SAN FRANCISCO PLANNING DEPARTMENT,
BETTER NEIGHBORHOODS 2002

Technical Memorandum

Vehicle Ownership in San Francisco

San Francisco Planning Department

BETTER NEIGHBORHOODS 2002

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Table of Contents

Table of Figures

Introduction

This paper provides an overview of private vehicle ownership in San Francisco, and the factors that lie behind it, in order to assist in determining residential parking standards for new development. While it considers vehicle ownership citywide, the particular focus is on the Market/Octavia study area for Better Neighborhoods 2002. The paper concludes with a discussion of policy implications of the data. It also challenges the implicit assumption that vehicle ownership rates equate to the amount of parking supply that should be provided. Instead, parking supply should be considered as an additional tool for managing the transportation system.

Vehicle ownership is considered in terms of vehicle availability to a household, regardless of ownership (leasing is not ownership). This provides a better picture of parking requirements, and ensures compatibility with census data.

The main conclusions can be summarized as follows:

- The key variables that are associated with different vehicle availability rates are **tenure, income, household size, commute mode, rent, housing type, density, transit accessibility, parking cost at work and parking availability at home.**
- It is difficult to say whether these are causes or effects of different vehicle availability levels. However, from the point of view of determining parking requirements, the direction of the causal relationship is of little significance.
- Vehicle availability rates vary substantially in different parts of the city. They range from 0.08 per household for renters in parts of the Tenderloin to nearly 2.0 for owner-occupiers in parts of Pacific Heights (1990 figures at census tract level).
- At a smaller scale (census block group level), the variations are also substantial. Within the Market/Octavia study area, vehicle availability rates for renters range from 0.28 per household on the northeast side of Van Ness and Market, to 0.85 per household in the area bounded by Fulton, Gough, Laguna and Eddy.
- The number of vehicles per household rose by 9.1% between 1990 and 2000, from 1.06 to 1.15. The increase was more substantial for renters (from 0.83 to 0.93) than owner-occupiers (1.49 to 1.56).
- The case for development in Market/Octavia with little or no parking rests on the well below average rates of vehicle availability in the areas, how parking supply reduces the price and increases the consumption of vehicles, and a congested street network that cannot absorb new vehicle trips.

Overall Patterns of Vehicle Availability

Figures 1 and 2 show vehicle availability for owner-occupiers and renters in San Francisco tracts, based on 1990 census data. As can be seen, rates range from under 0.5 per household in the Tenderloin and Chinatown, to more than 1.5 in Seacliff, Laguna Honda and Ingleside. The most obvious correlation is with density, which is shown in Figure 3. High density areas in the north east of the city have the lowest vehicle availability rates.

