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Assessment of Out-of-State Heavy-Duty Truck Activity Trends in California

March 14, 2008

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ABSTRACT

The California Air Resources Board's emissions inventory estimates indicate that ambient air quality in several regions of California is substantially affected by the exhaust emissions of diesel trucks. There are insufficient data to accurately model the energy and emissions impacts of interstate-traveling trucks, many of which may be registered and/or fuel out-of-state. Emissions inventory estimates are based on adjustments to data on California-registered trucks. These estimates may not reflect the effect of non-California-registered trucks' attributes and operations. Further, the effects of out-of-state fueling by California-registered and non-California-registered interstate-traveling trucks are also not currently captured. In Summer 2006, an interview survey of 433 truck drivers was conducted to characterize the vehicle attributes and operations of interstate trucks that travel in California. We estimate that non-California-registered trucks account for approximately thirty percent of the Class 8 heavy-duty truck mileage on California roads. Also approximately thirty percent of all Class 8 heavy-duty truck mileage in California is fueled by out-of-state diesel. The effects of this are disproportionately concentrated in four air basins – the Mojave Desert, South Coast, the Sacramento Valley, and the San Joaquin Valley – with considerable ambient air quality issues.

EXECUTIVE SUMMARY

The California Air Resources Board's (CARB) emissions inventory estimates indicate that ambient air quality in several regions of California is substantially affected by the exhaust emissions of diesel trucks. The CARB issued a request for proposals in 2004 to examine whether current estimates of truck age, mileage, and fuel usage reflect that of interstate-traveling trucks—those that are registered, domiciled, and/or fueled outside California.

In the summer of 2006, researchers at the Institute of Transportation Studies at the University of California-Davis (ITS-Davis) conducted an interview survey of truck drivers' current trip and annual travel activity in California to quantify the number of out-of-state trucks, their mileage, their fuel use, and their fueling locations. Researchers also collected data on out-of-state fueling by California trucks. Drivers were solicited to participate in anonymous and voluntary three-minute surveys that were administered by ITS-Davis researchers. Surveying was conducted at seven California inspection stations near state borders with high commercial truck traffic. A total of 433 surveys were collected.

The survey results and the California state statistics on interstate truck activity differ. Official statistics from the California Department of Transportation (Caltrans) do not count interstate-traveling trucks, and the CARB estimates indicate a greater amount of truck mileage than the findings from this research. The survey results indicate that the contribution of the non-California-registered trucks is approximately 29-33% of Class 8 heavy-duty diesel mileage on California highways.

Of those that answered the survey question on fueling patterns, about one in eight of the surveyed trucks started their trips into California with California fuel. The remaining population was divided approximately evenly between those that intended never to use California fuel on that trip and those that would likely consume a mix of in-state and out-of-state fuel on their California trip. We estimate that approximately three quarters of interstate trucks' mileage in California is with non-California fuel. We estimate that 28-32% of total Class 8 heavy-duty diesel truck mileage in California is fueled by out-of-state diesel. The interstate truck activity in California is disproportionately concentrated in air basins – the South Coast, the Mojave Desert, Sacramento Valley, and the San Joaquin Valley – with considerable ambient air quality standard attainment issues.

The heavy-duty truck mileage and fuel use estimates based on the survey differ from those of the Caltrans and CARB. We recommend that the heavy-duty truck statistics that are used for emissions inventories and other planning purposes should be re-examined, and a sensitivity study should be conducted to determine the impact of the differing interstate activity and truck characterization estimates. Specifically, the heavy-duty diesel truck population, total mileage, mileage distribution by air basin, fuel use, and age distribution should be examined. The differing characteristics of the interstate-traveling, out-of-state trucks may warrant they be modeled as a separate category from the California-registered trucks.

I. INTRODUCTION

a. Background

California has developed a myriad of programs to reduce pollutant emissions in the state. Many of these emissions-reduction programs are aimed at achieving and maintaining compliance with ambient air quality standards. However, out-of-state vehicles, as well as the fuel from other jurisdictions, may not meet California goals. Interstate-traveling, heavy-duty diesel trucks in particular may be a significant source of emissions in California. According to emissions inventory estimates, although they are a relatively small part (i.e., about 1%) of the total vehicle population in California, heavy-duty Class 8 trucks are estimated to contribute to total California vehicle mileage (4% of vehicle miles traveled), fuel usage (13% of on-road petroleum fuel, 69% of on-road diesel), and on-road emissions (49% of NO_x and 50% of PM) in 2006 (CARB, 2007a).

There is significant uncertainty in the heavy-duty truck activity estimates, in large part due to inadequate data on the energy use and travel patterns of interstate-traveling, heavy-duty trucks. Estimates of truck activity in California primarily rely on records of California-registered vehicles and the sales of California-purchased fuel. These estimates do not adequately capture the activity from two important subpopulations that travel interstate: out-of-state registered trucks traveling in California and any trucks (including California-registered) that fuel outside of California. For those trucks fueling outside of California, the difference in fuel qualities in California, neighboring U.S. states, and Mexico (CARB, 2000; U.S. EPA, 2001; DieselNet, 2007a) are currently not reflected in emissions inventories. Out-of-state registered trucks may also have attributes and activity patterns not reflected in California's models. For certain model years, emissions regulations for truck engines certified by California have been more stringent than those in other U.S. states and Mexico (DieselNet, 2007b; DieselNet, 2006; INE, 1993). Fleet differences also exist between jurisdictions. For example, truck age, particularly engine model year, impacts the average emission rates estimates for the trucks (CARB, 2005; Sierra Research 2002).

b. Research Overview and Objectives

The CARB staff hypothesized that the impact of interstate-traveling trucks could contribute to significantly higher emissions from heavy-duty trucks than California emission inventories currently estimate. The purpose of this study is to characterize out-of-state trucks' vehicle attributes and operations in California and to characterize California-based trucks' use of out-of-state fuel in California. Parameters we examine via an in-person survey of truck drivers include fueling location, vehicle miles traveled (VMT), fuel consumption, and activity patterns. The intent is to improve the current understanding of these trucks' impact on California highway usage, fuel usage, and emissions. The study consists of a compilation of available public records, a comprehensive literature search, and an empirical data collection. Research facilities, public organizations, and trucking industry associations were contacted in an effort to compile existing data relevant to the study. From the available data, survey objectives were finalized, survey questions were formulated to determine which data were related to the most critical data gaps, and the survey strategy was designed. Interview surveying was conducted at seven border

sites across California. And, finally, the survey data were compiled, analyzed, and detailed in this report. The literature search findings are detailed in Section II. The description of the research method of the original data collection from surveying is summarized in Section III. Reporting of the survey data results is shown in Section IV. Analysis of these results is done in Section V, and the key findings, conclusions, and implications are discussed in Section VI.

II. LITERATURE REVIEW

In this section we review the pertinent data and research on interstate truck attributes, operations, and impacts within California. These are the data to which this project's results will be compared. This review of existing information elucidates the most crucial data gaps in understanding out-of-state truck activity as well as California-based truck fueling patterns, and it was used to determine the survey objectives. The first subsection (a) reviews more general data and trends on heavy-duty trucks and available data. Subsection (b) discusses the ways in which out-of-state trucks may have attributes and practices that may affect California emissions inventories. One study by the Caltrans (2001) was found particularly useful for this study; a portion of its raw data is analyzed extensively in part (c) of this Literature Review section.

a. General Data on Interstate Trucks in California

We sought out and reviewed relevant out-of-state truck activity and fuel use information to identify the most critical data needs for our survey. A search of truck reports, surveys, and studies revealed that there are abundant data on trucks' population and use in California. A summary of the key literature is given in Table 1. The table summarizes the studies' methods, variables investigated, and limitations related to this study.

Table 1. Summary of Available Pertinent Data on Heavy Duty Trucks in California

Study / Survey	Data Form, Survey, Sampling	Relevant Questions and Variables	Limitation(s)
California Motor Vehicle Stock, Travel and Fuel Forecast (Caltrans, 2006b)	Based on other sources (vehicle registrations, tax receipts)	Number of vehicles; amount of travel; fuel consumption for CA vehicles	No out-of-state trucks; crude trucks classification (TRK3, 10k<33k lbs.; TRK4, +33k lbs)
CARB Emissions Factor (EMFAC) Model (CARB, 2007a)	Based on other sources (vehicle registrations, tax receipts)	Vehicles; vehicle miles traveled; trips; weight classifications	No out-of-state trucks; no vehicle type classification (axle, vehicle type)
U.S. Census' *Vehicle Inventory and Use Survey* (US Census, 2002)	Mailback survey of 2100 CA-registered truck operators (1744 CA "home base" trucks) in 2002	Registration state; home base state; truck classifications (GVWR, axle); annual miles	No out-of-state trucks
International Registration Plan (IRP)	Department of Motor Vehicles (DMV) data on truck mileage estimations for travel in each state	Number of out-of-state trucks IRP-registered; mileage on California roadways	Not publicly available; synthesis of IFTA and IRP data conducted by Stonebridge Associates (Rozsa, 2006)
International Fuel Tax Agreement (IFTA)	California Board of Equalization (BOE) records for diesel fuel tax receipts of interstate trucks	Number of out-of-state trucks IFTA registered; amount of diesel fuel used	
California Annual Average Daily Traffic Counts (Caltrans, 2006a)	Periodic (every several years) electronic truck counting instrument updates on all CA routes	Truck crossings at all major CA borders; classification by number of axles	No data on state of registration; counts not categorized by Gross Vehicle Weight Rating (GVWR); some counts not updated regularly, vary greatly (e.g., seasonally)
Caltrans Heavy Duty Truck Travel Survey (Caltrans, 2001)	Truck intercept survey of 8287 drivers at 33 locations throughout CA in 2001	Origin-destinations; state of last refuel; vehicle classification (truck type, body)	No data on state registration or home base
Southern California Association of Governments' *Goods Movement Truck Count Study* (SCAG, 2002)	Intercept with survey mailback; 10 locations; 3219 completed surveys	Registration (CA/other); home base of vehicle; truck classifications (vehicle type, GVWR); origin-destination	Based on southern CA survey locations; mostly internal (i.e., not border) truck intercepts

The most prominent data uncertainty is in overall truck population and activity in California, irrespective of how many out-of-state trucks are traveling in California. These are several sources for heavy-duty diesel truck population, travel, and fuel use data. Table 2 compares the data used by the Caltrans and the CARB. The Caltrans' *Motor Vehicle Stock Travel and Fuel Forecast* estimates the total number of heavy-duty diesel trucks of greater than 33,000 pounds (labeled by Caltrans as category "TRK4") in 2006 to be 138,000 trucks (Caltrans, 2006b). From CARB's emissions modeling, there are approximately 194,000 of these trucks (which CARB [2007a] refers to as Heavy, Heavy-Duty Trucks [HHDT] and labels in EMFAC as "T7" and "T8"). Data from CARB includes a correction factor to account for an estimated 25% out-of-state truck activity (with the remaining 75% of the HHDT vehicle population, travel, and fuel use from California-registered trucks). The Caltrans data for truck population includes only California-registered vehicles; however, the Caltrans mileage estimation includes in-state travel by all trucks, including non-California-registered trucks (Khoii, 2008). A third data source for truck population is the U.S. Census' *Vehicle Inventory and Use Survey,* which was conducted in 2002. This study estimates that there were about 144,000 Class 8 trucks (those with gross vehicle weight rating of greater than 33,000 pounds)[1] registered in California in 2002 (U.S. Census, 2004). This initial data uncertainty on truck population is significant for this study because estimates for out-of-state truck travel are estimated in reference to the total California population. In the remainder of this report, we refer to these heavy-duty trucks as Class 8 trucks.

Table 2. California Class 8 Heavy-Duty Diesel Truck Characteristics from Two Sources

Year	Truck Population		Vehicle Miles Traveled (millions miles/year)		Fuel Use (million gallons/year)	
	MVSTAFF (Caltrans, 2006b)	EMFAC (CARB, 2007a)	MVSTAFF (Caltrans, 2006b)	EMFAC (CARB, 2007a)	MVSTAFF (Caltrans, 2006b)	EMFAC (CARB, 2007a)
2006	138,000	193,614 [a]	9,037	12,141 [a]	1,518	2,277 [a]
2007	140,000	202,211 [a]	9,369	12,959 [a]	1,567	2,400 [a]
2008	142,000	213,551	9,703	13,627	1,615	2,524
2009	144,000	216,419	9,986	13,802	1,655	2,558
2010	146,000	219,416	10,273	14,042	1,696	2,604

[a] *Data for years 2006 and 2007 are updated for the latest California Air Resources Board assumptions (CARB, 2007b)*

The extent to which out-of-state trucks in particular are captured in official state data varies. The Caltrans and CARB data utilize state vehicle registrations to estimate truck population, and the U.S. Census data use trucks' company home addresses ("home base") to survey truck owners. The CARB uses a correction factor, multiplying heavy-duty mileage and population by 1.33 to account for "out-of-state" trucks' estimated 25% of activity (CARB, 2006).[2] The Caltrans truck population is California-registered trucks only; whereas the Caltrans data on miles traveled include all trucks regardless of registration status. Therefore, the information uncovered from

[1] Note that the U.S. Department of Transportation's designation of Class 8 trucks for those with greater than 33,000 gross vehicle weight rating is used in this report. Class 8 coincides with the CARB's classes "T7" and "T8" (together) and Caltrans' "TRK4" categories.

[2] Note that the 25% out-of-state activity estimation used by CARB results from multiplying California registered trucks by 1.33. Thus, the new corrected value (for population, VMT, etc.) is 33% higher than for California registered trucks alone. Therefore, the estimated percent of out-of-state activity in California is 0.33/1.33, or approximately 25% of total activity.

this study on non-California-registered trucks will be considered differently when comparing to the different reference datasets. These issues will be further discussed in the analysis.

The number of "out-of-state" trucks traveling into California is even less clear. Definitions of out-of-state trucks differ, and much of the existing data are not public. On the topic of definitions, trucks can be headquartered, registered, "home-based," or primarily driven in various states and countries; however, due to the large traveling distances and market demands involved in long-haul trucking, these classifications do not always coincide with one another. For example, a truck tractor can be registered and licensed in a southeastern state, where the truck's company office is headquartered. Yet the tractor (and/or the tractor's primary driver) could be "home based" in another non-California state that is a primary delivery location or where the primary driver's family is located. This truck could be registered in the International Registration Plan (IRP), a widely used voluntarily program which tracks state-by-state truck mileage for truck taxation toward highway expenditure allocation, through its registered state's Department of Motor Vehicles. In contrast to the above long-haul example, and on the other side of the spectrum, are more local California trucks, which could be licensed and home-based in California and travel almost exclusively in California, save for infrequent drop-offs just across the border into Nevada. We focus on non-California-registered long-haul trucks that travel through California.

There are two programs that track records related to non-California-registered trucks that travel in California: the IRP as introduced above, and the International Fuel Tax Agreement (IFTA). The IRP offers a certification program for out-of-state commercial vehicles that intend to travel in California, for which trucks declare the maximum expected weight of the loaded truck and truck mileage while traveling in the state. Records from the California Department of Motor Vehicles (DMV) for 2005 indicate that 1.7 million trucks from other states are IRP-registered for California travel, while more than 50,000 California-licensed trucks are IRP-registered for non-California travel (Conway, 2006). However, of more importance than the total truck numbers, is the extent to which they are traveling on California roadways. It is likely that only a fraction of the 1.7 million CA-IRP-registered trucks are in California on any given day. The data for IRP truck numbers, their classification (by weight and vehicle type), and their mileage in California are held by the individual states in which these trucks are headquartered. However, such detailed information is not available in electronic form at the California DMV level (Conway, 2006) or at the federal-level IRP (Ward, 2006).

The second program that tracks inter-state truck travel is the IFTA. The IFTA offers a registration plan that streamlines permitting and fuel taxation for truck companies and is used to allocate state fuel taxes. As with IRP data, no data have been found to be publicly available from IFTA databases. A synthesis of IFTA and IRP data from state records has been conducted by Stonebridge Associates, but this work is not freely, publicly available (Rosza, 2006).

Although information on the frequency of out-of-state truck entries into California from the two interstate agencies (i.e., IRP and IFTA) has not been found, data from several other sources offer enough information to make pre-survey estimations of out-of-state truck travel and non-California fuel usage and help determine the key variables to examine in the survey.

Caltrans estimates annual average daily vehicle traffic volume on all state routes via periodic (i.e., every several years) traffic counts and estimations. There are several potential concerns

related to the validity of the Caltrans data, due to infrequent actual truck counting and reliance on unverified estimation methods (SCAG, 2002); nonetheless, the Caltrans (2005a, 2006a) traffic count data are the only comprehensive dataset of statewide truck counts for the California highway system and are therefore presented and utilized here. These data are shown for interstate truck routes in Table 3. Adding up the traffic counts at all of the state routes that cross the California state line offers an estimation of the total border crossing volume, the highest traffic flow routes, and the breakdown of trucks by number of axles. From Caltrans estimates, approximately 28,000 trucks enter California each day. Of this total number of trucks, about 70% are five-axle trucks (which are most likely to be heavy-duty diesel trucks). And, relevant to this survey, of the five-axle trucks, more than three-quarters enter California on seven main interstate routes (SR-905, SR-7, I-10, I-40, I-15, I-80, and I-5).

Table 3. Commercial Truck Entry into California, 2004-2005

Bordering Region	Route	2005 [a]		2004 [b]	
		All Trucks	5+ Axle	All Trucks	5+ Axle
Oregon	I-5	2,061	1,744	2,103	1,779
	SR-97	658	551	642	537
	SR-101	388	80	398	82
	SR-139	254	194	236	176
	SR-199	250	90	235	85
	SR-395	75	53	265	70
Nevada	SR-6	106	69	106	69
	I-15	3,637	2,539	3,457	2,414
	SR-50	496	54	512	55
	I-80	2,645	1,857	2,784	1,954
	SR-88	163	99	133	81
	SR-95	204	157	186	143
	SR-127	90	76	105	88
	SR-167	1	1	1	1
	SR-178	44	13	40	12
	SR-182	13	5	15	6
	SR-266	6	3	6	3
	SR-266	2	0	2	0
	SR-299	2	0	265	70
	SR-395	120	105	265	70
Arizona	I-8	1,756	1,145	1,436	936
	I-10	5,015	4,160	4,600	3,815
	I-40	3,757	3,287	3,647	3,191
	SR-62	683	478	473	331
Mexico	I-5	1,166	363	1,331	414
	SR-7	936	635	783	193
	SR-111	774	191	783	193
	SR-186	257	67	279	72
	SR-188	394	172	407	177
	SR-905	2,032	1,394	1,835	1,258
Total		27,981	19,575	27,328	18,275

[a] *based on Caltrans annual average daily truck counts (Caltrans, 2006a)*

[b] *based on Caltrans annual average daily truck counts (Caltrans, 2005a)*

Note that percent changes from 2004 to 2005 truck counts for each individual highway should not necessarily be construed as one-year changes in truck traffic counts; these changes could result from periodic corrections made to the database that are generally made on several-year intervals.

The interstate traffic counts in Table 3 are consistent with the expected overall California truck activity increases. California agencies project steady increases in overall commercial truck vehicle miles traveled and fuel use of about 3% to 4% per year through the year 2010 (Caltrans, 2006b; CARB, 2007a; CARB, 2007b). However, any impacts of interstate trucks found in this study's investigation of interstate trucks must be seen in the context of the potential increasing commercial truck activity and in particular increasing international trucking related to the full implementation of the North American Free Trade Agreement (NAFTA). One point of note is the potential for some highway border crossings to experience more growth than others in future years.

As shown in Table 3, the two primary Mexico-California corridors, in terms of both 2005 truck counts and growth, are SR-905 (Otay Mesa to San Diego) and SR-7 (from Mexicali to Calexico). Multi-year data from the SR-905 at Otay Mesa in Figure 1 show truck crossings (from CHP, 2006). At the time of the study, the majority of these Mexico-based trucks were limited to traveling within 20 miles of the Mexico border on their trips into the U.S.; however, this restriction may change to allow more Mexico-based trips into California (CARB, 2005).

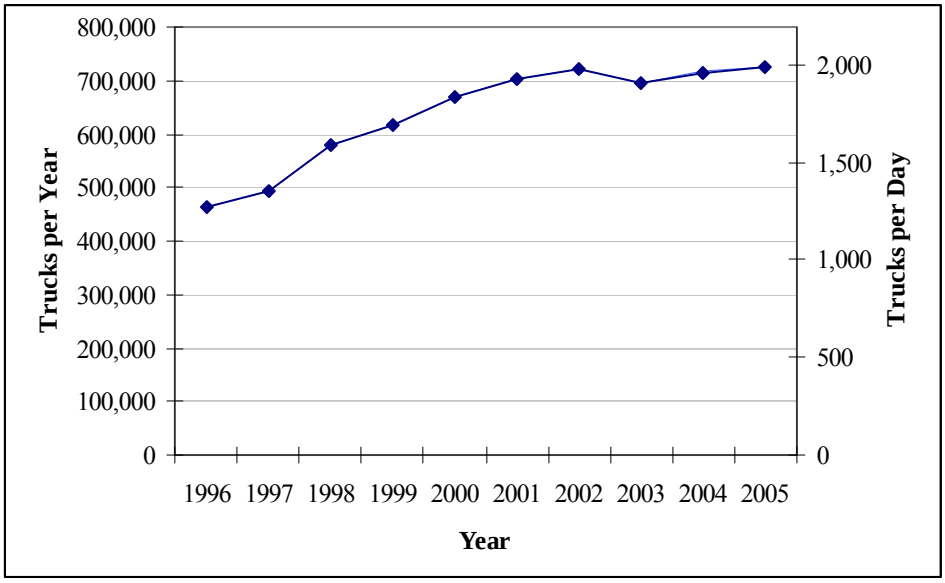

Figure 1. Commercial Truck Entries into California at Otay Mesa Inspection Station (CHP, 2006)

While this research provided the numbers of trucks, total mileage, fuel use, and on the frequency of trucks crossing California boundaries, we sought additional information for the subset of long-haul interstate trucks that travel in California. Given the lack of previous studies, we used various sources to approximate out-of-state truck and fuel use. These approximations provide a clearer understanding of the data gaps that the survey questions were designed to fill in.

