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Massachusetts Bay Transportation Authority Advisory Board
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MEMORANDUM

DATE March 15, 2012

TO Boston Region MPO

FROM Mike Callahan, Project Manager, MPO Staff

RE Results of the Boston Region MPO's 2010 Freight Study – A Profile of Truck Impacts

INTRODUCTION

Efficient motor freight transportation contributes to a vibrant economy; however, it is also a significant contributor to congestion and crashes, and it accelerates the deterioration of roads and bridges. These are among the reasons federal transportation legislation encourages metropolitan planning organizations (MPOs) to carefully consider freight movement and issues during the metropolitan transportation-planning process.

The findings of the 2010 Massachusetts State Freight Plan and State Rail Plan reinforce the importance of studying freight movement in the Boston region. The State Freight Plan predicts that the volume of freight moving within or through Massachusetts will increase 70 percent between 2007 and 2030. Freight transportation relies on the same road and rail networks that people use to access their everyday needs. These networks are often congested at peak hours and have acute maintenance needs. Therefore, the predicted increase in freight volume may affect system performance for both freight transport and passenger travel.

The projected increase in freight volume will have a particularly acute effect on the highway system. The State Freight Plan estimates that 87 percent of the current freight volume by tonnage and 80 percent of the current freight volume by value in Massachusetts is moved by trucks. The plan also predicts that the truck mode share will increase between 2007 and 2030. Recommended by the State Freight Plan and State Rail Plan are several investments that support shifting freight transport, when feasible, from trucks to trains and ships in order to mitigate some of the harmful effects of trucking in Massachusetts. While increasing the share of freight moved by other modes would yield benefits for the region's road network, trucks will most likely continue to distribute the vast majority of freight within the Boston Region MPO area (also called "the Boston region" throughout this memorandum). Therefore, better understanding the general nature of truck movements and their effects on the transportation system is an important first step in preparing for the anticipated increase of freight volume in the region.

The primary purpose of this study was to examine how, where, and to what extent trucks affect the region's transportation system. To that end, it has produced a profile, documented in this memorandum, of truck impacts in the region, with a focus on highway volumes and truck-involved crashes. This information will help improve the Boston Region MPO's capabilities for conducting freight planning and for analyzing projects and programs for their freight benefits. The data and findings also point to areas where further inquiry would be useful.

Definition of "Truck"

An important preliminary step in this study was to define "truck." There are several different schemes used to classify trucks by different entities that are concerned with truck movements. This study relied on the classification scheme of the Federal Highway Administration (FHWA), which includes three categories of trucks. As shown in Table 1, single-unit trucks, the first category, include all vehicles in FHWA classes 5 through 7. The second category is single tractor-trailers, which includes all vehicles in FHWA classes 8 through 10. The third category is multiple trailers, which includes all vehicles in FHWA classes 11 through 13. Collectively, these three categories cover all vehicles that are considered trucks. Tractor-trailers and multiple trailers are occasionally referred to as "very large trucks." Table 1 also shows the relationship between the FHWA classification scheme and the one used for this study.

TABLE 1
Vehicle Classification Scheme

FHWA Classification	FHWA Description	MPO Study Classification
Class 1	Motorcycles	All Other Vehicles
Class 2	Passenger Cars	All Other Vehicles
Class 3	Four-Tire, Single Units	All Other Vehicles
Class 4	Buses	All Other Vehicles
Class 5	Two-Axle, Six-Tire, Single Units	Single-Unit Trucks
Class 6	Three-Axle, Single Units	Single-Unit Trucks
Class 7	Four-or-More-Axle, Single Units	Single-Unit Trucks
Class 8	Four–or-Fewer-Axle, Single Trailers	Tractor-Trailers
Class 9	Five-Axle, Single Trailers	Tractor-Trailers
Class 10	Six-or-More-Axle, Single Trailers	Tractor-Trailers
Class 11	Five-or-Fewer-Axle, Multiple Trailers	Multiple Trailers
Class 12	Six-Axle, Multiple Trailers	Multiple Trailers
Class 13	Seven-or-More-Axle, Multiple Trailers	Multiple Trailers

*Classes 5 to 13 are collectively defined as trucks for the purposes of this study.

**Classes 8 through 13 may also be referred to as very large trucks.

The vehicles excluded from the truck definition include pickups, sport utility vehicles, and buses. These vehicles are excluded from the truck definition for the purposes of this study because it is assumed that they are frequently used for personal or work travel, while the other categories of trucks are more frequently used only for freight transport. The vehicles defined as trucks for the purposes of this study also tend to be heavy, which causes them to contribute more significantly to roadway and bridge wear and tear, to have more severe consequences in crashes, to have different acceleration and deceleration characteristics, to consume greater amounts of fuel, and to emit greater amounts of some pollutants.

Data Resources

The four main sources of data used for this study were the Boston Region MPO's truck model, traffic classification counts conducted by the Massachusetts Department of Transportation, toll collection data from Interstate 90 (the Massachusetts Turnpike), and vehicle crash records of the MassDOT Registry of Motor Vehicles (RMV) Division. Basic information about each of these resources is described in this section.

Truck Model

The Boston Region MPO's truck model estimates the distribution of truck trips on the region's roadway network. The model is a computer tool that estimates the generation of truck trips by geographically defined zones and their distribution on the region's roadway network. Among the data inputs that are used to estimate the distribution of truck trips are truck inventory and use surveys, current population and employment figures, population and employment projections from the MetroFuture[1] land use plan, truck trip generation rates, vehicle classification counts, field observations of trucks, and surveys of local businesses. Trucks are classified for the model by use categories, which include tankers, household goods, truckload/less-than-truckload, food and warehouse distribution, intermodal, package, heavy, retail, and pickup/van. These categories are aggregated into pickup/van, HAZMAT (hazardous materials) cargo vehicles, and large trucks before the results are presented. The latter two model categories – HAZMAT and large trucks – are captured by the truck definition used for this study.

Unlike the truck counts described next, the model can help explain where trucks are coming from, where they are going, and how changes in land use and employment would affect truck traffic on the region's highways. It can also help fill in data for the gaps on the highway network where trucks have not been counted. For this study the model was used to study several different elements of truck travel at the regionwide level, such as the number of trucks traveling into, out of, through, and wholly within the Boston Region MPO area, and to estimate daily vehicle-miles traveled (VMT) for trucks in the region. Model results were also used to map truck trip generation in the Boston region and how it is expected to change between 2009 and 2030 in the many geographic zones used by the model.[2]

Classification Counts

The two sources of truck count data that are available were used to estimate the volume of trucks at locations on the region's highway system. The first source is counts conducted by the

[1] MetroFuture is the Boston region's land use plan. It was developed by the Metropolitan Area Planning Council (MAPC) and adopted in 2008.

[2] The region is divided into 2,727 geographic zones, known as transportation analysis zones (TAZs), for the purpose of modeling travel demand.

Massachusetts Department of Transportation (MassDOT) on highways throughout the state. The traffic-counting program involves the systematic collection of traffic data utilizing automatic traffic recorders. Counts are conducted either continuously or, more frequently, periodically, the latter type of count being performed for at least a 48-hour period. Vehicles passing a small fraction of MassDOT's count locations are classified according to the FHWA's 13 classes. These classification counts were conducted at 145 arterial roadway locations and on 35 limited-access highways in the Boston Region MPO area between 2000 and 2009. Unfortunately, the 48-hour counts are only conducted for the outermost lanes. The problem of estimating truck volume for the middle lanes was addressed by using a factor that was applied to the truck count of the rightmost lane. This process will be described in greater detail later in this memorandum.

The other source of classification counts is toll collection reports for Interstate 90 (the Massachusetts Turnpike). Tolls on I-90 are calculated based on vehicle class. Vehicles receive a ticket upon entering the Western Turnpike and pay upon exiting. Vehicles pay at each tollbooth on the Turnpike Extension and in the Boston tunnels. The data allow volumes by classification for each link on the Turnpike to be determined. Unfortunately, MassDOT uses a different classification scheme to assess tolls than the scheme developed by the FHWA. Additionally, three different classification schemes are used on I-90: one for the Western Turnpike (I-90 west of I-95), one for the Turnpike Extension (I-90 east of I-95), and one for the tunnels. However, all of the classification schemes are similar enough to allow the number of trucks traveling along most segments of limited-access-highways to be estimated.

Vehicle Crash Records

Another important source of data used in the study was traffic crash records obtained from the RMV. Data from Motor Vehicle Crash Police Reports and Motor Vehicle Crash Operator Reports allow crashes that involve trucks to be studied. The reports, if complete, include the time, location, environment, and characteristics of individual crashes such as the types of vehicles involved. Crashes are recorded if they take place on a public road and involve damage to any one vehicle or property exceeding $1,000, or any injury or fatality. Crash records for the three-year period of 2006 through 2008 were analyzed to identify truck crashes in the Boston Region MPO area. One problem with these data is that some municipalities do not consistently report crashes. However, the sample of crashes used for this study is large and allows comparisons between crashes involving trucks and crashes involving other vehicles.

Road Map of the Report

A basic outline of this memorandum is provided below:

- Truck Trips by Type of Movement
- Annual Vehicle-Miles of Truck Travel
- VMT and Emissions
- Trip Ends
- Truck Travel by Time of Day
- Areas with High Volumes of Truck Traffic Based on Counts

- Truck Volumes on Interstate 90 (the Massachusetts Turnpike)
- Locations with a High Number of Truck Crashes
- Locations with a High Rate of Truck Crashes
- Key Findings
- Areas for Future Research

GENERAL REGIONWIDE TRUCK INFORMATION

Among the items described in this section are truck trips by movement type (inbound, outbound, internal, or through the region), aggregated truck vehicle-miles traveled, truck trip generation by geographic zone, and truck travel by time of day. It does not describe the localized impacts of trucks, such as truck volume or crashes at specific locations. Those impacts are described in subsequent sections. The truck model was used to estimate truck travel patterns, truck vehicle-miles traveled, and truck trips by geographic zone. Traffic classification counts were used to describe truck travel by time of day.

Truck Trips by Type of Movement

Trucks traveling in the Boston region may be passing through during a long journey, or they may spend most of their time engaged in daily deliveries that rarely take them out of the region. The MPO's truck model estimates that there are approximately 815,000 truck trips on a typical weekday in the region. This estimate excludes trips made by pickup trucks and vans, which are estimated by the model but are not considered trucks for the purposes of this study. A truck is likely to make several trips per day. For instance, a truck leaving a distribution facility may stop at multiple destinations before returning to the distribution facility at the end of the day. Each leg of the day's journey is considered a trip.

As shown in Table 2, 66 percent of the trips estimated by the truck model begin and end within the Boston region. Twenty-three percent are through trips that both begin and end outside of the region. The remaining 11 percent of truck trips are split fairly evenly between trips coming into the Boston region and trips leaving the Boston region. These trucking patterns are important because they help planners to better understand the potential of moving freight by other modes, such as rail. The internal traffic is unlikely to move by a mode other than truck, as was discussed in the State Freight Plan.

