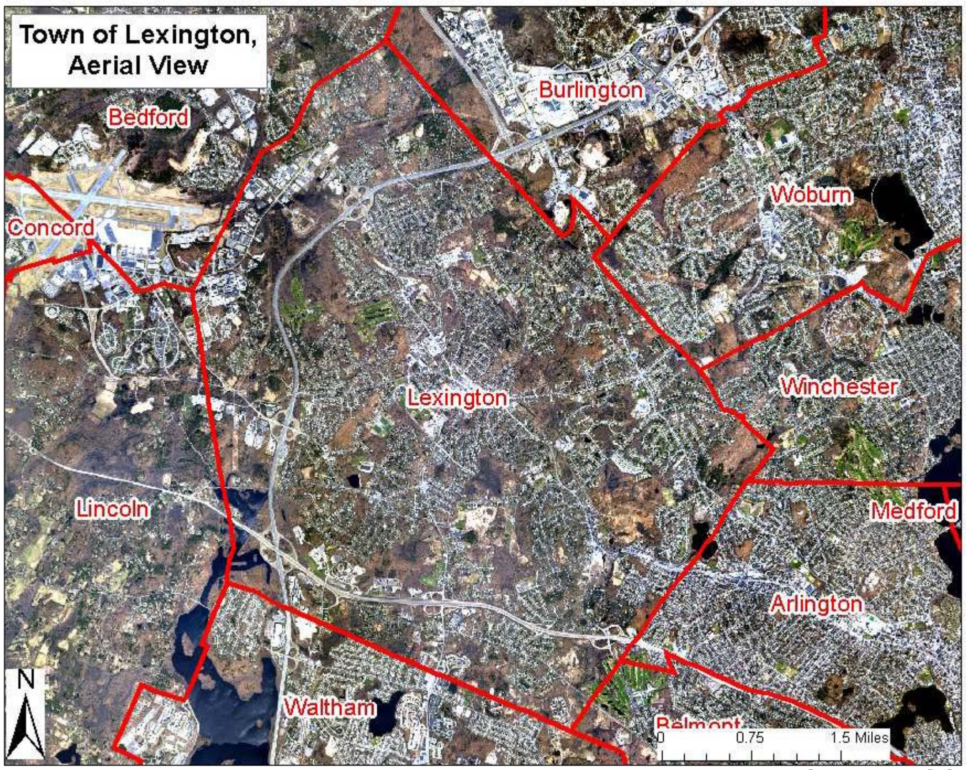
Should Reading be interested in pursuing either of these or other concepts further, it is encouraged to prepare an application, with the assistance of CTPS, to the Suburban Mobility Funding Program. While not prohibitive, the amount of personnel resources required to complete the application is not insignificant. The application is intended to demonstrate that the community has given thorough consideration to fiscal, operational, and marketing considerations. The application must also demonstrate, in order to receive the CMAQ (Congestion, Mitigation, and Air Quality) funding upon which the Suburban Mobility Funding Program is based, that the proposal decreases local air pollutant emissions. As such, travel demand reviews, market research, and financial plans are all necessary components of a community's application. CTPS is available to provide data and analytical advice upon direction of the MPO's Suburban Mobility/TDM Subcommittee. CTPS can assist communities with the preparation and analysis of surveys and the estimation of predicted ridership and emissions as well as provide examples and review drafts of fiscal, operational, and marketing plans. Communities may obtain additional information on suburban transportation by consulting the first Suburban Transit Opportunities Study prepared by CTPS as well as the Transportation Research Board's TCRP Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services. Both reports are available on the respective organizations' websites. The information provided in this Reading Transit Analysis is intended to assist Reading in determining whether to prepare an application and whether or not demand-responsive transit service is viable given the potential costs and demand.

LEXINGTON

Physical Criteria

Figure 77 presents an aerial photograph of the town of Lexington and the surrounding area from 2005. From this photograph, one can see how development is spread throughout the town but most concentrated in the very center of town and the area bounded by Route 2 to the south and Route 128 to the west and north. Outside this boundary, the extent to which development is concentrated diminishes, particularly in the western corner of town at the border of Lincoln and Bedford. To the east, from north to south, the towns of Burlington, Woburn, Winchester, Arlington, and Belmont border Lexington, while Waltham lies on the southern border.

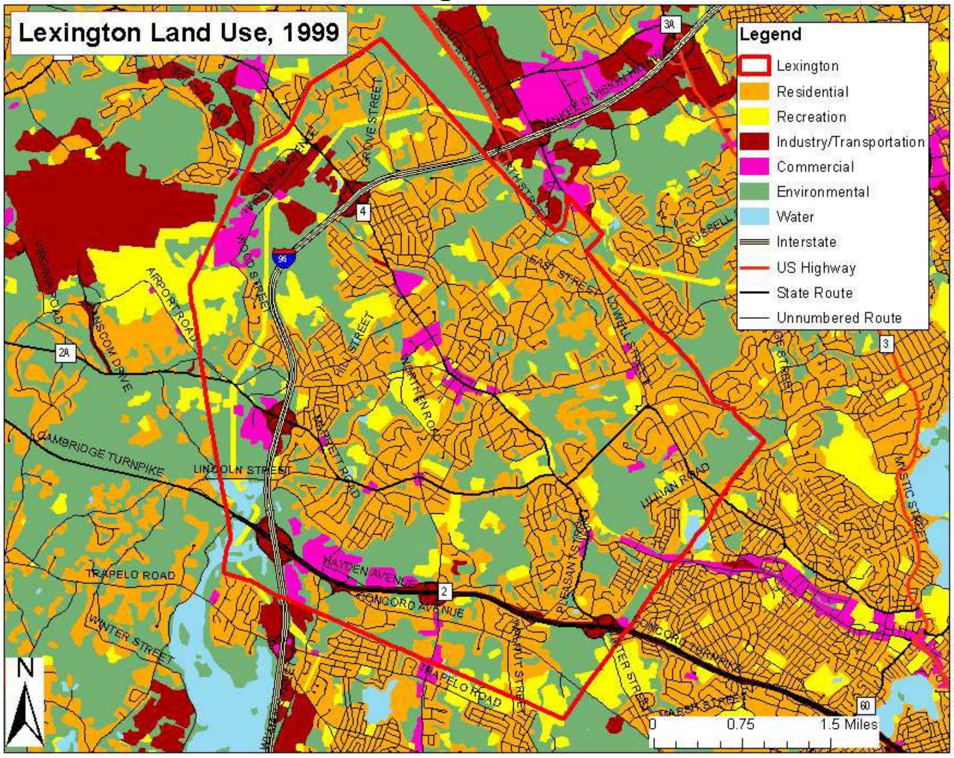
Figure 77



Source: MassGIS

Figure 78 shows these characteristics even more clearly by depicting the various land uses of the town. This survey was conducted for the entire Boston Region MPO region in 1999 and breaks down land uses into 21 categories. Figure 78 combines these categories into five general land-use designations: commercial, industry/transportation, residential, recreation, and environmental. The residential category includes low-to-high density residential areas as well as multi-family units. Recreation includes both participation and spectator recreational land uses as well as urban and rural open space and the environmental category is composed of cropland, pasture, forest, and non-forested wetlands. As seen in the figure, residential land uses predominate with environmental and recreational land uses distributed throughout the town. Lincoln Laboratories represent the industrial development located in the northwestern corner of town while commercial development is concentrated around Routes 2 and 128 along the edges of town and Route 4/225 running through the center of town. The industrial and commercial development associated with the Burlington Mall and Northwest Office Park lies northeast of Lexington in the town of Burlington.