Combining the Caltrans (2006a) truck traffic counts and IRP (Conway, 2006) interstate truck registrations, discussed previously, we estimate the total number of trips into California per year by interstate-traveling trucks. From Conway (2006), 1,736,156 trucks are registered in non-California states and are IRP-registered for interstate travel, and an additional 57,019 trucks are California-registered and IRP-registered for interstate hauling. From the Caltrans traffic counts

for highway routes of entry into California (i.e., 27,981 truck entries per day, or about 10.2 million truck entries per year), we approximate that interstate trucks take about 6 trips into California per year. However, further information from IRP, e.g., on the distribution of trips per truck across the IRP-registered trucks, was not available.

Some additional data were acquired from various other sources. Traffic counts by the California Highway Patrol (CHP) personnel at the border inspection facilities provided total commercial truck crossing numbers. The Arizona Department of Transportation records provided another set of estimations for the three Arizona-California interstate highway border crossings. These additional data sources, shown in Table 4 (by highway) and Table 5 (by bordering state/country), highlight the uncertainty in the data. This is not surprising since these data were collected from various sources with various methods and assumptions.

Table 4. Interstate Truck Travel Entries into California, by Major Highways

State or country of entry	Highway	Number of Trucks Entering California Daily (Trucks/day)				
		Caltrans (2006a) Counts All Commercial Trucks	Caltrans (2006a) Counts 5-Axle Trucks	From Caltrans (Avis, 2006) 5-Axle Trucks	CHP Commercial Truck Counts	Arizona Commercial Truck Counts (ADOT, 2005)
Oregon	I-5	2,061	1,744	1,938	1,545	-
Nevada	I-80	2,645	1,857	1,803	-	-
	I-15	3,637	2,539	2,867	-	-
Arizona	I-40	3,757	3,287	2,673	-	2,800
	I-10	5,015	4,160	-	-	4,375
	I-8	1,756	1,145	-	-	1,411
Mexico	SR-905	2,032	1,394	-	1,983	-
	SR-7	936	635	-	-	-
Total	-	21,838	16,761	-	-	-

Table 5. Interstate Truck Travel Entries into California, by State

State or country of entry	Primary highway (s) from state or country	Number of Trucks Entering California Daily (Trucks/day)			
		Caltrans (2001) Survey, 5+ Axle	Caltrans (2006a) Counts All Routes, All Commercial Trucks	Caltrans (2006a) Counts from All Routes, 5+ Axle Trucks	Caltrans (2006a) Counts from Primary Highways, All Trucks
Oregon	I-5	3,485	3,686	2,710	2,061
Nevada	I-80, I-15	7,891	7,528	4,977	6,282
Arizona	I-40, I-10, I-8	13,146	11,210	9,069	10,527
Mexico	I-5, SR-905, SR-7	1,296	5,559	2,820	2,968
Total	-	25,817	27,981	19,575	21,838

The truck counts are annual-average daily counts, taken from state agency data. The tables document the average flow of trucks into and out of California; however these traffic counts vary substantially on both seasonal and weekly bases. This seasonality may be of interest from a pollutant standpoint, such as ozone, which has strong seasonal variations. Data illustrating the temporal variations for several major trucking routes are shown in Figures 2 (daily variation) and Figure 3 (monthly variation) from two data sources (Avis, 2006; CHP, 2006). The average daily

data for interstate truck routes reveal heavier traffic through the weekdays, with weekend counts often averaging approximately half of the weekday figures.

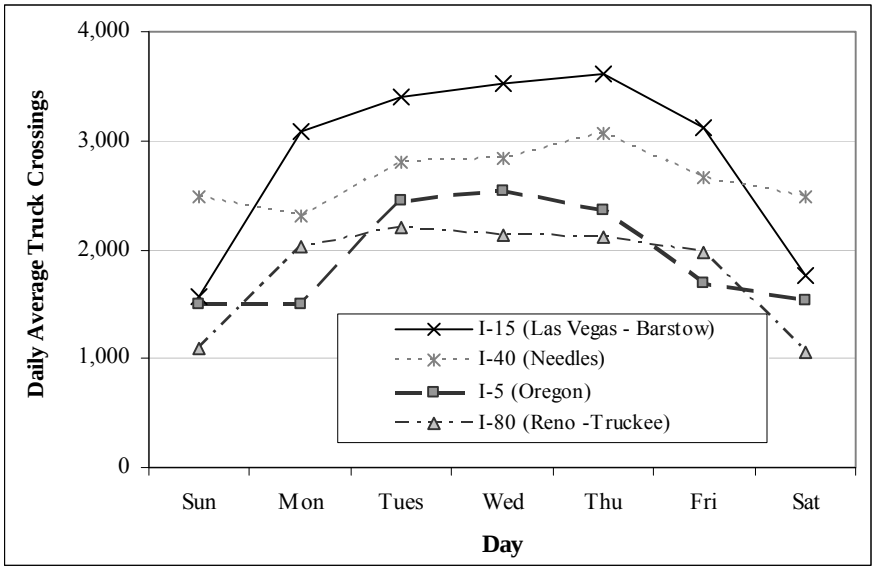

Figure 2. Average Daily Truck Crossings into California in 2005, by Day of Week

Referring to Figure 3, throughout the year, the interstate truck entry data that are available reveal steady and relatively high traffic through the summer and fall months, with some increase until the winter holiday period, then a drop-off after the holiday season into the first months of the year. The peak late summer traffic counts were generally between 20% and 50% higher than the January-February counts for each location. The largest increase was for the I-80 Reno-to-Truckee corridor, which had 50% higher traffic in September than for January. An exception to the seasonal spiking is for the Oregon I-5 truck traffic, which was more steady throughout the year, with only an 11% difference between low- (January) and high- (June) traffic months.

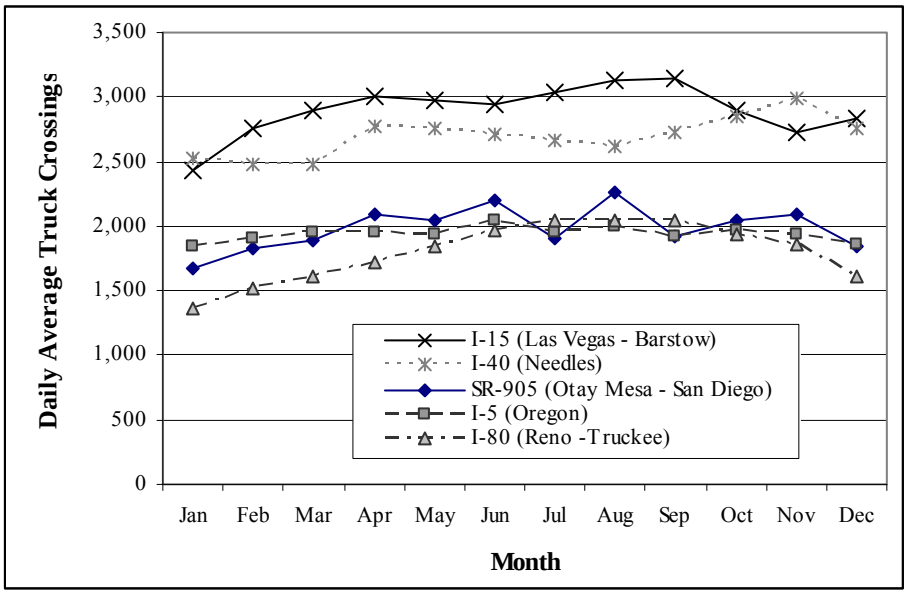

Figure 3. Average Daily Truck Crossings into California in 2005, by Month

b. Emissions and Fuel Considerations for Interstate Trucks

The emissions and fuel characteristics of California and non-California-registered trucks could differ due to several factors. For example, emissions standards for older trucks differ. Figure 4 depicts the change in heavy-duty diesel engine emissions standards over time for California, the rest of the U.S. and Mexico (DieselNet, 2007b; INE, 1993). The Mexican truck fleet is older on average by model year than the U.S. fleet. Although a comprehensive breakdown of trucks is not available, it is estimated that 25% of the Mexico-based trucks are of model year 1980 or older, and 66% of the Mexican fleet is of 1993 model year and older (CARB, 2005). According to the U.S. Census' *VIUS* data from 2002, only 29% of heavy-duty truck vehicle miles by California-based trucks are by trucks from model year 1993 or before (U.S. Census, 2004).

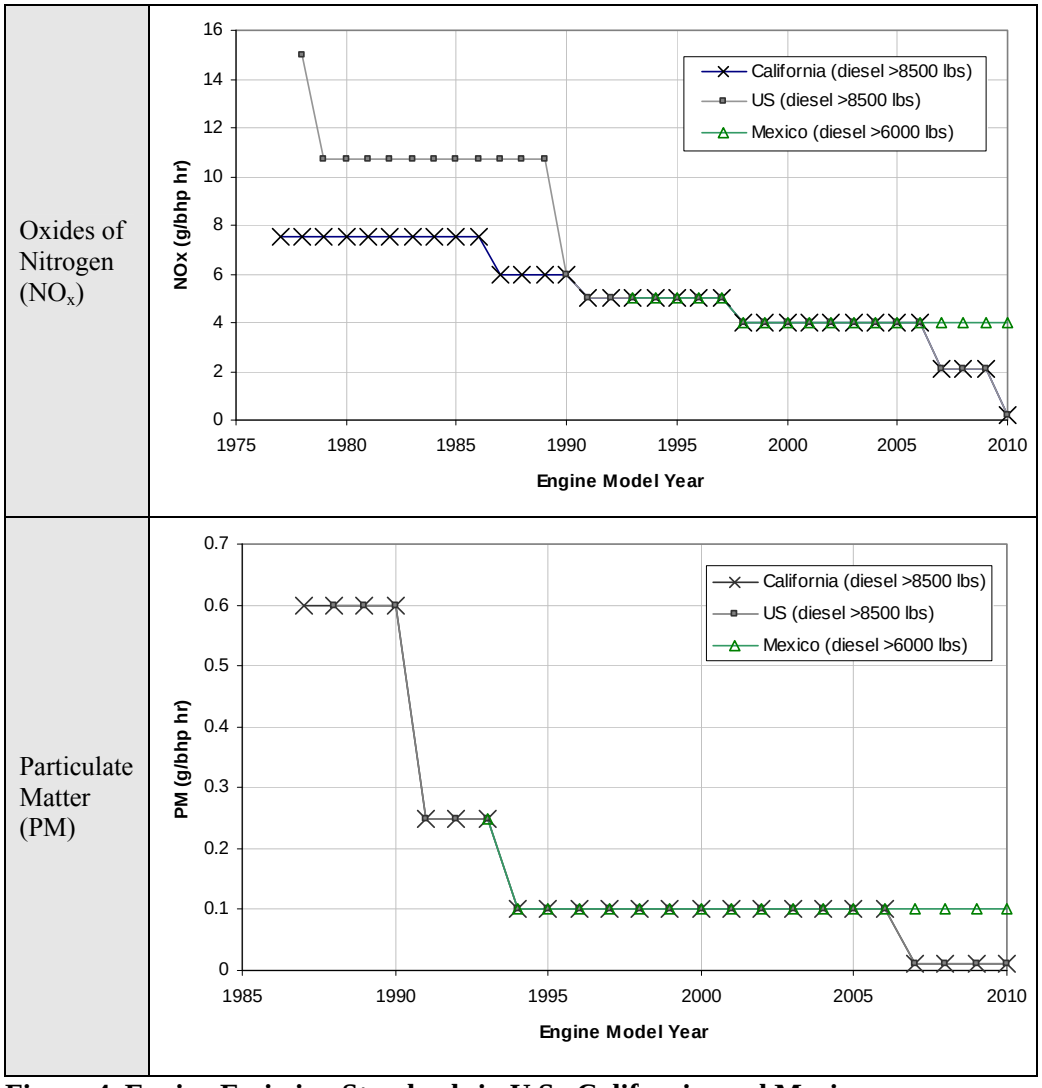

Figure 4. Engine Emission Standards in U.S., California, and Mexico

Trucks of the same model year from the U.S. and Mexico have been found to have differing emissions characteristics. For Mexico-registered trucks, emissions characteristics have been estimated with a system whereby engines of a given year are assigned an equivalent U.S. model year for emissions (Sierra Research, 2002); for example, a 1990 Mexican truck is given emission rate of a 1986 U.S. truck. Using the Sierra Research (2002) truck model year correction, U.S. and California engine model year standards, and average EMFAC emission rates for heavy heavy-duty diesel PM rates, the difference between Mexico-based and California-certified trucks by model year is presented in Figure 5. As shown in the figure, for model years 1990 and before, Mexico trucks have substantially higher gram-per-mile rates.

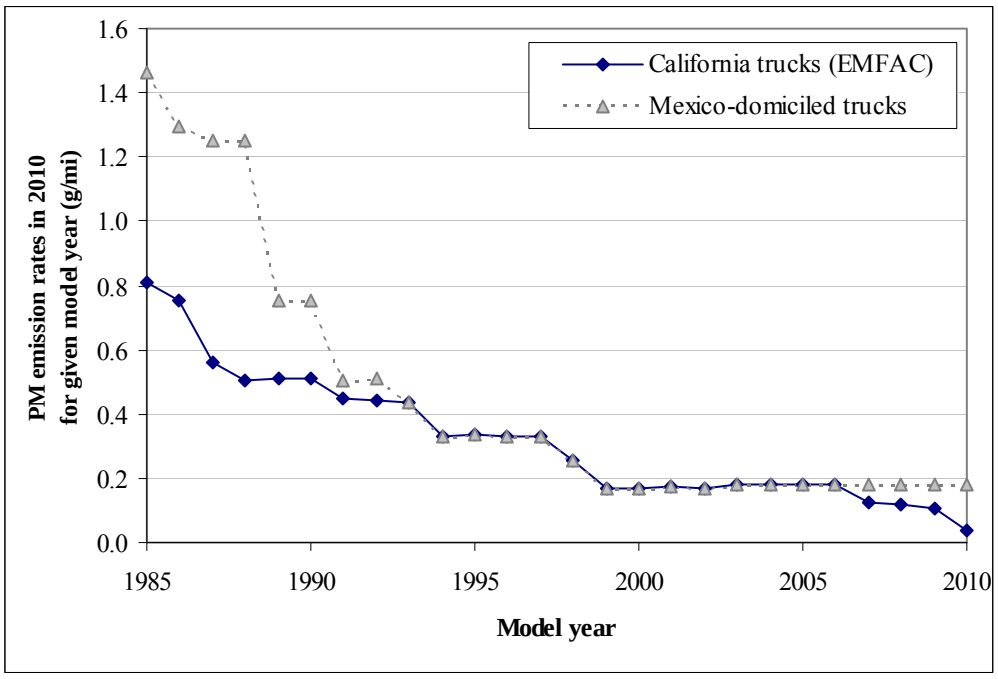

Figure 5. California and Mexico Heavy Duty Diesel Truck Emission Rates by Truck Model Year

Fuel quality differences may affect emissions. Fuel quality differences impact emissions in two primary ways: (1) certain fuel characteristics directly impact emission rates from vehicles and (2) certain fuel characteristics can affect various vehicle aftertreatment emission-reduction devices for vehicles. The impact of the different diesel fuels on emissions is complex and based on a multitude of vehicle factors, including engine technology, vehicle age, and fuel characteristics (see for example, U.S. EPA, 2001; Hadder et al., 2002). A thorough investigation that quantifies these fuel-related emission differences is outside of this research study's scope. However these factors are mentioned here, because they are motivating factors for adjusting the fundamental truck activity data statistics, which could affect average emissions characteristics.

One prominent difference from an emissions standpoint is in the sulfur content of the diesel fuels; other fuel content differences include aromatic compound content and the fuel's cetane number. Figure 6 depicts regulatory levels for diesel fuel sulfur content. Federal and California diesel fuel regulations were in a transition at the time of this literature search—shifting to a lower sulfur content level. At the federal level, the U.S. Environmental Protection Agency (U.S. EPA) regulates diesel fuel properties, and through 2004, the fuel sulfur content was regulated to be lower than 0.05% or 500 parts per million (ppm) by weight. Estimates for actual U.S. highway

diesel sulfur content include 333, 340, and 350 ppm (from respectively, U.S. EPA, 2001; Leister, 2003; WSUEEP, 2002), although no comprehensive data appears to validate any particular value. The EPA upheld its proposal to mandate a transition to 15-ppm sulfur content maximum for diesel from 2004-2006 to aid in truck engine manufacturers' efforts to achieve 2007-2010 emissions regulations. From 2006 through 2010, 80% of diesel must be at or below 15 ppm, and the remaining 20% is subject to the 500-ppm maximum (DieselNet, 2006).

Through 2005, California diesel was mandated by the CARB to be less than 0.05% sulfur, or 500 ppm, by weight (CARB, 2004). However, California diesel fuel has been consistently and substantially lower than the minimum sulfur content regulation. Surveys through the late 1990s have shown that sulfur content has been 100 to 150 ppm. A 1997 California Energy Commission (CEC) survey reported California volume-weighted diesel to contain 141 ppm sulfur (CARB, 2000). Similarly, a survey of Los Angeles area diesel from 1995 through 2000 found a sulfur content of 130 ppm (U.S. EPA, 2001).

Mexico's standard grade diesel fuel was 0.5% sulfur (5000 ppm) and only in a few cities was the 500-ppm sulfur diesel fuel known as "Diesel Sin," introduced (DieselNet, 2007a). Proposed regulation (NOM – 086) would take the sulfur content maximum down to 15 ppm (Sanchez, 2004; Berumen, 2004). No data were found to be available on the actual diesel fuel qualities in Mexican trucks entering the U.S. border. Ongoing US EPA-commissioned studies seek to study the fuel quality and driving practices of trucks at the US-Mexico border (APF, 2005a; APF, 2005b).

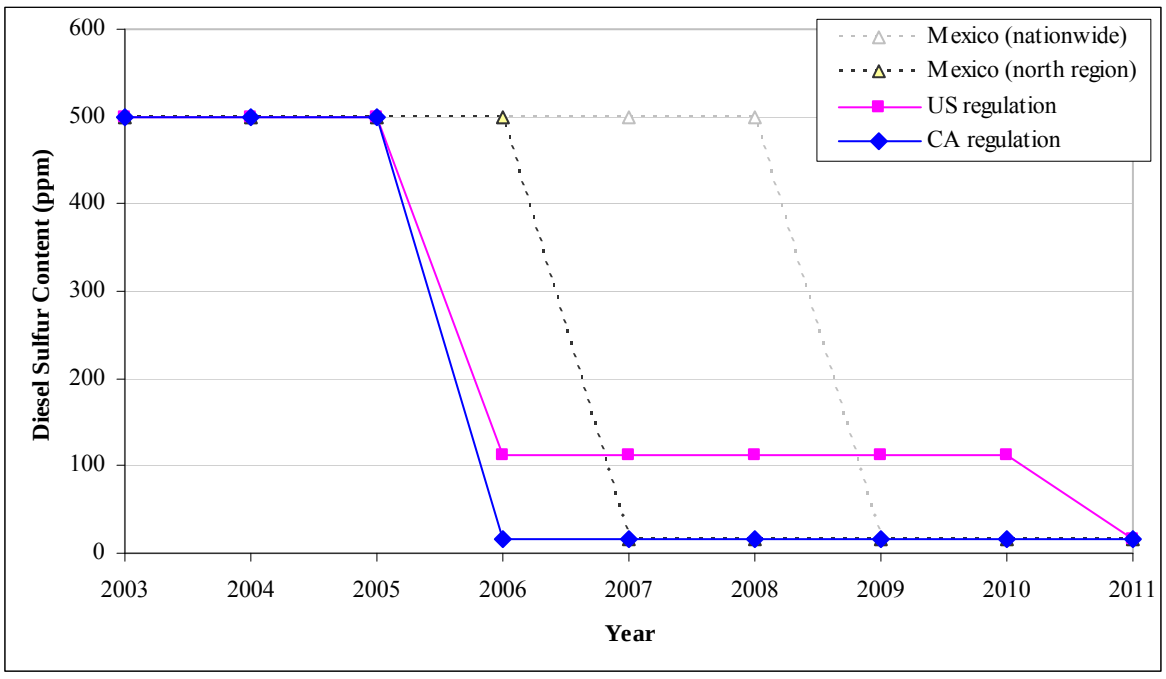

Figure 6. Diesel Sulfur Content in US, California, and Mexico

c. Analysis of Caltrans (2001) Heavy Duty Truck Travel Survey Data

The Caltrans' (2001) *California Heavy Duty Truck Travel Survey on Selected Sites*, although focused more generally toward overall statewide truck patterns, also offers important information on out-of-state truck activity in California. The survey was an assisted, in-person interview of with truck drivers in 1999 and 2000, and it resulted in 8287 collected surveys from 33 sites. The survey locations were state inspection facilities (weigh and agricultural enforcement facilities) and roadside rest areas. The location selection inherently captures interstate trucks. The surveys were often conducted over the busiest periods of day, for 8 to 16 hours in a day, and these data were expanded to 24-hour periods via periodic videotaping. All the data were collected mid-week (on Tuesdays, Wednesdays, and Thursdays), so the extent to which travel patterns differ on weekends is not represented in the data.