TABLE 2
Daily Truck Trips by Movement Type

Movement Type	Percentage of Daily Truck Trips	Number of Daily Truck Trips
Inbound	5%	44,000
Outbound	6%	46,000
Internal	66%	540,000
Through	23%	185,000
Total	100%	815,000

Annual Vehicle-Miles of Truck Travel

The MPO's travel model was also used to estimate the collective miles traveled on a typical weekday for several types of vehicles. For this study, vehicle-miles traveled was estimated for single-occupant vehicles, high-occupant vehicles, commercial trucks, commercial pickups, and HAZMAT vehicles. Commercial truck and HAZMAT cargo vehicles are the only types of truck included in the definition of truck for the purposes of this study, and are therefore the two vehicle classes of interest.

Table 3 breaks down the vehicle-miles traveled by vehicle type. Commercial trucks are estimated to account for 8.2 percent of the typical weekday vehicle-miles traveled (VMT) in the region. Hazardous (HAZMAT) cargo vehicles make up a fairly small percentage of the VMT on a typical weekday – less than one-half of one percent. Overall, trucks account for about 8.6 percent of the typical weekday VMT.

TABLE 3
Daily Vehicle-Miles Traveled (VMT) by Vehicle Type

Vehicle Type*	Typical Weekday Vehicle-Miles Traveled (VMT)	Percentage of Typical Weekday VMT
Commercial Trucks	5,781,000	8.2%
HAZMAT Cargo Vehicles	271,000	0.4%
All Other Vehicles	64,658,000	91.4%
Total	70,710,000	100%

*Commercial Trucks and HAZMAT Cargo Vehicles combined equal trucks.

VMT and Emissions

Estimating truck VMT is important because emissions from the transportation sector are heavily influenced by it. However, emissions are also influenced by the vehicle mix and fuels used by those vehicles. Freight transportation is heavily reliant on vehicles that use diesel fuel, and its exhaust is a major source of particulate matter, nitrogen oxide, and sulfur dioxide pollution. Approximately 26 percent of the nitrogen oxide emissions produced by the transportation sector nationwide are from heavy-duty diesel trucks and buses. Nitrogen oxides interact with volatile organic compounds in the presence of sunlight to form ozone, making the diesel engines that drive freight transportation a significant contributor to ozone formation. Diesel engines are also significant producers of particular matter that is less than 10 microns in diameter (PM 10) and particulate matter that is less than 2.5 microns in diameter (PM 2.5) – the latter is also known as fine particulate matter. Heavy-duty trucks and buses account for 17 percent of the nationwide transportation emissions of PM 10. Diesel engines are not, however, major emitters of carbon monoxide.[3]

The U.S. Environmental Protection Agency introduced stringent caps on emission of particulate matter, nitrogen oxides, and other pollutants for the model year 2007 and later. It has also mandated the use of ultra-low sulfur diesel (ULSD) fuel in heavy-duty trucks starting with model year 2007. This fuel enables the use of more advanced pollution control technology. These new regulations have led to efforts such as the Massport Clean Truck Program, which seek to replace older trucks serving the Conley Container Terminal at the Port of Boston with newer trucks – model year 2007 or later. The emissions produced by trucks will be reduced on a per-mile-traveled basis as the truck fleet in the Boston region is replaced with newer, cleaner trucks.

One possible area for future planning work that deals with freight transport is the estimation of emissions factors that could be applied to VMT for each of the truck types for which VMT is estimated by the truck model. This would better help the MPO understand the impact trucks have on air quality in the region, and also help the MPO quantify the benefits of programs that are designed to reduce truck emissions.

Trip Ends

The truck model can also be used to estimate truck trip ends at the geographic scale of a transportation analysis zone (TAZ). A TAZ is an area defined for the purposes of tabulating transportation-related data, such as journey-to-work and place-of-work statistics. There are more than 2,500 TAZs in the MPO area. The truck model can estimate how many trips will begin or end in each of the TAZs. Each time a trip begins or ends in one zone on a typical weekday counts as one trip end.

The estimated numbers of truck trip ends by TAZ in 2009 are displayed in Figure 1. Interestingly, all of the TAZs that have a large number of truck trip ends (2,000 to 3,900) are located next to, or very close to, an express highway. This is also true of the TAZs with a number of truck trip ends that falls into the second-highest category of truck trip ends (1,000 to 2,000). Figure 2 displays truck trip ends by TAZ in 2009 for the region's central area, which encompasses much of Boston, Cambridge, Somerville, and several other communities close to Boston. This map shows that several locations in Boston Proper, Logan International Airport, and the fuel and food facilities in the vicinity of Route 99 in Everett generate a large amount of truck traffic. These locations are dense areas of employment that require daily deliveries of goods and supplies. They also are distribution points for goods and energy resources consumed in the region.

Figures 3 and 4 display the projected change in truck trips by TAZ between 2009 and 2030 for the MPO area and the central area, respectively. Truck trip ends are expected to increase for most TAZs due in part to projected employment gains. Many of the areas expected to experience the greatest increase in truck trip ends are those where large developments are expected, which is not surprising since truck trips are strongly influenced by population and employment. Among these

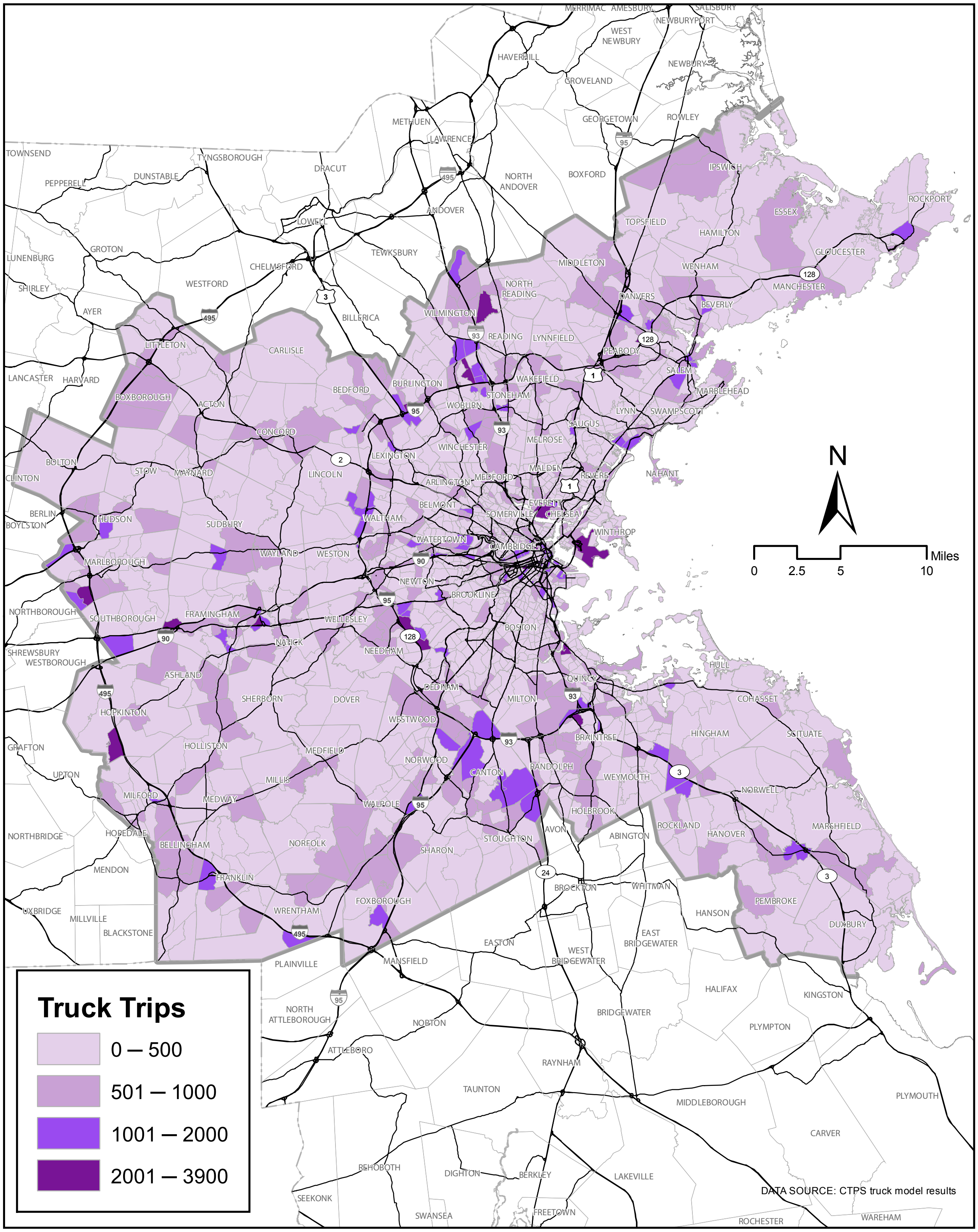
[3] Freight and Air Quality Handbook, Federal Highway Administration, May 2010

developments are the proposed Westwood Station, Assembly Square in Somerville, and the Seaport District of South Boston. The five TAZs predicted to have the greatest growth in truck trip ends between 2009 and 2030 are shown in Table 4.

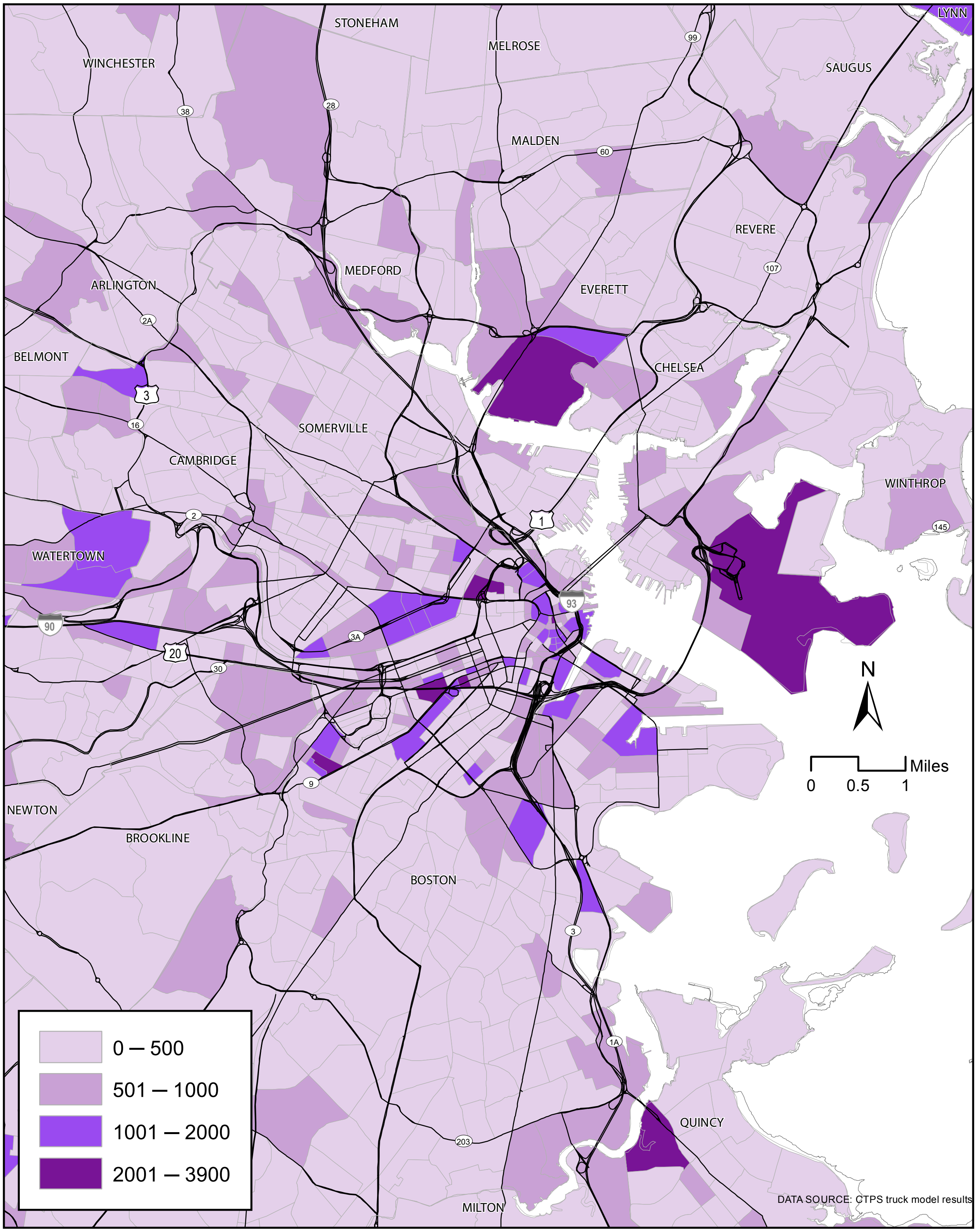
TABLE 4
Transportation Analysis Zones (TAZs) with the Largest Projected Increase in Truck Trips, 2009 to 2030