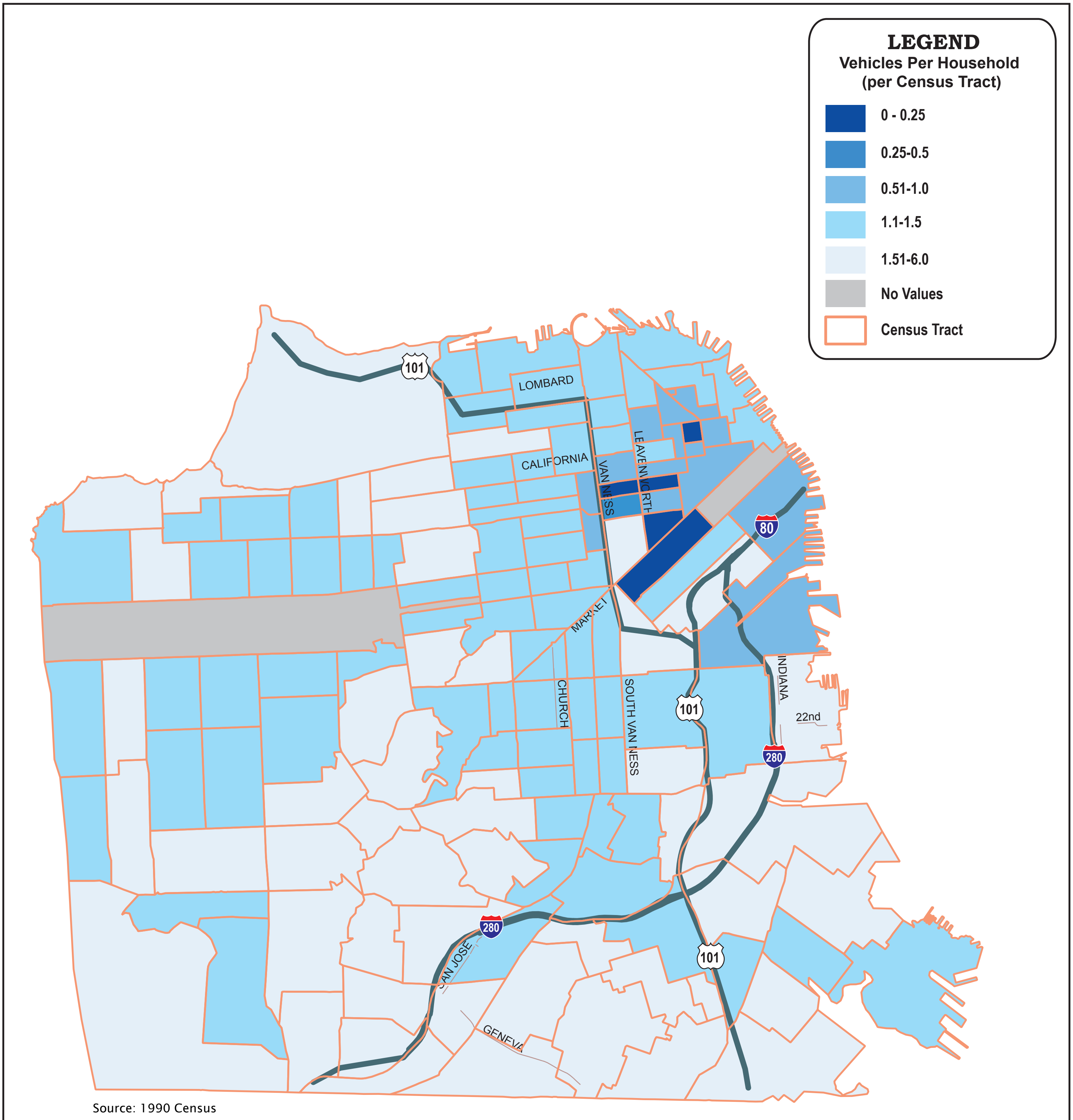

Figure 1 | **Vehicles Per Household 1990, Owner Occupiers**

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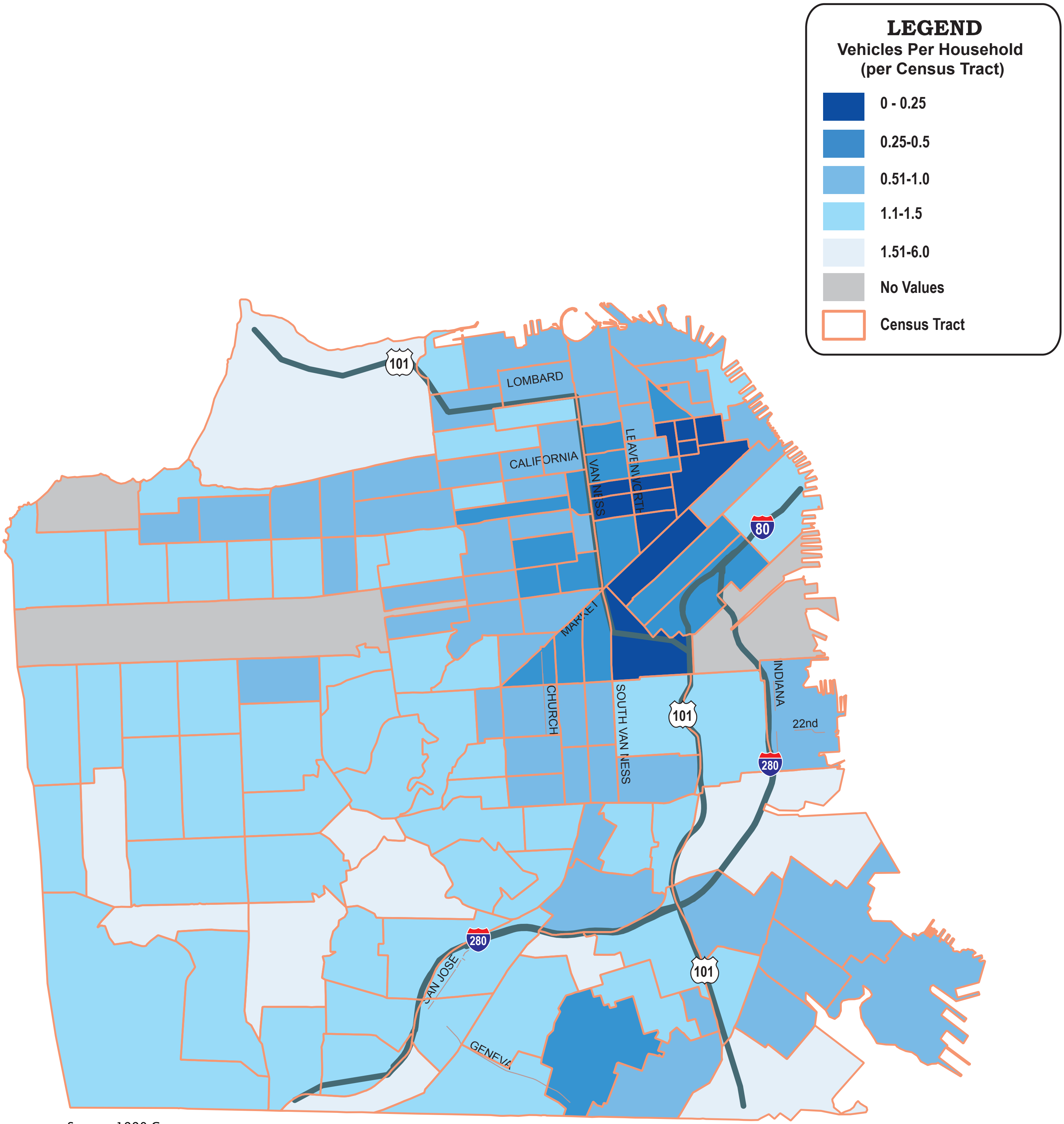
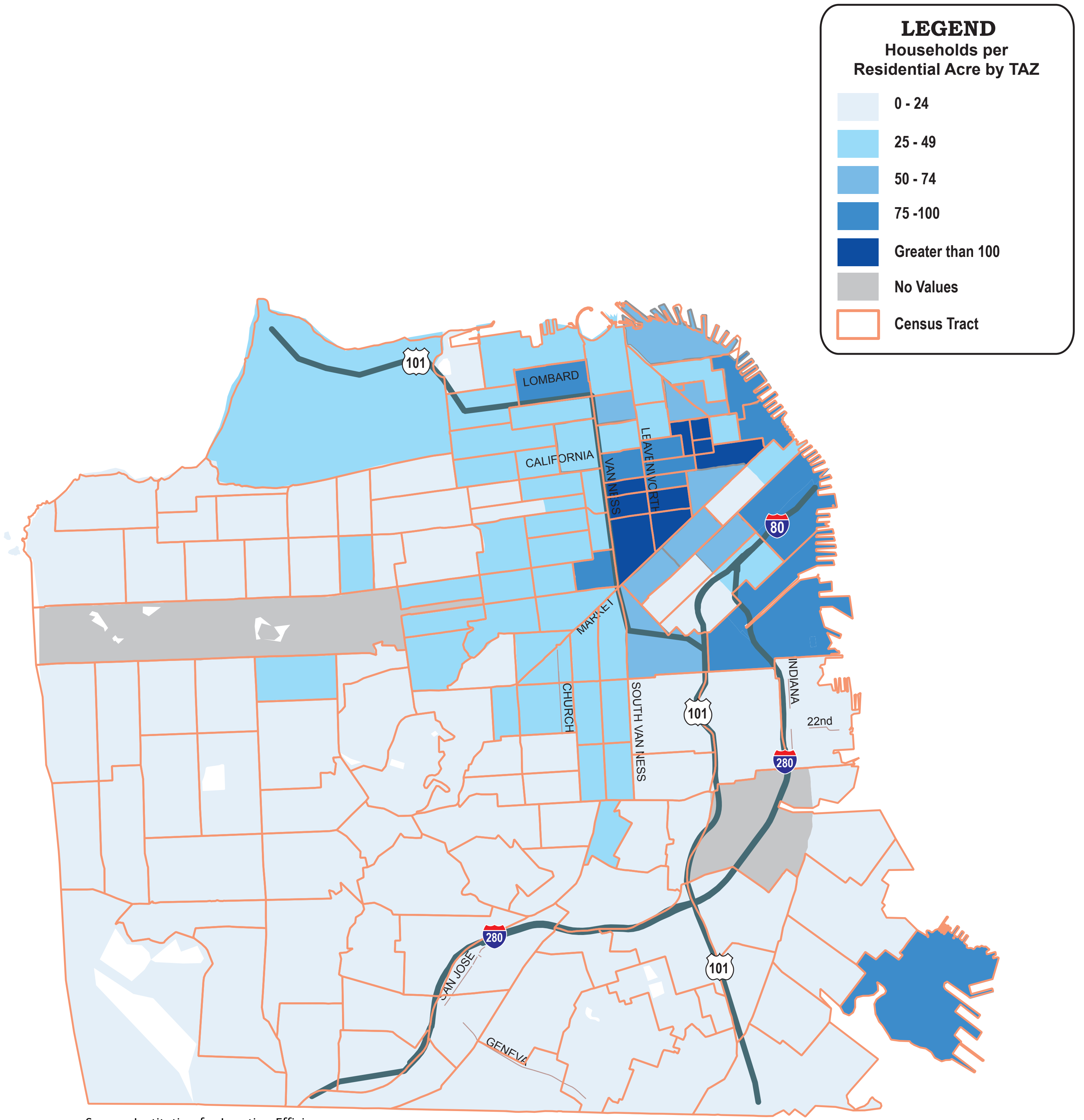