Our analysis here of the Caltrans (2001) dataset is an original analysis of relevant portions of the raw data set (Khoii, 2006). From the full data set, we excerpted the truck survey data entries for trucks that began and/or ended their current leg of their trips outside of California. Also we excluded the small percentage of 3- and 4-axle trucks that made up approximately 1% of the data set; this exclusion was justified to allow comparison with other datasets. After these exclusions, there are 2014 surveys of interstate trucks traveling in California.

The Caltrans dataset contained information on trucks' last stop, next stop, last fueling location, and daily mileage. Additionally, the data had also been geocoded and translated into origins and destinations (by California counties and regions) by Caltrans researchers. The Caltrans survey also logged accompanying truck traffic count data, which enabled us to extrapolate from the sample to the state-level.

We analyzed the data to identify trucks entering California by the state or country in which they last loaded, unloaded, or started the day. These data are summarized by the state of the trucks' previous stop in Table 6. As shown in the table, more than half of the heavy-duty trucks entering California last stopped in Arizona. About two-thirds of all the interstate-traveling trucks that were in California last refueled outside of California.

Table 6. Interstate Heavy Duty Truck Activity for Heavy Duty Trucks Entering California [a]

State/Country of Last Stop (for load, unload, or start of day)	Survey Responses	Survey Responses that Last Fueled Outside California	Estimated Interstate Truck Traffic (trucks/day)	Estimated Truck Traffic of Trucks Carrying Non-CA Fuel (trucks/day)	Percent of Interstate Trucks Carrying Non-CA Fuel
Arizona	684	519	16,476	11,532	70.0%
Nevada	293	205	8,008	4,989	62.3%
Mexico	226	72	2,469	792	32.1%
Oregon	117	90	3,037	2,417	79.6%
New Mexico	38	34	871	677	77.7%
Utah	29	21	1,197	608	50.8%
Washington	9	7	306	189	61.7%
Texas	3	2	99	67	68.0%
Total	1399	950	32,463	21,271	65.5%

[a] *Based on Caltrans (2001) California survey data for 5-axle trucks for which the last stop was outside of California; estimated truck traffic in last three columns based on that study's truck count expansion numbers.*

Table 7 shows Caltrans' data for trucks that are exiting California during the day that they were surveyed. A total of 615 surveys were extrapolated (from the survey's accompanying truck traffic count data) to represent 19,170 trucks per day that are exiting California.

Table 7. Interstate Heavy Duty Truck Activity for Heavy Duty Trucks Exiting California [a]

State/Country of Next Stop (for load, unload, or start of day)	Survey Responses	Survey Responses that Last Fueled Outside California	Estimated Interstate Truck Traffic (trucks/day)	Estimated Truck Traffic of Trucks Carrying Non-CA Fuel (trucks/day)	Percent of Interstate Trucks Carrying Non-CA Fuel
Arizona	215	77	7,743	2,770	35.8%
Nevada	170	55	4,490	1,472	32.8%
Mexico	7	3	122	38	31.1%
Oregon	81	18	2,696	580	21.5%
New Mexico	13	5	382	162	42.5%
Utah	54	18	1,314	420	31.9%
Washington	26	5	879	157	17.8%
Texas	15	5	538	208	38.7%
Other States	34	10	1,005	339	33.7%
Total	615	196	19,170	6,146	32.1%

[a] *Based on Caltrans (2001) California survey data for 5-axle trucks for which the last stop was outside of California; estimated truck traffic in last three columns based on that study's truck count expansion numbers.*

Several data manipulations were required to estimate the average mileage and fuel use. Because drivers reported mileage driven between the next and last stops, there is no direct measure from the Caltrans (2001) survey of what amount of the truck miles were on California highways. Therefore, we subtract for non-California miles to attempt to correct for the potential over-counting for mileage of the trucks that was traveled out of state.

Each state of origin (and destination) was assigned an approximate mileage based on the most prominently listed city in that state on each interstate route. That location's distance from the California border was recorded. For example, trucks last stopping in Oregon on I-5 before entering California, get a daily mileage subtraction of 29 miles, for the distance between Medford, Oregon and the California border; this correction reduces the average responded daily

total truck travel of 479 miles/day/truck to a *California-specific* average of 450 miles/day/truck for trucks that have Oregon as an origin or destination.

Determining points of entry was more straightforward. For all non-border states that were listed as the last (or next) stop, trips were assigned to the most logical port of entry; New Mexico assigned to Arizona, Washington to Oregon, Utah to Nevada.

One final data approximation was employed to determine the percentage of interstate truck mileage that is driven on non-California fuel. Because data were taken on the state of last fuel but not the exact location of fueling, the refueling location for trucks that fueled in California was assumed to be the midpoint in California for that day of travel for each truck. For example, a truck from Oregon that started in Medford and traveled 450 miles in California and refueled that first day in California was assumed to have refueled at the midway point in California, at 225 miles. Likewise, for trucks that first refueled in California on the day that they exited California, half of the in-California miles are apportioned to California fuel (and half to non-California fuel).

The following two tables show the numbers of interstate trucks, these trucks' average mileage on California highways, and their miles that involve out-of-state fuel. Table 8 shows these numbers for trucks on their day of entry into California from each bordering state (or country) from which the trucks could enter California. Table 9 shows trucks on the day that they exit California and presents the data according to the state (or country) into which the trucks will exit California.

As shown in Tables 8 and 9, on average, interstate trucks on their entry and exit days are traveling approximately 350 miles per day in California. Trucks arriving from and departing for Oregon average longer total traveling in California – with 433 miles on the day of entry and 466 on the day of exit – compared with other bordering regions, and this is consistent with the longer distances from the main California ports, urban areas, and economic centers from the Oregon border. Average truck travel from Mexico-based trucks deviated the most from the rest of interstate trucks. Trucks from Mexico traveled less in California on their entry day, were more likely to have California fuel, and traveled less on their exit day. A reason for the lower mileages to and from Mexico is likely the legal restriction of many of these trucks to traveling within 20 miles of the California border.

Table 8. Interstate Truck Travel on California Highways, on Day of California Entry

State or country of entry	Surveys	Trucks	Trucks with non-CA fuel	Percent of trucks with non-CA fuel	Average mileage (mi/day/truck)	Average mileage with non-CA fuel (mi/day/truck)	Percent of interstate truck miles with non-CA fuel
Oregon	126	3,343	2,606	78.0%	433	387	89.3%
Nevada	322	9,205	5,598	60.8%	375	303	80.6%
Arizona	725	17,446	12,275	70.4%	365	311	85.1%
Mexico	226	2,469	792	32.1%	119	79	66.0%
Total	1399	32,463	21,271	65.5%	356	299	83.8%

Table 9. Interstate Truck Travel on California Highways, on Day of California Exit

State or country of exit	Surveys	Trucks	Trucks with non-CA fuel	Percent of trucks with non-CA fuel	Average mileage (mi/day/truck)	Average mileage with non-CA fuel (mi/day/truck)	Percent of interstate truck miles with non-CA fuel
Oregon	109	3,626	760	21.0%	466	228	48.8%
Nevada	251	6,577	2,166	32.9%	361	167	46.3%
Arizona	249	8,845	3,182	36.0%	300	158	52.8%
Mexico	7	122	38	31.1%	207	78	37.5%
Total	616	19,170	6,146	32.1%	352	174	49.4%

We assume that trucks are entering California one day and exiting the next day to the same bordering region. The resulting composite two-day trips into California are estimated in Table 10. These data for trucks entering and trucks exiting are not the same actual truck drivers responding about their entrance and exit from the state – they are different trucks and drivers, and their data are being concatenated under the assumption that they are taking two-day trips into California. Note that, as a result of this composite estimation, the mileage-weighted daily average miles-per-truck values change somewhat with the resampling of the number of trucks for two-day trips to make the number of trucks into and out of each state equivalent.

From Table 10, the average two-day trip summaries for trucks trips into California from each bordering region are shown. The table includes mileages for the entry day, exit day, two-day composite. The mileage-averaged California trip by interstate trucks is 365 miles on the day of entry and 336 miles on the day of exit, making for a trip total of 701 miles in California from entry to exit. Of the 701-mile California trip, 473 miles are estimated to have been driven on out-of-state fuel.

Table 10. Interstate Truck Trip Mileage in California

State or country of entry and exit	Average each-way truck traffic, entering and exiting (truck/day)	Entry day		Exit day		Composite two-day trip	
		Average Mileage (mi/day/truck)	Average Mileage, Non-CA Fuel (mi/day/truck)	Average Mileage (mi/day/truck)	Average Mileage, Non-CA Fuel (mi/day/truck)	Miles per CA Trip	Non-CA Fuel Miles per CA Trip
Oregon	3,485	433	387	466	228	899	614
Nevada	7,891	375	303	361	167	737	470
Arizona	13,146	365	311	300	158	665	469
Mexico	1,296	119	79	207	78	326	156
Total	25,817	365	307	336	166	701	473

Based on the average truck activity estimations above, a simple schematic representation of trucks entering and exiting California is shown in Figure 7. Over a typical two-day trip, which is equivalent to entering one day and exiting the next, interstate heavy-duty trucks entering from Oregon, Nevada, and Arizona generally drove between 300 and 500 miles on the first day before their resting period. During that entry day, about 34% of trucks refueled at California fueling stations. Out of the 66% remaining, nearly one-half refueled in California on their exit day.

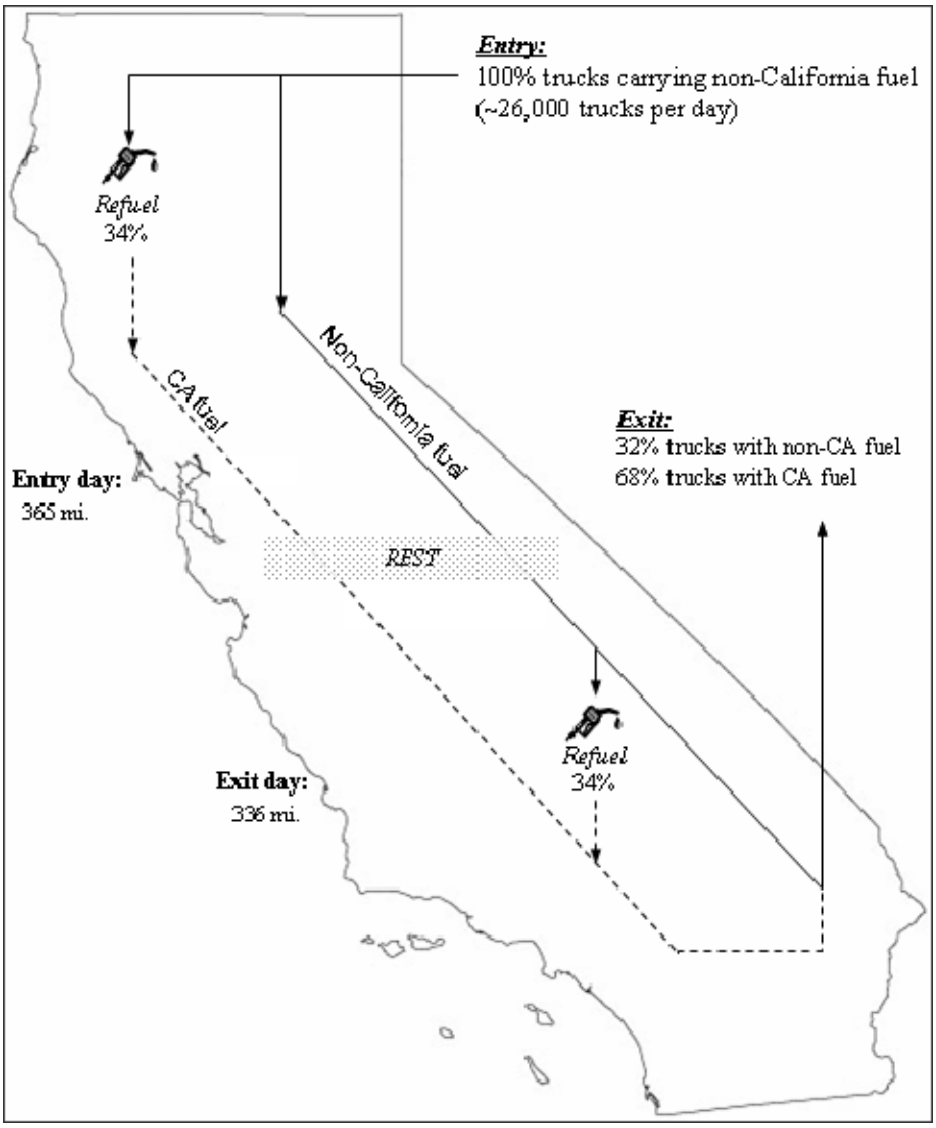

Figure 7. Estimated Pre-Survey Interstate Truck Travel and Fueling Pattern in California

Table 11 shows the average interstate truck mileage characteristics in California. The total travel, in million miles per year, is calculated as the product of the number trucks, the mileage per day per truck, and days per year, divided by one million. This calculation is done for each row (i.e., each neighboring region) and summed. The same system of calculations is done for the mileage on non-California fuel. Assuming two-day trips for each of the approximately 26,000 trucks per day, the total impact of these interstate trucks is to add approximately 3.3 billion miles to California roads. We estimate approximately 2.2 billion of these miles are driven on out-of-state fuel.

Table 11. Interstate Heavy-Duty Trucks' Mileage and Out-of-State Fuel Usage in California

State or country of entry and exit	Estimated number of interstate trucks in CA at any time (trucks)	Miles per day in CA (mi/day/truck)	Miles per day with non-CA fuel (mi/truck)	Total travel by interstate trucks in CA (million mi/yr)	Total travel by interstate trucks in CA with non-CA fuel (million mi/yr)
Oregon	3,485	450	307	572	391
Nevada	7,891	368	235	1,062	677
Arizona	13,146	332	234	1,596	1,125
Mexico	1,296	163	78	77	37
Total	25,817	351	237	3,307	2,230

Table 12 summarizes interstate and non-interstate heavy-duty truck travel in California. These estimations are compared with official California figures from Caltrans (2005b) and CARB's EMFAC2002 (CARB, 2003). It is not clear exactly how and to what extent interstate truck activity is already included in these two California agency estimations for year 2000 statistics. In the table we present the estimations *in addition to* California data from Caltrans and CARB. Depending on the data source for comparison (Caltrans or CARB), heavy-duty interstate trucks make up 14% to 17% of the heavy-duty truck population in California at a given time. These trucks account for approximately 28% to 29% of total heavy-duty truck mileage in California. Our estimation of the amount of these trucks' California mileage that is accrued with the use of non-California fuel amounts to 19% to 20% of all heavy-duty mileage. We note that the calculations here do not include subtracting CARB's 1.33 out-of-state truck factor, which we assume to have been included only in CARB's updated EMFAC2007 model (CARB, 2007a), as discussed in CARB (2006).

Table 12. Truck Population and Activity, Total California Heavy-Duty Trucks and Interstate

		Truck Population in CA on a Given Day	Vehicle Miles Traveled (millions miles/yr)
Heavy-Duty Trucks (Class 8, GVWR 33,000+ lbs) in 2000 from Two Sources	MVSTAFF (Caltrans, 2005b)	126,000	8,065
	EMFAC2002 (CARB, 2003)	158,204	8,448
Interstate Truck Activity on Primary Commercial Interstate Routes (Based on this analysis of Caltrans, 2000 data)	Interstate-Traveling Trucks	25,817	3,307
	Interstate Truck Non-CA Fuel	-	2,230
New Estimated Class 8 Heavy-Duty Trucks, If Interstate Trucks Considered *In Addition to* California Estimates	Based on MVSTAFF (Caltrans, 2005b)	151,817	11,372
	Based on EMFAC2002 (CARB, 2003)	184,021	11,755
Percent of Total Activity that is Interstate	Based on MVSTAFF (Caltrans, 2005b)	17%	29%
	Based on EMFAC2002 (CARB, 2003)	14%	28%
Percent of Activity by Non-CA Fuel	Based on MVSTAFF (CalTrans, 2005b)	-	20%
	Based on EMFAC2002 (CARB, 2003)	-	19%

d. Summary of Literature Review Findings and Key Data Needs

Using data available we characterized interstate truck travel on California highways. We accumulated relevant data on total truck populations, general truck activity, truck entries into California, and emissions and fuel attributes of trucks. An analysis of a dataset from Caltrans (2001) was utilized. The results identify the pivotal data gaps for our original survey data collection, and thus provide a starting point for constructing the survey data questionnaire.

The literature review and this analysis of Caltrans (2001) survey data serve as a basis for reasonable estimations and/or data on

- Number of California-registered trucks
- Total annual mileage of California-registered trucks
- Total fuel use of California-registered trucks
- Number of total trucks that annually enter California
- Number of U.S. trucks (and breakdown by number of axles) of trucks entering California on each route
- Miles per day traveled by interstate trucks in California
- Truck model year of California-registered heavy-heavy duty diesel trucks
- General fuel characteristics of California, U.S. (non-California), and Mexico diesel

Deficiencies in our understanding include -

- Number of unique interstate-traveling trucks that travel in California
- Trips per year by interstate trucks into California
- Days per trip into California of interstate trucks entering California (before next leaving)
- Amount of fuel that interstate trucks are carrying into California when entering
- Truck model year of interstate trucks entering California
- Locations, travel patterns of interstate trucks in California
- Breakdown of the interstate-traveling truck attributes by registration status (i.e., California or non-California)
- Breakdown of the interstate-traveling truck attributes by point of entry (e.g., Arizona, Nevada, Mexico)
- Interstate-traveling truck activity (mileage, mileage on non-California fuel) in each California Air Basin

These lists define the variables that we attempt to measure in our survey.

III. DATA COLLECTION

The primary data collection method for this study is an in-person interview survey of truck drivers at points of entry into California. This section describes and summarizes the key elements of the survey strategy, survey instrument design, administration of the surveys, and processing of the survey data.

a. Sampling Design

The targeted population of the survey is heavy-duty trucks entering California. There is no complete directory of this population of vehicles or these vehicles' drivers. The particular drivers, companies, and trucks that enter California differ on daily, monthly, and seasonal bases. However, general data on the number of trucks that make up this sampling frame for the population of interest are approximated by Caltrans traffic counts. Caltrans (2006a) estimates total counts of trucks and their breakdown by number of axles for all major roadways in California primarily collected by periodic truck counting by automated truck counts. The Caltrans data counts and potential surveying facility sites on these routes are shown in Table 13. The Caltrans database was the only one that could be located for all highway routes into California.

Table 13. Potential Sampling Locations and Estimated Truck Entries into California

Bordering Region	Route	2005 Traffic Counts [a]		Potential Survey Locations	
		All Trucks	5+ Axle Trucks	CHP/CADF [b] Inspection Stations	Actual Survey Locations
Oregon	I-5	2,061	1,744	X	X
	SR-97	658	551		
	SR-101	388	80		
	SR-139	254	194		
	SR-199	250	90		
	SR-395	75	53		
Nevada	SR-6	106	69		
	I-15	3,637	2,539	X	X
	SR-50	496	54		
	I-80	2,645	1,857	X	X
	SR-88	163	99		
	SR-95	204	157		
	SR-127	90	76		
	SR-167	1	1		
	SR-178	44	13		
	SR-182	13	5		
	SR-266	6	3		
	SR-266	2	0		
	SR-299	2	0		
	SR-395	120	105		
Arizona	I-8	1,756	1,145	X	
	I-10	5,015	4,160	X	X
	I-40	3,757	3,287	X	X
	SR-62	683	478		
Mexico	I-5	1,166	363	X	
	SR-7	936	635	X	X
	SR-111	774	191		
	SR-186	257	67		
	SR-188	394	172		
	SR-905	2,032	1,394	X	X
Total truck counts		27,981	19,575		
Sampling frame (survey location counts)		20,082	15,615		

[a] *based on Caltrans (2006a) counts, divided by two*
[b] *CHP= California Highway Patrol; CAFD=California Agriculture and Food Department*

The sampling frame is trucks entering California at seven ports of entry. The chosen state highways of entry were based on the truck counts from Caltrans (2006a). The six most heavily crossed highways – I-5 from Oregon; I-80 and I-15 from Nevada; I-40 and I-10 from Arizona; and SR-905 from Mexico – into California were chosen for surveying (note that later the commercial Mexico-domiciled trucks were routed from the San Ysidro [I-5] to the Otay Mesa [I-905] entry). Surveying was also conducted at a seventh location, SR-7, the second most traveled route for commercial trucks from Mexico. Polling truck drivers at these interstate routes offers a sampling frame that represents approximately 72% of the commercial trucks (and 80% of all 5+ axle trucks) entering California, according to the Caltrans traffic counts.