Rank	City or Town	Area	2009 Trips	2030 Trips	Growth
1	Westwood	Near Interchange of I-93 and I-95	862	2,869	2,007
2	Boston	Near World Trade Center*	284	2,037	1,753
3	Somerville	Assembly Square	166	1,601	1,435
4	Boston	Near World Trade Center*	202	1,535	1,333
5	Boston	Near River Street Bridge	130	1,326	1,196

*Two separate TAZs in the World Trade Center area are among the top 5.



BOSTON REGION MPO	**FIGURE 1** **Daily Truck Trips in 2009: Boston Region MPO Area**	*A Profile of Truck Impacts*



BOSTON REGION MPO

FIGURE 2
Daily Truck Trips in 2009: Central Area

A Profile of Truck Impacts

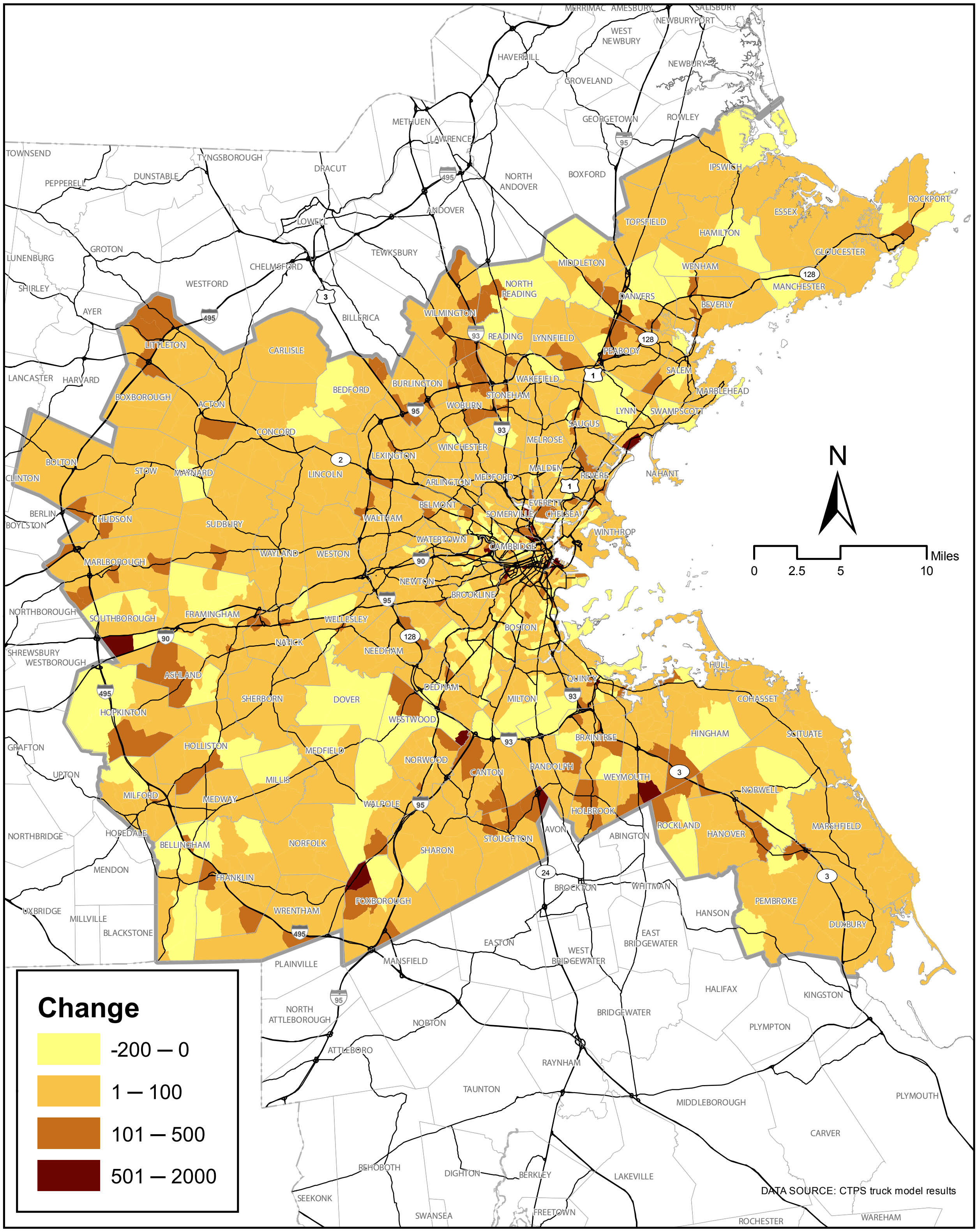


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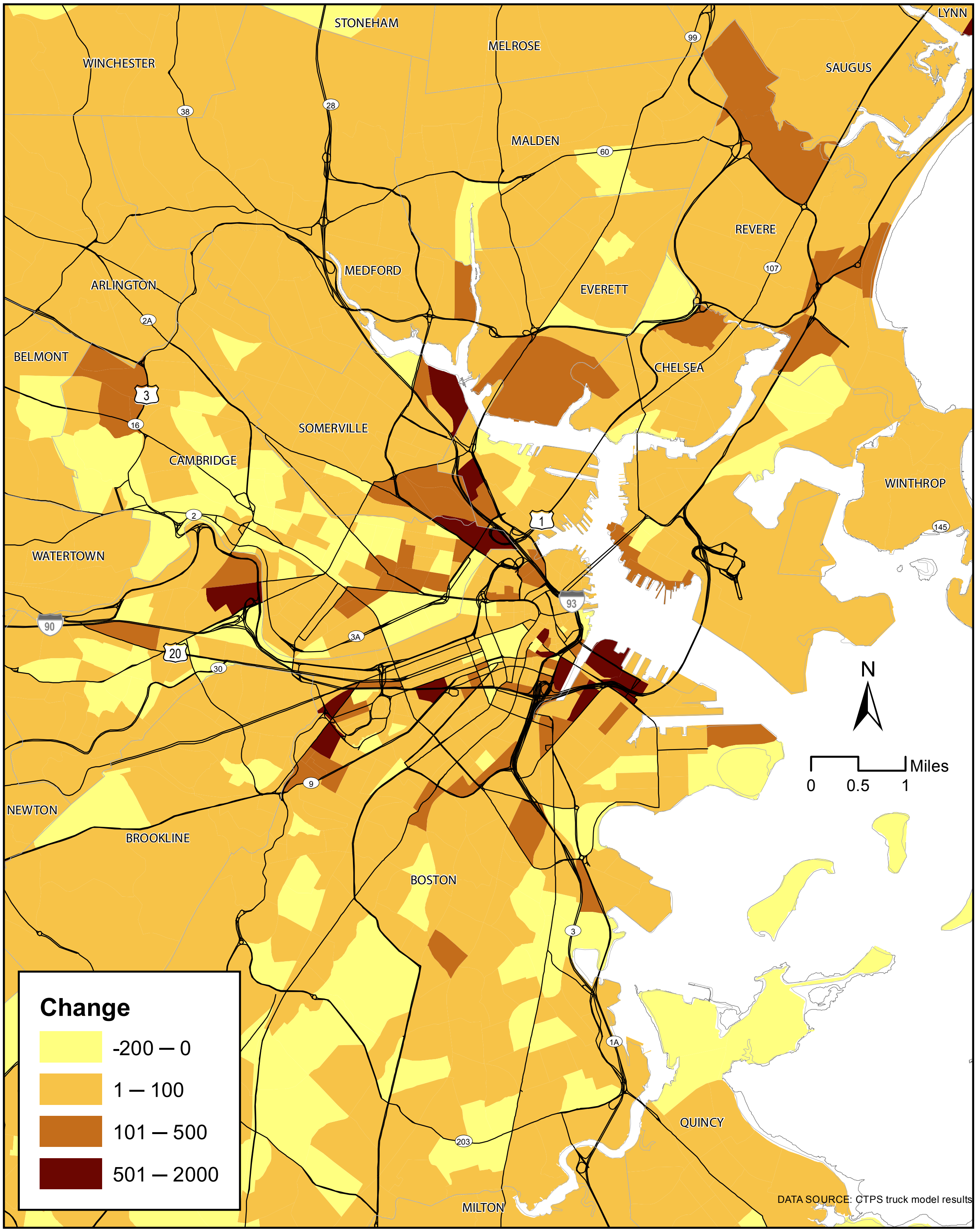
FIGURE 3
Daily Truck Trips: Change from 2009 to 2030

A Profile of Truck Impacts



BOSTON REGION MPO

FIGURE 4
Daily Truck Trips: Change from 2009 to 2030, Central Area

A Profile of Truck Impacts

Truck Travel by Time of Day

The variation in truck travel by time of day is another important aspect of trucking for planners to consider because it can help planners understand the contributions of trucking to congestion. Truck travel patterns were analyzed and compared with the travel patterns of other vehicles, using all available data from the classification count locations. The results of this work are presented in this section as three charts that show the distribution of travel by vehicle type over the course of a typical weekday. The distribution of multiple-trailer trucks over the course of a day is not presented in a chart due to the relatively small volume of travel of this vehicle type. For Charts 1, 2, and 3 below, the line represents the percentage of total daily volume for the vehicle type that travels during the corresponding hour of the day, found on the horizontal axis.

Several interesting observations can be drawn by looking at how single-unit and tractor-trailer travel, and the travel of other vehicles, are distributed over the course of a typical weekday. Chart 1 displays the travel pattern for vehicles other than trucks. The class of vehicles includes passenger cars, small trucks, and motorcycles as described in Table 1. The volume of these vehicles tends to peak between approximately 7:00 AM and 9:00 AM and 4:00 PM and 6:00 PM as clearly seen in Chart 1.