Source: 1990 Census

Figure 2 Vehicles Per Household 1990, Renters



Source: Institution for Location Efficiency

Figure 3	**Residential Density, San Francisco**	nelson\nygaard consulting associates

Vehicle availability varies considerably at the smaller scale of census block groups, as shown for the Market/Octavia area in Figure 4. The full data are shown in Figures 5-7. The same block group may have a high vehicle availability rate for renters, but a low one for owner-occupiers, and vice versa. In general, however, the lowest rates are towards the east, in the block groups east of Gough.

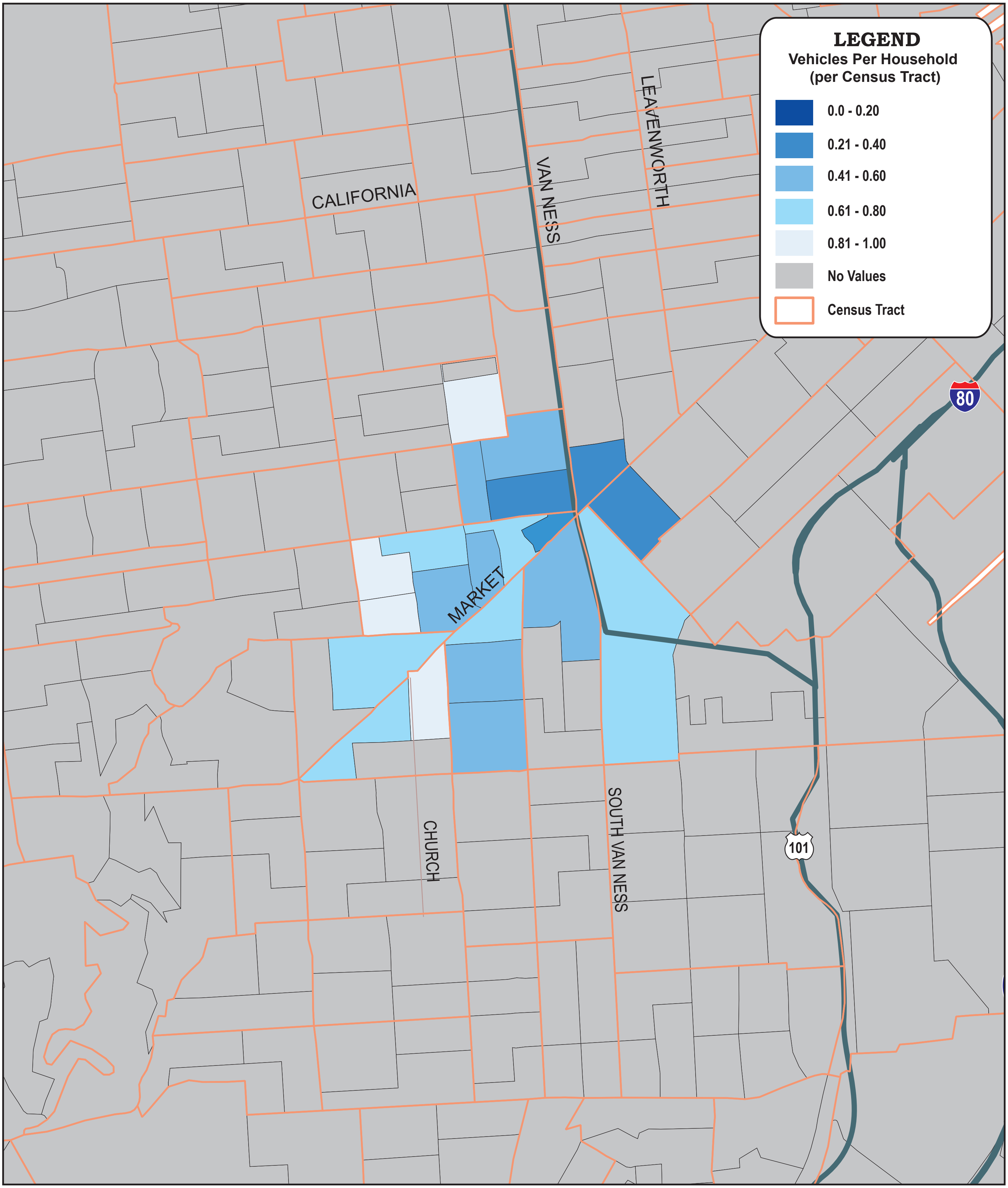


Figure 4 | **Vehicles Per Household In Market/Octavia, 1990**

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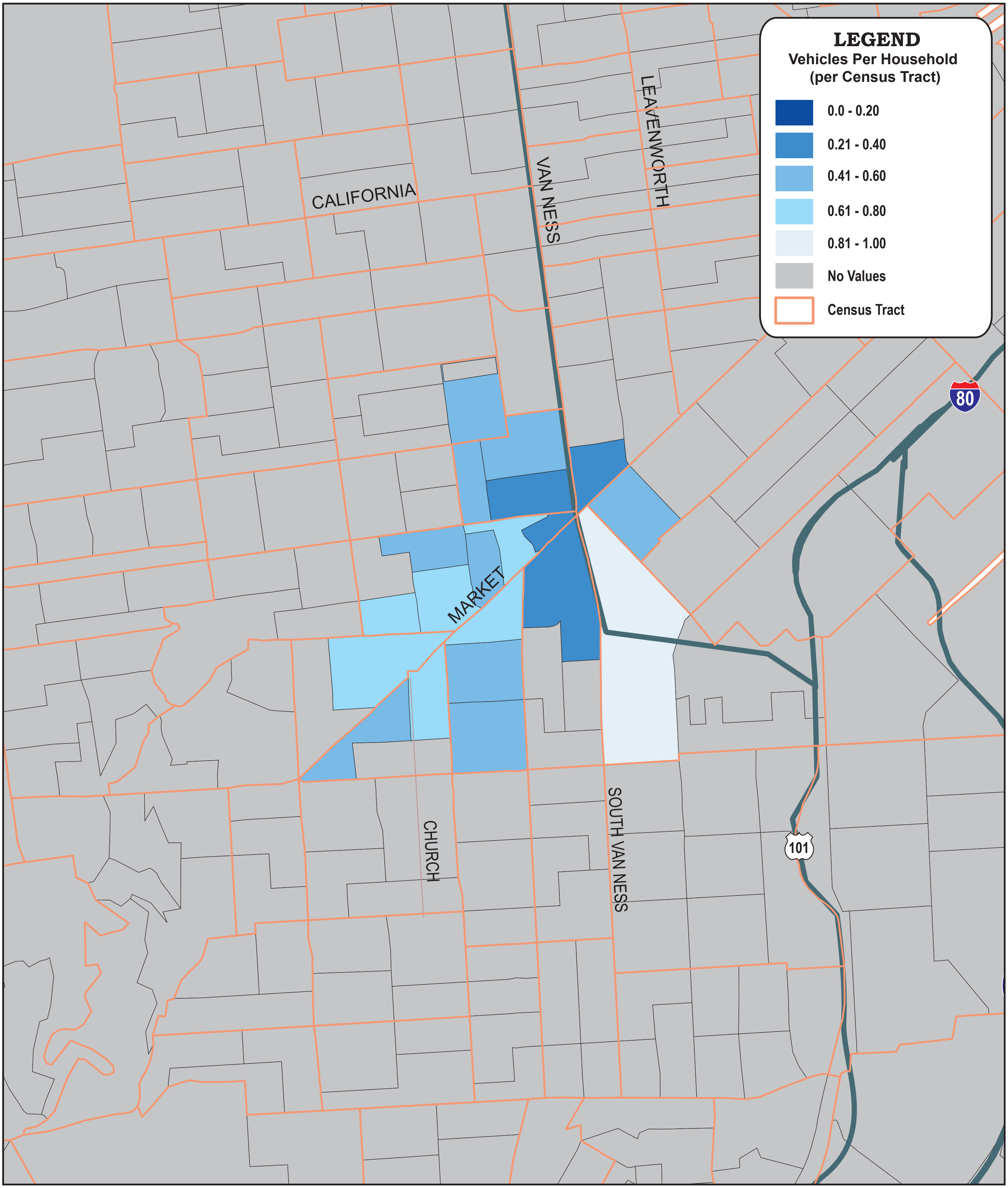


Figure 5	Vehicles Per Rental Unit In Market/Octavia, 1990	nelson\nygaard consulting associates