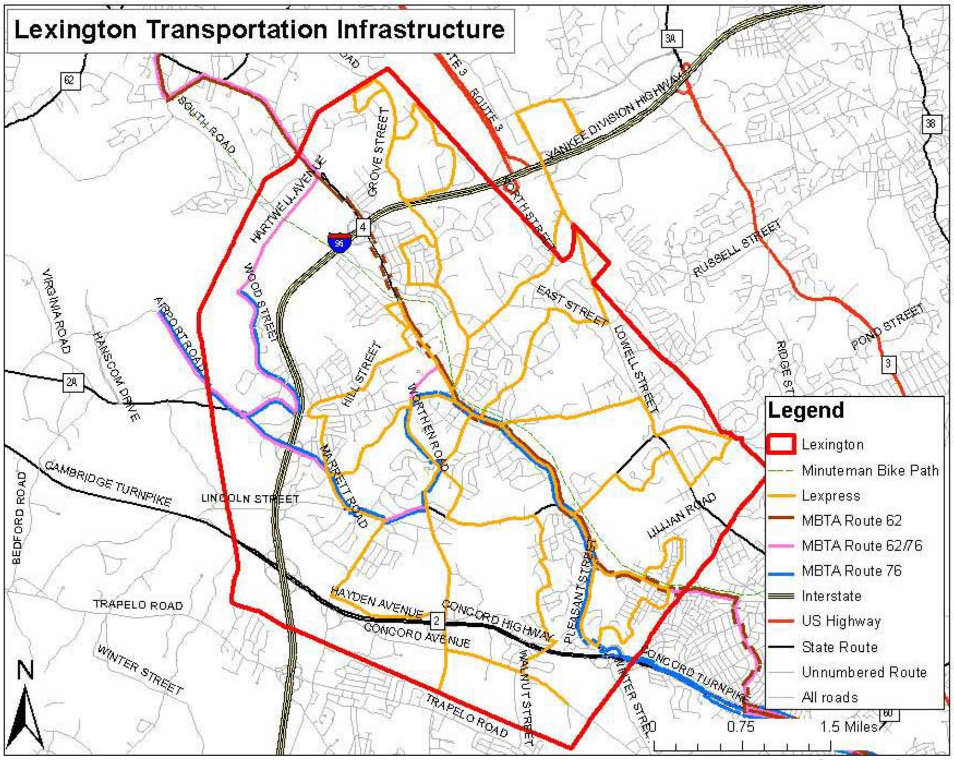
Figure 78



Source: MassGIS

Figure 79 depicts the transportation infrastructure in the town of Lexington. As mentioned above, Routes 2 and 128 are both limited-access highways lying towards the southern and western borders, respectively, of town. Route 4/225 provides local access and passes through the center of town, intersecting with Route 128 in the north of town before continuing north to Bedford. Route 2A is the other major arterial in Lexington, running east-west between northern Arlington and Lincoln. While Lexington is not served by commuter rail, it does lie approximately halfway between two commuter rail lines with stations in Waltham and Woburn that are accessible by Route 128. Several bus routes serve Lexington, providing connections to other modes with headways of 30 minutes during the peak periods and as much as one hour during the off-peak. MBTA bus Route #62 provides local stops along Route 4/225 throughout town. Bus Route #76 serves the southern portion of Route 4/225 in Lexington before passing through neighborhoods in the southwestern section of town and continuing north to Lincoln Laboratories and Hanscom Field. The weekend combination of these two routes, bus Route #62/76, has headways throughout the day of 60 or 70 minutes. LEXPRESS, Lexington's neighborhood bus system, also operates several routes throughout town. Each route has a frequency of one hour. The Minuteman Bike Path also passes through Lexington from Arlington before terminating in Bedford.

Figure 79



Source: MassHighway and CTPS

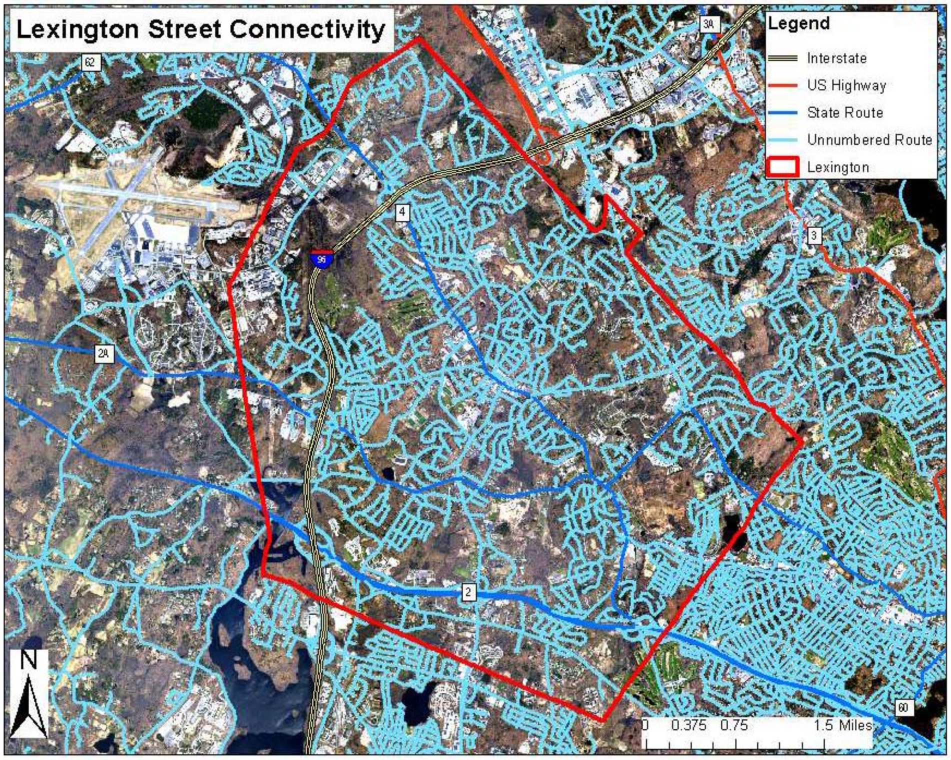
Figure 80 overlays the street network on top of the aerial photograph of Lexington, highlighting the street connectivity in the town. As seen in the figure, Lexington, while having few areas with the grid-like street network that is easiest for transit to serve, does have a fairly high level of street connectivity. There are few cul-de-sacs and roads often have several points of access, meaning that there are several potential paths for a driver to choose when navigating a neighborhood. Most neighborhoods are also fairly well connected to the town's arterial system and the regional transportation corridors of Routes 2 and 128 through this system of local roads.

Demographic Criteria

The demographic characteristics considered in this analysis are some of those that have the potential to affect or be indicative of a community's suitability for transit. These characteristics include population, residential, and employment densities, the rate of vehicle ownership, commuting destination, household median income, and the percentages of residents aged 10-19 or 65 and above.