Single-unit trucks, shown in Chart 2, and tractor-trailers, shown in Chart 3, display a similar morning peak period, between approximately 7:00 AM and 9:00 AM. However, the volume of both single-unit trucks and tractor-trailers on the region’s highways drops off only slightly after the morning peak period. According to available data, approximately 56 percent of the single-unit trucks and 52 percent of the tractor-trailers, on a typical weekday, travel between 9:00 AM and 3:00 PM. In comparison, 40 percent of vehicles other than trucks travel during this time period. Including the morning peak period, 68 percent of tractor-trailers and 74 percent of single-unit trucks travel between 7:00 AM and 3:00 PM, compared to 54 percent of all other vehicles. Clearly, the travel pattern of passenger vehicles and other small vehicles is more spread out throughout the day than truck travel, which tends to be most prevalent during business hours.

It is also interesting to note that both single-unit and tractor-trailer trucks drop off significantly after 3:00 PM, while the number of vehicles other than trucks increases substantially. Approximately 9 percent of the single-unit trucks and 11 percent of the tractor-trailers, on a typical weekday, travel between 4:00 PM and 6:00 PM, compared to approximately 16 percent of vehicles other than trucks. Two possible reasons for this are that some truck operators seek to finish their daily work before the evening rush hour begins and the demand for deliveries is much higher in the morning.

So far, the discussion of travel by time period has not distinguished between different facility types. The same pattern is also evident for limited-access highways. All vehicle types have a morning peak period of approximately 7:00 AM to 9:00 AM, and most trucks seek to get off of the limited-access roads before the evening peak period, which begins at approximately 4:00 PM. However, tractor-trailers tend to use limited-access roadways during late-night and early-morning hours. Approximately 11 percent of tractor-trailers on limited-access highways, on a typical weekday, travel between 11:00 PM and 5:00 AM. Meanwhile, only about 4 percent of single-unit trucks and all other vehicles traveled during this overnight period. Arterial roadways follow the same pattern described for limited-access highways, with the exception of tractor-trailers being only slightly more common at night than other vehicles.

Throughout the course of studying trucks in the Boston region, it has become clear that I-495 is a high demand facility when it comes to trucks. The standard peak periods of 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM apply for passenger vehicles, but the daily truck patterns on I-495 exhibit some different traits. First, I-495 carries a large number of multiple-trailer trucks compared with the other limited-access highways in the region. The large number of multiple-trailer trucks on I-495 allows their daily travel patterns to be more easily studied. Remarkably, multiple-trailer trucks usually travel at night through the Boston region to a much greater extent than any other class of vehicle. The single hour of 1:00 AM to 2:00 AM accounts for approximately 11 percent of the multiple-trailer trucks observed at locations on I-495 during a typical weekday. Approximately 45 percent of the multiple-trailer trucks on I-495 in the region during a typical weekday travel between 11:00 PM and 5:00 AM Meanwhile approximately 15 percent of the tractor-trailers on I-495 travel during these overnight hours. This is significant because I-495 does not face congestion problems during the overnight hours, and therefore, multiple-trailer trucks using I-495 likely contribute less to congestion than do passenger vehicles, which have a much higher volume of traffic during the morning and evening peak periods.

It is important to note that the charts below do not include data for I-90. Fortunately, the tolls on I-90 are collected by class, and hourly class counts were available for June 2010 for the tolls in Weston. The daily traffic pattern at this location matched the pattern observed at the MassDOT classification count locations almost identically. Single-unit trucks and tractor-trailer volumes drop off substantially after 4:00 PM, just before the volume of passenger cars increases during the evening rush hour.

Chart 1

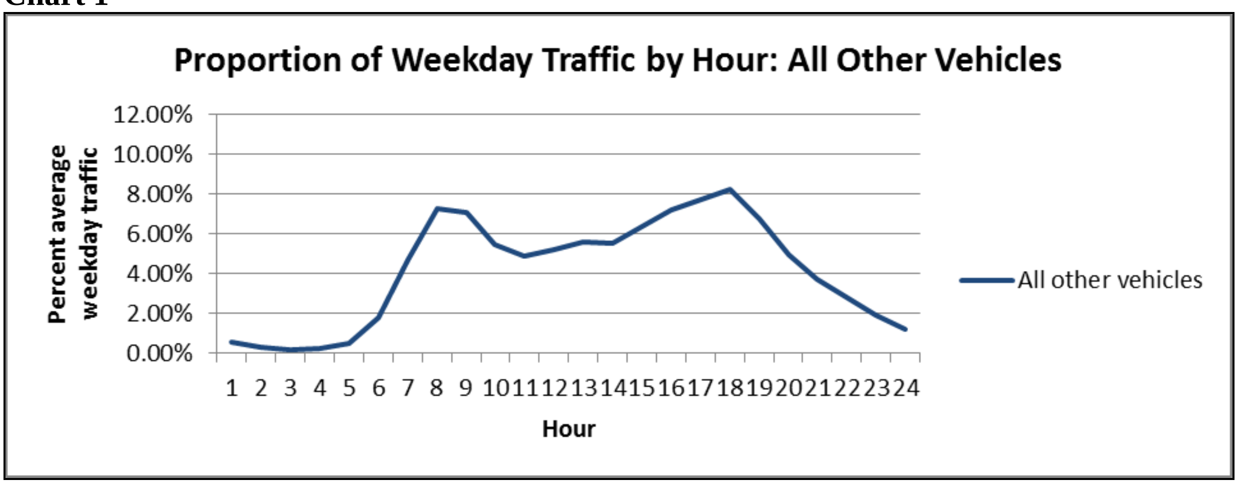


Chart 2

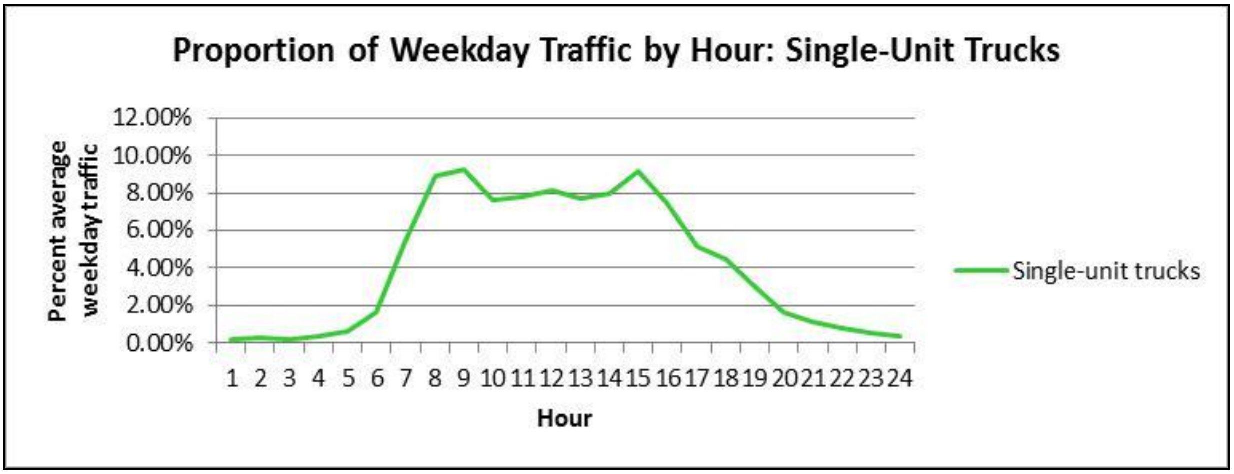
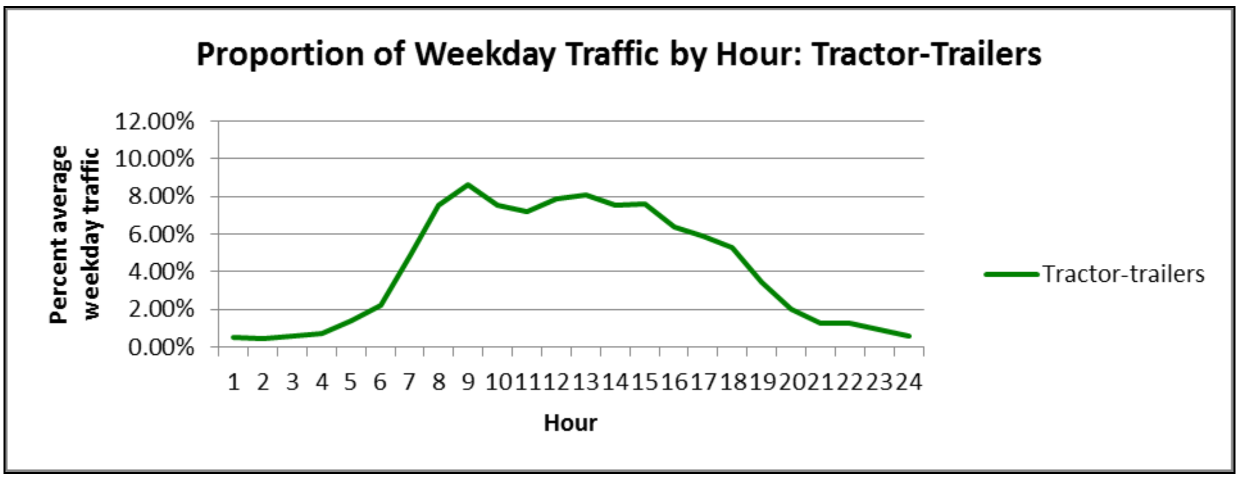


Chart 3



The information presented in this section is important for planning because it highlights the extent to which trucks contribute to congestion during the peak periods. During the evening peak period, when traffic congestion is often at its worst, truck operators are more likely to avoid the highways. However, it is also important to recognize that trucks are typically larger than passenger vehicles and have different operational characteristics. It was assumed for the development of the truck model that trucks occupy an amount of space on a highway equivalent to 1.6 to 2.2 passenger vehicles. This results in trucks having a larger impact on the traffic stream than smaller vehicles. Overall, it is difficult to tell how successful a program for diverting freight from trucks to other modes would be for alleviating congestion. However, moving freight by other modes would also have environmental and maintenance cost benefits.

TRUCK TRAFFIC

The preceding section provided some basic information about trucks in the Boston region. This section will describe where trucks are prevalent on limited-access highways and arterial roadways based on classification count data. Due to the limited number of classification counts available, the locations identified in this section cannot be said to be the top locations for truck traffic volumes. However, the available counts do reveal important information about the types of facilities that are heavily used by trucks, as well as other useful findings, which are described below.

Methods

Two sources of truck count data are available. The Massachusetts Department of Transportation (MassDOT) regularly counts traffic on major highways throughout the state. The traffic-counting program involves the systematic collection of traffic data by automatic traffic recorders. Counts are conducted either continuously or periodically for at least a 48-hour period. Vehicles passing a small fraction of MassDOT's count locations are classified according to the FHWA's 13 classes. Usable classification counts were conducted at 180 locations in the Boston Region MPO area between 2000 and 2009. Nearly all of the classification counts were conducted for a 48-hour period. At several of the locations, trucks were counted on more than one occasion. At those locations, the average volume by hour of the day was calculated using all available data. The average for each hour was then added up to produce the average daily (weekday) truck volume at each location.

One problem with the MassDOT count data merits special attention before the data are presented. The periodic 48-hour counts are conducted using tubes laid across the surface of the highway. Unlike the continuous count locations, the tube counts are conducted only for the two outside lanes (in each direction) of a highway. Many of the limited-access highways in the Boston region have at least three lanes in each direction. Furthermore, trucks are restricted by state law to the two rightmost lanes on any highway that has more than two lanes in each direction.[4] In order to estimate total truck volume on a segment of highway greater than two lanes in each direction, the truck volume for the second lane from the right, which will be called the truck passing lane, must be estimated.