Figure 6 Mean vehicles per household, Market/Octavia, 1990

Census Tract	Block Group	Total Households		Mean Vehicles/Household		
		Owner Occupied	Renters	Owner Occupied	Renters	All Households
124	3	0	431	-	0.28	0.28
161	1	93	246	1.01	0.85	0.89
162.98	1	9	350	0.56	0.48	0.48
162.98	2	5	391	2.00	0.31	0.34
162.98	3	22	396	1.36	0.53	0.57
168.98	1	0	75	-	0.32	0.32
168.98	2	62	271	1.15	0.54	0.65
168.98	3	51	471	0.61	0.59	0.59
168.98	4	47	403	0.51	0.61	0.60
168.98	5	56	582	1.29	0.58	0.64
168.98	6	75	495	1.59	0.82	0.92
168.98	7	88	354	1.27	0.71	0.83
169	1	117	948	1.07	0.68	0.73
176.98	4	17	21	0.00	0.52	0.29
177	3	12	493	1.00	0.78	0.78
201.98	1	15	267	2.00	0.32	0.41
202.98	1	66	560	1.55	0.51	0.62
202.98	2	131	1132	0.94	0.52	0.56
202.98	4	165	793	0.96	0.48	0.56
203	1	88	643	1.11	0.80	0.84
203	3	81	459	1.27	0.52	0.63

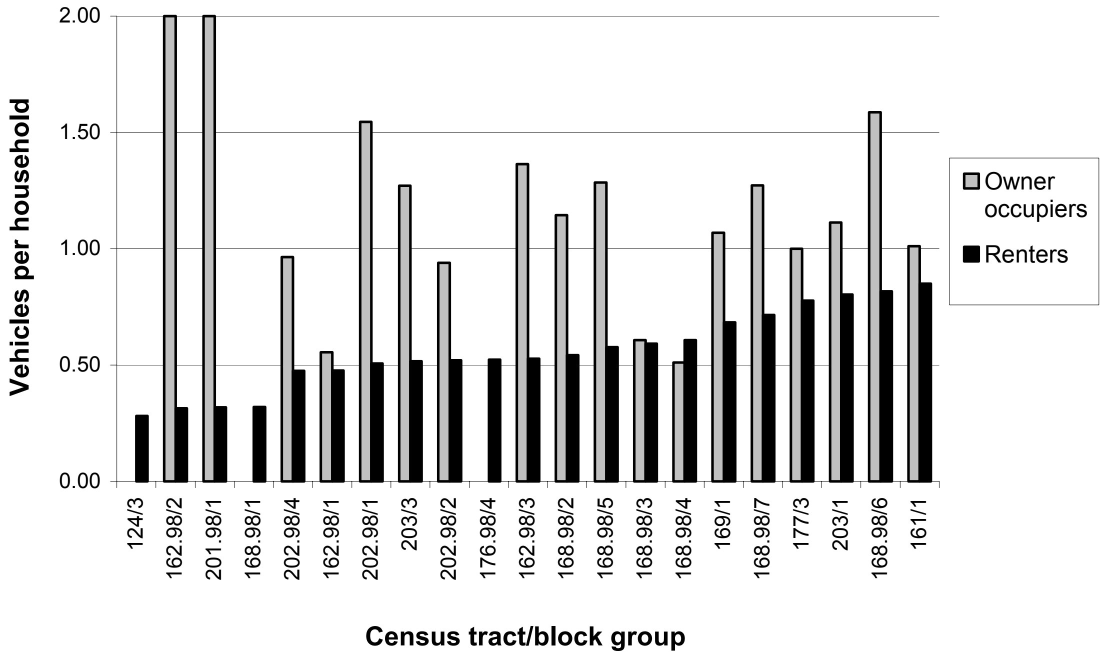
Source: US Census 1990.