As the density of population, residents, or employees increases, so too does the potential suitability of public transportation. In the suburban context, higher population densities are a likely indicator of greater potential transit demand, as trip origins and destinations tend to be more concentrated, trip distances tend to be shorter, and the number of trips

Figure 80



Source: MassGIS and MassHighway

tends to be greater. Figure 81 shows the 2010 projections for population density by residential acre. As seen in the figure, there is a wide range of residential densities throughout Lexington and often in the same neighborhood. The most prevalent category of residential densities appears to be the range of 4-6 persons per acre, though many other acres fall into higher density categories. These varying residential densities across town are indicative of the mixed development patterns throughout Lexington. Covering most of the town, higher-density residential neighborhoods are often located side-by-side lower-density areas. Transit is generally assumed to be most suitable in areas of high density, less so in medium-density locations, and difficult to justify in low-density locations due to the concentration of trip origins and destinations and the ability of public transit to provide convenient service to these locations.

The residential densities depicted in Figure 81 are therefore important for determining the locations of potential origins and destinations of transit users and the type of service that would be most appropriate in Lexington. Another significant origin/destination for travel within Lexington lies at places of employment. These locations represent large collections of trips to and from the same place usually at the same general time of day. Commute trips between work and home generally make up an important segment of transit ridership. In the town of Lexington, Figure 82 depicts the employment density, measured as the number of employees per developed commercial acre. As seen in the figure, while there are only a few areas of employment spread throughout the town, most of it is characterized by a high number of employees per acre.

Figure 81

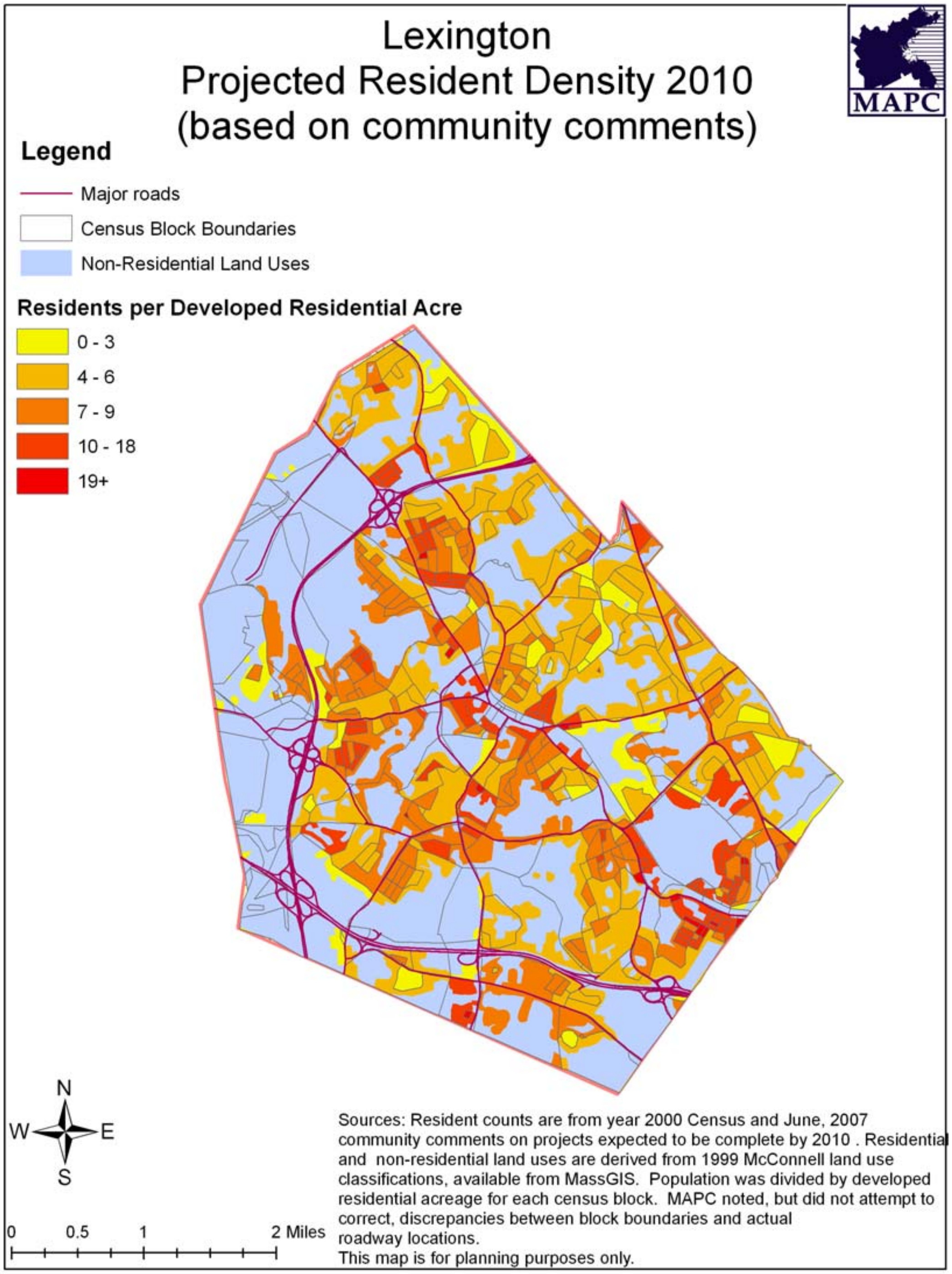
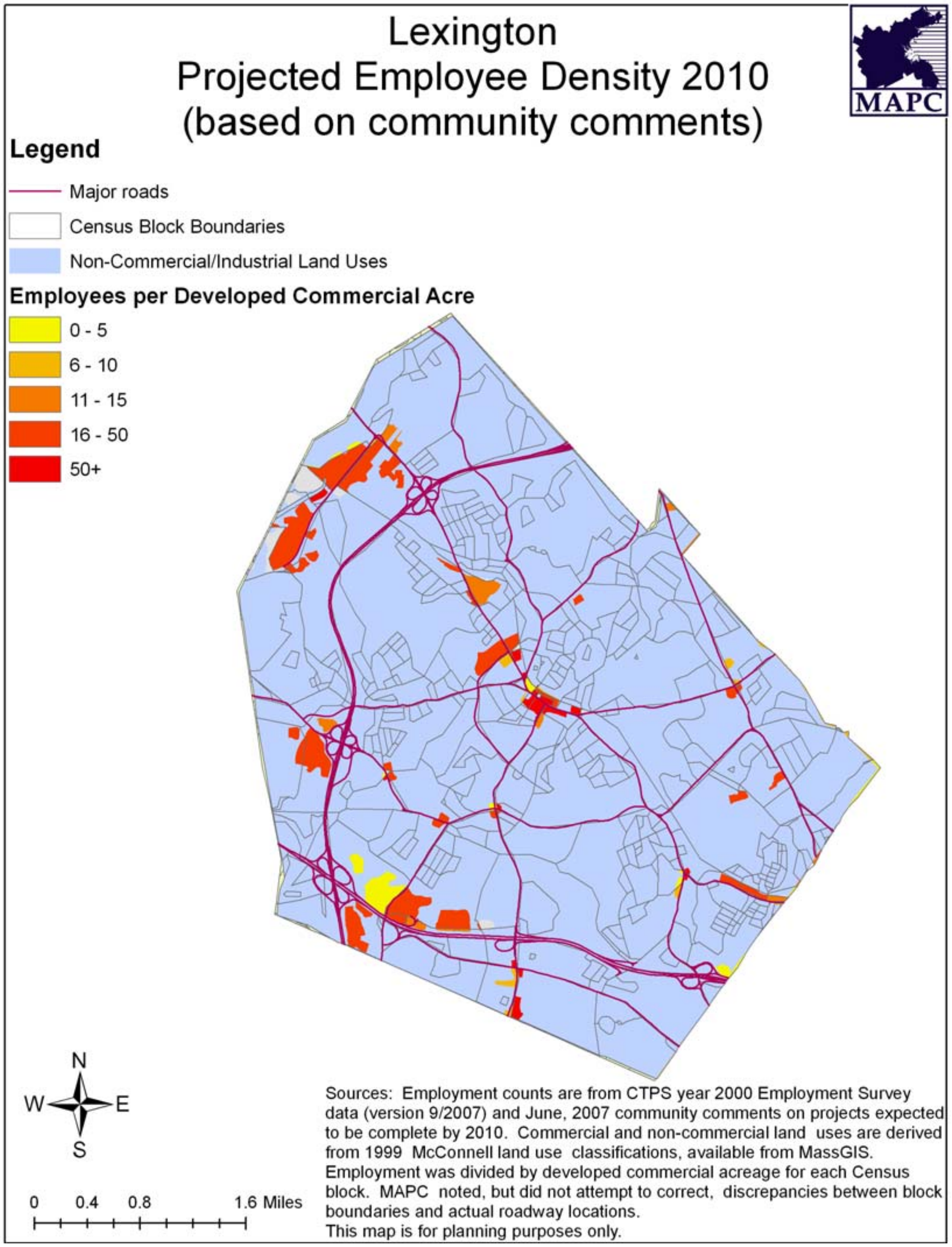
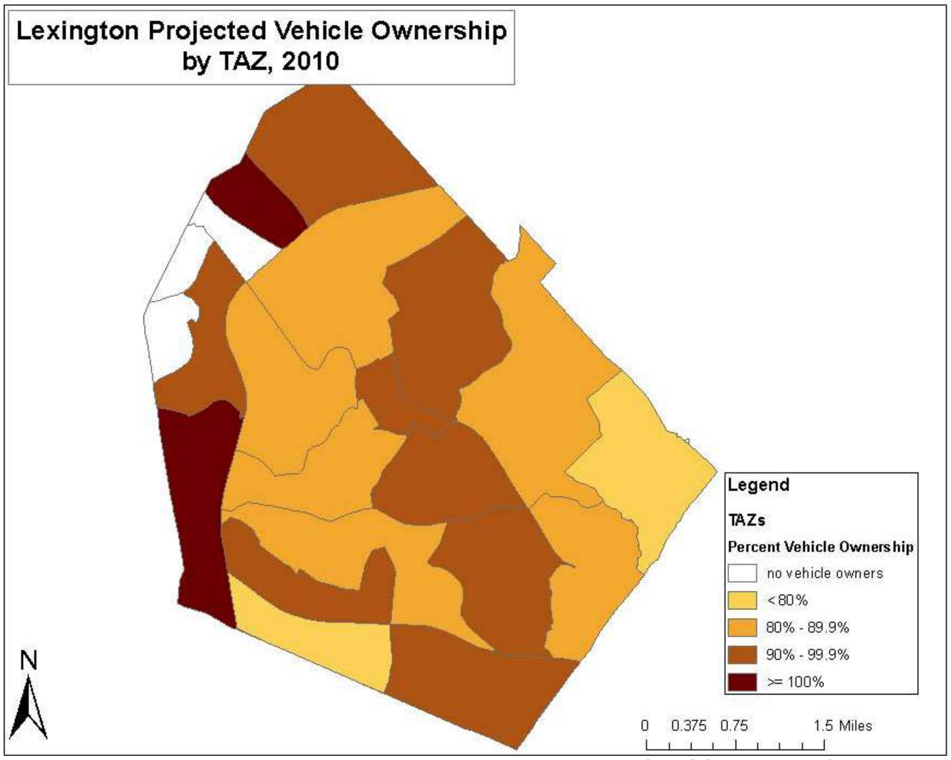