The volume of trucks in the truck passing lane was estimated by applying a factor to the truck volume in the rightmost lane. At some locations on the limited-access highway network, sensors are embedded in the pavement and are able to count vehicles by class in each lane. Unfortunately, only one of these locations is in the Boston Region MPO area. This location was on I-93 near the Braintree split. Trucks at this location were more prominent in the truck passing lane than the rightmost lane. However, it was determined that this location is not appropriate for developing the factor because it is too close to the Braintree split and the counts were influenced by the weaving associated with trucks entering and exiting I-93. A pair of classification count locations outside of the MPO region along a six-lane cross-section of I-95 slightly south of I-495 were also utilized. These count locations showed higher truck volume in the rightmost lane relative to the truck passing lane. However, it was also determined that this location was not appropriate for developing a factor because of its close proximity to I-495, which is a major truck route. Therefore, a conservative factor was developed that assigns one truck to the truck passing lane for each truck in the rightmost lane. Additionally, despite restrictions on truck traffic in the leftmost lane, an occasional truck uses the lane. Many segments of the region's limited-access highway network are

[4] Massachusetts General Laws, Chapter 89, Section 4C

more than three lanes in width. Since trucks are restricted from all lanes but the rightmost lane and the truck passing lane, it was assumed that the truck volume in any truck restricted lane is the same as the counted leftmost lane.

The one-to-one factor was applied to all of the available tube-based classification counts on highway segments with more than two lanes in each direction in order to estimate total truck volume at these locations. This method certainly has flaws. The factor does not take into consideration the variation of truck volume by lane that likely occurs throughout the region. Future work on this subject should include manual counts at several locations in order to develop a better universal factor, or to develop factors that are specific to areas of interest. Meanwhile, the method used is suitable for one purpose of this study, which is to gain some understanding of the relative truck traffic among various locations on the limited-access highway network.

The other source of classification counts is toll collection data from I-90 (the Massachusetts Turnpike), which are calculated based on vehicle class. Vehicles receive a ticket upon entering the Western Turnpike (west of I-95) and pay upon exiting. Vehicles pay at each tollbooth on the Turnpike Extension (east of I-95). Unfortunately, different classification schemes are used on the two segments of the Turnpike. In order to be counting the same vehicle types as trucks on both segments, it is necessary to adjust down the total count of trucks on the Turnpike Extension by 0.61 percent, which removes buses, limousines, and passenger vehicles pulling a trailer. These vehicle types are captured by separate classes on the Western Turnpike, but get mixed in with several truck categories on the Turnpike Extension. The adjustment factor was developed by calculating the share of total traffic consisting of buses, limousines, and passenger vehicles pulling a trailer on the Western Turnpike between Route 30 in Natick and I-95 in Weston, which is the closest segment to the Turnpike Extension.

Areas with High Volumes of Truck Traffic Based on Counts

The following sections describe truck volume at locations on the region’s limited-access highway and arterial roadway system where trucks were recently counted. The available counts are not widespread enough to determine that these are the locations where trucks are most prevalent. However, there are enough count locations in the region to make comparisons between different facilities and facility types. Also described in this section are truck volumes and travel patterns on I-90.

Truck Volumes at Limited-Access Highways Locations with a Recent Classification Count

Truck volumes were estimated for limited-access highways using the methods described in the introduction. Factors were applied to volume observed in the rightmost lane to estimate volume in the truck passing lane(s). Only counts conducted between 2000 and 2009 were used. The counts presented in this section capture trucks traveling in both directions on the highway segment. The counts shown in Table 5 demonstrate that I-495 is a major truck route in the Boston region.

TABLE 5
Limited-Access Highway Count Locations with More than 5,000 Daily Trucks

Count Location	City or Town	Weekday Trucks	Share of Total Traffic
I-495, North of Route 4	Chelmsford	18,000	14.9%
I-495, North of Route 119	Littleton*	16,700	13.6%
I-495, South of I-90	Hopkinton	13,500	12.6%
I-90, West of I-495	Hopkinton	10,800	11.6%
I-93, North of Route 28	Quincy	10,700	4.8%
I-95, South of Route 20	Weston	10,400	5.1%
I-495, South of Route 20	Marlborough	9,600	9.5%
I-95, North of Route 140	Foxborough	9,500	8.8%
I-95, South of Neponset St.	Norwood	8,500	7.2%
I-95, North of Route 2	Lexington	7,800	3.9%
I-93, South of I-95	Woburn	7,700	3.8%
I-93, between Routes 24 and 28	Randolph	7,700	3.5%
I-95, South of I-93 Interchange	Canton	7,600	6.7%
I-90, Between Route 30 and I-95	Weston	7,500	5.5%
I-90, Between I-495 and Route 9	Southborough	7,200	7.0%
Route 24, South of Route 139	Stoughton	7,200	5.9%
I-90, Between Routes 9 and 30	Framingham	7,100	6.1%
I-95, North of Route 1	Peabody	7,100	4.8%
I-95, South of Route 38	Woburn	7,100	3.5%
I-95, North of Route 3A	Burlington	7,000	3.5%
I-90, East of Allston-Brighton Tolls	Boston	6,400	4.5%
I-95, North of Route 1	Topsfield	6,100	6.7%
I-90, West of Allston-Brighton Tolls	Boston	5,400	4.0%

* Three count locations in close proximity on I-495 in Littleton had similar truck volumes. Only one location is included in the table.

I-495 snakes in and out of the region along its western border. In order to view the highway in its entirety, we examined the portion between I-95 in Foxborough and Route 3 in Chelmsford, although the latter is slightly outside the MPO area. The three highest volume locations with an available count were on I-495. The truck share of traffic volume was nearly 15 percent at the highest count location along I-495. This high truck share may be due to the role I-495 plays in connecting northern New England with southern New England and points beyond. The other limited-access highway locations in the top 10 were along Interstates 90, 93, and 95, which also play a critical role in distributing goods around the region.

Truck Volumes at Non-Limited-Access Arterial Locations with a Recent Classification Count

Large truck volumes were estimated on non-limited-access arterials (also called arterial roadways) using the same method used for limited-access highways. The counts shown in Table 6 demonstrate that Route 1, both north and south of Boston, is an important truck route. The truck volumes on arterial roadways are typically much smaller than on limited-access highways. None of the arterial roadway locations at which data were available had a truck volume greater than 4,000.

Meanwhile, most of the count locations on limited-access highways had truck volumes of greater than 4,000. The truck share of volume is also much smaller on arterials than on limited-access highways. Trucks made up about 3.0 percent of traffic at arterial count locations and 6.3 percent at limited-access highway locations. The differences between both absolute volume and share of total traffic between limited-access highways and arterial roadways highlights the importance of the limited-access highway system for the movement of freight.

Locations on arterial and limited-access highways where more than 2,000 trucks were counted on an average weekday are shown in Figure 5.

TABLE 6
Arterial Roadway Count Locations with More than 1,000 Daily Trucks per Average Weekday

Count Location	City or Town	Weekday Trucks	Share of Total Traffic
Haul Road, North of West 2nd St.	Boston	3,400	28.1%
Route 1, South of University Ave.	Norwood	3,000	6.8%
Route 1, North of Lynn Fells Parkway	Saugus	2,400	2.0%
Route 1, North of Jug handle	Peabody	2,400	4.0%
American Legion Highway, South of Revere St.	Revere	2,200	5.7%
Route 1, South of Old Post Rd.	Sharon	1,800	5.6%
Route 140, North of Forbes Blvd.	Foxborough	1,700	5.0%
Mystic Ave., North of Dorrance St.	Boston	1,600	6.5%
Route 1, South of Pine St.	Foxborough	1,600	5.3%
Route 1, South of Coney St.	Walpole	1,500	4.6%
Route 1, South of Dean St.	Norwood	1,500	4.1%
Maffa Way, East of Caldwell St.	Boston	1,400	9.3%
Route 60, West of Pemberton St.	Revere	1,300	5.0%
Route 9, East of Hammond St.	Brookline	1,300	2.9%
Route 60, West of Newman St.	Revere	1,200	4.6%
Route 9, West of Centre St.	Newton	1,200	2.0%
Route 37, South of Peach St.	Braintree	1,100	4.2%
Route 1, South of Pine St.	Walpole	1,100	3.7%
Highland Ave., West of Gould St.	Needham	1,000	4.7%

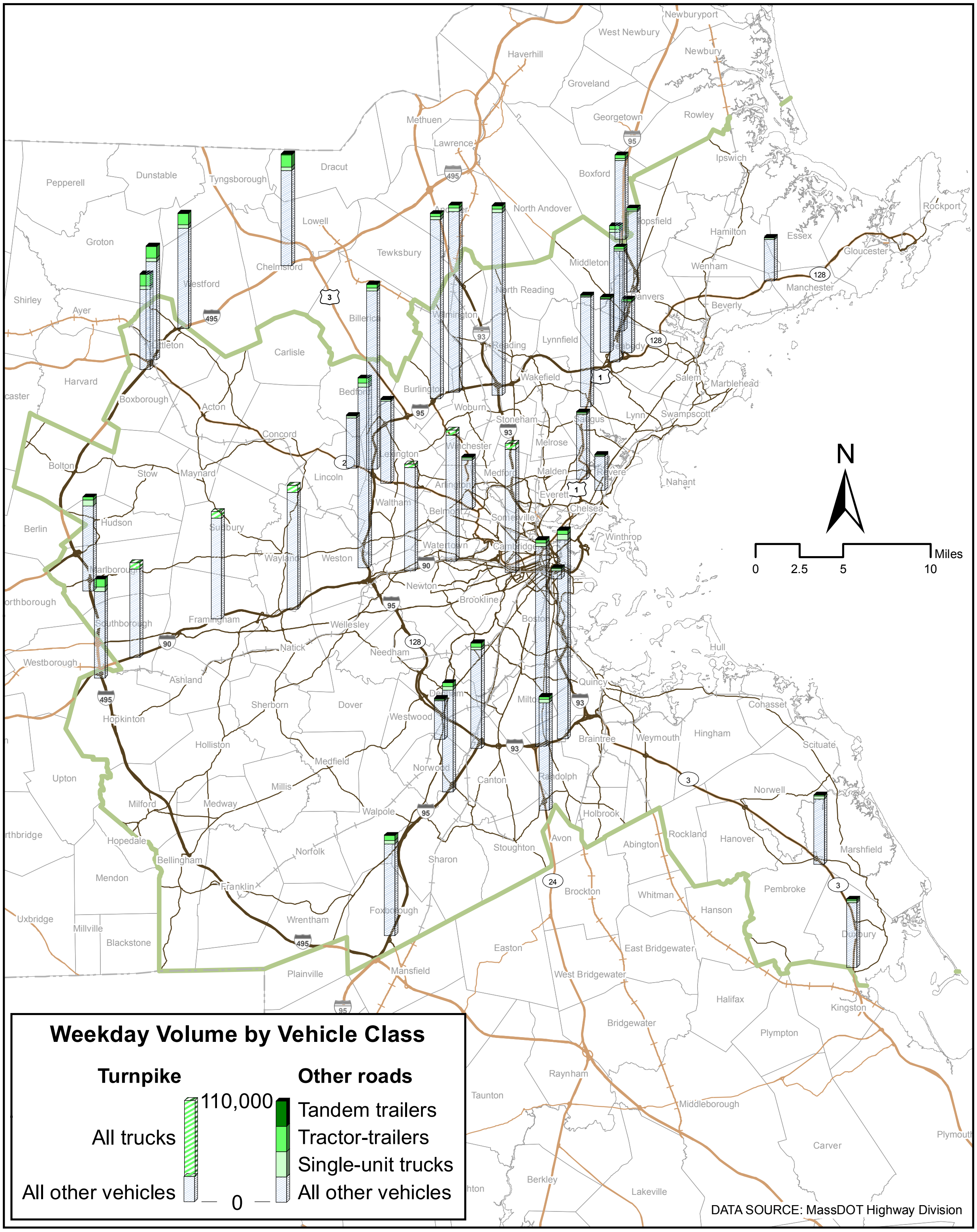


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FIGURE 5
Average Weekday Traffic Volume from 2000 to 2009
at Sampled Locations with Truck Volumes of More Than 2,000