Figure 7 Vehicles per household, Market/Octavia, 1990

		Owner occupied						Renter occupied					
Census Tract	Block Group	None	1	2	3	4	5+	None	1	2	3	4	5+
124	3							78.9%	16.5%	2.3%	2.3%	0.0%	0.0%
161	1	28.0%	43.0%	29.0%	0.0%	0.0%	0.0%	26.0%	63.0%	11.0%	0.0%	0.0%	0.0%
162.98	1	44.4%	55.6%	0.0%	0.0%	0.0%	0.0%	52.3%	47.7%	0.0%	0.0%	0.0%	0.0%
162.98	2	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	68.5%	31.5%	0.0%	0.0%	0.0%	0.0%
162.98	3	31.8%	0.0%	68.2%	0.0%	0.0%	0.0%	53.8%	42.9%	0.0%	3.3%	0.0%	0.0%
168.98	1							68.0%	32.0%	0.0%	0.0%	0.0%	0.0%
168.98	2	0.0%	85.5%	14.5%	0.0%	0.0%	0.0%	52.4%	41.0%	6.6%	0.0%	0.0%	0.0%
168.98	3	39.2%	60.8%	0.0%	0.0%	0.0%	0.0%	53.3%	37.4%	6.2%	3.2%	0.0%	0.0%
168.98	4	48.9%	51.1%	0.0%	0.0%	0.0%	0.0%	46.2%	46.9%	6.9%	0.0%	0.0%	0.0%
168.98	5	14.3%	42.9%	42.9%	0.0%	0.0%	0.0%	51.4%	39.5%	9.1%	0.0%	0.0%	0.0%
168.98	6	20.0%	30.7%	20.0%	29.3%	0.0%	0.0%	38.4%	46.9%	9.5%	5.3%	0.0%	0.0%
168.98	7	0.0%	72.7%	27.3%	0.0%	0.0%	0.0%	43.2%	44.6%	9.6%	2.5%	0.0%	0.0%
169	1	15.4%	68.4%	10.3%	6.0%	0.0%	0.0%	48.3%	38.7%	9.3%	3.7%	0.0%	0.0%
176.98	4	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	47.6%	52.4%	0.0%	0.0%	0.0%	0.0%
177	3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	43.4%	42.4%	10.8%	0.0%	3.4%	0.0%
201.98	1	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	70.8%	26.6%	2.6%	0.0%	0.0%	0.0%
202.98	1	0.0%	57.6%	30.3%	12.1%	0.0%	0.0%	51.8%	45.7%	2.5%	0.0%	0.0%	0.0%
202.98	2	39.7%	26.7%	33.6%	0.0%	0.0%	0.0%	58.0%	34.5%	4.9%	2.6%	0.0%	0.0%
202.98	4	5.5%	92.7%	1.8%	0.0%	0.0%	0.0%	60.4%	33.7%	3.9%	2.0%	0.0%	0.0%
203	1	4.5%	79.5%	15.9%	0.0%	0.0%	0.0%	36.9%	50.2%	10.9%	0.9%	0.0%	1.1%
203	3	14.8%	43.2%	42.0%	0.0%	0.0%	0.0%	59.9%	29.6%	9.4%	1.1%	0.0%	0.0%

Source: US Census 1990

Figure 8 Vehicles per household, Market/Octavia, 1990



Source: US Census 1990.

Changes Since 1990

Data on vehicle availability from the 2000 census are unlikely to be available until late 2002. However, some data is available from the 2000 American Community Survey. This is an ongoing survey conducted by the Census Bureau as a supplement to the decennial census. Purely by chance, San Francisco was one of the places included in the 2000 American Community Survey. While the estimates from this are not as statistically reliable as census data, and are not available for census tracts or any other sub-city level, they allow the overall picture of vehicle availability in San Francisco to be considered.

The results are shown in Figures 8-10 below. For both owner- and renter-occupied housing, the number of households with no vehicle available fell by around 3.4%. The largest increases were in households with two vehicles available.

Figure 9 Vehicle Availability in San Francisco, 1990-2000

Vehicles available	1990 Census	2000 ACS	% 1990	% 2000	Absolute change 1990-2000	Relative change 1990-2000
Total households	*305,584*	*325,596*				
Owner occupied	*105,514*	*116,724*				
None	14,342	11,982	13.6%	10.3%	-3.3%	-24.5%
One	43,034	48,138	40.8%	41.2%	0.5%	1.1%
Two	34,705	41,434	32.9%	35.5%	2.6%	7.9%
Three	9,971	11,051	9.4%	9.5%	0.0%	0.2%
Four	2,504	3,242	2.4%	2.8%	0.4%	17.0%
Five or more	958	877	0.9%	0.8%	-0.2%	-17.2%
Renter occupied	*200,070*	*208,872*				
None	79,464	75,599	39.7%	36.2%	-3.5%	-8.9%
One	84,237	89,013	42.1%	42.6%	0.5%	1.2%
Two	29,674	33,917	14.8%	16.2%	1.4%	9.5%
Three	5,297	7,126	2.6%	3.4%	0.8%	28.9%
Four	1,096	1,604	0.5%	0.8%	0.2%	40.2%
Five or more	302	1,613	0.2%	0.8%	0.6%	411.6%

Source: US Census 1990; American Community Survey 2000

Figure 10 Changes in Vehicle Availability, San Francisco, 1990-2000

Source: US Census 1990; American Community Survey 2000

During the same period, the average number of vehicles per household rose from 1.06 to 1.15, an increase of 9.1%.[1] The increase was more pronounced among renters (12.2%) than owner-occupiers (4.3%). These changes are shown in Figure 10 below.