Lexington
Projected Resident Density 2010
(based on community comments)
MAPC
Legend
Major roads
Census Block Boundaries
Non-Residential Land Uses
Residents per Developed Residential Acre
0 - 3
4 - 6
7 - 9
10 - 18
19+
N
W
E
S
0
0.5
1
2 Miles
Sources: Resident counts are from year 2000 Census and June, 2007 community comments on projects expected to be complete by 2010 . Residential and non-residential land uses are derived from 1999 McConnell land use classifications, available from MassGIS. Population was divided by developed residential acreage for each census block. MAPC noted, but did not attempt to correct, discrepancies between block boundaries and actual roadway locations.
This map is for planning purposes only.

Figure 82



One factor that can influence the potential of transit in an area is the ratio of vehicle ownership to population. Lower vehicle ownership percentages are a likely indicator of greater transit demand, as the number of people likely to already be using transit tends to be greater. As seen in Figure 83, vehicle ownership in Lexington varies between TAZs (Traffic Analysis Zones). Approximately one-half of the TAZs have a vehicle ownership rate between 90 and 100 percent. Only slightly fewer TAZs, however, have a rate between 80 and 90 percent, while two TAZs each fall into the highest and lowest ranges of greater than 100 percent and lower than 80 percent.

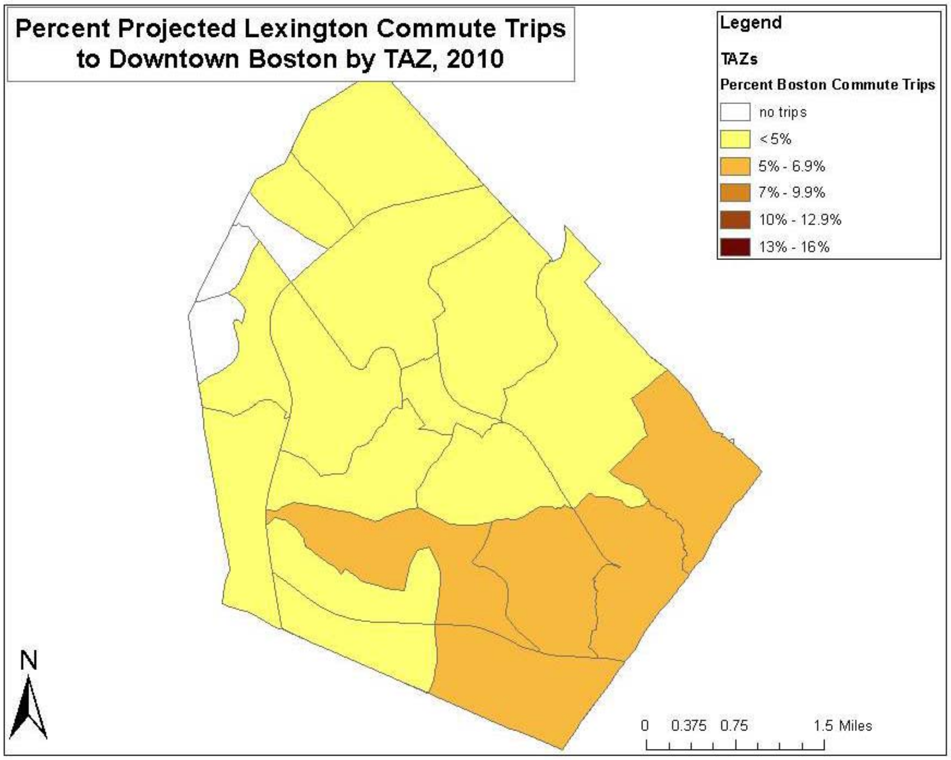
Figure 83



Source: CTPS Regional Model Smart Growth+ Projections

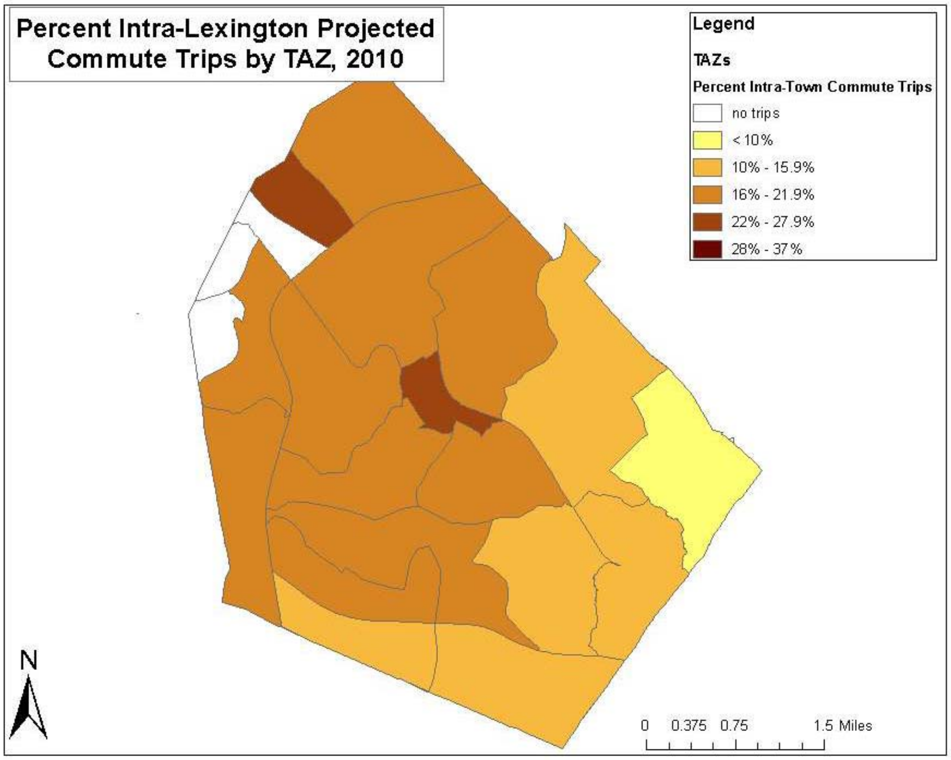
Given that work trips represent a significant portion of public transit usage, it is useful to know where residents are traveling to and from during their daily commute. Figure 84 presents the percentage of commute trips from Lexington to downtown Boston and Figure 85 shows the percentage of intra-Lexington commute trips. As seen in Figure 84, the percentage of workers who commute to downtown Boston is between 5 percent and 7 percent in the southeastern portion of town, while the rate in the remaining TAZs does not exceed 5 percent. A greater percentage of Lexington commute trips stay within the town borders, with only one TAZ having a rate of less than 16 percent, a majority of TAZs having rates between 16 percent and 22 percent, and two TAZs having a rate between 22 percent and 28 percent. When added to Boston commute trips, the combined intra-Lexington and Boston categories account for approximately 20 percent of all Lexington's home-based work trips. Thus, almost 80 percent of Lexington's commute trips are headed beyond the town to areas outside of downtown Boston. Many of these commute trips are likely destined for areas in Somerville and Cambridge, though most suburban destinations tend to necessitate private vehicle travel. When the number of trips expands to include all types of trips (both peak and off-peak – Figure 86), the percentage of intra-Lexington trips increases to only 28 percent on average with several TAZs in the southern part of town having rates below 20 percent. Many of these trips, given their TAZ location, are likely destined for areas north of Boston in Somerville and Cambridge.

Figure 84



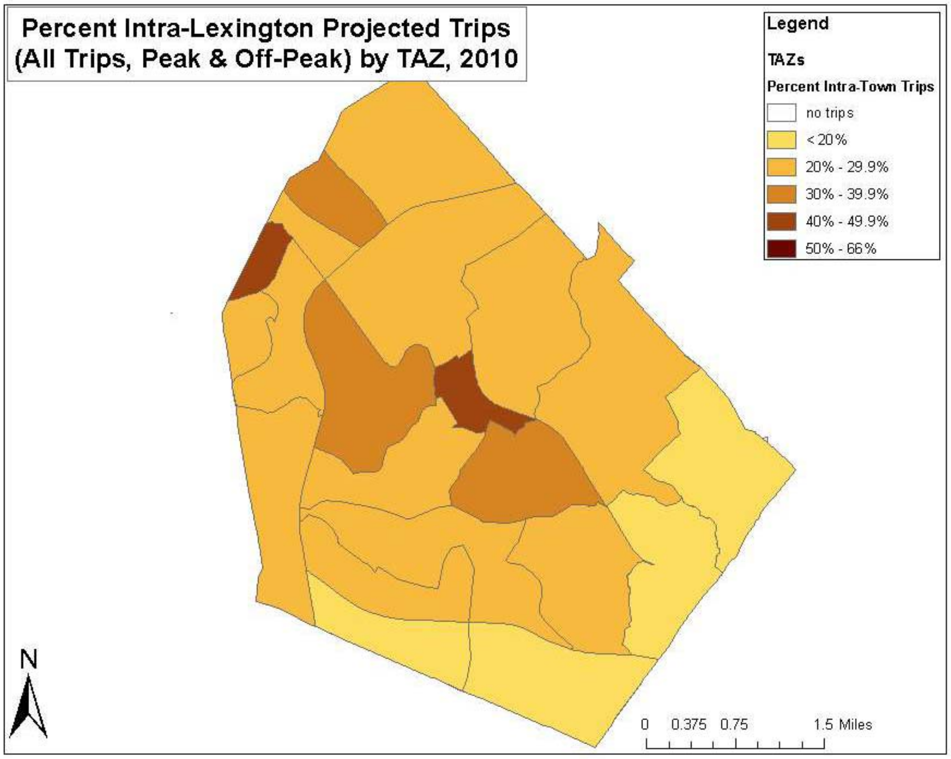
Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 85