A Profile of Truck Impacts

Areas Where Very Large Trucks Exceed Single-Unit Trucks

Typically, the number of single-unit trucks is close to the number of tractor-trailers and multiple-trailer trucks (collectively defined as very large trucks) on a segment of highway. However, there are areas where the number of very large trucks is far greater than the number of single-unit trucks. Assuming that very large trucks are more likely to be traveling long distances than single-unit trucks, a preponderance of very large trucks may be an indication that a segment of highway accommodates a large amount of through traffic. Perhaps not surprisingly, as shown in Table 7, I-495 in the northwest corner of the MPO area accommodates more than three times as many very large trucks as single-unit trucks. Meanwhile, on Interstates 93, 95 and on arterial roadways, the ratio of single-unit trucks to tractors-trailers is much closer to even.

TABLE 7
Count Locations with the Highest Weekday Ratio of Tractor-Trailers to Single-Unit Trucks

Count Location	City or Town	Tractor-Trailers	Single-Unit Trucks	Ratio
I--495, North of Route 4	Chelmsford	13,200	3,900	3.4
I-495, North of Route 2	Littleton	12,200	3,800	3.2
I-495, South of I-90	Hopkinton	8,800	4,600	1.9
I-95, North of Route 140	Foxborough	5,700	3,700	1.5
I-95, North of Route 1	Topsfield	3,700	2,400	1.5
I-95, South of I-93 Interchange	Canton	4,400	3,000	1.5
I-95, North of Route 128	Peabody	2,100	1,500	1.4
I-95, South of Neponset St.	Norwood	4,600	3,600	1.3
Maffa Way, East of Caldwell St.	Boston	660	550	1.2
I-95, North of Route 1	Peabody	3,800	3,300	1.2

*Does not include data for Interstate 90 (the Massachusetts Turnpike).

Truck Volumes on Interstate 90 (the Massachusetts Turnpike)

Truck volumes on I-90 merit extra consideration due to the extent and depth of the toll data, which allow the truck volumes for each segment of I-90 from the New York border to I-95 to be accurately calculated. A few clear patterns emerge when looking at the volumes presented in Table 8. The volume of trucks declines gradually between the western border of the MPO region and the city of Boston. However, the volume of other vehicles increases. Therefore, trucks make up an increasingly smaller percentage of total traffic volume as one moves from the outer areas of the MPO region to the central area. Nearly half of the trucks entering the MPO area traveling eastbound on I-90 exit onto I-495 in Hopkinton. This finding reinforces one of the central findings of this study, which is that I-495 is a major truck route in the region. Truck volumes decline sharply again east of I-95. Approximately 60 percent of the large trucks traveling eastbound from Route 30 in Natick exit at I-95.

TABLE 8
Large Truck Volume on I-90 between the Western MPO Border and Route 16

Location	City or Town	Weekday Count of Large Trucks	Share of Total Traffic
Entering the MPO region	Hopkinton	10,800	11.6%
Between I-495 and Route 9	Southborough	7,200	7.0%
Between Route 9 and Route 30	Framingham	7,100	6.1%
Between Route 30 and I-95	Weston	7,500	5.5%
Between I-95 and Route 16	Newton	4,300	3.7%
West of Allston-Brighton Tolls	Boston	5,400	4.0%
East of Allston-Brighton Tolls	Boston	6,400	4.5%

The 2010 Massachusetts Freight Plan found that trucks are very prevalent along Interstates 84 and 90, which are important routes for freight traveling between the New York City area and the Boston region.[5] Many of these trucks use I-290 to access I-495. Table 9 illustrates the patterns of trucks entering I-90 (the Massachusetts Turnpike) at its interchange with Interstate 84 in Sturbridge, Mass. Studying the patterns is important because it gives planners a general sense of where trucks entering the state from the south are going.[6]

It is clear that the dominant travel pattern for very large trucks entering I-90 at its interchange with I-84 is that the vast majority of them travel eastbound, and most of those trucks exit before reaching the Boston region's densest areas inside I-95. More than 77 percent of the very large trucks entering I-90 eastbound from I-84 exit at the I-90 interchanges with I-290, I-495, or I-95. Meanwhile, only about 8 percent of the very large trucks (excluding single-unit trucks) entering I-90 eastbound from I-84 in Sturbridge continue to points east of I-95 (Route 128).

The following travel patterns for trucks entering I-90 from I-84 in Sturbridge were observed in 2009.

- Approximately 95 percent of the trucks travel east

- Of the very large trucks traveling east:
  - Approximately 40 percent exit I-90 at I-290.
  - Approximately 24 percent exit I-90 at I-495.
  - Approximately 14 percent exit I-90 at I-95.
  - Approximately 8 percent travel to points beyond I-95.

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[5] Massachusetts State Freight Plan, September 2010, p. ES-25
[6] Interstate 84 terminates at Interstate 90 (the Massachusetts Turnpike) in Sturbridge. Therefore, all trucks entering I-90 from I-84 are coming from points to the south.

TABLE 9

Exit Point for Trucks Entering I-90 at Sturbridge (from Interstate 84 Eastbound) in 2009

From Interstate 84 Eastbound to:	Single-Unit Trucks	Very Large Trucks*	Average Daily Truck Traffic
West Stockbridge	1,680	18,200	54
Lee	510	1,370	5
Westfield	930	4,310	14
West Springfield (I-91)	2,320	6,300	24
Chicopee	1,660	2,440	11
Springfield (I-291)	4,510	12,800	47
Ludlow	1,960	1,660	10
Palmer	2,450	5,080	21
Sturbridge (I-84)	1,100	700	5
Worcester (I-290)	57,350	435,260	1,350
Worcester (Rte. 146)	13,770	81,060	260
Worcester/Millbury	7,920	44,940	145
Westborough (I-495)	43,300	264,730	844
Framingham	4,010	18,700	62
Natick (Rte. 30)	2,320	8,990	31
Weston (Rte. 128)	31,180	148,800	493
Beyond Rte. 128**	26,680	92,440	326

*Very large trucks are the sum of tractor-trailers and multiple trailers.

**Continued traveling east beyond the Weston toll plaza.

TRUCK CRASH HOT SPOTS

Crash records provided by the MassDOT Registry of Motor Vehicles Division were used to study the crash experiences of trucks in the Boston Region MPO area. These data were analyzed to understand where the most truck crashes occur, where trucks crash at a high rate for the facility type, and to compare the severity of crashes involving a truck to crashes that do not.

Methods

Traffic crash records are developed by the Registry of Motor Vehicles using the Motor Vehicle Crash Police Reports and Motor Vehicle Crash Operator Reports. The reports, if complete, include the time, location, environment, and characteristics of individual crashes. Crashes are recorded if they take place on a public road and involve damage to any one vehicle or property exceeding $1,000, or any injury or fatality.

Fortunately, for the purposes of this study the crash report also includes a field for vehicle type. The vehicle type classes are nearly compatible with the four classes used for the purposes of this study. However, crash data are presented in aggregate form in this section due to the large number of crashes involving heavy trucks that could not be classified. The options for vehicle type on a crash report include (with the vehicle class for this study listed in parentheses) passenger car (all other vehicles), light truck (all other vehicles), motorcycle (all other vehicles), bus – 15 or more passengers (all other vehicles), bus – 7 to 15 passengers (all other vehicles), single-unit truck with two axles (single-unit trucks), single-unit truck with three or more axles (single-unit trucks), truck/trailer (single-unit trucks), truck tractor – bobtail (single-unit trucks), tractor/semi-trailer (tractor-trailers), tractor/doubles (multiple trailers), tractor/triples (multiple trailers), unknown heavy truck (truck[7]), and motor home/recreational vehicle (all other vehicles). There are also "other" and "unknown" categories for which the vehicles involved in these crashes could not be classified.

As part of this study, crash records for the three-year period of 2006 through 2008 were analyzed to identify crashes involving trucks in the Boston Region MPO area. The records were studied to determine the total number of crashes that took place in the region during this period and the percentage of the crashes that involved a truck. Crashes were classified according to the heaviest vehicle involved in the crash. So if a crash involved a multiple-trailer truck and a passenger vehicle, it was classified as a crash involving a multiple-trailer truck. Likewise, if a crash involved a tractor-trailer or a single-unit truck with a multiple-trailer truck, it was also classified as a crash involving a multiple-trailer truck. This way of classifying crashes was used because for the purposes of this study the primary interest was in the location and severity of crashes involving trucks.

Approximately 85 percent of the crash reports include the location of the crash. This location information was used to analyze crashes for various facility types and also allowed the crashes to be displayed on a map. In order to identify locations with a high crash rate, the average share of crashes involving trucks for three facility types – limited-access highway interchanges, rotaries, and arterial roadways – was calculated. Areas with a high truck crash rate were identified as those where the share of crashes involving a truck exceeded the average share for the facility type. The three facility types were selected because they are the most frequent locations of truck crashes.

A weakness of this data set is that some municipalities do not report many of the crashes occurring within their jurisdiction. The underreporting of crashes makes it difficult to gain a full understanding of problem spots for all vehicles, including trucks. However, enough data are available to at least identify some hot spots where trucks are involved in an unusually high number of crashes and for studying the fatality, injury, and property damage rates for crashes by vehicle type. Future work in this area may involve updating the truck crash statistics provided in this study once improvements are made in the reporting of crashes to the RMV.

General Crash Statistics

Table 10 displays truck crash statistics for reported crashes in the Boston Region MPO area. Of approximately 200,000 crashes in the region from 2006 through 2008, the vehicles involved could

[7] The RMV category "unknown heavy truck" does not fit within any of the truck classifications used for this study. Crashes that involved this vehicle type were included in the aggregate crash statistics for trucks.

not be identified in 22,783 crashes. Of the remaining 177,891 reported crashes in the MPO area, trucks were involved in 10,834 crashes.

TABLE 10
Reported Crashes in the Boston Region MPO Area by Vehicle Type, 2006-08

Vehicle Type Involved	Crashes	Fatal Crashes	Injurious Crashes	Property Damage Crashes
Trucks	10,834	31	1,856	8,947
All Other Vehicles*	167,057	360	43,118	123,579
Not Classified	22,738	9	5,082	17,647
Total	200,629	400	50,056	150,173

*These are crashes that did not involve any trucks.