Figure 11 Vehicles per Household, San Francisco, 1990-2000

Vehicles per household	1990	2000	% change
Owner occupiers	1.49	1.56	4.3%
Renters	0.83	0.93	12.2%
All	1.06	1.15	9.1%

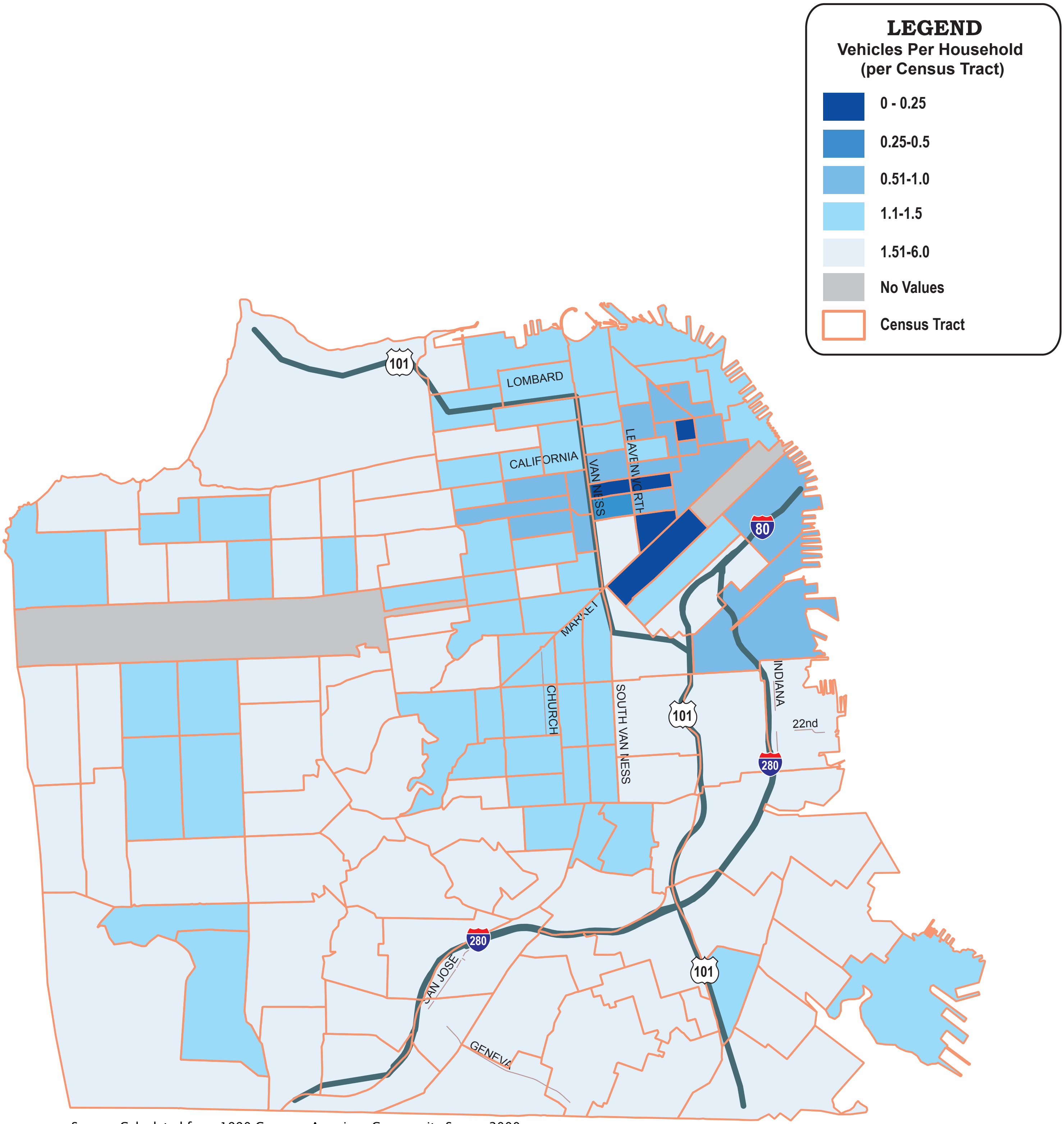
Source: US Census 1990; American Community Survey 2000.

Projected Changes 1990-2000

Assuming that changes in vehicle availability were uniform citywide, the changes at the county level between 1990 and 2000 can be used to project changes at the census tract level.

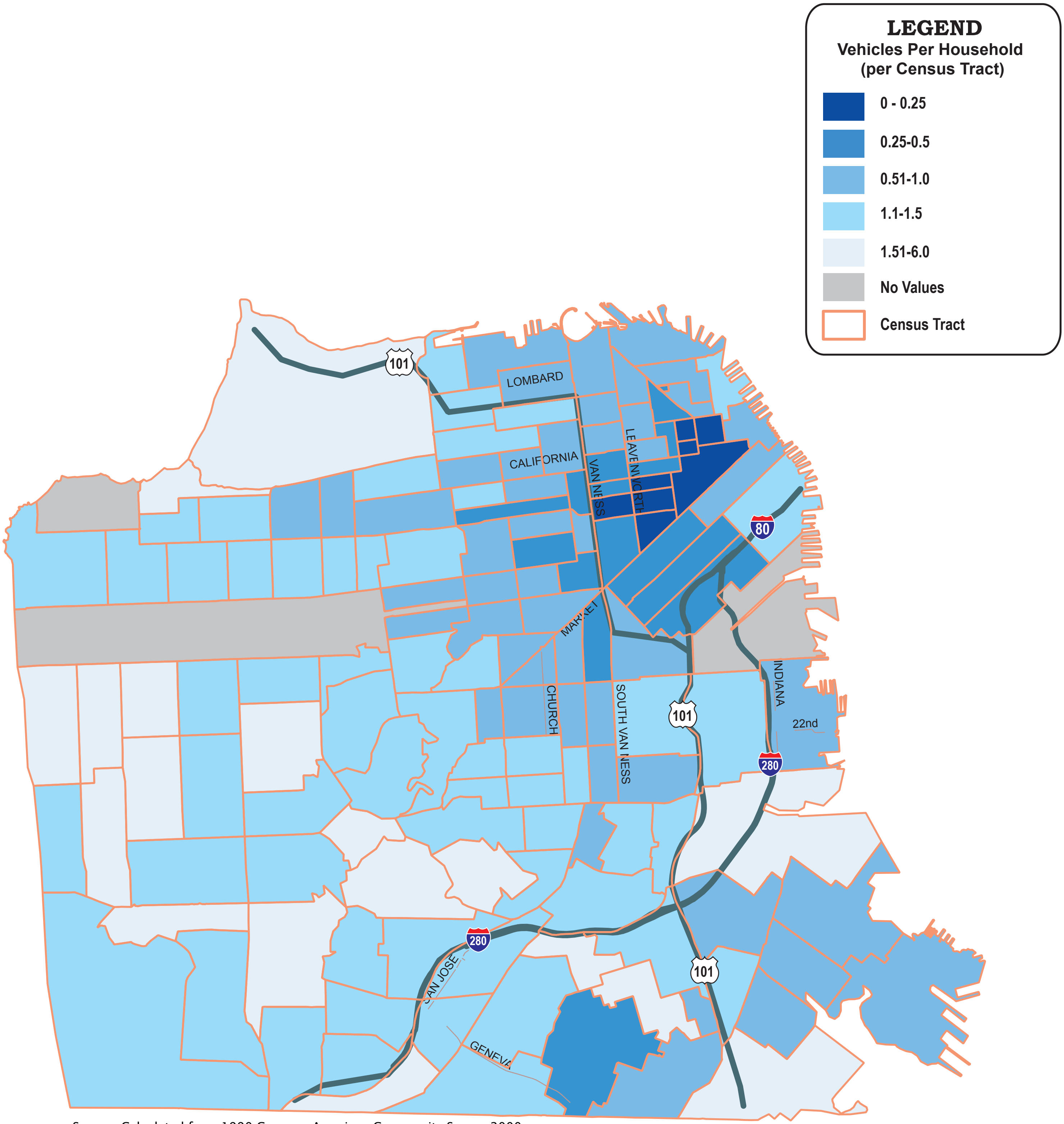
Figures 11 and 12 show the results of these projections. Vehicle availability in Tract 169, for example, which encompasses most of the Market/Octavia study area, is likely to have risen from 1.12 to 1.17 vehicles per owner occupied household, and from 0.75 to 0.84 for renters. The relative rate of vehicle availability between different census tracts is not, however, affected, as a uniform rate of increase is assumed. Thus, the *patterns* of vehicle availability are the same as those in Figures 1-2.