Source: CTPS Regional Model Smart Growth+ Projections

Figure 86

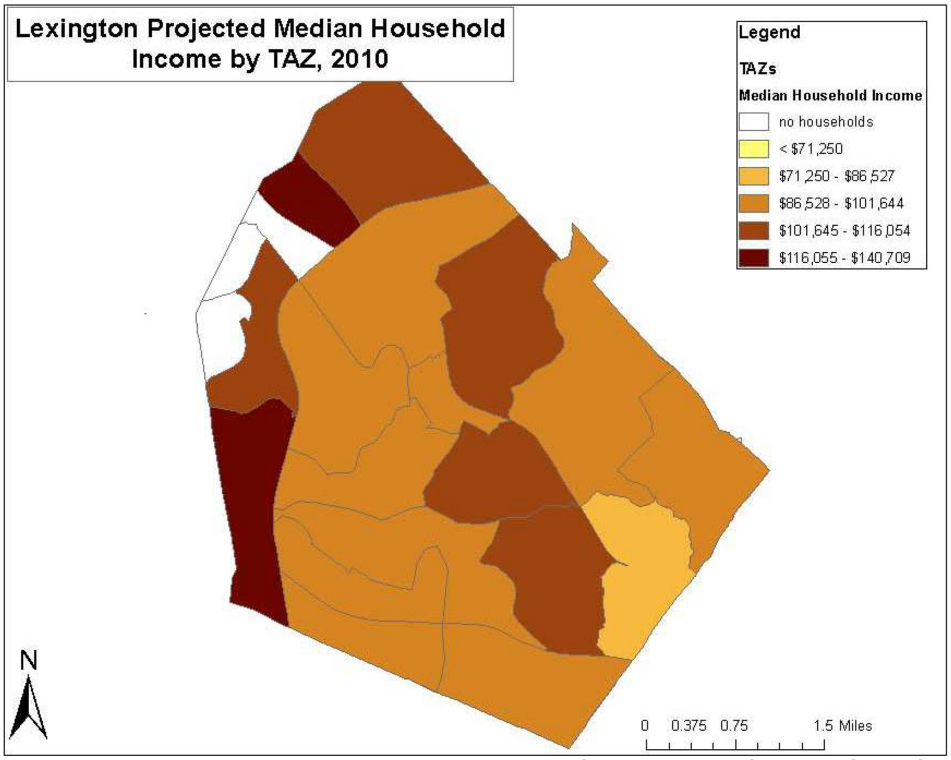


Source: CTPS Regional Model Smart Growth+ Projections

Two demographic characteristics that are often used as predictors for potential transit usage are median household income and population age. Lower household incomes (below 75 percent of the Boston Region MPO median household income, or $41,850) are a likely indicator of greater transit demand, as lower income residents are less able to afford the cost of a motor vehicle and are thus more dependent on transit. As seen in Figure 87, no TAZs in the town of Lexington have a median household income below $71,250. Most TAZs fall into the range of $86,528-$101,644, with only one TAZ having an income lower than this and a few TAZs falling into higher ranges. The highest incomes tend to be located along the edge of town west and north of Route 128.

With regard to population age, the relevant statistic is the percentage of population with ages above and below certain thresholds. Greater percentages of residents aged 10-19 and 65 and above are a likely indicator of greater transit demand, as these age groups tend to have fewer mobility options and are thus more dependent on transit. According to MAPC, approximately 13.3 percent of the population of the town of Lexington will fall between the ages of 10 and 19 in 2010. Similarly, with regard to population aged 65 and above, MAPC predicts that this population group will compose 18.4 percent of the total population in 2010. Thus, 31.7 percent of the projected 2010 population is predicted to fall into these two age categories where mobility is traditionally more limited and public transit demand is generally higher.