Approximately 6.1 percent of reported crashes in which the vehicle type was identified involved a truck. However, as shown in Table 11, trucks were involved in approximately 7.9 percent of the fatal crashes for which the vehicle type was identified, and approximately 4.1 percent of the injurious crashes for which the vehicle type was identified.

TABLE 11
Share of Reported Crashes* in the Boston Region MPO Area by Vehicle Type, 2006-08

Vehicle Type Involved	Share of Crashes	Share of Fatal Crashes	Share of Injurious Crashes	Share of Property Damage Crashes
Trucks	6.1%	7.9%	4.1%	6.8%
All Other Vehicles**	93.9%	92.1%	95.9%	93.2%

*Only includes crashes that could be classified by vehicle type.

**These are crashes that did not involve trucks.

Locations with a High Number of Truck Crashes

The locations with the 10 highest numbers of crashes involving a truck were identified for each facility type. An aggregated EPDO (Equivalent Property Damage Only) figure was also calculated for each location. EPDO is a weighted ranking system used to describe the severity of crashes at a location. A fatal crash is assigned 10 points, an injurious crash is assigned 5 points, and a crash involving only property damage is assigned 1 point. In this case, the EPDO was calculated only for crashes involving a truck. However, the crash locations for each facility type were ranked on the number of crashes, rather than the severity, because the objective of this task was to identify locations with a high number of truck crashes.

Between 28 and 71 truck crashes occurred at the top 10 limited-access-highway interchange crash locations. These are shown in Figure 6 and also listed in Table 12, below. Nearly all of the top interchange crash locations are along or inside of I-95, with the exception of the location with the second-highest number of truck-involved crashes, which was the intersection of I-90 and I-495. Interstate 93 between the Braintree Split and the Thomas P. “Tip” O’Neill Tunnel includes five of the top interchange crash locations.

TABLE 12
Top Truck Crash Locations at Interchanges of Limited-Access Highways, 2006–08

Location	Truck-Involved Crashes	EPDO
I-90 at I-95, Weston and Newton	71	143
I-90 at I-495, Westborough and Hopkinton	66	102
I-93 at I-95; Reading, Stoneham, and Woburn	63	140
I-90 at I-93, Boston	53	89
I-93 at Granite St., Braintree	52	117
I-93 at Columbia Rd., Boston	40	80
I-93 at Massachusetts Ave., Boston	32	52
I-95 at Route 9, Wellesley and Needham	32	72
I-93 at William T. Morrissey Blvd., Boston	29	69
I-93 at Montvale Ave., Woburn	28	68

There were 12 to 50 crashes at each of the top six rotary crash locations from 2006 to 2008. Only six rotary locations were included on the map because there were very few crashes at the other rotary locations in the region. The segment of Route 16 in Medford and Everett between I-93 in Medford and Second Street in Everett experienced a large number of truck crashes. Three of the top six rotary crash locations are along this segment. Trucks use Route 16 to access key fuel and food facilities along Route 99 and Beacham Street in Everett, and Williams Street in Chelsea. The top six rotary crash locations are shown in Figure 6 and are listed in Table 13, below.

TABLE 13
Top Truck Crash Locations at Rotary Intersections, 2006–08

Location	Truck-Involved Crashes	EPDO
Wellington Circle (Route 16 at Route 28), Medford	50	86
Sweetser Circle (Route 16 at Route 99), Everett	23	51
Kosciuszko Circle (Columbia Road, east of I-93), Boston	14	14
Santilli Circle (Route 16 at Santilli Highway), Everett	13	25
Brown Circle (Route 60 at Route 107), Revere	13	21
Reformatory Circle (Route 2 at Route 2A), Concord	12	24

There were 9 to 19 crashes at each of the top 10 arterial intersection locations. Eleven arterial intersections are listed because multiple locations had 9 crashes each. The top arterial intersection crash locations are shown in Figure 6 and are listed in Table 14, below.

TABLE 14
Top Truck Crash Locations at Arterial Roadway Intersections, 2006-08

Location	Truck-Involved Crashes	EPDO
Mass. Ave. at Mass. Ave. Connector, Boston	19	31
Williams St. at Spruce St., Chelsea	12	24
Williams St. at Broadway, Chelsea	11	19
Route 129 at Broadway, Lynn	10	18
Page St. at Turnpike St., Stoughton	10	22
Totten Pond Rd. at Lexington St., Waltham	10	10
Franklin St. at Western Ave., Lynn	9	21
Speen St. at Route 9 ramps, Natick	9	13
Route 1 at Dean Street, Norwood	9	17
Route 117 (Main St.) at Route 20 (Weston St.), Waltham	9	9
Everett Ave. at Spruce St., Chelsea	9	25

Figure 7 compares the top overall crash locations with the top truck crash locations. The figure displays three maps in separate panels. The first panel, titled “Top Crash Locations for All Vehicle Types,” shows the top crash clusters in the MPO area based on the EPDO index. The second panel shows the top crash cluster locations for trucks based on the EPDO index applied only to truck-involved crashes. The third panel compares the results of the first two panels and displays the locations that are hot spots for both truck crashes and for all motor vehicle crashes. The purpose of the third panel is to show the locations at which addressing a safety problem might provide the greatest benefits by focusing on areas where passenger vehicles and trucks are frequently crashing.

Nearly all of the locations that were in the lists of both the top overall crash locations and the top truck crash locations were along I-95 and I-93. The stretch of I-93 between the Braintree Split and the Tip O’Neill Tunnel stands out in particular, as does the stretch of I-95 near Route 3 north of Boston. It is also interesting to note that six locations along I-495 are high truck crash locations, but are not among the top overall crash locations. This is likely due to the higher volume of trucks that use I-495 relative to the other limited-access highways in the Boston region. It should also be noted that nearly all of the interchanges linking limited-access highways in the region are high truck crash locations, including the interchanges of I-495 and 90, both interchanges of I-93 and I-95, I-90 and I-93, Routes 24 and 3 with I-93, and Route 3 with I-95.

Locations with a High Rate of Truck Crashes

Locations with a high rate of truck crashes were identified by finding locations where the share of crashes involving a truck were higher than average for the facility type. The average share of crashes involving a truck was calculated for limited-access highway interchanges, rotaries, and arterial roadway intersections. The average share of crashes involving a large truck at interchanges was 8.0 percent, at rotaries it was 7.5 percent, and at arterial intersections it was 8.0 percent. Areas identified as having a high rate of truck crashes are those where the share of crashes involving a truck for the facility type exceeds the average for the facility type. Figure 8 shows these locations.

Unfortunately, truck counts are not available for the vast majority of these locations. Therefore, it is not possible to know if the higher percentage of the crashes at these locations than at other locations involves trucks simply because trucks constitute a higher percentage of vehicles using the facility, or if the geometry of the facility or some other factor is causing the high share of truck crashes. For instance, if the share of crashes involving a truck is much higher than the truck share of the volume at the location, it might point to a highway geometry problem. The lack of truck volume data at most of the high truck crash locations makes it nearly impossible to tell why an area is experiencing a high rate of truck-involved crashes. Further work to study the volume of trucks at the highest truck crash locations would make the data represented in Figure 8 more useful.

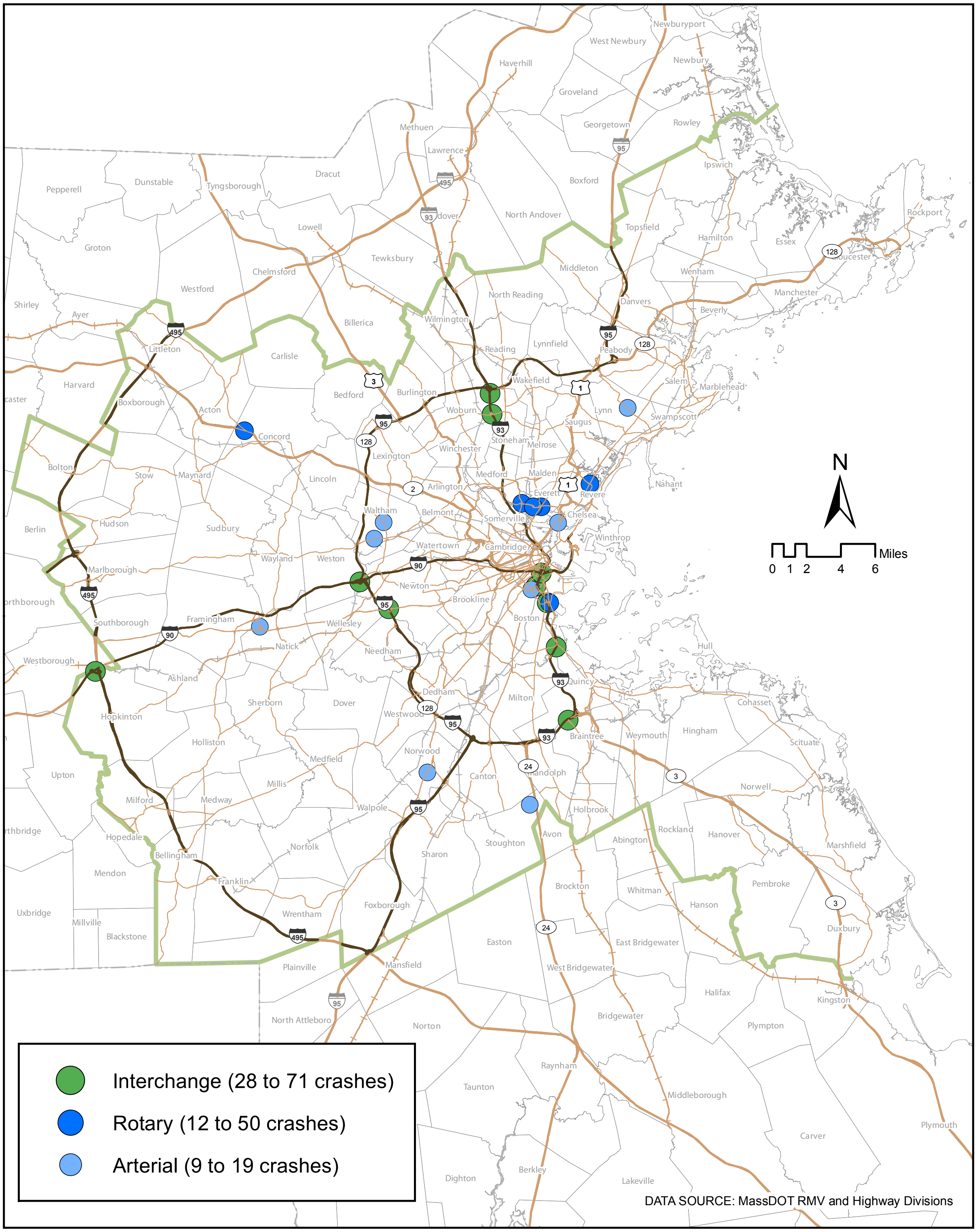

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FIGURE 6
Top Truck High-Crash Locations on Interstates, Rotaries, and Arterials, 2006 to 2008

A Profile of Truck Impacts

Top Crash Locations for All Vehicle Types | **Top Truck Crash Locations** | **Locations on Lists of Both Top All-Vehicle Crashes and Top Truck Crashes**