While the highways were chosen by their expected traffic counts, the actual survey site locations were dictated by the availability of state facilities that offered access to our surveying staff, ability to quickly achieve sufficient amounts of completed surveys, and safety and convenience

for surveying to take place without impeding the flow of truck travel into the state. These factors pointed to two primary state facilities types for surveying – CHP Commercial Enforcement Facilities (or "weigh stations") and California Department of Food and Agriculture (CDFA) inspection facilities (or "bug stations"). The resulting survey locations are shown on a map of California with major highways in Figure 8.

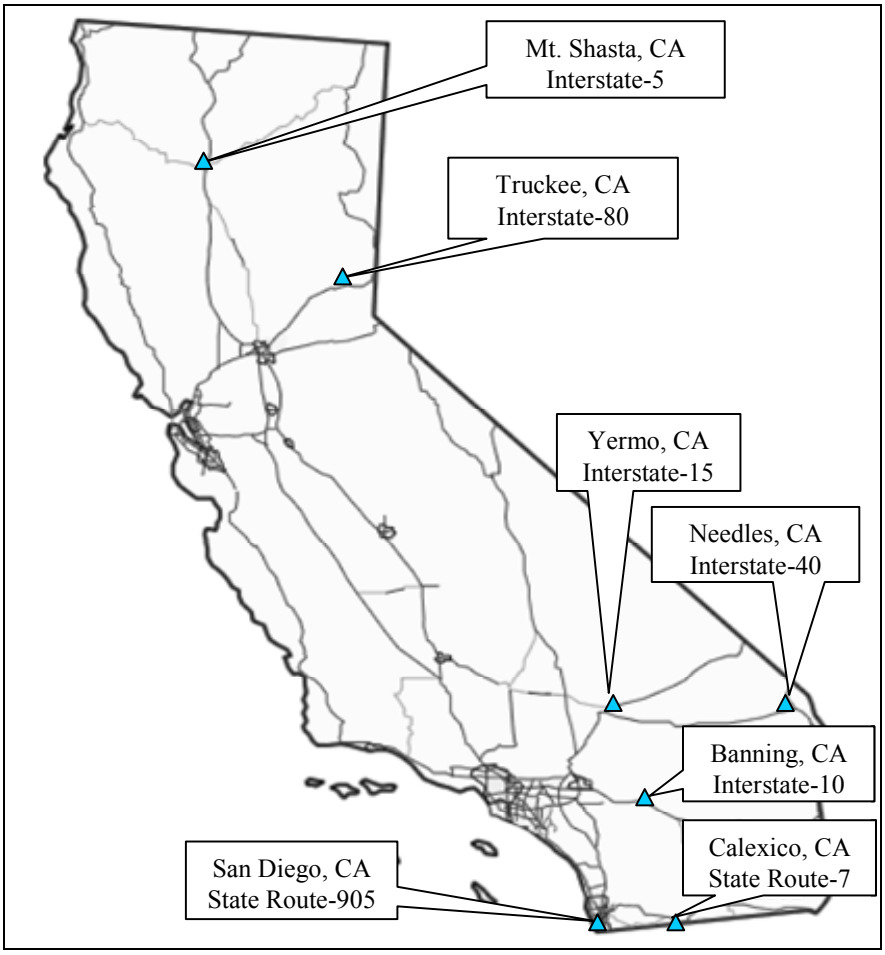

Figure 8. Survey Locations

Determination of the target sample size for statistical significance of the survey is dependent upon the particular variables of interest and intended uses of the data. The significance of any of the results of the survey are dependent on the sample variables' mean and standard deviation variables, and how those relate to the comparable variables for the known population. However, because the chief purpose of this study is to characterize and quantify data for an *unknown population* (i.e., out-of-state trucks), pre-survey target size calculations were not possible. Instead the determination of the number of surveys to be collected from the various locations was dictated by the availability of personnel to facilitate the surveying, time constraints of truck facility operation, and the study's budget.

b. Survey Instrument Design

The survey instrument, shown in Figure 9, was designed to capture the key variables that were outlined in the literature section. With the in-person interview format of the survey, the surveyors could accommodate rarer responses, clarify drivers' responses, and allow for alternative methods of answering questions. For example, nested (i.e., "if so,…") questioning was employed, and alternative units for quantitative variables were offered as options. Questions were asked with the vehicle as the analysis unit, and not the driver (e.g., "how many miles is this truck driven?") to be able to compare the results with estimations of registered trucks. The use of each of the surveyed variables is described later.

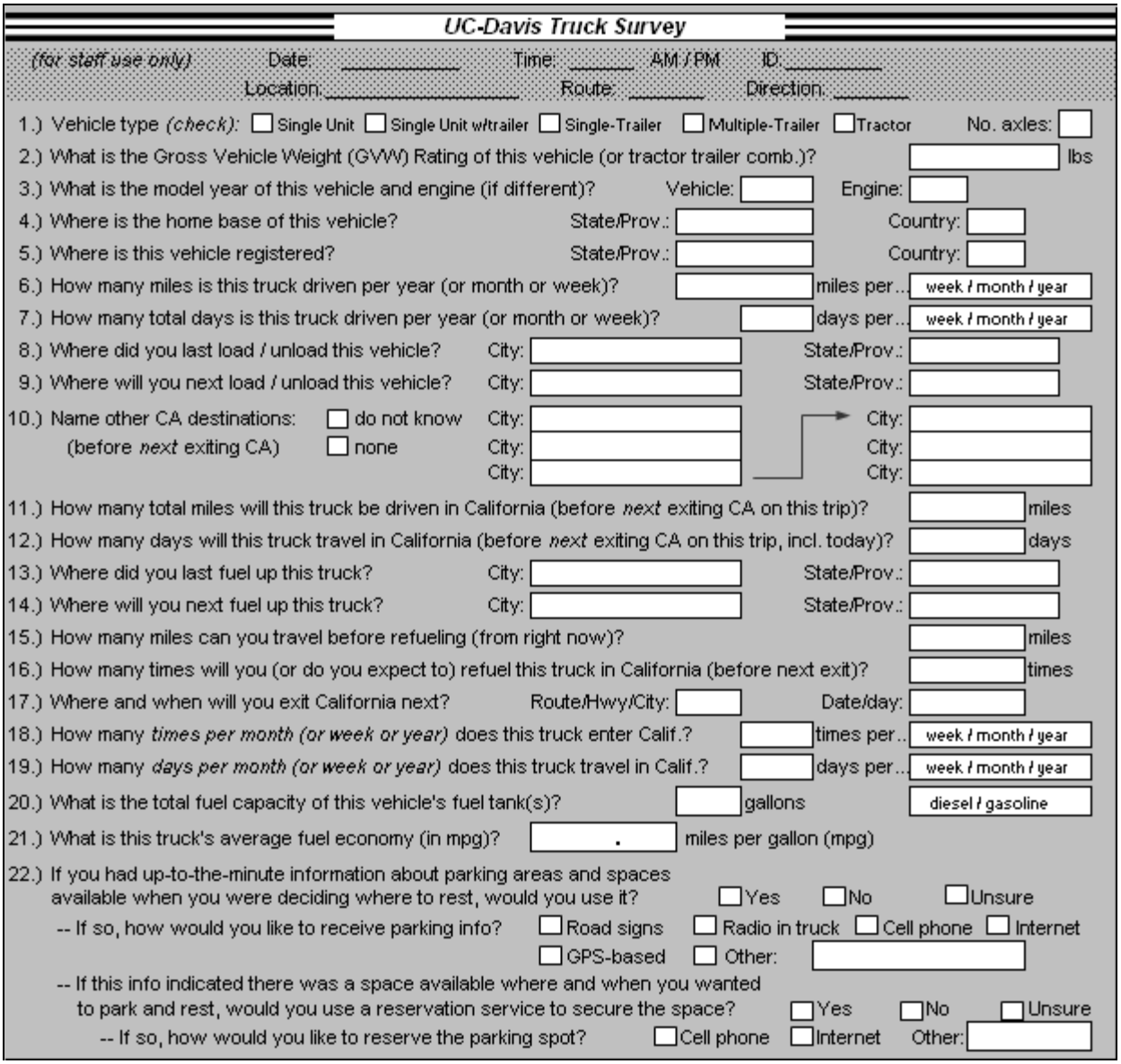

Figure 9. Survey Instrument

There was a survey cover letter that was made available to potential survey respondents. Also, the survey was translated into Spanish. That survey and the cover letters are shown in Appendix A.

c. Survey Administration

The administration of the survey was done by ITS-Davis graduate student researchers in coordination with the inspection personnel at the seven different survey locations. This type of survey is sometimes referred to as truck intercept surveys, because it generally entails intercepting truck drivers who are slowed or stopped at various types of inspection stations. Each surveying location had a slightly different procedure, timing, and survey completion rate, which accommodated the normal operations and truck flow at the truck inspection facilities.

Table 14 provides a summary description of the administration of the surveys at the various locations. The inspection personnel with whom we worked in coordination were the Commercial Vehicle Inspection Specialists at the CHP facilities, the CDFA inspectors, and the CARB inspectors. The surveys were conduced in an interview style, with surveyors holding clipboards with the questionnaires, asking the truck drivers about their travel into California. Most often the surveying was done with drivers remaining in the truck.

Table 14. Survey Administration Timing, Location, and Description

Survey Location, Highway and City	Facility Type(s)	Date(s) in 2006	Completed Surveys	Description
I-80 (Truckee, CA)	CHP and CDFA	8/16, 8/17	68	In CHP commercial vehicle inspection bays, surveys conducted while CHP Commercial Vehicle Inspection Specialists conducted truck and trailer inspection.
I-5 (Mt. Shasta, CA)	CHP	8/22, 8/23	66	In CHP commercial vehicle inspection bays, surveys conducted while CHP Commercial Vehicle Inspection Specialists conducted truck and trailer inspection.
SR-905 (San Diego, CA)	CHP	9/5, 9/6	71	After CHP inspection terminal, trucks were flagged for CARB pollution equipment inspection. Surveys conducted concurrent with CARB inspection
SR-7 (Calexico, CA)	CHP	9/7	33	After CHP inspection terminal, trucks were flagged for CARB pollution equipment inspection. Surveys conducted concurrent with CARB inspection
I-10 (Banning, CA)	CHP	9/13, 9/14	73	Before the CHP terminal, the drivers from the truck queue were flagged into staging area, were the survey was conducted. At the conclusion of the interview, trucks were immediately installed back into the truck queue.
I-40 (Needles, CA)	CDFA	9/18	72	After the CDFA station, trucks were flagged over into coned-off area where interview was conducted.
I-15 (Yermo, CA)	CDFA	9/19	50	After the CDFA station, trucks were flagged over into coned-off area where interview was conducted.

CHP=California Highway Patrol; CDFA= California Department of Food and Agriculture; CARB=California Air Resources Board

The surveying was conducted in the summer of 2006, during the months of August and September, which available data indicated were among the busiest months for interstate truck travel (see Figure 3). The surveying was conducted only between Monday and Thursday, between 7 a.m. and 10 p.m. This timing was to avoid the drop in traffic that is common from Friday through Sunday at the border crossings (see Figure 2) and to accommodate the working hours of the inspection personnel with whom the ITS-Davis researchers were collaborating.

A total of 433 surveys were completed from the seven locations. The number of surveys collected from each facility was largely dependent on the operations of each. Surveying at the Truckee (I-80 from Nevada) and Mt Shasta (I-5 from Oregon) facilities was conduct from within the equipment inspection bays. There are garages in which the CHP inspection personnel check the trucks' equipment and monitor whether trucks are properly registered. Because these facilities take in only several dozen vehicles per day, three full shifts of surveying were required to achieve the target number of completed surveys. Similarly, when surveying in coordination with the CARB inspection facilities (at Mexico crossing locations, CA-7 and CA-905), one truck was pulled over at a time, to ensure that the flow of trucks was not unduly restricted. At the I-10, I-40, and I-15 locations, truck drivers were asked to drive their vehicles out of the truck queue (where they had been waiting to approach the CHP or CDFA terminals) to undertake the brief surveys before being returned to the queue as quickly as possible.

Generally the truck driver interview was conducted with the interviewer standing, with clipboard in hand, outside of the driver-side truck window. Once the trucks were stopped, the surveyors asked the drivers if they would like to participate in a survey ("Would you mind doing a brief three-minute survey today? We are collecting some data for the state."). Upon request, more information was given about the study (e.g., "We are helping the state of California get a better understanding of interstate truck travel to help us better understand and plan for the future."). Upon further inquiry, the objectives of the study, outlined above, were summarized. Participation in the survey, it was stressed, was strictly voluntary. Fewer than ten drivers (or about 2% of the greater than 400 drivers approached) declined to take the survey. These drivers generally cited timing constraints and the need to get back on the road.

Throughout the interviews, clarifying marks were made on the survey forms when relevant. For example, certain information was not known by the drivers (e.g., when drivers were asked about their total mileage on that trip into California, some drivers were uncertain). In some cases, drivers worked through the miles of that trip (e.g., from Needles to Los Angeles and back to Needles), while others would simply write down the path to be traveled in California. Researchers would later fill in the mileage. In much of the surveying at the two Mexico highway border crossings, when the trips were very short shuttle runs back and forth across the border, the drivers often did not know their mileage. Assumptions were made accordingly at the time of data entry, as will be discussed below.

d. Sampling Error and Bias

Potential shortcomings include sampling errors and bias due to the format of the survey. The sampling of trucks at only the major interstate highway entry points inherently misses the trucks that use the more rural, non-primary routes into California. These trucks are smaller in number and generally travel shorter regional distances. We assume that our findings do not accurately extrapolate to all trucks entering California, but only to trucks entering California on major interstate highways.

Furthermore, even some trucks that do cross the California borders are outside of our data collection. There are trucks that bypass inspections of CHP facilities, because they are part of the PrePass system, whereby trucking companies register and get approval in advance via more stringent registration protocol and the payment of a small fee. The interstate CHP site personnel estimated their PrePass truck throughput at about 5%. The activity of PrePass trucks from Mexico was thought to be rarer, with 2% or less of the trucks estimated to not be included in the CHP truck counts and sampling frame. These PrePass trucks were not exempt from the agricultural inspection stations. Finally, the sampling of trucks at the CHP facilities could involve some bias due to the types of trucks that were flagged for inspection at the I-80 and I-5 locations. Trucks that receive CHP inspection generally have an issue with proper registration tags or a visually recognized problem with their truck or trailer. Trucks with such issues may not properly represent interstate truck travel in to California.

Other limitations include the following. The in-person interview method of administering the survey could lead to errors in communication between the replies of the drivers and the written reported responses on the survey sheets by surveyors. This potential problem is greater when a language barrier between surveyor and driver was more apparent, which was more typical in southern California locations. The format of the survey interview questions could introduce errors due to the translation of the surveys into the Spanish language for the surveying of truck drivers that were without training in English.

e. Data Processing

The survey data were entered into a Microsoft Excel spreadsheet. The most common post-data-entry processing modifications were made to the estimated mileage for the trucks' travel in California. Some modifications were made for obvious mistakes for which logical corrections could be made. For example, if a driver estimated 800 miles to be traveled on the particular trip in California, but was simply driving to and from San Francisco from Reno with no other stops, a corrected mileage estimation was substituted based on roundtrip mileage from an online map web page (i.e., maps.google.com). Similarly, for some of the Mexico-originating trips, many drivers could not readily estimate their round-trip mileage to distribution centers just across the border in the U.S. (often within 5 miles of the border) and back to Mexico, and these were similarly estimated.

IV. RESULTS

This section reports on the descriptive statistics of the dataset. The first subsection introduces more basic truck sample statistics, including by truck classification, age, annual mileage, and other characteristics. The second and third subsections of this "Results" section segment these survey data according to the places from which the trucks are registered and the places from which the trucks entered California. We show both forms of segmented data, because both of these data formats may be of interest to researchers and planners. All extrapolations of these data (including the use of other external data sources) are undertaken in the following section, where we weigh the survey response data according to truck count data on interstate truck travel to extrapolate to the total population of trucks in California.

a. General Truck Sample Statistics

This first section details some of the statistics for the dataset. That these statistics are shown here to introduce the data variables that will be examined in further sections for differences in the trucks from the various surrounding states, and how their trucking activity in California differ. The predominant truck of the sample is a Class 8 truck of 33,000 lbs. or greater gross vehicle weight rating (97% of survey responses). Other common vehicle characteristics were a single trailer vehicle type and 5 or greater axles. Distributions are shown in Appendix B.

A fundamental statistic for this study is the official classification of the trucks by their home state. Due to the different affiliations of the trucks, two questions on the survey inquired about the status of the trucks' registration and "home base." The registration corresponds to the official state where the truck is licensed (i.e., the state on the tractor license plate). The "home base" is a less clearly defined term, which the U.S. Census refers to as "the location where the vehicle was usually parked when it was not on the road, such as a home, farm, terminal, etc." in the *Vehicle Inventory and Use Survey*. As shown in Table 15, 25% of the trucks crossing state borders into California were found to be "home-based" in California, whereas about 19% of trucks were registered exclusively in California. In the case of the trucks at the Mexico border (sites on highways CA-905 and CA-7), the trucks are required to have dual registration from both a Mexico state (mostly from Baja California) and a U.S. state (mostly California). From these data and depending on the definition of "out of state," the percent of trucks crossing California borders could be considered 75% (not California-home-based), 57% (not California-registered), or 81% (not *exclusively* California-registered). Where trucks are registered and where they are home-based closely coincided – 87% of surveyed trucks were based and registered in the same state.

Table 15. Classification of California and "Out of State" Trucks

State	Categorized by Home Base		Categorized by Area of Registration	
	Survey Responses	Percent	Survey Responses	Percent
California	110	25.4%	82	18.9%
Dual (California/Mexico)	0	0.0%	103	23.8%
Non-California	323	74.6%	248	57.3%

The average age of the vehicles in the sample is about 7 years old, with a median reported model year of 2000. About a quarter of the surveyed trucks were 2 or fewer years old, and about 64% of the trucks were of model year 1999 or later. Table 16 shows the breakdown of the survey sample by vehicle age (with model year 2007 considered "0 years"). The 12% of surveyed trucks that are pre-1993 model year are significant, given their relatively high emissions compared to later model year trucks.

Table 16. Vehicle Age Breakdown

Vehicle Age Range (Model years)	Responses	Percent
0-2 years (2005-2007)	116	26.9%
3-5 years (2002-2004)	62	14.4%
6-8 years (1999-2001)	98	22.7%
9-11 years (1996-1998)	61	14.2%
12-14 years (1993-1995)	41	9.5%
15+ years (pre-1993)	53	12.3%
	Number of responses	*431*
	Mean model year	*1999.5*
	Standard deviation	*5.9*
	Median model year	*2000*

Truck drivers were asked to estimate the total days of operation and mileage driven per year (Tables 17 and 18). When the survey respondents more readily answered these questions in terms of per-month or per-week answers, the responses were translated accordingly to annual averages. The average annual operation of the trucks in the sample approximates a five-days-per-week work schedule, with the mean or 271 day/year and a median of 260 days/year.

Table 17. Annual Truck Operation Breakdown

Annual Operation (days/year/truck)	Responses	Percent
0-99	4	0.9%
100-149	4	0.9%
150-199	20	4.7%
200-249	62	14.5%
250-299	198	46.2%
300+	141	32.9%
	Number	*429*
	Mean annual days per year per truck	*271*
	Standard deviation	*50*
	Median annual days per truck	*260*

From Table 18, the mean and median annual mileages for the sample were 115,362 and 120,000 miles per year per truck, respectively. However the mileage results showed much wider distributions than for the annual days of operation per truck. As shown in the table almost a quarter (24%) of the respondents tallied less than 50,000 miles per year. Generally these lower mileage trucks tended to be used in trips across the border (e.g., Tijuana-San Diego).

Table 18. Annual Truck Mileage Breakdown

Annual Truck Mileage (mi/truck/yr)	Responses	Percent
<50,000	103	24.0%
50,000 - 74,999	20	4.7%
75,000 - 99,999	25	5.8%
100,000 - 124,999	75	17.5%
125,000 - 149,999	83	19.3%
150,000 - 174,999	62	14.5%
175,000 - 199,999	19	4.4%
200,000+	42	9.8%
	Number of responses	*429*
	Mean annual mileage	*115,362*
	Standard deviation	*75,681*
	Median annual mileage	*120,000*

b. Segmentation by Place of Registration

The sample was segmented by truck affiliation (home base or registration state or country) and the area from which these trucks came (i.e., Oregon, Nevada, Arizona, Mexico). Table 19 shows the distribution of survey responses regarding the age of the trucks, segmented according to the area in which the trucks are registered or home-based. The average by origin differs. For example, Mexico-registered trucks were an average model year of 1993, while California- based trucks were an average model year 1999 or 2000. Trucks that were U.S.-registered, but in a state other than California, were an average model year 2002. Based on the similarities between results for the trucks that were home-based and registered in the same location, throughout this section we chose to simply report truck statistics based on registration location (and not also based on home base location).