Figure 87

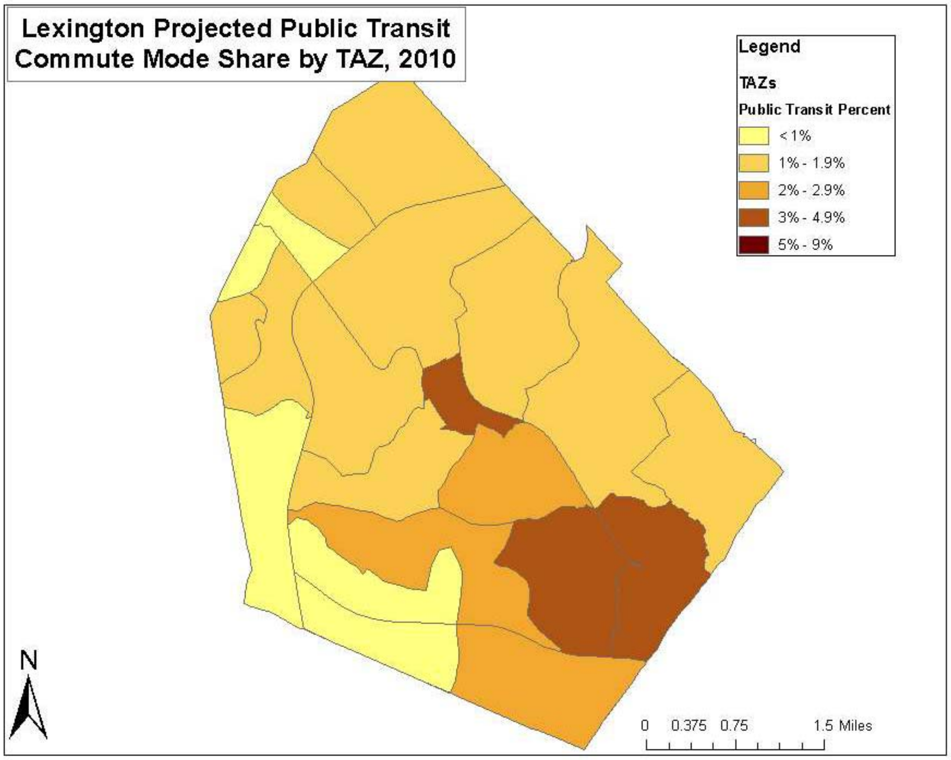


Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Transit Demand Assessment

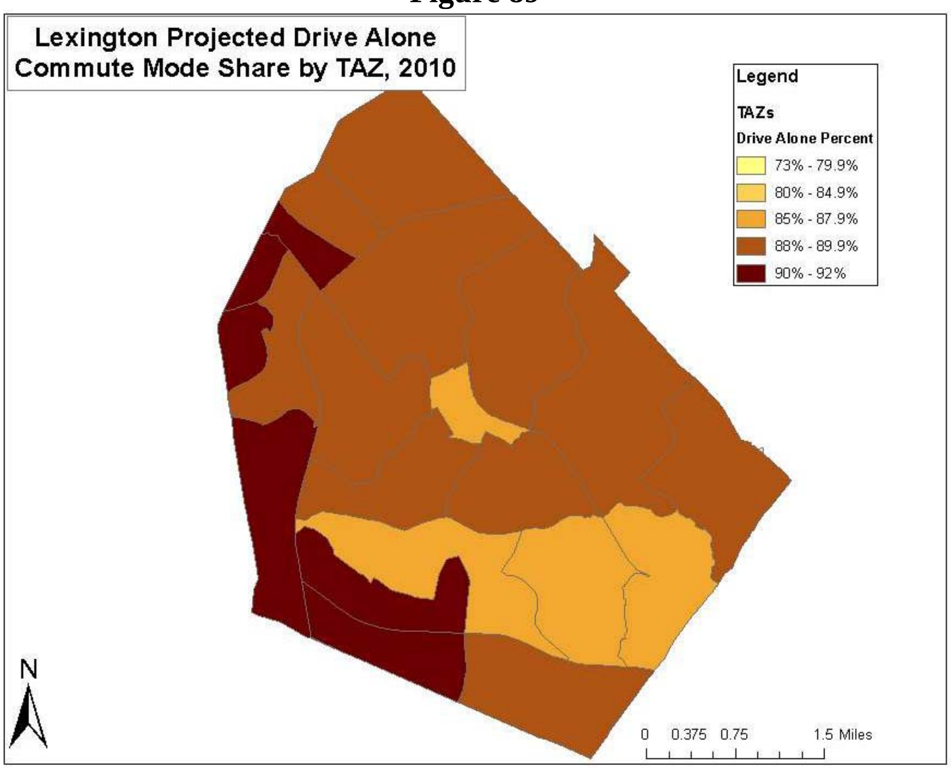
Compared to many suburban communities, Lexington has higher population and employment densities and a greater level of street connectivity. In addition, several MBTA bus routes serve Lexington, as does the LEXPRESS town bus system, which provides access to almost the entire town as well as trips to the Burlington mall. Despite these characteristics, which are usually associated with lower rates of vehicle ownership and a greater percentage of people using public transit, more than half of the TAZs in Figure 88 have public transit commute mode shares below 2 percent. Public transit usage is the highest in the south and very center of town, from which many trips, as discussed previously, are liked destined towards areas in Somerville and Cambridge and for which reasonable transit options exist. Transit usage declines outside of these areas. Most of Lexington's transit commute trips can generally be assumed to be those destined for areas outside of town, most likely to Somerville, Cambridge, or Boston via MBTA bus service possibly with a transfer to the rail system. LEXPRESS, through its network of local bus routes, is able to serve the small number of intra-town transit commute trips. Given the relatively low public transit use, the vast majority of commute trips in Lexington are made using a private vehicle. As seen in Figure 89, the high drive alone commute shares basically mirror the low public transit commute mode shares shown in Figure 88. The highest rates of drive alone commutes occur in the westernmost TAZs, though most TAZs have rates above 80 percent.

Figure 88



Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

Figure 89

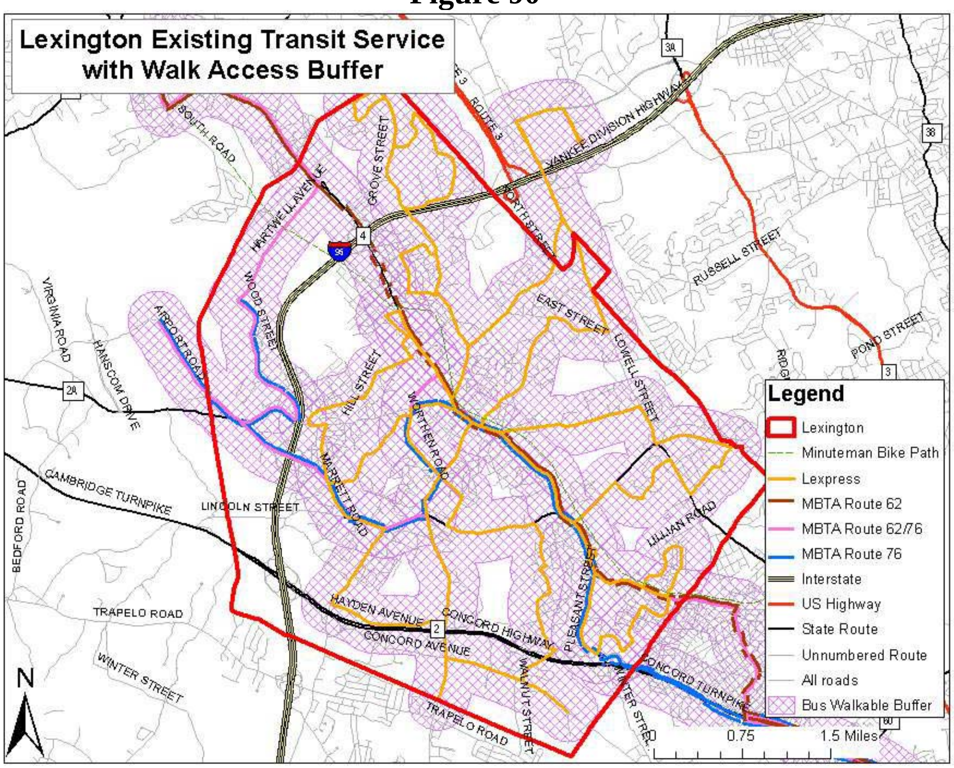


Source: CTPS Smart Growth+ Projections used in Air Quality Analysis

In terms of demand-responsive services, Lexington is part of the service area for The RIDE, a paratransit dial-a-ride service (door-to-door shuttle service where customers call ahead to reserve a time slot) provided by the MBTA that offers transportation throughout the region. Outside of Lexington Center, LEXPRESS service stops upon passenger request but does not deviate from its assigned route. Passengers wishing to board a LEXPRESS bus outside of Lexington Center must stand along the road in an area visible to the driver and wave as the bus approaches. The fares are $1.50 for adults and $0.75 for seniors and persons with disabilities with a $0.25 transfer fare between routes. Service along the six LEXPRESS routes runs approximately once every hour starting at 6:45 A.M. and ending around 6:30 P.M. All buses are equipped with wheelchair lifts and are ADA compliant. During Federal Fiscal Year 2007 (July 2006 through June 2007), LEXPRESS carried 63,184 riders. Through its extensive coverage of Lexington, LEXPRESS thus serves many of the same markets as a potential new demand-responsive service would, and while The RIDE is available only to certain segments of the population, LEXPRESS imposes no such eligibility criteria for service.

Figure 90 demonstrates the extent to which the various areas of town lie within walking distance of either MBTA bus service or LEXPRESS. The quarter-mile buffer depicted around MBTA bus Routes is based on the maximum distance that a person is generally assumed to be willing to walk to fixed-route bus service. This buffer is assumed to be much smaller for LEXPRESS. As seen in the figure, almost every Lexington neighborhood has some amount of service provided by either the MBTA or LEXPRESS. While MBTA bus service runs primarily along the major corridors in Lexington and provides regional accessibility through connections to the rapid transit network out of

Figure 90



Alewife, LEXPRESS serves as the local transit network, providing travel to MBTA bus Routes or around town.