[1] The American Community Survey does not give data on the total number of vehicles. The estimates here were derived from data on the number of households with no vehicle, one vehicle, and so on. Households with five or more vehicles were assumed to have 5.56 vehicles (owner occupiers) and 5.78 vehicles (renters) – these figures were derived from the 1990 data.



Source: Calculated from 1990 Census; American Community Survey 2000

Figure 12	Projected Vehicles Per Household 2000, Owner Occupiers	nelson\nygaard consulting associates



Source: Calculated from 1990 Census; American Community Survey 2000

Figure 13 | **Projected Vehicles Per Household 2000, Renters**

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Analysis of Census Block Groups

The tables below show 1990 census data for block groups in San Francisco grouped according to vehicle availability.[2] Block groups in San Francisco comprise an average of around 517 households, and therefore provide a very fine resolution of detail. However, the figures are still aggregated, and do not permit possible explanations to be analyzed at the individual household level.

Each table shows the same data, except vehicle availability is defined differently. Figure 13 is classified by the proportion of households with no vehicle, while Figure 14 is classified by the average number of vehicles per household.

The figures in the tables do not indicate whether the factor is either a cause or effect of high or low vehicle availability. Indeed, there may be no causal relationship at all, due to the high intercorrelation between various factors, and no attempt here is made to control for factors such as income, density and tenure. However, they do indicate the demographic factors that characterize neighborhoods with high or low vehicle availability.

[2] All block groups are included, with the exception of a limited number that were primarily non-residential and had very low population.

Figure 14 Block group demographics after 'no vehicle' households

% households with no vehicle	No. of block groups	Aggregate vehicles per hhold	% Male	% children < 18	% 65+	Mean household size	% at same house 1985	% drive alone to work	% public transit to work	Median hhold income	Median unit value	Median rent	% detached	% attached	% duplex	% apartments	Median year built	% built before 1970	% rental
0-9	97	1.58	50.3%	18.7%	14.7%	2.63	54.8%	55.3%	24.8%	54,687	340,323	794	39.8%	29.2%	8.0%	22.0%	1946	77.1%	36.7%
10-19	196	1.37	48.7%	17.1%	15.0%	2.54	52.2%	49.1%	31.7%	42,945	329,941	746	26.7%	25.7%	14.1%	32.1%	1943	86.9%	49.0%
20-29	113	1.12	48.2%	14.5%	13.6%	2.30	46.7%	44.4%	39.5%	37,915	372,268	684	13.8%	13.3%	16.0%	55.6%	1942	86.0%	67.8%
30-39	71	0.95	49.4%	16.1%	12.7%	2.35	45.2%	39.8%	44.2%	31,834	345,861	625	9.9%	8.3%	14.8%	65.5%	1944	84.2%	74.8%
40-49	36	0.75	52.6%	14.5%	12.9%	2.14	40.5%	33.9%	50.7%	27,528	342,847	579	4.0%	3.7%	10.7%	79.4%	1946	78.7%	83.8%
50-74	52	0.50	52.2%	16.8%	14.8%	2.27	43.0%	28.9%	57.4%	21,209	220,992	475	2.0%	2.9%	5.1%	87.3%	1945	77.4%	91.2%
75+	26	0.15	57.6%	11.8%	21.5%	1.83	41.7%	14.8%	72.1%	12,890	144,423	373	0.3%	0.2%	0.7%	91.8%	1945	85.6%	97.5%
All households	**591**	**1.06**	**50.0%**	**16.2%**	**14.6%**	**2.37**	**48.2%**	**44.2%**	**38.5%**	**38,365**	**324,815**	**677**	**16.9%**	**15.1%**	**11.6%**	**54.4%**	**1944**	**83.3%**	**65.5%**