Table 19. Distribution and Statistics for Truck Age, by Area of Home Base or Registration

Truck Age (years)	Number of Survey Responses of Given Truck Age that are…						
	California Home-Based	California Registered	US, Non-CA-Homebased	US, Non-CA-Registered	Canada Registered	Mexico Registered	All Trucks
0-2	13	9	97	101	3	3	116
3-5	15	13	39	41	4	4	62
6-8	43	38	50	54	0	6	98
9-11	18	13	22	23	1	24	61
12-14	11	7	12	15	0	19	41
15-17	7	1	2	2	0	19	22
18-20	2	0	1	1	0	21	22
20+	0	0	0	0	0	9	9
(blank)	1	1	1	1	0	0	2
Total, All Ages	110	82	224	238	8	105	433
Average Model Year	1999	2000	2002	2002	2004	1993	1999
Average Age (yrs)	7.8	7.1	4.7	4.8	3.3	14.3	7.5
Median Age (yrs)	8.0	7.0	3.0	3.0	3.0	14.0	7.0
Standard Deviation (yrs)	4.2	3.3	3.9	4.0	2.8	5.7	5.9

Truck characteristics, organized by place of registration, are shown in Table 20. The trucks that are registered in U.S. states other than California (and also those in Canada) most closely coincide with what are generally referred to as "long haul" trucks. These trucks tend to be the newest (median model year of 2004), have higher average fuel economy, have larger fuel capacity, travel the most, and travel furthest. The California-registered trucks in the sample are likely to include both "long haul" trucks and trucks that operate more typically with shorter, regional routes, and these trucks are slightly older (three to four years older on average) and travel slightly less (about 15% less mileage per year). The Mexico-registered trucks tend to be oldest (median model year 1993), have the lowest reported fuel economy, and travel the fewest miles.

Table 20. Average Truck and Annual Operation Characteristics, by Place of Registration

Place of Registration	Average Truck Age (years)	Median Model Year	Fuel Capacity (gallons)	Fuel Economy (mpg)	Annual Mileage (mi/yr)	Annual Operation (day/yr)	Average Miles per Day of Operation (mi/day)	Average Annual Operation (mi/day)
California	7.1	2000	229	6.1	126,000	258	496	345
US, Non-California	4.8	2004	247	6.2	149,000	280	556	407
Canada	3.3	2004	263	5.9	158,000	247	641	432
Mexico	14.3	1993	213	5.2	28,000	264	114	76
All Trucks	7.5	2000	236	6.1	115,000	271	439	316

The trucks surveyed for this study reported their activity in California for both the immediate trip upon which they were embarking and their more general annual activity in California. Table 21 shows average statistics for the trucks' California travel activity, according to their place of registration. The average trip into California was 2.1 days. This means that the trucks were by and large exiting the day after entering the state (i.e., 1 one-day trip would mean leaving the

same day as entering). Over that trip, the average mileage within California is 482 miles. The average interstate-traveling truck took about 200 trips into California per year, traveled about 30,000 miles per year in California, and operated in California for 172 days per year.

The most striking difference in California operations comes from the Mexico-registered trucks, which take the shortest average trip into California (72 miles per trip) taking the shortest average duration (less than one day per trip). On an annual basis, these Mexico domiciled trucks took the most average trips (averaging 590 trips per year per truck, or about 2.2 trips per day of truck operation). These trucks on average log about half of their annual mileage in California and operate in California during almost every day that the truck is operated.

The survey sample's largest segment based on place of registration is trucks with U.S. registration status other than California (with 238 surveyed trucks out of 433). These trucks had an average California trip of 629 miles over 2.3 days. Annually these trucks were driven on average into California 59 times, totaling 112 days per year. These trucks averaged about 21% of their annual mileage and 40% of their days of operation in California.

The California-registered trucks reported similar characteristics to other U.S. trucks but with somewhat longer California trips duration (3 days per trip instead of two), more annual mileage in California (38%), and a much higher percentage of days of operation in California (86%)[3]. The smaller sampling (9 surveys) of Canada-registered trucks had similar characteristics to the U.S.-registered trucks, but they tended to be driven many more miles and more days per year in California.

Table 21. Surveyed Interstate Trucks' California Activity, by Place of Registration

Place of Registration	California Trip Mileage (mi/trip)	California Trip Duration (day/trip)	California Annual Operation (trip/yr)	Annual Mileage in California (mi/yr)	Percent of Annual Mileage in CA	California Annual Operation (day/yr)	Percent of Annual Days in CA
California	565	3.1	100	48,113	38.1%	223	86.4%
US, Non-California	629	2.3	59	31,758	21.3%	112	40.1%
Canada	903	2.8	61	41,301	26.1%	154	62.4%
Mexico	72	<1	590	15,687	56.8%	263	99.8%
All Trucks	482	2.1	201	30,621	26.5%	172	63.4%

To estimate the extent to which non-California fuel was being utilized by the interstate-traveling trucks in California, we asked drivers about where they last fueled their trucks and about where they next intended to refuel their trucks. The results for last and next fueling locations, organized by trucks' place of registration, are shown in Table 22. As shown, California-registered trucks were more likely to already have California fuel when re-entering California. About 31% of California-registered trucks entered California with California fuel, whereas only 7% of trucks that are registered in other states entered California with California fuel. The vast majority of non-California-registered trucks had fuel from non-California locations.

[3] Many California-registered trucks did not know the expected "per trip" miles in California.

Table 22. Survey Responses for Last and Next Fueling Location, by Place of Registration

Place of Registration	Number of Surveys	Last Fueling Location			Next Fueling Location		
		California	Non-California	Unknown	California	Non-California	Unknown
California	82	30.5%	68.3%	1.2%	73.2%	22.0%	4.9%
US, Non-California	238	7.1%	92.9%	0.0%	60.9%	38.2%	0.8%
Canada	8	0.0%	100.0%	0.0%	75.0%	12.5%	12.5%
Mexico	105	21.0%	78.1%	1.0%	27.6%	61.0%	11.4%
All Trucks	433	14.8%	84.8%	0.5%	55.4%	40.2%	4.4%

Using mileage of the trucks' current trips into California, the last and next fueling locations, and drivers on the estimated miles until the drivers had to refuel, the extent to which these interstate trucks' mileage is driven with California fuel was estimated. In Table 23, we summarize these estimates of California trip mileage with and without California fuel, by the trucks' place of registration. Of those that answered this survey question, about one in eight of the surveyed trucks started their trips into California with California fuel. The remaining population was divided approximately evenly between those that intended never to use California fuel on that trip and those that would likely consume a mix of in-state and out-of-state fuel on their California trip.

Table 23. Surveyed Interstate Trucks Fueling Characteristics on Trip into California

Place of Registration	Average Times Refueling in CA on Trip	Percent of Trucks that…				Average CA Trip Distance (mi)	Average CA Trip Mileage with Non-CA Fuel (mi)	Percent of Miles in CA with Non-CA Fuel
		Start Trip with CA Fuel	Consume Mix of CA and non-CA fuel	Never Use CA Fuel in CA	Unknown			
California	0.8	30.5%	42.7%	22.0%	4.9%	560.7	310.0	55.3%
US, Non-CA	0.7	7.1%	54.6%	37.4%	0.8%	625.6	490.5	78.4%
Canada	1.2	0.0%	75.0%	12.5%	12.5%	938.7	489.8	52.2%
Mexico	0.1	17.1%	12.4%	58.1%	12.4%	72.5	55.8	77.0%
All Trucks	0.6	13.9%	42.5%	39.0%	4.6%	491.7	357.2	72.7%

c. Segmentation by Place of Origin

Table 24 contains truck characteristics and annual operation organized by place from which the sample trucks entered California. Based on place-of-origin, there are two statistically different subsets of the survey sample: (1) trucks entering from the U.S. (Oregon, Nevada, and Arizona) and (2) trucks entering from Mexico. Trucks entering from the U.S. were median model years between 2001 and 2003, could hold about 230 to 259 gallons of fuel, average more than 6 miles per gallon, are driven from 133 to 159 thousand miles per year, are operated about 263 to 280 days out of the year, and average between 503 and 601 miles per day. The trucks entering California from Mexico were older, with a median model year of 1991 to 1994, had lower fuel economy (5.1 to 5.6 miles per gallon), and were driven much less per year (about 27,000 miles per year).

Table 24. Average Truck and Annual Operation Characteristics, by Place of Origin

Place of Origin	Highway	Surveys	Average Age (yrs)	Median Model Year	Fuel Capacity (gal)	Fuel Economy (mpg)	Annual Mileage (mi/yr)	Annual Operation (d/yr)	Average Miles per Day of Operation (mi/day)	Average Annual Operation (mi/day)
Oregon	I-5	66	5.6	2002	259	6.1	133,000	263	503	363
Nevada	I-80	68	4.9	2003	237	6.1	141,000	280	568	386
	I-15	50	5.7	2001	243	6.2	138,000	276	510	379
Arizona	I-40	72	5.0	2002.5	250	6.1	159,000	273	601	434
	I-10	73	5.4	2002	230	6.3	142,000	273	523	390
Mexico	SR-7	33	16.0	1991	186	5.6	30,000	258	136	83
	SR-905	71	13.7	1994	223	5.1	27,000	270	102	73
All Trucks		433	7.5	2000	236	6.1	115,362	271	439	316

Table 25 shows both the results for the immediate trip into California and for the generalized annual California travel. On an annual basis, the Mexico-originated trucks took the most average trips (averaging 596 trips per year per truck). These trucks on average log about half of their annual mileage in California and operate in California during almost every day that the truck is operated.

Compared to the large differences between Mexico-based trucks and U.S.–based trucks, the differences between trucks from the various U.S. states are relatively minor. Generally the trucks from all three U.S. states were on two to three day trips into California and were driven about 40% to 60% total operational days on California roads. Trucks from Oregon (entering California on I-5) averaged the longest California trip (855 miles per trip), the most annual mileage in California (~50,000 miles per year), and the highest percentage of annual mileage in California (37%), compared with trucks from other U.S. states. Comparatively, the trucks from Nevada (I-80 and I-15) and Arizona (I-40 and I-10), were driven for more total mileage per year, were driven for less California mileage per year, and therefore were driven in California for a lower percentage of their annual miles.

Table 25. Surveyed Interstate Trucks' California Activity, by Place of Origin

Place of Origin	California Trip Mileage (mi/trip)	California Trip Duration (day/trip)	California Annual Operation (trip/yr)	Total Annual Mileage (mi/yr)	Annual Mileage in California (mi/yr)	Percent of Annual Mileage in CA	California Annual Operation (day/yr)	Percent of Annual Days in CA
Oregon	855	3.0	71	132,744	49,635	37.4%	162	61.6%
Nevada	531	2.2	84	139,784	38,067	27.2%	162	58.1%
Arizona	585	2.4	54	150,507	27,722	18.4%	110	40.2%
Mexico	67	<1	596	27,732	15,669	56.5%	265	99.8%
All Trucks	482	2.1	201	115,362	30,621	26.5%	172	63.4%

The results for last and next fueling locations, organized by trucks' state of entry into California, are shown in Table 26. All trucks were very likely to have non-California fuel when entering California. Over half (55%) of the trucks refueled in California within that trip into the state.

However, the trucks from Oregon were much more likely than trucks from the other locations to refuel in California. The number of Mexico-originated trucks that would refuel on that trip into California was considerably lower, with just 28%.

Table 26. Survey Responses for Last and Next Fueling Location, by Place of Origin

Place of Origin	Number of Surveys	Last Fueling Location			Next Fueling Location		
		California	Non-California	Unknown	California	Non-California	Unknown
Oregon	68	14.7%	85.3%	0.0%	89.7%	7.4%	2.9%
Nevada	116	22.4%	77.6%	0.0%	66.4%	32.8%	0.9%
Arizona	145	4.1%	95.2%	0.7%	50.3%	46.9%	2.8%
Mexico	104	21.2%	77.9%	1.0%	27.9%	60.6%	11.5%
All Trucks	433	14.8%	84.8%	0.5%	55.4%	40.2%	4.4%

From the above data on California activity and refueling characteristics, we see the extent to which the interstate trucks' mileage is driven with California fuel. The Arizona-based trucks travel the highest percentage of their California trip miles (89%) on non-California fuel. Oregon-originated trucks, on the other hand, are driven the longest distances per trip in California and accumulate the lowest percentage (57%) of their California mileage with non-California fuel.

Table 27. Surveyed Interstate Trucks Fueling Characteristics on Trip into California

Place of Origin	Average Times Refueling in CA on Trip	Percent of Trucks that…				Average CA Trip Distance (mi)	Average CA Trip Mileage with Non-CA Fuel (mi)	Percent of Miles in CA with Non-CA Fuel
		Start Trip with CA Fuel	Consume Mix of CA and non-CA fuel	Never Use CA Fuel in CA	Unknown			
Oregon	1.0	14.7%	75.0%	7.4%	2.9%	857.9	486.9	56.8%
Nevada	0.8	22.4%	44.0%	32.8%	0.9%	532.0	339.1	63.6%
Arizona	0.5	4.1%	47.6%	45.5%	2.8%	575.9	516.0	89.3%
Mexico	0.1	17.3%	12.5%	57.7%	12.5%	66.4	49.9	76.8%
All Trucks	0.6	13.9%	42.5%	39.0%	4.6%	491.7	357.2	72.7%

Numerous drivers commented on higher diesel prices in California than in neighboring states. Data from several sources for diesel prices during the surveying months reveal that average California diesel prices were significantly higher than other states at the time of surveying. California's average retail diesel sales price for August and September 2006 was $3.12 per gallon (U.S. EIA, 2006a). Average interstate highway diesel prices for Arizona at Kingman (on I-10) and Yuma (on I-8) during this time period were on average $2.98 per gallon, or $0.14 lower than California diesel (Arizona DOC, 2006). Oregon diesel prices were much lower for this time period at $2.61 per gallon (U.S. EIA, 2006b). Average highway diesel prices for Nevada were not available. Sampling methods for these fuel prices could differ, and interstate trucks could receive discounted company fuel price rates, so there is uncertainty in these numbers.

Drivers were asked about their fueling patterns in an effort to better understand the extent to which they are using California fuel while traveling in California. Specifically, drivers were asked about their last fueling locations and their next expected fueling location (Table 28). The trucks having immediately entered from outside California were primarily fueled from non-California locations. Of the 14.8% of responses that entered California already having California diesel, most are either home-based in California (32 responses) or are routinely shuttling between Mexico and California (18 responses). Also of those that previously California-fueled, the vast majority will next refuel in California. However, only about half of the 367 respondents who had previously fueled outside California refueled in California. Therefore, more than a third both entered without California fuel and intended to not refuel with California fuel on the current trip into California. Furthermore, we examined the respondents who gave responses for both their expected California trip mileage and their "miles until they next had to refuel" to discern whether they would be forced to refuel in California (before running out of fuel) or were relatively indifferent to where they next fueled. Of those refueling in California, 57% had to do so, and 43% did not have to refuel in California but planned to do so anyway.

Table 28. Last and Next Fueling Destination of Survey Sample Trucks Entering California

Previous Fueling Location	Previous Fueling Location		Next Fueling Location Responses *Percent*		
	Responses	Percent	California	Non-California	Unknown
California	64	14.8%	55 *86%*	5 *8%*	4 *6%*
Non-California	367	84.8%	184 *50%*	169 *46%*	14 *4%*
Unknown	2	0.5%	1 *50%*	0 *0%*	1 *50%*

Table 29 lists where trucks were last fueled, according to the bordering region from which the trucks entered. As shown, the majority of the trucks carrying non-California fuel from bordering regions have fuel from the bordering region (e.g., 59% of Oregon-originating trucks had fuel from Oregon, and not from some further away, non-bordering area). About 20% to 25% of trucks surveyed from bordering U.S. states carried fuel from at least two states away (e.g., Utah, New Mexico, Texas, and Washington). These results will be weighted according to mileage driven in California in the following "Analysis" chapter.

Table 29. Last Fueling Location of Surveyed Trucks, by Place of Origin

Truck Place of Origin	Percent of Trucks with the Following Last Fueling Locations						
	Nevada	Oregon	Arizona	Other U.S. States	Canada	Mexico	California
Oregon	1.5%	58.8%	1.5%	22.1%	1.5%	0.0%	14.7%
Nevada	50.9%	0.9%	4.3%	21.6%	0.0%	0.0%	22.4%
Arizona	0.7%	0.0%	70.1%	24.3%	0.0%	0.7%	4.2%
Mexico	0.0%	0.0%	0.0%	0.0%	0.0%	78.6%	21.4%
All Surveyed Trucks	14.1%	9.5%	24.7%	17.8%	0.2%	18.9%	14.8%

V. ANALYSIS

Originally, this research proposed to conduct original traffic counts simultaneously with truck surveying at the truck inspection locations. However, the Caltrans truck count dataset was used instead. The Caltrans counts are routinely updated and account for seasonal fluctuation with annual averaging. The primary interstate commercial truck routes all have data estimates from the year 2000 and later (Caltrans, 2006a).

Table 30 shows the key survey parameters extrapolated to the state level. 21,838 truck entries per day (on the primary routes) are represented by the 433 trucks surveyed.

Table 30. Survey Collection and Data Expansion Parameters

Place of Origin	Surveys Collected	Annual Average Daily Truck Traffic Entering California on Primary Commercial Truck Routes (truck/day)	Equivalent Expansion Factor (daily truck entries per surveyed truck)
Oregon	68	2,061	30.3
Nevada	116	6,282	54.2
Arizona	145	10,527	72.6
Mexico	104	2,968	28.5
All	433	21,838	50.4

In the following sections we represent results for the California truck population, highway usage, and fuel use.

a. Interstate Truck Population in California

The operating truck population is calculated as the total daily truck entries (from Caltrans, 2006a), multiplied by the percent of trucks of a given registration status, multiplied by the number of average days per year per truck operating in California, divided by the average number of entries per year per unique truck. This calculation is performed for trucks entering California from each place of origin, and the results are summed (or averaged) accordingly. Table 31 shows the results for calculations of the total population of non-California-registered trucks in California.

Of the commercial truck entries into California per day on the eight primary interstate routes, 66% are not registered in California[4]. In total, we estimate that approximately 27,000 non-California-registered trucks are operating in California at any given time. Trucks entering from Arizona make up the majority of these trucks, with 58% of the total average daily operating population in California.

[4] Mexico-based trips involve mostly trucks that are registered in both Mexico and California, and therefore are not included in this figure (and many others) for *non-California-registered* trucks.

Table 31. Statistics for Interstate Activity of Non-California-Registered Trucks

Place of Origin	Total Trucks Entering CA on Primary Commercial Truck Routes (entry/day) [a]	Percent of Trucks Entering That Are Not Registered in California	Non-CA-Registered Trucks Entering CA on Primary Commercial Truck Routes (entry/day)	Average CA Entries Per Year per Unique Truck (entry/yr/ truck)	Average Annual Operation in California (day/yr/ truck)	Days in CA per Truck Entry (day/ entry)	Average Daily Population Operating in CA on a Given Day (trucks)	Average Daily Population Operating Outside of CA on a Given Day (trucks)
Oregon	2,061	70.6%	1,455	53	119	2.3	3,283	3,439
Nevada	6,282	72.4%	4,549	63	108	1.7	7,791	11,320
Arizona	10,527	79.3%	8,349	49	91	1.9	15,490	28,154
Mexico	2,968	1.0%	29	-	-		-	-
All	21,838	65.9%	14,381	54	99	1.9	26,564	42,914

[a] *Caltrans (2006a) highway traffic counts, See Table 3 above*

Table 32 shows statistics on California interstate truck activity for California-registered trucks. These California-registered, interstate-traveling trucks represent 34% of total truck entries into California. These trucks differ from the non-CA-registered trucks in that, not surprisingly, they spend more time operating in California. California-registered interstate-traveling trucks contribute 11,061 trucks to the average population of trucks in California on the road on any given day.

Table 32. Statistics for Interstate Activity of California-Registered Trucks

Place of Origin	Total Trucks Entering CA on Primary Commercial Truck Routes (entry/day) [a]	Percent of Trucks Entering That Are Registered in California	CA-Registered Trucks Entering CA on Primary Commercial Truck Routes (entry/day)	Average CA Entries Per Year per Unique Truck (entry/yr/ truck)	Average Annual Operation in California (day/yr/ truck)	Days in CA per Truck Entry (day/ entry)	Average Daily Population Operating in CA on Given Day (trucks)	Average Daily Population Operating Outside of CA on a Given Day (trucks)
Oregon	2,061	29.4%	606	92	183	2.0	1,201	400
Nevada	6,282	27.6%	1,733	134	220	1.6	2,852	589
Arizona	10,527	20.7%	2,178	66	173	2.6	5,699	2,719
Mexico	2,968	99.0%	2,939	594	265	0.4	1,309	1,309
All	21,838	34.1%	7,456	92	193	2.2	11,061	5,016

[a] *Caltrans (2006a) highway traffic counts, See Table 3 above*

In Table 33, we estimate the total number of unique trucks that are engaged in interstate travel and in travel in California. Based on each of these trucks' travel characteristics and their reported annual days of operation in, and trips into, California, the total number of these interstate-traveling trucks that are operating in California on any given day averages about 38,000 trucks. We note that these figures differ dramatically from the much larger out-of-state truck population of 1.7 million IRP-registered trucks that are registered for California travel. It is conceivable that a very large number of the IRP-registered trucks actually travel in California very rarely or not at all.