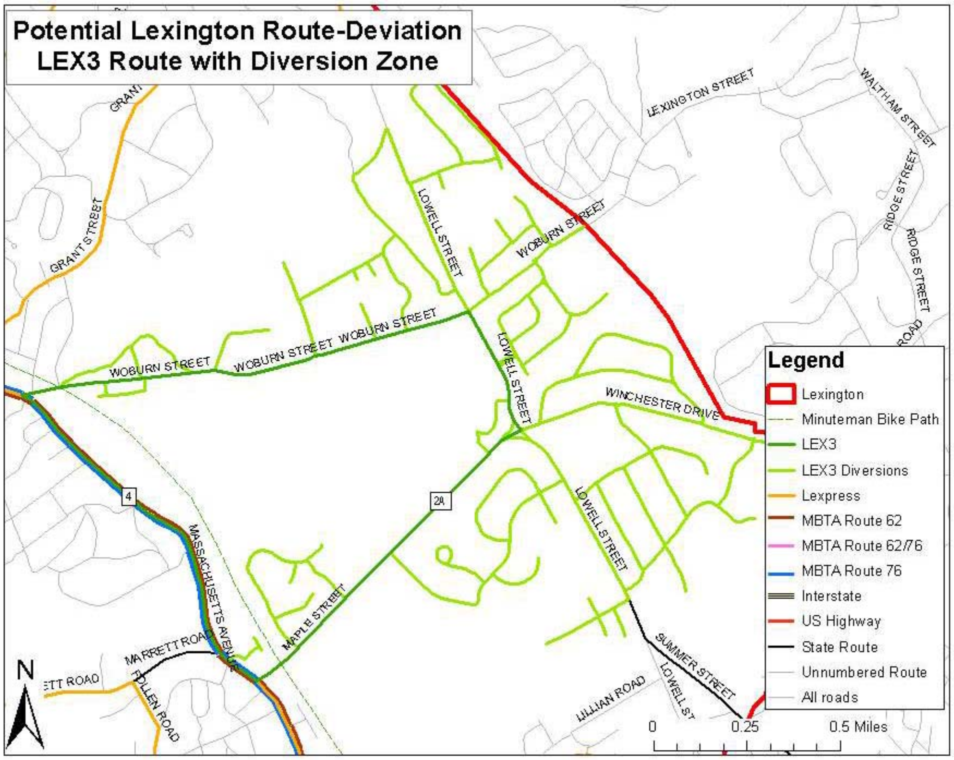
Potential New Services

While the existing network of transit services in Lexington does provide a high level of accessibility, demand-responsive service may be feasible in some neighborhoods outside of downtown Lexington. It is in these areas that LEXPRESS, due to its service characteristics, likely finds it difficult to attract passengers. Some residents who do not live directly along or close to the fixed routes of LEXPRESS, for instance, may not wish to walk any significant distance to reach the service. Moreover, the loop design of each LEXPRESS route and the resultant lengthy running times may discourage some potential passengers, particularly those that would need to board the bus in the beginning of the route. In addition, some people may be dissuaded from riding LEXPRESS due to the fact that, outside of Lexington Center, passengers must wait by the side of the road along a route, without any shelter and with no defined schedule, to wait for the bus to arrive. Finally, with all routes beginning their last runs at either 5:30 P.M. or 6:00 P.M., LEXPRESS offers little in the way of evening service. A route deviation service might, therefore, replace a low-ridership LEXPRESS route or supplement such a route in the evening hours. Route deviation would travel a basic route through a neighborhood but divert from this route as necessary to pick up or drop off passengers at their origin or destination, eliminating the need to wait outside for a bus to come. However, such a system would require passengers to make a reservation. Any existing LEXPRESS route transformed into a route-deviation service would need to be shortened so as to allow for sufficient time for any diversions and adhere to the same frequencies of one hour.

Any switch from fixed-route to route-deviation service would need to be based on an analysis of LEXPRESS ridership levels and characteristics. One metric that could be used would be to compare the costs and ridership of individual routes and at certain times of day to that of the system as a whole. LEXPRESS averaged slightly more than four passengers per trip in the last fiscal year. Routes averaging ridership levels above this level may not need to alter service; however, routes with trips carrying on average fewer than four passengers may want to consider a form of service that may be more appropriate for the area. Similarly, the highest ridership levels on LEXPRESS tend to occur around school start and release times. Where groups of students have similar travel patterns, the current fixed-route LEXPRESS service likely remains appropriate. However, it may make less sense to continue running the same service at times of day when there are fewer passengers and their trip origins and destinations are more dispersed. The same logic of where to operate fixed-route versus route-deviation service would need to be employed should LEXPRESS consider expanding service hours later into the evening. Higher levels of expected ridership could be best served by continuing the fixed-route service with which residents are familiar. Route deviation, on the other hand, may be more suitable in areas with lower expected ridership.

Figure 91 presents an example of how an existing LEXPRESS route could be transformed into a route-deviation service. Route 3 runs through eastern Lexington, serving the Harrington School and the residential neighborhoods in the area. As seen in the figure, this example shortens the basic route to run solely along Woburn Street, Lowell Street, and Maple Street, while allowing for diversions into the surrounding area. Passengers could, as always, choose to board or alight the bus along the basic route; however, with route deviation, passengers can reserve a diversion directly to their origin or destination. Route 3 currently operates once every hour. The potential route-deviation service could also reasonably run this route, with diversions, every hour using the same bus as is currently used. Additional personnel may be necessary to compile and schedule reservations.

Figure 91



Services such as these in other metropolitan areas generally tend to cost between $55.00-$65.00 per vehicle revenue-hour to operate. The associated cost per passenger of more successful and mature services tends to fall anywhere between $5.00-$10.00. The reservation component of demand-responsive services may add to this cost, however. In fiscal year 2007, LEXPRESS as a system achieved an average operating cost of $55.29 per vehicle revenue-hour and a cost per passenger of $7.65. As with any average, there are certain LEXPRESS routes or times during the day for which these costs are higher and lower. Any route-deviation service is unlikely to improve upon cost levels lower than these; however, for current LEXPRESS routes with higher costs per vehicle revenue-hour and passenger, such an alternative could potentially be less expensive than fixed-route service. Like all other public transit services, fares are unlikely to recover much of this cost. Any route-deviation alternative to fixed-route service for LEXPRESS is likely to keep the same fare structure, though it does present the possibility of adding a premium to any trip that deviates beyond the basic route. The extent to which public or private sources subsidize the service can also affect fare levels and the premium charged for diversions.

Conclusion

Unlike many suburban communities in which low residential densities and poor levels of street connectivity reduce the potential for transit service, Lexington has several characteristics that can potentially make transit feasible. Indeed, the extent to which Lexington is already served by several different transit services – MBTA fixed-route bus, the LEXPRESS neighborhood bus, and paratransit – is indicative of this potential. While an examination of the geographic coverage of these services seems to indicate that Lexington is already well served by transit for intra-town travel, there is perhaps a more optimal distribution of the town's transit resources. The high level of accessibility provided by the LEXPRESS route structure, for example, may actually discourage some potential riders if they feel their trip is unduly lengthened. Route-deviation demand-responsive alternatives to fixed-route LEXPRESS routes, such as the example described above, may be able to serve more passengers at the same or lower cost either by complementing a revised fixed-route system or replacing certain fixed routes entirely.

Should Lexington be interested in pursuing this or other concepts further, it is encouraged to prepare an application, with the assistance of CTPS, to the Suburban Mobility Program. While not prohibitive, the amount of personnel resources required to complete the application is not insignificant. The application is intended to demonstrate that the community has given thorough consideration to fiscal, operational, and marketing considerations. As such, travel demand reviews, market research, and financial plans are all necessary components of a community's application. CTPS is available to provide data and analytical advice upon direction of the MPO's Suburban Mobility/TDM Subcommittee. This document is intended to assist Lexington in determining whether to prepare an application and whether or not demand-responsive transit service is viable given the potential costs and demand.