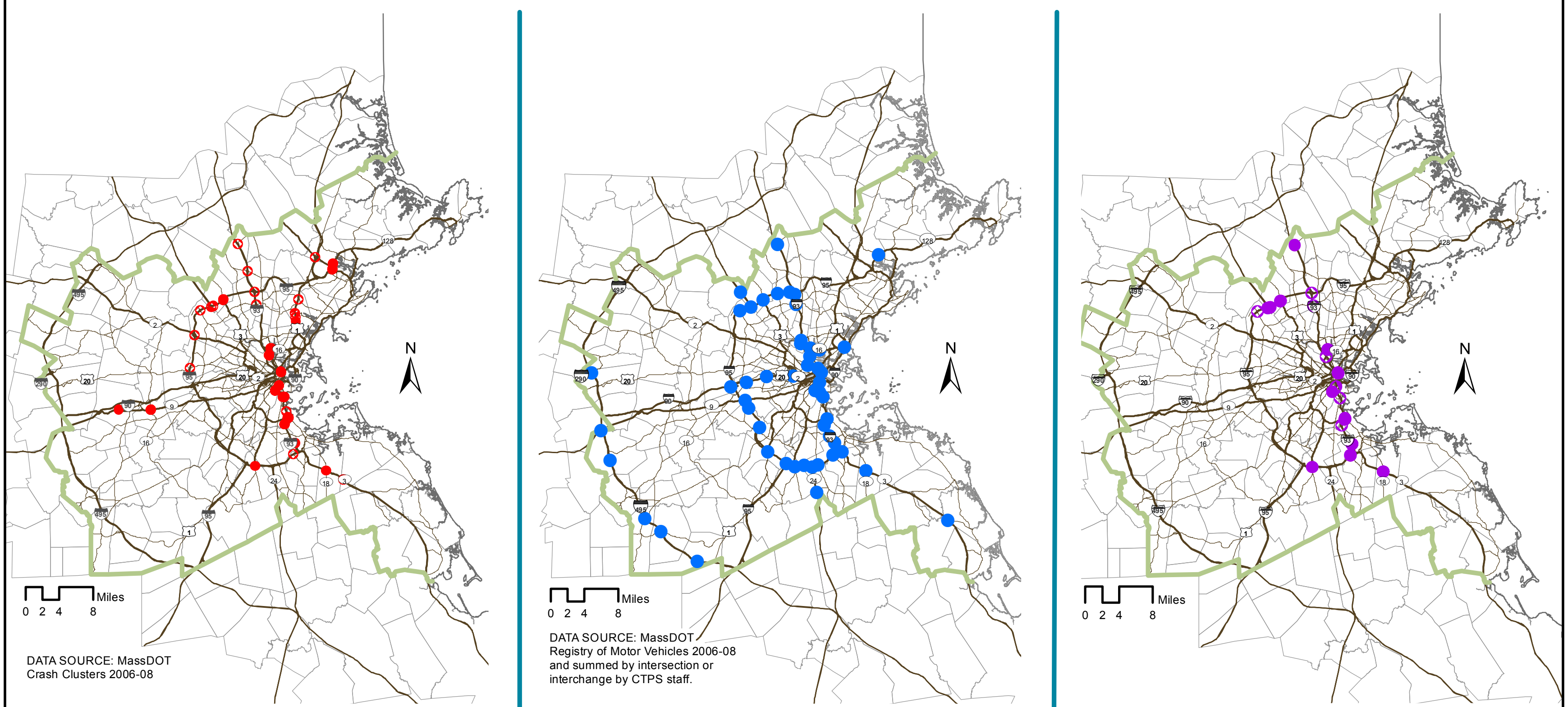

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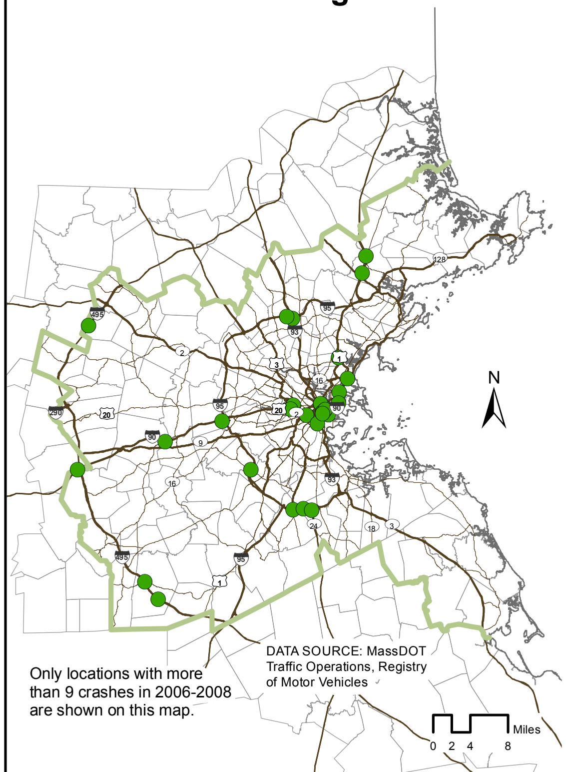
FIGURE 7
Comparison of Top Crash Locations from 2006 to 2008
for All Vehicle Crashes and Truck Crashes

A Profile of Truck Impacts

Interchanges

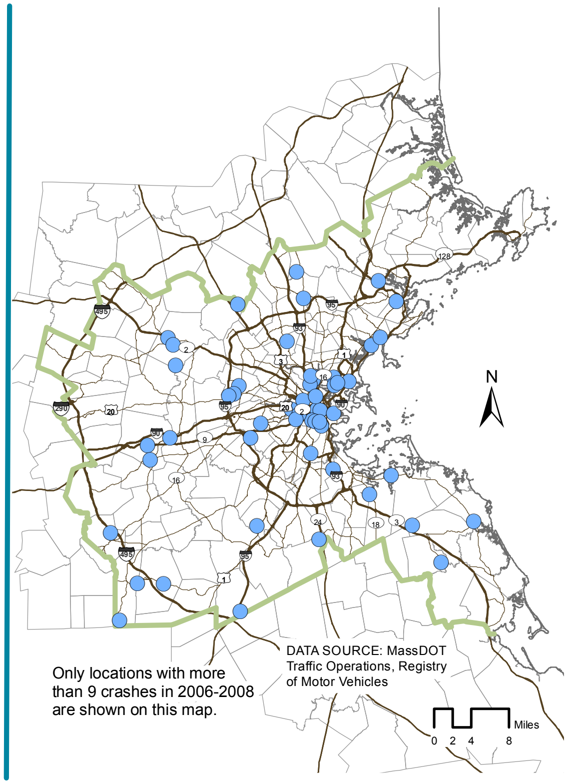


Mean percent of crashes involving trucks at interchanges (204 locations) is 8.01%.

Rotaries

Mean percent of crashes involving trucks at rotaries (22 locations) is 7.51%.

Arterials



Mean percent of crashes involving trucks on arterials (381 locations) is 8.04%.

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FIGURE 8
Locations Where the Percentage of Crashes Involving Trucks is Higher than the Mean for the Intersection Type, from 2006 to 2008

A Profile of Truck Impacts

KEY FINDINGS

This study has shed light on the behavior and impacts of trucks in the Boston region. Among the key findings are the following:

- Approximately two-thirds of trucks on highways are making trips within the Boston region. Nearly another quarter are traveling through the Boston region without stopping.
- Approximate 8.6 percent of the weekday vehicle-miles traveled in the region are by trucks.
- Trucks travel approximately 6 million miles on the region's highways during a typical weekday.
- Truck traffic is most prevalent on the region's highways during the morning peak and mid-day periods. Truck traffic falls sharply before the evening peak period.
- Interstate 495 is the region's most prominent trucking route. Trucks make up between 10 and 15 percent of the weekday traffic on the segment between I-90 and Route 3.
- The ratio of tractor-trailers to single-unit trucks is much higher on I-495 than on the other limited-access highways. This may indicate that I-495 accommodates a large amount of through traffic relative to other limited-access highways.
- A large percentage of the trucks coming into Massachusetts from the south via I-84 use I-90 to access Interstates 290 and 495. Nearly 60 percent of the trucks entering I-90 from I-84 are traveling to these two highways.
- The top truck crash locations in the Boston region are the interchanges linking major limited-access highways.
- Trucks are involved in 6.1 percent of the reported crashes in the region, but 7.9 percent of the reported fatal crashes and 4.1 percent of the reported injurious crashes.
- More classification counts are needed to better understand truck traffic and truck-involved crashes in the region.

AREAS FOR FUTURE RESEARCH

This study has revealed gaps in the knowledge of freight transportation in the Boston region. While this study has helped fill some of the gaps, there remains a need for more data in order for the MPO to have a more complete understanding of freight transportation.

Classification Counts

More classification counts should be conducted throughout the region. The counts relied upon for this study were inadequate in number and frequency. They are also primarily tube counts, which do not collect truck volume data for the truck passing lane on limited-access highways that have more than two lanes in each direction. The lack of comprehensive truck volume data makes it difficult to understand why a location might be experiencing a large number of truck-involved crashes. An area with a high rate of truck crashes relative to similar facilities may be experiencing a high rate of crashes simply because the location handles a large number of trucks, or because of issues with highway geometry that make it a difficult location for trucks to navigate. In the latter case, if the percentage of crashes involving a truck is much higher than the percentage of traffic comprising trucks, it might point to a highway geometry problem.

A comprehensive, systematic program should be developed in which classification counts are conducted periodically at several key locations throughout the region. Conducting counts at the same location at different times of the year would also allow the MPO to have a better sense of the effects of different seasons. The locations should also be selected in a manner in which gaps in our existing knowledge about truck traffic should be prioritized. For instance, there is a dearth of data on truck traffic for I-93 between the two interchanges with I-95 despite the high number of truck crashes occurring on that segment of highway. Volume data are also limited for I-495 south of I-90 and for stretches of I-95 (Route 128) between Route 3 and I-93.Volume data for the arterial roadways in the region are also very limited. Of particular interest would be data on truck volumes along Route 16 in Everett and Medford, especially because of the high number of truck crashes along this segment of roadway and its role in serving the important food and fuel terminals located near Route 99 in Everett.

Improved truck data for arterial roadways could be obtained by incorporating trucks into the regular data collection work of the Boston Region MPO and other agencies. For instance, trucks should be counted when data are collected at intersections as part of the MPO’s Congestion Management Process. A standard classification scheme should be used for all work conducted for the MPO.

Truck Emissions Factors

Another possible area for future work in freight would be the development of truck emissions factors that correspond to the truck use categories in the MPO’s truck model. Presently, universal emissions factors are applied to vehicle-miles traveled (VMT) in the region. Truck emissions factors could be applied to the truck VMT that is estimated by the truck model. This would better help the MPO understand the impact trucks have on air quality in the region, and help the MPO quantify the benefits of programs for reducing truck emissions.

General Information about Freight Transportation

Finally, it also would be useful to learn more about how freight transportation works. Unlike personal travel, freight often travels great distances. In addition, a product or material arriving in the Boston region typically takes many forms and shapes, traveling on many different modes, and through other states and even countries before reaching distribution facilities, homes, and businesses. The complexity of freight transportation makes it difficult to model, which makes it difficult to understand how public policies or actions will affect matters such as mode choice. Interviews and surveys of both shippers and freight carriers could provide useful information that would help inform the MPO as it grapples with choices that affect freight distribution. These areas for future research may be the subject of the next phase of the MPO's freight studies.

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