Table 33. Truck Entries and Average Population of Interstate Trucks that Operate in California

Category	Trucks Entering CA on Primary Commercial Truck Routes (truck entries/day)	Average CA Entries Per Year per Unique Truck	Annual CA Truck Entry Count on Primary Commercial Truck Routes (truck entries/year)	Population of Unique Trucks in Year	Population on At Given Time Operating…		
					In CA	Outside CA	Not Operating
Non-CA-Registered	14,381	54	5,252,803	96,877	26,564	42,914	27,398
CA-Registered	7,456	122	2,723,344	22,271	11,061	5,016	6,194
All	21,838	67	7,976,147	119,147	37,625	47,930	33,592

Because current official California Class 8 truck population estimates from Caltrans (2006b) and CARB (2007a) are based on California-registered trucks, the above findings on interstate trucks impact the state figures in two ways: (1) non-California-registered interstate-traveling truck activity *within California* must be added to the truck population and (2) California-registered interstate traveling truck activity *outside California* must be subtracted from the truck population. However, for the CARB truck population, first their 1.33 out-of-state truck correction factor as discussed above (based on CARB, 2006) must be subtracted before conducting these two calculations.

In Table 34, we perform these calculations to estimate the average daily impact of interstate trucks on the heavy-duty truck population in California. Starting from Caltrans (2006b) estimation of 138,000 trucks in 2006, the addition of the 26,564 non-California-registered trucks and the subtraction of the approximately 5,016 California-registered trucks operating outside California nets 159,548 trucks, or a 16% increase from the original Caltrans estimate. After subtracting CARB's out-of-state correction, the CARB population of California-registered, Class 8 diesel trucks is 145,575. Then, after adding the non-California-registered trucks that are in California and subtracting the California-registered trucks that are not in California, the new population is 167,123. These survey findings suggest that out-of-state (i.e., non-California-registered) trucks represent about 16% to 17% of the truck population operating in California on any given day. Therefore, the CARB estimation of 25% out-of-state truck population is larger than indicated by this survey.

Table 34. California Class 8 Heavy-Duty Truck Population, with New Data on Interstate Trucks

		Truck Population in CA on a Given Day	
		Based on MVSTAFF [a] (Caltrans, 2006b)	Based on EMFAC2007 [a] (CARB, 2007a)
Heavy-Duty Diesel Trucks (Class 8, GVWR 33,000+ lbs) in 2006	CA-Registered	138,000	145,575
	Non-CA-Registered	-	48,040
	Total	138,000	193,614
Interstate Trucks from Primary Commercial Interstate Routes on Average Day (From This Study)	CA-Registered, in CA	11,061	
	Non-CA-Registered, in CA	26,564	
	CA-Registered, Outside CA	5,016	
New Estimated Truck Population		159,548 [b]	167,123 [c]
Percent Correction Due to Interstate Truck Activity		16%	-14%
Percent of Activity by Non-California-Registered Trucks		17%	16%

[a] *MVSTAFF= Motor Vehicle Stock and Fuel Forecast (Caltrans, 2006b); EMFAC2007=Emission Factor model (CARB, 2007a; CARB,2007b)*
[b] *MVSTAFF estimation, plus non-California-registered trucks in CA, minus California-registered trucks operated outside California*
[c] *EMFAC estimation, divided by 1.33, plus non-California-registered trucks in California, minus California-registered trucks operated outside California*

b. Interstate Truck Activity in California

The following tables show the summary statistics for the in-California and out-of-California activity of interstate-traveling California heavy-duty trucks. The longest average trips into California are from Oregon-originating trucks. The net mileage of these trucks' California travel is 2,988 million miles of travel on California highways, or about 24% of their total annual mileage. Trucks from Arizona make up more than half of this non-California-registered truck mileage that is in California.

Table 35. Summary Statistics for Activity of Non-California-Registered Interstate Trucks

Bordering Region	Average Total Annual Mileage (mi/yr/truck)	Activity Within California			Activity Outside California		
		Average Annual Mileage (mi/yr/truck)	Average CA Trip (mi/truck entry)	Total Mileage (million mi/yr)	Average Annual Mileage (mi/yr/truck)	Average Outside CA Trip (mi/truck exit)	Total Mileage (million mi/yr)
Oregon	144,450	43,631	828	440	100,818	1,914	1,017
Nevada	147,905	32,268	510	847	115,637	1,827	3,036
Arizona	158,289	27,274	558	1,701	131,015	2,680	8,171
Mexico	-	-	-	-	-		
Weighted Averages	153,595	30,515	570		123,080	2,332	
Total				2,988			12,224

The summary statistics for California-registered trucks' annual activity in and out of California is shown in Table 36. These trucks are driven less on average than interstate-traveling non-California-registered trucks. The Mexico-based trucks are driven far fewer miles annually than the others.

Table 36. Summary Statistics for Total Mileage Impacts of California-Registered Interstate Trucks

Bordering Region	Average Total Annual Mileage (mi/yr/truck)	Activity Within California			Activity Outside California		
		Average Annual Mileage (mi/yr/truck)	Average CA Trip (mi/truck entry)	Total Mileage (million mi/yr)	Average Annual Mileage (mi/yr/truck)	Average Outside CA Trip (mi/truck exit)	Total Mileage (million mi/yr)
Oregon	124,253	66,043	716	159	58,210	631	140
Nevada	135,592	56,254	420	266	79,338	592	375
Arizona	137,489	30,311	458	365	107,178	1,621	1,289
Mexico	26,866	15,420	26	28	11,446	19	21
Weighted Averages	92,368	33,376	300		58,992	670	
Total				817			1,825

Similar to the above Table 34 calculations to correct state estimations for the trucks populations, in Table 37 we perform modifications for the California Class 8, heavy-duty diesel truck mileage estimates based on our survey data. Note that comparisons to the two reference data sources, Caltrans and CARB, differ due to their differing inclusion of non-California-registered trucks. Caltrans mileage data already includes all truck activity from in-state and out-of-state registered trucks, but does not offer an estimated breakdown of that mileage by registration status. Therefore, the total mileage of non-California-registered truck operation on California roads, 2,988 million miles per year, is compared directly to the Caltrans mileage of 9,037 million miles.

From this calculation, this survey's findings indicate that non-California-registered truck mileage on California roads is approximately 33% of the Caltrans reference mileage for Class 8 trucks.

For comparing the survey's results to the CARB reference data, the calculation is done differently due to out-of-state correction factor that CARB already assumes in its own reference data. To compare to the CARB truck mileage estimation, first the total Class 8 truck mileage is reduced by 25%, resulting in a CARB estimation of mileage of California-registered trucks to be 9,128 million miles per year. Then, after adding the non-California-registered trucks that are in California and subtracting the California-registered trucks that are not in California, the new population is calculated. The total mileage of non-California-registered truck operation on California roads, 2,988 million miles per year, is added to the state vehicle miles traveled estimations. The amount of mileage that California-registered trucks accumulate outside of California, 1,825 million miles per year, is subtracted from total state, heavy-duty truck mileage. The contribution of the non-California-registered trucks to the new overall mileage totals is approximately 29% of total Class 8, diesel truck mileage. Therefore, the CARB 1.33 out-of-state correction factor for Class 8 mileage – where out-of-state trucks account for 25% of Class 8 truck mileage – appears to approximately estimate the net impact of interstate trucks on California vehicle miles traveled.

Table 37. California Class 8, Heavy-Duty Truck Activity, with New Data on Interstate Trucks

		Vehicle Miles Traveled (millions miles/yr)	
		Based on MVSTAFF [a] (Caltrans, 2006b)	Based on EMFAC2007 [b] (CARB, 2007a)
Heavy-Duty Diesel Trucks (Class 8, GVWR 33,000+ lbs) Activity in 2006	CA-Registered	-	9,128
	Non-CA-Registered	-	3,012
	Total	9,037	12,141
Interstate Trucks from Primary Commercial Interstate Routes on Average Day (From This Study)	CA-Registered, in CA	817	
	Non-CA-Registered, in CA	2,988	
	CA-Registered, Outside CA	1,825	
New Estimated Annual Heavy-Duty Truck Activity		9,037	10,292 [c]
Percent Correction Due to Interstate Truck Activity		-	-15%
Percent of Activity by Non-California-Registered Trucks		33%	29%

[a] *MVSTAFF= Motor Vehicle Stock and Fuel Forecast (Caltrans, 2006b) - breakdown by truck registration status not available.*
[b] *EMFAC2007=Emission Factor model (CARB, 2007a; CARB,2007b)*
[c] *EMFAC estimation, divided by 1.33, plus non-California-registered trucks in California, minus California-registered trucks operated outside California*

c. Interstate Truck Fuel Consumption in California

The following calculations are conducted to estimate the extent to which heavy-duty truck activity in California is fueled out of state. We use the survey data on the states in which the trucks were last fueled and the miles in California before the trucks next would be re-fueled to determine the amount of California mileage on non-California fuel. In Table 38, the percent of miles on California trips that are fueled by non-California fuel is shown. For each bordering region, these results differ from those in the previous section in that they involve stratification by registration status and weighting according to total California truck entries from each bordering region.

The majority of Arizona-based trucks' travel is fueled by non-California fuel. Trucks that are California-registered, on average, travel a lower percentage of California miles on non-California fuel than non-California-registered trucks. Trucks that entered California from Oregon and Nevada use a relatively lower portion of out-of-state fuel. After weighting all interstate truck trips into California, approximately 75% of interstate trucks' mileage in California is fueled by non-California fuel.

Table 38. Truck Mileage in California on Out-of-State Fuel by Interstate-Traveling Trucks

Bordering Region	Non-California-Registered Trucks		California-Registered Trucks	
	Percent of California Mileage on Non-CA Fuel	Mileage on Non-CA Fuel (million mil/yr)	Percent of California Mileage on Non-CA Fuel	Mileage on Non-CA Fuel (million mil/yr)
Oregon	52.9%	233	64.0%	102
Nevada	70.0%	593	38.0%	101
Arizona	88.1%	1,499	88.4%	323
Mexico	-	-	78.0%	22
Weighted Averages	77.8%		66.9%	
Total		2,325		547

In Table 39, the out-of-state fuel usage by interstate-traveling trucks in California is shown in context with the overall heavy-duty truck mileage totals. The results are shown in mileage, and not in gallons of fuel usage, for two reasons: (1) the mileage estimates are more firmly known, as the fuel consumption estimations involve an additional calculation based on the trucks' estimated average fuel economy, (2) emission factors are most commonly calculated on a per-mile basis. Neither the Caltrans (2006b) nor CARB (2007a) datasets offer estimations for the amount of mileage in California that is fueled by non-California fuel. The resulting estimation for out-of-state fuel usage by the interstate-traveling trucks in California is that approximately 28-32% of all heavy-duty truck mileage is fueled by out-of-state fuel, based on the Caltrans and CARB truck mileage estimates.

Table 39. Summary Statistics for Interstate Truck Activity on California and Non-California Fuel

		Annual Mileage (million mi/yr), by Fuel Origin	
		Based on MVSTAFF [a] (Caltrans, 2006b)	Based on EMFAC2007 [b] (CARB, 2007a)
Heavy-Duty Diesel Truck (Class 8, GVWR 33,000+ lbs) Activity in 2006, Updated in This Study	CA fuel	-	-
	Non-CA Fuel	-	-
	Total	9,037	10,292 [c]
Non-California-Registered Interstate Truck Activity in California by Fuel Origin (This Study)	CA fuel	663	
	Non-CA Fuel	2,325	
	Total	2,988	
California-Registered Interstate Truck Activity in California by Fuel Origin (This Study)	CA fuel	270	
	Non-CA Fuel	547	
	Total	817	
Heavy-Duty Diesel Truck Activity in 2006, Updated from This Study	CA fuel	6,165	7,420
	Non-CA Fuel	2,872	2,872
	Total	9,037	10,292
Percent Heavy-Duty Mileage Using Non-CA Fuel		32%	28%

[a] *MVSTAFF= Motor Vehicle Stock and Fuel Forecast (Caltrans, 2006b) - breakdown by fuel origin not available.*
[b] *EMFAC2007=Emission Factor model (CARB, 2007a; CARB,2007b) – breakdown by fuel origin not available.*
[c] *EMFAC estimation, divided by 1.33, plus non-California-registered truck mileage in California, minus California-registered truck mileage outside California*

Due to the potential impact of the out-of-state fuel usage on emissions, we show from where the out-of-state fuel came by country and U.S. state. Unsurprisingly, most of the fuel came from the nearest bordering states from which the trucks entered California. For example, about 77% of Arizona-based trucks' non-California fuel was from Arizona. Percentages by location from which bordering region the trucks came from are shown in the right-most column; here we find that 63% of out-of-state fuel mileage is by trucks that entered California through Arizona, and Mexico-based trucks contribute less than 1% to this total mileage. In the bottom-most row, we find that, overall, the most out-of-state fuel mileage come from Arizona (52%), Nevada (15%), Oregon (9%), and Texas (9%). Other is 15%.

Table 40. Truck Mileage in California with Out-of-State Diesel Fuel

Bordering Region from Which Trucks Enter California	Annual Miles Within California with Diesel from Each Location (million mi/yr)										Percent of Miles from Out-of-State Fuel that is from Trucks of Each Bordering Region
	Oregon	Nevada	Arizona	Mexico	Canada	Utah	Texas	Wash.	Other US States	Total	
Oregon	255	2	10	6	0	0	0	61	0	335	11.6%
Nevada	7	392	84	0	0	162	0	16	33	694	24.2%
Arizona	0	24	1,414	0	0	0	255	0	129	1,822	63.4%
Mexico	0	0	0	0	22	0	0	0	0	22	0.8%
Total	262	418	1,507	6	22	162	255	77	162	2,872	100.0%
Percent of Non-CA Fuel Mileage from Each Location	9%	15%	52%	0.2%	0.8%	5.7%	9%	2.7%	5.6%	100%	

d. Interstate Truck Age in California

The vehicle model year is an important characteristic for determining the emission rate of heavy-duty vehicles. This section discusses the truck age statistics for interstate trucks that travel in California. From the previous section, we found trucks entering California from other U.S. states were of median truck model year 2001 to 2002, and Mexico-based trucks were of median model years 1991 to 1993. In Table 41, the percentages for the mileage for each vehicle age category are shown. More than 50% of truck mileage from Oregon, Nevada, and Arizona is from relatively new trucks of model year 2002 and later. On the other hand, approximately 85% of Mexico-based truck mileage in California is from trucks of model year 1998 or earlier. However, the older Mexico trucks, representing less overall truck entry traffic and California mileage than trucks from other regions, have little impact on the mileage-weighted truck age.

Table 41. Interstate Truck Mileage in California by Model Year and Place of Origin

Place of Origin	Truck Count (entry/day)	Total CA Mileage (million mi/yr)	Average Age (yrs)	Average Model Year	Percent of California Mileage by Vehicle Model Year					
					2005-2007	2002-2004	1999-2001	1996-1998	1993-1995	Pre-1993
Oregon	2,061	727	5.6	2001.4	27.5%	29.6%	23.7%	9.0%	7.0%	3.2%
Nevada	6,282	1,316	5.3	2001.7	41.1%	11.2%	31.5%	12.5%	3.6%	0.0%
Arizona	10,527	2,286	5.2	2001.8	37.3%	15.1%	22.1%	11.2%	14.2%	0.1%
Mexico	2,968	29	14.6	1992.4	0.5%	10.9%	4.2%	38.8%	9.2%	36.4%
Weighted Averages			5.4	2001.6	36.6%	16.3%	25.1%	11.4%	9.8%	0.8%

Table 42 and Figure 10 compare the truck ages and corresponding mileages. This study and the U.S. Census' *VIUS* (2002)[5] results reveal that newer trucks drive proportionally more miles than older model year trucks. However, there is an age-related difference between the interstate trucks captured in this survey and the California-registered, heavy-duty trucks: interstate trucks are newer than the California-registered trucks. The California-mileage-weighted average age for interstate-traveling trucks that enter California is 5.4 years, which is 2.1 years newer than the U.S. Census figure for California-registered trucks.

[5] The *VIUS* data explicitly exclude non-CA-registered trucks that are traveling in the State, but do include the annual mileage of these CA-registered trucks outside of California.

Table 42. Breakdown of Truck Populations and Truck Mileage by Age for Interstate Trucks and California-Registered Trucks

Vehicle Age (yrs)	Percent of Trucks		Percent of California Mileage	
	Interstate Trucks (This study)	California Registered Class 8 Heavy-Duty Trucks (US Census, 2006)	Interstate Trucks (This study)	California Registered Class 8 Heavy-Duty Trucks (US Census, 2006)
0-2	31.5%	12.1%	36.6%	13.8%
3-5	16.9%	22.2%	16.3%	27.4%
6-8	17.2%	18.2%	25.1%	22.1%
9-11	13.8%	15.0%	11.4%	13.4%
12-14	6.8%	13.1%	9.8%	11.4%
15+	9.4%	19.5%	0.8%	12.0%
Truck count-weighted average (yr)	6.6	8.7		
Mileage-weighted average (yr)			5.4	7.5

Figure 10 shows average truck mileage accrual by vehicle age compared to data from CARB (2006) and U.S. Census' *VIUS* (2002). The CARB and *VIUS* data show the same characteristic reduction trend in average truck use for later model years, but they differ greatly in magnitude. The *VIUS* data are based on California-registered heavy-duty trucks. The CARB results for truck mileage accrual approximately double the *VIUS* results for the first five years.

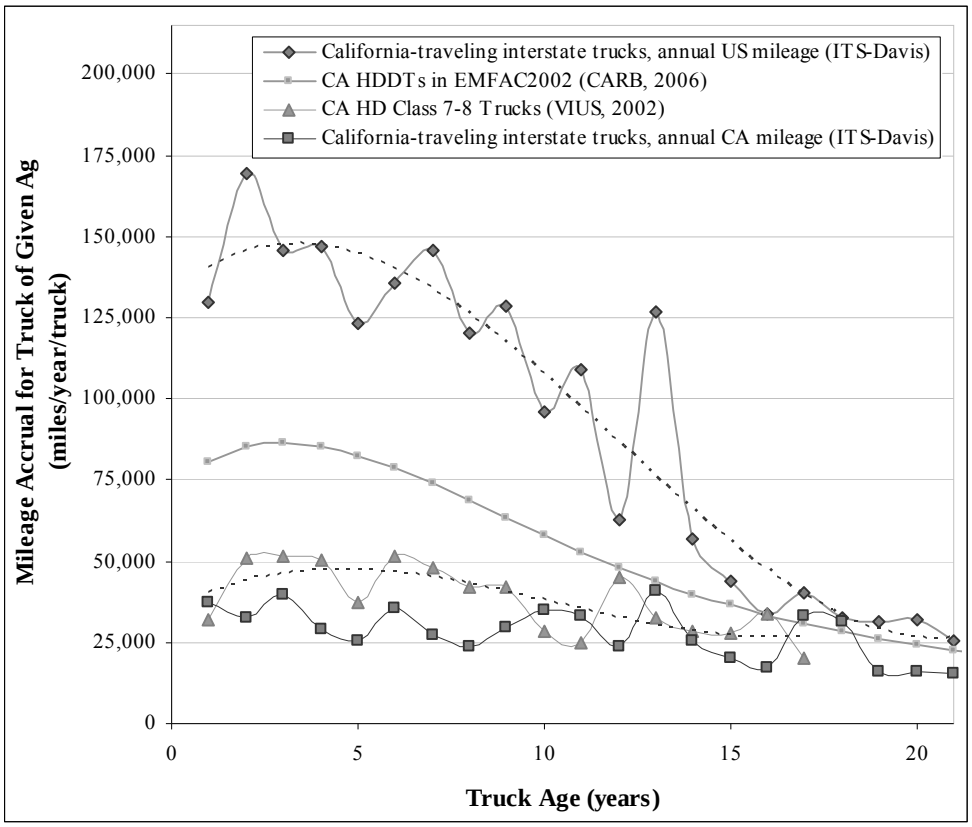

Figure 10. Mileage Accrual by Truck Age

e. Interstate Truck Activity by California Air Basin

This section examines the distribution of truck mileage and use of out-of-state fuel across the California Air Resources Board's Air Basins. The Air Basins into which the truck activity is apportioned, and the California highway network, are shown in the maps of Figure 11.

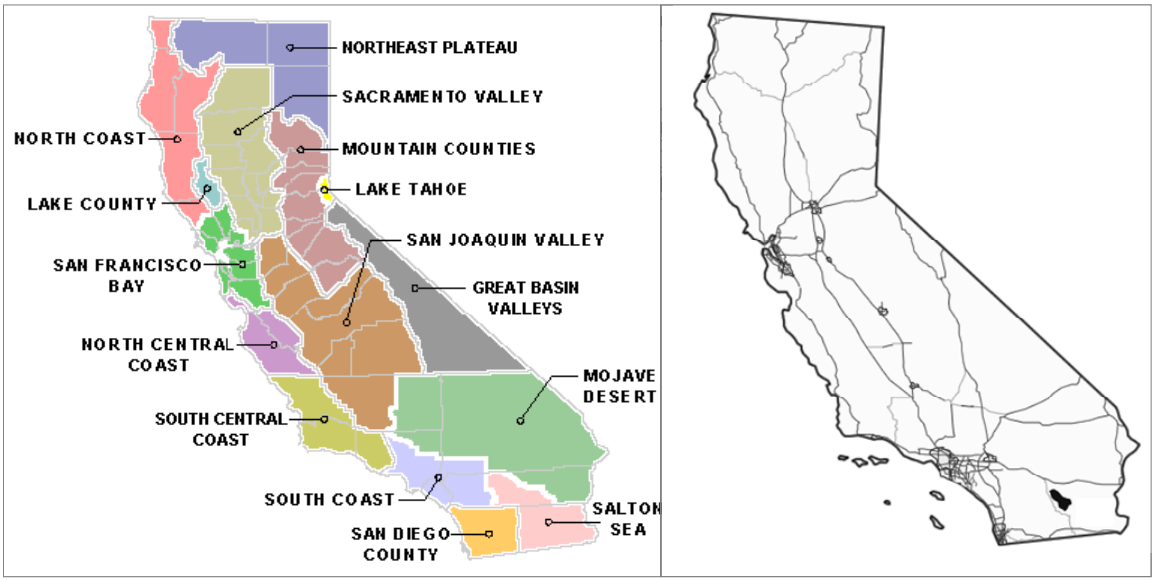

Figure 11. California Air Basins and Major Highway Network

The data utilized are each truck's California entry location, exit location, reported mileage, which city (or cities) in California the truck would stop at on that trip, and total trips per year into California. Additionally, we employ (1) a comprehensive California cities-counties listing, (2) a California counties-Air Basin listing to determine the final Air Basin destination, (3) a Caltrans database of all state highways to determine mileage on interstate routes within each county, and (4) and an online map program to check trucks' California trip mileage.

To apportion each truck's entry mileage in California Air Basins, first, a "lookup" tool was developed to assign each of the California destination cities to a destination county. Then another lookup function associated counties to the trucks' destination Air Basins. Ten major California cities were chosen as centroid destination cities within the Air Basins. This simplified the destinations of truck travel and allowed us to estimate the truck trip mileage on each highway, in each county, and in each Air Basin.

Using eight border cities and ten centroid cities (See Table 43), each leg of the each truck trip is assigned to one of 80 possible routes. Mileage from each of the potential legs is assumed to take place on major highways (almost entirely interstate highways). We used Caltrans mileposts to determine the mileage. The mileage of each of the 80 potential legs is checked against an online map program. Due to drivers' rough approximations about their miles (e.g., rounding and/or estimating to nearest 100 miles), we opt to use our own California trip mileage estimations for this part of the analysis. The Mojave Desert was not reported as a trip destination, but trucks did frequently travel through this Air Basin.

Table 43. Entry and Destination Cities Used in Mileage Apportionment

California Entry Points		California Destinations	
Border Cities	Highway	Internal Centroid Cities	Air Basin
Blythe, CA	I-10	Alturas	Northeast Plateau
Calexico, CA	CA-7	Auburn	Mountain Counties
Chula Vista, CA	CA-905	Bakersfield	San Joaquin Valley
Hilt, CA	I-5	El Centro	Salton Sea
Needles, CA	I-40	Eureka	North Coast
Primm, NV	I-15	Hayward	San Francisco
Verdi, NV	I-80	Los Angeles	South Coast
Winterhaven, CA	I-8	Sacramento	Sacramento Valley
		Salinas	North Central Coast
		San Diego	San Diego

In order to distribute the drivers' reported California trip mileage into Air Basins, we made several assumptions about trucks' routes and mileage. For the drivers that did not know the highways on which their trucks would exit California, we assumed that they would exit on the same highway on which they entered. In a small number of cases, where there was a substantial disagreement between the drivers' reported trip mileage and the estimated mileage, we made an estimate.

The following four tables show the mileage impacts of interstate truck activity in California Air Basins. Table 44 shows the total annual mileage by all interstate-traveling trucks (i.e., both California-registered and non-California-registered) in California Air Basins. Approximately 37% of all interstate truck mileage on California roads is estimated to occur in the South Coast Air Basin. The second highest mileage amount is in the Mojave Desert Air Basin, which accumulates 1,080 million miles per year, or 28% of the California interstate truck mileage. The only other two prominent interstate truck mileage Air Basins are the San Joaquin Valley (16%) and the Sacramento Valley (10%). These four Air Basins account for 91% of interstate truck mileage. Of the four Air Basins, the Mojave Desert is the only one without major industry and population centers; it instead accumulates a large percentage of the mileage due to large traffic volumes passing through on interstate highways I-15, I-40, and I-10.

Table 44. Total Interstate Truck Activity in California, by Location of Truck Entry and Air Basin

Bordering Region	California Mileage by Interstate Trucks (million mi/yr)	Annual Miles Within CA, by CA- and Non-CA-Registered Interstate Trucks in Each California Air Basin (million mi/yr)										
		Mountain Counties	Sacramento Valley	San Francisco	North Central Coast	San Joaquin Valley	South Coast	San Diego	Northeast Plateau	North Coast	Mojave Desert	Salton Sea
Oregon	599	12	277	20	2	152	38	2	80	7	10	1
Nevada	1,113	134	74	22	7	176	307	0	6	0	388	0
Arizona	2,066	2	37	13	4	257	1,053	9	11	0	674	5
Mexico	28	0	0	0	0	3	14	0	0	0	9	0
Total	3,805	147	387	55	13	588	1,412	12	98	7	1,080	6
Percent of CA- and non-CA-registered interstate truck mileage in each Air Basin		3.9%	10.2%	1.4%	0.3%	15.5%	37.1%	0.3%	2.6%	0.2%	28.4%	0.2%

Table 45 shows mileage of the *non-California-registered* trucks within each Air Basin. Similar to above (for all interstate-traveling trucks), the non-California-registered trucks accumulate the vast majority, 92%, of their mileage within four Air Basins: South Coast (38%), Mojave Desert (29%), San Joaquin Valley (15%), and Sacramento Valley (10%). This percentage breakdown by Air Basins in Table 45 does not differ much from that of Table 44, which also included the activity of California-registered trucks.

Table 45. Non-California-Registered Truck Activity in California, by Truck Entry and Air Basin

Bordering Region of Truck Entry	California Mileage by Non-CA-Registered Interstate Trucks (million mi/yr)	Annual Miles Within CA, by Non-CA-Registered Interstate Trucks in Each California Air Basin (million mi/yr)										
		Mountain Counties	Sacramento Valley	San Francisco	North Central Coast	San Joaquin Valley	South Coast	San Diego	Northeast Plateau	North Coast	Mojave Desert	Salton Sea
Oregon	440	9	203	14	1	112	28	1	59	5	7	0
Nevada	847	102	56	17	5	134	234	0	5	0	295	0
Arizona	1,701	1	30	11	3	212	867	8	9	0	555	4
Mexico	-	-	-	-	-	-	-	-	-	-	-	-
Total	2,988	112	290	42	10	457	1,129	9	73	5	857	5
Percent of non-CA-registered truck mileage in each Air Basin		3.7%	9.7%	1.4%	0.3%	15.3%	37.8%	0.3%	2.5%	0.2%	28.7%	0.2%

Table 46 shows the mileage in California by interstate-traveling trucks that are fueled by out-of-state fuel. This table includes impacts of California-registered and non-California-registered trucks, which both contribute to the in-state usage of out-of-state fuel. The distribution of the out-of-state fuel usage was calculated by multiplying the percentages of California mileage from non-California fuel by bordering region of entry (Table 40) by the out-of-state mileage totals by Air Basin (Table 44). From this table, we wee that 92% of all non-California-fuel truck travel

takes place in four Air Basins (South Coast, Mojave Desert, San Joaquin Valley, Sacramento Valley).

Table 46. Mileage in California on Non-California Fuel, by Truck Entry and Air Basin

Bordering Region of Truck Entry	California Mileage by Interstate Trucks on Non-CA Fuel (million mi/yr)	Annual Miles Within CA, by Non-CA-Registered Interstate Trucks in Each California Air Basin (million mi/yr)										
		Mountain Counties	Sacramento Valley	San Francisco	North Central Coast	San Joaquin Valley	South Coast	San Diego	Northeast Plateau	North Coast	Mojave Desert	Salton Sea
Oregon	335	7	155	11	1	85	21	1	45	4	5	0
Nevada	694	83	46	14	4	110	191	0	4	0	242	0
Arizona	1,822	1	32	12	4	227	929	8	10	0	595	5
Mexico	22	0	0	0	0	0	6	10	0	0	0	5
Total	2,872	91	233	36	9	422	1,147	20	59	4	841	10
Percent of non-CA-fuel mileage in each Air Basin		3.2%	8.1%	1.3%	0.3%	14.7%	39.9%	0.7%	2.1%	0.1%	29.3%	0.4%

Table 47 shows the distribution of this mileage according to the bordering regions from which trucks entered California and the California Air Basins in which the mileage is driven. The results indicate that (as above) the largest mileage impacts are seen in four Air Basins: South Coast (with 30% of the state annual mileage net change), Mojave Desert (26%), San Joaquin Valley (17%), and Sacramento Valley (15%).

Table 47. Net Changes in Heavy-Duty Truck Mileage, by Truck Entry and Air Basin

Bordering Region	California Mileage Change due to Interstate Trucks (million mi/yr)	Estimated Mileage Net Change[a] by Interstate Trucks in Each California Air Basin (million mi/yr)										
		Mountain Counties	Sacramento Valley	San Francisco	North Central Coast	San Joaquin Valley	South Coast	San Diego	Northeast Plateau	North Coast	Mojave Desert	Salton Sea
Oregon	300	6	139	10	1	76	19	1	40	3	5	0
Nevada	472	57	31	9	3	75	130	0	3	0	164	0
Arizona	412	0	7	3	1	51	210	2	2	0	134	1
Mexico	-21	0	0	0	0	0	-5	-10	0	0	0	-5
Total	1,163	63	177	22	5	202	354	-7	45	3	304	-4
Percent of total CA mileage that is in each CA Air Basin		5.4%	15.2%	1.9%	0.4%	17.3%	30.4%	-0.6%	3.9%	0.3%	26.1%	-0.3%

[a] *"Net Change" is the non-CA-registered truck activity in this Air Basin, minus CA-registered truck activity that is outside CA*

Table 48 shows survey results compared with CARB EMFAC2007 (CARB, 2007a). To use and compare this survey's results to CARB's, we first subtract the 25% out-of-state correction factor that CARB currently is using for non-California-registered interstate trucks. Also shown in the table is the contribution of out-of-state fuel to the HHDDT VMT totals. We estimate that non-

California fuel usage makes up 25% of the updated overall HHDDT VMT total. The Mojave Desert, South Coast, Mountain Counties, Northeast Plateau, and Sacramento Valley Air Basins all show greater than 20% of their total HHDDT mileage being fueled by non-California fuel.

Table 48. Vehicle Miles Traveled by Heavy-Heavy Duty Diesel Trucks, based on EMFAC2007 (CARB, 2007a) Estimates and Survey Implications

Air Basin	EMFAC2007 for Year 2006 (CARB, 2007a)		With Results from This Study				
			On Total VMT			On Non-California Fuel	
	Total HHDDT VMT (million mi/yr)	Out-of-State HHDDT VMT (million mi/yr)	Net Change [a] VMT (million mi/yr)	Updated VMT [b] (million mi/yr)	Percent Change from EMFAC to Updated	HHDDT VMT on Non-CA-Fuel (million mi/yr)	Percent of Updated VMT on Non-CA Fuel
Mountain Counties	209	52	63	220	5%	91	41%
Sacramento Valley	1,107	275	177	1,009	-9%	233	23%
San Francisco	916	227	22	711	-22%	36	5%
North Central Coast	225	56	5	174	-23%	9	5%
San Joaquin Valley	3,747	930	202	3,019	-19%	422	14%
South Coast	2,654	659	354	2,350	-11%	1,147	49%
San Diego	471	117	-7	347	-26%	20	6%
Northeast Plateau	163	40	45	167	3%	59	35%
North Coast	161	40	3	124	-23%	4	3%
Mojave Desert	1,547	384	304	1,467	-5%	841	57%
Salton Sea	711	176	-4	530	-25%	10	2%
Other Air Basins	231	57	0	173	-25%	0	0%
All	12,141	3012	1,163	10,292	-15%	2,872	28%

[a] *"Net Change" is the non-CA-registered truck activity in this Air Basin, minus CA-registered truck activity that is outside CA*

[b] *"Updated VMT" is EMFAC2007 VMT, minus EMFAC Out-of-State, plus "Net Change"*

f. Discussion of Impacts on Emission Inventories

There are three main sources of impact: (1) the net impact of more trucks with mileage on California roads due to the previously unaccounted-for out-of-state truck activity, (2) the impact of the use of non-California fuel on per-mile emission rates, and (3) and impact of different truck characteristics (e.g., truck age) on per-mile emission rates. Moreover, there may be disproportionate effects in particular areas. This study's findings suggest that interstate truck travel activity and use of non-California fuel is among the highest in the California Air Basins that have the greatest ambient air quality challenges.

Based on the CARB reference data, the survey findings indicate that approximately 28% of the Class 8 diesel (or HHDDT) mileage in California is from non-California fuel, and some Air Basins have larger non-California fuel impact (e.g., 49% of South Coast HHDDT mileage is fueled by out-of-state diesel). However, because the effects on emissions due to fuel quality are complex, the resulting emissions impact is highly uncertain. Further confounding the emission calculation are the survey findings on the distribution of truck mileage. For example, more of the mileage from interstate trucks on California roads is accrued by later model (i.e., 2002-2007 model year) trucks than is presented in CARB (2007a) for all of heavy-duty diesel trucks. Distributing more mileage toward later model years could have emission-reducing impact by allocating more HHDDT mileage toward newer trucks with lower gram-per-mile emission rates.

There is considerably more complexity and uncertainty associated with estimating the out-of-state truck activity impacts on emissions. The additional mileage, the use of out-of-state fuel, and the differing truck attributes could have considerable implications on emissions in California. Properly accounting for and estimating the numerous potential truck activity and population changes from this survey's findings would require numerous simultaneous changes to the base data files of the updated CARB EMFAC2007 (CARB, 2007a) emission inventory estimation tool. Accounting for the emissions implications of this survey's results is an area for future research.

VI. CONCLUSIONS

The purpose of this study was to better understand the ways in which interstate truck activity impacts highway usage, fuel consumption, and emissions in California. We conducted an interview-style, in-person survey of truck drivers at the most heavily traveled, commercial truck entries into California to attain data. In conducting a background literature search, we found that California agency figures and survey findings on truck population, truck mileage, and fuel usage differ. In addition, these effects may be disproportionately high in several California Air Basins that have long had ambient air quality attainment challenges for ozone and particulate matter, to which heavy-duty diesel trucks are prime contributors.

In terms of activity of interstate trucks, we find about 3.0 billion annual miles in California are traveled by non-California-registered trucks. This non-California-registered truck travel amounts to approximately 29-33% of all heavy-duty truck miles in California. California-registered trucks are driven 1.8 billion miles *outside* of California annually. We took Caltrans and CARB data, and adjusted for non-California-registered truck activity in California and California-registered truck activity outside California, to estimate corrections to their vehicle-miles traveled statistics. Our estimations indicate that, accounting for interstate trucks activity, the Class 8, heavy duty truck mileage estimation of CARB would be decreased by 15%. Much of the interstate truck mileage in California (63%) originates from trucks entering California from Arizona.

About one-eighth of surveyed trucks started their trips into California with California fuel; the remaining survey responses were divided approximately evenly into those that intended never to use California fuel on that trip and those who would likely consume a mix of in-state and out-of-state fuel on their California trip. Approximately three-quarters of interstate-traveling trucks' mileage in California, or approximately 2.9 billion miles per year, is fueled by non-California fuel. Approximately 28-32% of all of the Class 8, heavy-duty diesel truck mileage in California (i.e., including non-interstate-traveling trucks) is fueled by non-California diesel. Most out-of-state mileage (52%) uses diesel fuel from Arizona.

We find that the impact of interstate trucks is concentrated disproportionately across the state. For four different mileage variables – (a) interstate truck mileage, (b) non-California-registered truck mileage, (c) additional interstate truck mileage, and (d) non-California fuel use mileage – the impact of interstate trucks is predominantly on highways of four Air Basins: South Coast (30-40%), Mojave Desert (26-29%), San Joaquin Valley (15-17%), and Sacramento Valley (8-15%). The Mojave Desert, South Coast, Mountain Counties, Northeast Plateau, and Sacramento Valley Air Basins all show greater than 20% of their total heavy-duty diesel truck mileage totals being fueled by non-California fuel.

The survey results for truck population, mileage, and fuel use differ from that of the CARB and Caltrans. The mileage, the use of out-of-state fuel, and differing truck age attributes could have considerable implications on properly accounting for the true contribution of heavy-duty trucks to the overall emissions inventories. Based on the survey, these effects appear to be disproportionately concentrated in four air basins – the South Coast, the Mojave Desert, Sacramento Valley, and the San Joaquin Valley. We recommend that the official heavy-duty truck statistics that are used for emissions inventories should be re-examined with respect to the

survey data on interstate-traveling trucks in California, and a sensitivity analysis should be conducted to determine the magnitude of effect that the activity characterizations may have on the emissions inventory in each air basin. The differing characteristics (e.g., age, mileage, fuel economy) and the more elusive nature of their data collection (i.e., these trucks are non-California registered and interstate-traveling) of these out-of-state trucks suggest that perhaps making them a separate category within heavy, heavy-duty diesel trucks would be an improvement over aggregating them.

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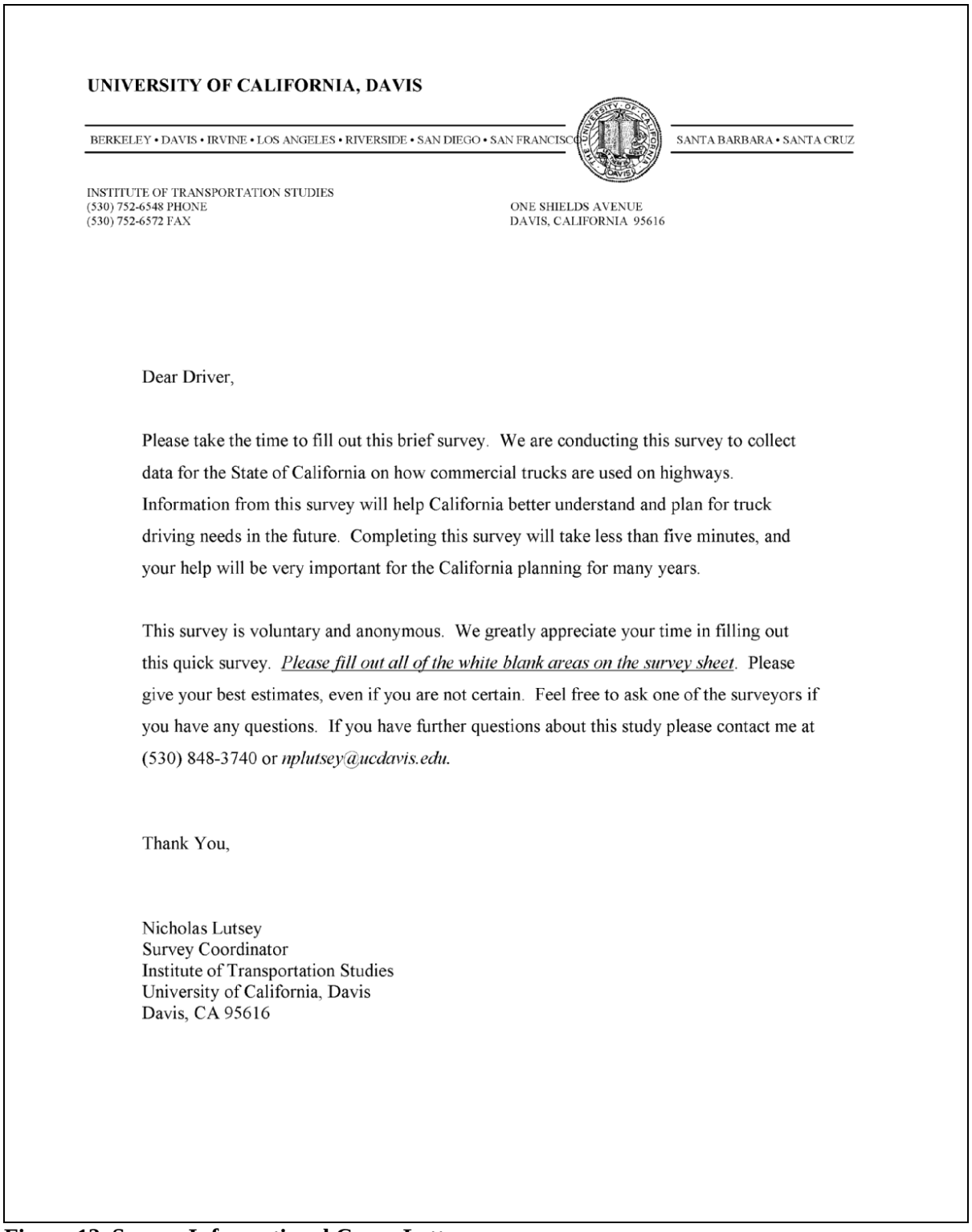
VIII. GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

CA:	California
Caltrans:	California Department of Transportation
CARB:	California Air Resources Board
CDFA:	California Department of Food and Agriculture
CEC:	California Energy Commission
CHP:	California Highway Patrol
CVIS:	Commercial Vehicle Inspection Specialist
g/bhp:	gram per brake-horsepower
g/mi:	grams per mile traveled
GVWR:	Gross Vehicle Weight Rating
HHDDT:	Heavy-heavy duty diesel truck
INE:	Instituto Nacional de Ecologia (Mexico)
ITS-Davis:	Institute of Transportation Studies, University of California, Davis
NHTSA:	National Highway Traffic and Safety Administration
NO_x:	Oxides of nitrogen
PM:	Particulate matter
ppm:	Parts per million
US EPA:	United States Environmental Protection Agency

IX. APPENDICES

a. Appendix A. Survey Materials



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INSTITUTE OF TRANSPORTATION STUDIES
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(530) 752-6572 FAX

ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616

Dear Driver,

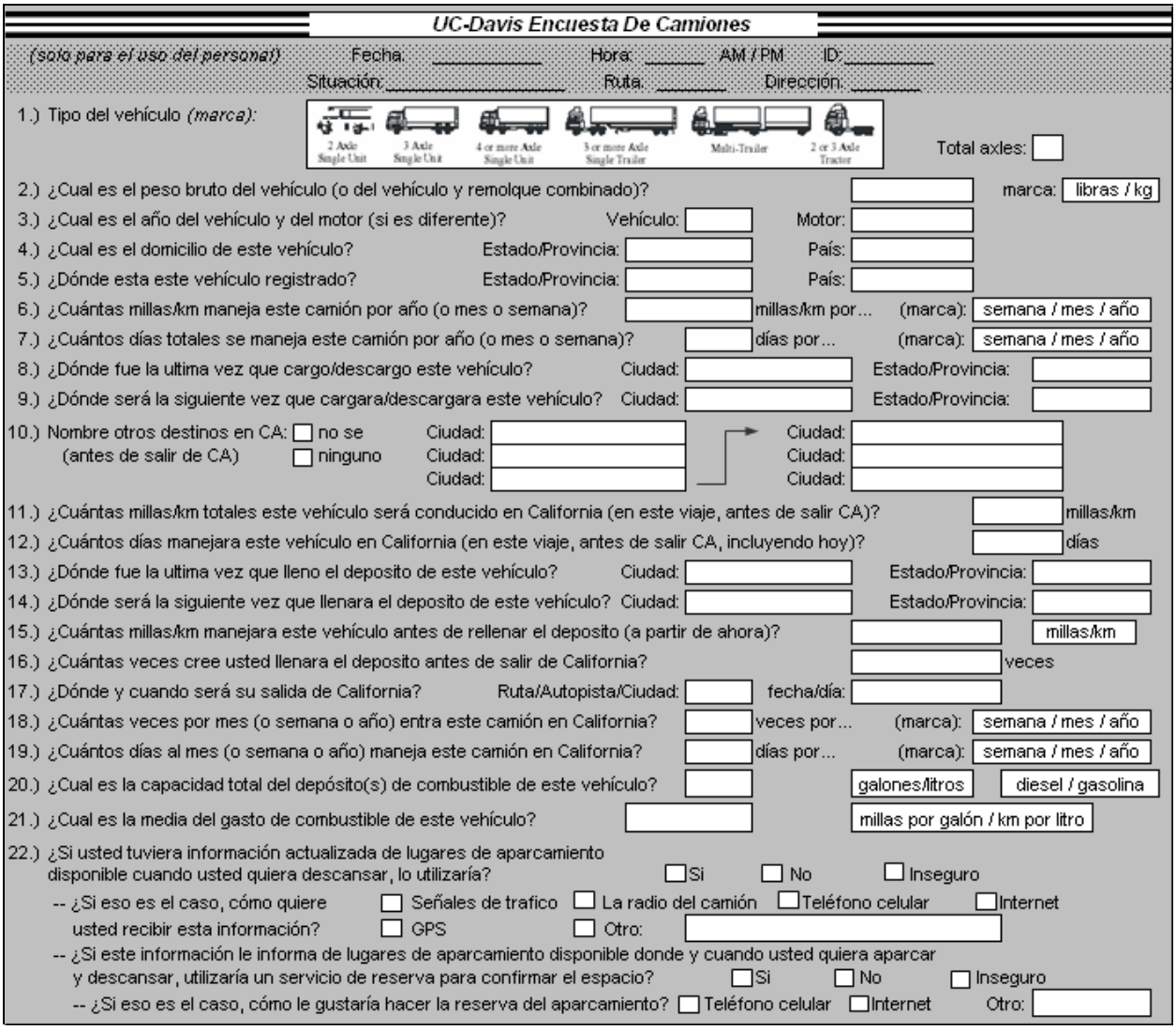
Please take the time to fill out this brief survey. We are conducting this survey to collect data for the State of California on how commercial trucks are used on highways. Information from this survey will help California better understand and plan for truck driving needs in the future. Completing this survey will take less than five minutes, and your help will be very important for the California planning for many years.

This survey is voluntary and anonymous. We greatly appreciate your time in filling out this quick survey. *Please fill out all of the white blank areas on the survey sheet*. Please give your best estimates, even if you are not certain. Feel free to ask one of the surveyors if you have any questions. If you have further questions about this study please contact me at (530) 848-3740 or *nplutsey@ucdavis.edu.*

Thank You,

Nicholas Lutsey
Survey Coordinator
Institute of Transportation Studies
University of California, Davis
Davis, CA 95616

Figure 12. Survey Informational Cover Letter



UC-Davis Encuesta De Camiones

(solo para el uso del personal) Fecha: _____ Hora: _____ AM / PM ID: _____
Situación: _____ Ruta: _____ Dirección: _____

1.) Tipo del vehículo *(marca)*: 2 Axle Single Unit | 3 Axle Single Unit | 4 or more Axle Single Unit | 5 or more Axle Single Trailer | Multi-Trailer | 2 or 3 Axle Tractor — Total axles: ☐

2.) ¿Cual es el peso bruto del vehículo (o del vehículo y remolque combinado)? ☐ marca: libras / kg

3.) ¿Cual es el año del vehículo y del motor (si es diferente)? Vehículo: ☐ Motor: ☐

4.) ¿Cual es el domicilio de este vehículo? Estado/Provincia: ☐ País: ☐

5.) ¿Dónde esta este vehículo registrado? Estado/Provincia: ☐ País: ☐

6.) ¿Cuántas millas/km maneja este camión por año (o mes o semana)? ☐ millas/km por... (marca): semana / mes / año

7.) ¿Cuántos días totales se maneja este camión por año (o mes o semana)? ☐ días por... (marca): semana / mes / año

8.) ¿Dónde fue la ultima vez que cargo/descargo este vehículo? Ciudad: ☐ Estado/Provincia: ☐

9.) ¿Dónde será la siguiente vez que cargara/descargara este vehículo? Ciudad: ☐ Estado/Provincia: ☐

10.) Nombre otros destinos en CA: ☐ no se ☐ ninguno (antes de salir de CA) Ciudad: ☐ Ciudad: ☐ Ciudad: ☐ → Ciudad: ☐ Ciudad: ☐ Ciudad: ☐

11.) ¿Cuántas millas/km totales este vehículo será conducido en California (en este viaje, antes de salir CA)? ☐ millas/km

12.) ¿Cuántos días manejara este vehículo en California (en este viaje, antes de salir CA, incluyendo hoy)? ☐ días

13.) ¿Dónde fue la ultima vez que lleno el deposito de este vehículo? Ciudad: ☐ Estado/Provincia: ☐

14.) ¿Dónde será la siguiente vez que llenara el deposito de este vehículo? Ciudad: ☐ Estado/Provincia: ☐

15.) ¿Cuántas millas/km manejara este vehículo antes de rellenar el deposito (a partir de ahora)? ☐ millas/km

16.) ¿Cuántas veces cree usted llenara el deposito antes de salir de California? ☐ veces

17.) ¿Dónde y cuando será su salida de California? Ruta/Autopista/Ciudad: ☐ fecha/día: ☐

18.) ¿Cuántas veces por mes (o semana o año) entra este camión en California? ☐ veces por... (marca): semana / mes / año

19.) ¿Cuántos días al mes (o semana o año) maneja este camión en California? ☐ días por... (marca): semana / mes / año

20.) ¿Cual es la capacidad total del depósito(s) de combustible de este vehículo? ☐ galones/litros diesel / gasolina

21.) ¿Cual es la media del gasto de combustible de este vehículo? ☐ millas por galón / km por litro

22.) ¿Si usted tuviera información actualizada de lugares de aparcamiento disponible cuando usted quiera descansar, lo utilizaría? ☐ Si ☐ No ☐ Inseguro

-- ¿Si eso es el caso, cómo quiere usted recibir esta información? ☐ Señales de trafico ☐ La radio del camión ☐ Teléfono celular ☐ Internet ☐ GPS ☐ Otro: ☐

-- ¿Si este información le informa de lugares de aparcamiento disponible donde y cuando usted quiera aparcar y descansar, utilizaría un servicio de reserva para confirmar el espacio? ☐ Si ☐ No ☐ Inseguro

-- ¿Si eso es el caso, cómo le gustaría hacer la reserva del aparcamiento? ☐ Teléfono celular ☐ Internet Otro: ☐

Figure 13. Survey Instrument, In Spanish

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(530) 752-6572 FAX

ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616

Estimado Conductor,

Por favor, dedique un momento a rellenar esta encuesta. Estamos haciendo esta encuesta para obtener información sobre la utilización de camiones comerciales en las carreteras del Estado de California. Los resultados de esta encuesta ayudarán a California a resolver más fácilmente las necesidades futuras del camionero. Completar esta encuesta le tomará menos de cinco minutos, y su ayuda será muy importante para la planificación futura de California.

Esta encuesta es voluntaria y anónima. Apreciamos mucho su tiempo en completar esta encuesta. *Por favor, llene todas las áreas en blanco de la hoja de la encuesta*. Por favor, responda de manera estimada si no esta seguro de la respuesta correcta. No dude en preguntar a los encuestadores si usted tiene cualquier pregunta. Si usted tiene alguna pregunta adicional sobre este estudio por favor contacte al (530) 848-3740 o nplutsey@ucdavis.edu.

Gracias,

Nicholas Lutsey
Survey Coordinator
Institute of Transportation Studies
University of California, Davis
Davis, CA 95616

Figure 14. Survey Informational Cover Letter, In Spanish

b. Appendix B. Additional Survey Statistics

The survey results are dependent on the sample variables' mean and standard deviation, and how those relate with the comparable variables for the known population. However, because the chief purpose of this study is to characterize and quantify data for an unknown population (i.e., out-of-state trucks), pre-survey target size calculations were not possible. Instead, the determination of the number of surveys to be collected from the various locations was dictated by the availability of personnel to facilitate the surveying, time constraints of truck facility operation, and this particular study's budget.

The ability to usefully examine the statistical significance of the results as compared to known data on heavy-duty truck populations is limited because (a) there are no data on the population of interstate-traveling trucks that travel in California and (b) comparing the survey data to the wider population of California trucks (the population that by and large does not travel inter-state) shows the obvious differences between these populations that are the reasons for this data collection in the first place. For example, related to point (b), in Table 49, we show statistical results for this survey's sample versus state estimates for commercial trucks. As expected, differences in annual total mileage of interstate traveling trucks and these trucks' annual mileage in California are statistically significant at a 95% confidence level when compared to the California truck population at large.

Table 49. Statistical Significance Tests for Survey Variables

Characteristic to be Tested		Sample			Population		Statistic		
Characteristic	Variable	Number	Mean	Standard deviation	Source	Mean	Test	Z/t	Statistically Significant Difference?
Annual truck mileage	mi/truck/yr	429	115,362	75,681	Caltrans, 2005b	63,848	one-sample t-test of means	14.1	Yes
Annual truck mileage	mi/truck/yr	429	115,036	75,876	CARB, 2003	53,301	one-sample t-test of means	16.9	Yes
CA annual mileage	mi/truck/yr	385	30,621	32,018	Caltrans, 2005b	63,848	one-sample t-test of means	-20.4	Yes
CA annual mileage	mi/truck/yr	385	30,621	32,018	CARB, 2003	53,301	one-sample t-test of means	-13.9	Yes
Fuel economy	mi/gallon	308	6.05	1.19	Caltrans, 2005b	5.95	one-sample t-test of means	1.4	No
Fuel economy	mi/gallon	308	6.05	1.19	CARB, 2003	4.55	one-sample t-test of means	22.1	Yes
Proportion trucks 5-axle at Entry	%	431	0.97		Caltrans, 2006a	0.78	one-proportion z-test	-21.3	Yes

p = 0.05, resulting in t=z=1.64 (for n>30)

In the case of fuel economy, the mean 6.05 miles-per-gallon (standard deviation 1.19) are similar to the Caltrans (2005b) result and statistically different from the CARB (2003) result. There is much bigger uncertainty in the estimated statewide populations' fuel economy than in the survey sample itself, making the comparison not useful until better statewide population estimations (or better disaggregation of the data to understand the data differences) are on hand. The survey

result for average fuel economy would appear to support the Caltrans (2005b) fuel economy figure over the lower CARB (2003) result.

A third case for which a California agency estimated variables for heavy-duty trucks is for the breakdown of trucks by their number of axles. Comparing the survey samples 5-axle (or greater) proportion of 97% with Caltrans (2006a) result for trucks on the same entry routes into California of 78%, we find that the survey result is statistically different. Because of the considerable amount of uncertainty about the truck counts' reliability and the accuracy of the truck counts breakdown by axle number, the ability to use this result is limited. In this case, we conclude that the sample is a more reliable first-hand accounting of actual truck axle breakdown (that interstate trucks are predominantly 5-plus axle by a very wide margin).

Table 50. Survey Responses on Vehicle Type

Vehicle Type	Responses	Percent
Single Unit	8	1.9%
Single unit w/trailer	1	0.2%
Single trailer	402	93.1%
Multiple trailer	15	3.5%
Tractor	6	1.4%

Table 51. Survey Responses on Vehicle Weight

Vehicle Weight Rating	Responses	Percent
Class 8 (33,001+ lbs)	420	97.4%
Class 7 (26,001-33,000 lbs)	2	0.5%
Class 6 (19,001-26,000 lbs)	9	2.1%

Table 52. Survey Responses on Vehicle Axle Number

Number of Axles	Responses	Percent
2	8	1.9%
3	6	1.4%
4	1	0.2%
5+	416	96.5%

c. Appendix C. Summary Comparison of Mexico-Based Truck Attributes

The characteristics of Mexico-based trucks, and their potentially differing future trends, are sufficiently different to justify considering modeling them separately in the emissions inventory. As such, in the Table 53, the data results from the above sections are summarized to highlight the differences between trucks entering California from Mexico and those entering from other areas.

Table 53. Comparison of Mexico-Based and Non-Mexico-Based Interstate-Traveling Trucks that Travel in California

Characteristic		Mexico-Based	Non-Mexico-Based
Surveys collected		104	329
Annual average daily truck entries (truck/day)		2,968	18,870
Vehicle Attributes	Average truck age	14.3	5.4
	Median truck model year	1,993	2,002
	Fuel capacity (gal)	211	248
	Fuel economy (mpg)	5.2	6.1
Annual Operation	Annual mileage	26,866	139,704
	Days of operation per year	266	270
	Average miles/day (when operating)	113	531
	Average miles/day	76	382
California Operation	Miles per California trip	26	548
	Days per California trip	<1	2.6
	California entries per year per truck	596	70
	Annual California mileage	15,669	40,289
	Percent of annual mileage in California	56.5%	29.3%
	Annual operation in California (day/yr)	265	147
	Percent of annual days in California	99.8%	54.5%
Fueling Patterns	Percent of trucks that start CA trip with CA fuel	17.3%	13.7%
	Percent of trucks that using CA and non-CA fuel on given trip	12.5%	58.9%
	Percent of trucks that will not use CA fuel on given trip	57.7%	25.0%
	Uncertain	12.5%	2.3%
Impact	Annual miles in California (million mi/yr)	28	3,777
	Annual miles in California on non-CA fuel (million mi/yr)	22	2,850

d. Appendix D. Responses to Parking-Related Questions

Table 54. Survey Responses on Annual California-Specific Truck Activity of Interstate-Traveling Truck that Travel in California

Survey Site	California Operation								
	Surveys	CA Trip Miles (mi/ entry)	Days in CA for this CA Entry [a]	Average Days in CA per CA Entry	CA Entries per Truck per Year	Annual CA Mileage	Percent of Annual Mileage in CA	Annual CA Operation (d/yr)	Percent of Annual Days in CA
I-5	66	855	3.0	2.3	71	49,635	37%	162	62%
I-80	68	543	2.2	2.0	60	31,718	23%	121	43%
I-15	50	515	2.1	1.9	115	46,448	34%	216	78%
I-40	72	657	2.6	2.3	36	21,994	14%	82	30%
I-10	73	513	2.3	1.9	73	33,372	23%	137	50%
SR-7	33	88	<1	0.4	615	20,287	67%	257	100%
SR-905	71	57	<1	0.5	586	13,523	51%	269	100%
	433	482	2.1	0.9	201	30,621	27%	172	63%

[a] *For the California trip mileage, 1 day is equivalent to leaving the same day, 2 days is leaving the next day.*

Table 55. Survey Responses on Use of Hypothetical Parking Information Service

Origin State	Highway	Nearby City	Surveys Collected	Regarding Question #22a, the percent of survey respondents who….			
				Would use parking info	Would not use parking info	Are unsure about use of parking info	[blank]
Oregon	I-5	Mt. Shasta, CA	66	77.9%	11.8%	8.8%	1.5%
Nevada	I-80	Truckee, CA	68	72.7%	16.7%	10.6%	0.0%
	I-15	Yermo, CA	50	60.0%	30.0%	6.0%	4.0%
Arizona	I-40	Needles, CA	72	70.8%	22.2%	4.2%	2.8%
	I-10	Banning, CA	73	64.4%	20.5%	9.6%	5.5%
Mexico	SR-7	Calexico, CA	33	57.6%	15.2%	0.0%	27.3%
	SR-905	San Diego, CA	71	64.8%	22.5%	0.0%	12.7%
All Trucks			433	67.9%	19.9%	6.0%	6.2%

Table 56. Survey Responses on Preferred Method of Receiving Parking Information

Origin State	Highway	Nearby City	The percent of survey respondents who might use parking info ("yes" or "unsure" to #22a) that would opt to receive such info by [a] …					
			Road Signs	Radio	Cell Phone	Internet	GPS	"Other"
Oregon	I-5	Mt. Shasta, CA	50.8%	30.5%	13.6%	6.8%	10.2%	15.3%
Nevada	I-80	Truckee, CA	54.5%	16.4%	14.5%	10.9%	9.1%	12.7%
	I-15	Yermo, CA	60.6%	21.2%	6.1%	9.1%	3.0%	30.3%
Arizona	I-40	Needles, CA	70.4%	20.4%	13.0%	9.3%	7.4%	9.3%
	I-10	Banning, CA	50.0%	27.8%	20.4%	9.3%	7.4%	35.2%
Mexico	SR-7	Calexico, CA	21.1%	0.0%	31.6%	26.3%	0.0%	21.1%
	SR-905	San Diego, CA	4.3%	0.0%	58.7%	4.3%	0.0%	32.6%
All Trucks			47.2%	18.8%	21.6%	9.4%	6.3%	21.6%

[a] *More than one response to this question was allowed per survey*

Table 57. Survey Responses on Willingness to Use Parking Place Reservation Service

Origin State	Highway	Nearby City	For survey respondents who would use parking info ("yes" or "unsure" to #22a), the percent of respondents who…			
			Would reserve a parking spot in advance	Would not reserve a spot	Are Unsure	[blank]
Oregon	I-5	Mt. Shasta, CA	49.2%	32.2%	13.6%	5.1%
Nevada	I-80	Truckee, CA	41.8%	52.7%	5.5%	0.0%
	I-15	Yermo, CA	39.4%	48.5%	3.0%	9.1%
Arizona	I-40	Needles, CA	25.9%	59.3%	9.3%	5.6%
	I-10	Banning, CA	33.3%	33.3%	18.5%	14.8%
Mexico	SR-7	Calexico, CA	68.4%	31.6%	0.0%	0.0%
	SR-905	San Diego, CA	80.4%	15.2%	2.2%	2.2%
All Trucks			45.9%	39.7%	8.8%	5.6%

Table 58. Survey Responses on Preferred Method of Reserving Truck Parking Place

Origin State	Highway	Nearby City	For survey respondents who might use parking info ("yes" or "unsure" to #22a) and might reserve a parking spot ("yes" or "unsure" to #22c), the preferred means of making a reservation are…				
			Cell Phone	Internet	Nextel [a]	Other	Blank
Oregon	I-5	Mt. Shasta, CA	86.5%	5.4%	0.0%	5.4%	2.7%
Nevada	I-80	Truckee, CA	88.5%	3.8%	0.0%	0.0%	7.7%
	I-15	Yermo, CA	85.7%	0.0%	0.0%	0.0%	14.3%
Arizona	I-40	Needles, CA	84.2%	10.5%	0.0%	0.0%	5.3%
	I-10	Banning, CA	57.1%	21.4%	0.0%	0.0%	21.4%
Mexico	SR-7	Calexico, CA	0.0%	30.8%	69.2%	0.0%	0.0%
	SR-905	San Diego, CA	0.0%	5.3%	89.5%	5.3%	0.0%
All Trucks			56.6%	9.7%	24.6%	2.3%	6.9%

[a] *walkie-talkie-type cell phone service*