Source: US Census 1990

Figure 15 Block group demographics after average vehicle availability

Aggregate vehicles per household	No. of block groups	% households with no vehicle	% Male	% children < 18	% 65+	Mean household size	% at same house 1985	% drive alone to work	% public transit to work	Median hhold income	Median unit value	Median rent	% detached	% attached	% duplex	% apartments	Median year built	% built before 1970	% rental
< 0.5	51	78.1%	55.8%	12.8%	20.3%	1.97	41.8%	21.2%	66.1%	15,470	144,702	393	0.5%	0.8%	1.4%	92.0%	1946	82.1%	96.3%
.50-0.74	44	51.3%	52.0%	15.7%	12.9%	2.14	42.0%	31.6%	53.7%	25,522	308,753	565	2.3%	3.5%	7.0%	84.8%	1946	76.4%	87.1%
0.75-0.99	103	33.6%	50.1%	14.0%	12.3%	2.14	42.7%	38.3%	46.5%	33,104	371,358	636	6.2%	5.4%	14.0%	72.8%	1943	84.3%	79.2%
1.00-1.24	131	22.0%	48.6%	14.8%	13.5%	2.30	45.8%	46.7%	36.4%	38,652	361,549	686	15.1%	12.8%	16.8%	53.9%	1943	84.3%	66.6%
1.25-1.49	132	15.1%	48.8%	16.8%	14.5%	2.52	52.8%	50.1%	31.3%	40,760	330,590	739	25.8%	25.9%	15.8%	31.2%	1943	85.7%	49.9%
1.50-1.74	94	10.8%	49.2%	21.2%	15.0%	3.04	54.7%	50.4%	29.4%	47,234	305,520	773	39.8%	39.0%	7.5%	12.6%	1945	82.9%	32.7%
1.75-2.24	36	7.5%	48.3%	19.5%	17.7%	2.81	63.9%	54.8%	23.0%	67,779	360,964	807	63.2%	26.5%	4.7%	4.9%	1944	86.6%	19.4%
All households	**591**	**30.7%**	**50.0%**	**16.2%**	**14.6%**	**2.37**	**48.2%**	**44.2%**	**38.5%**	**38,365**	**324,815**	**677**	**16.9%**	**15.1%**	**11.6%**	**54.4%**	**1944**	**83.3%**	**65.5%**

Source: US Census 1990.

- **Gender.** There is no obvious strong relationship between vehicle availability and the gender balance of a block group. This is unsurprising, as most block groups are relatively evenly balanced between males and females. Any effect would probably only be apparent on the individual household level.
- **Children.** Block groups with a higher proportion of people under 18 years of age tend to have higher vehicle availability. Nearly 19% of the population is under 18 in block groups where more than 90% of households have at least one vehicle available. Where 25% or fewer households have at least one vehicle available, less than 12% of people are under 18. However, the relationship is not unambiguous, as the figures show.
- **Seniors.** There appears to be a 'U' shaped relationship between vehicle availability and the proportion of people 65 and over in a block group. The proportion of seniors falls as vehicle availability falls, apart from in the block groups with the lowest levels of vehicle availability, which have high proportions of seniors.
- **Household size.** Large households tend to own more vehicles. The mean household size in block groups where 25% or fewer households have a vehicle available is 1.83. In block groups where at least 90% have a vehicle, mean household size is 2.63.
- **Residential mobility.** Block groups with a high proportion of stable households, which were in the same house or apartment five years previously, tend to have higher vehicle availability. This may be because stable households tend to be more affluent and to own, rather than rent, their homes.
- **Commute mode.** People in block groups with the lowest vehicle availability are more than three times as likely to commute to work on public transit, rather than driving alone. It is difficult to classify commute mode as either a cause or effect on vehicle availability, as the two decisions are often made concurrently by a household. Households with more space to park a vehicle will also tend to live in lower-density neighborhoods which are more poorly served by transit.
- **Income.** There is a strong link between vehicle availability and income. Block groups with the highest vehicle availability have median incomes more than four times those of block groups with the lowest vehicle availability.

  Major exceptions to this trend are the neighborhoods of Nob Hill, Telegraph Hill and North Beach. This is due to the high levels of neighborhood services, their location adjacent to a major job centers, access to quality transit, and high parking costs. The implications of this on the Market/Octavia plan area are discussed in the Neighborhood Comparison section of this memorandum.
- **Housing prices.** Other than in block groups with the very lowest levels of vehicle availability, where median prices are less than half of the citywide median, there appears to be little relationship between the price of owner-occupied housing and vehicle availability at the block group level. This may be because the proportion of owner-occupied housing in many block groups is too

small to have a major impact on overall vehicle availability. Another possible explanation is that once the income levels needed to purchase housing in San Francisco are reached, income has little further effect on vehicle availability.

- **Rent.** There is a clear relationship between median rent and vehicle availability in a block group. Rents in block groups with the highest vehicle availability levels are more than double those in block groups with the lowest vehicle availability. This is likely to be largely an effect of income, but also the higher rents charged for housing with parking.
- **Housing type.** Block groups with more single-family housing have higher vehicle availability. The block groups with the lowest vehicle availability have just 0.5% single-family homes. In contrast, the proportion of apartments rises as vehicle availability falls. Duplexes occupy the middle ground. The reasons are probably complex, and may be due to higher income levels and more owner-occupiers in single-family homes, poorer transit in the lower-density areas characterized by single-family homes, and more space available for vehicle storage.
- **Housing age.** A relationship between housing age and vehicle availability might be expected, due to the off-street parking requirements for more recent housing. However, there appears to be little correlation at the block group level between vehicle availability and either median year built or the proportion of housing built before 1970. This may be due to the limited range of housing ages in the city (90% of San Francisco block groups have a median housing age between 1939 and 1955).
- **Tenure.** Perhaps the strongest relationship is between the proportion of rental housing in a block group and vehicle availability. In block groups with the highest vehicle availability, 37% of units are rental. In those with the lowest vehicle availability, virtually all the units are rental.

San Francisco Vehicle Availability Model

As part of the San Francisco Travel Model for the Transportation Authority, Cambridge Systematics has developed a vehicle availability model.[3] This estimates the number of vehicles that are likely to be available to a household.

The multinomial logit model was developed using data mainly from the 1990 Metropolitan Transportation Commission Bay Area Travel Survey, and validated with 1990 census data. It considered a wide variety of variables that might explain variations in vehicle availability:

Household variables

- Various measures of income
- Household size, and the ages of household members
- Number of workers (full time and part time)
- Number of retirees
- Number of children
- Number of licensed drivers (or individuals old enough to be licensed)
- Dwelling unit type
- Housing tenure

Locational variables

- Residential density, as a potential measure of congestion and the competition for residential parking
- Employment density, as a measure of the likelihood of being able to walk to work and non-work destinations
- Employed resident density – the number of workers living in a zone
- Pedestrian and bicycle environment, based on building setbacks, sidewalk coverage, grades and other factors.
- Area time – central business district, urban or suburban

Accessibility variables

- Auto and transit travel time (or distance) to work
- Ratio of transit to auto level of service
- Auto and transit accessibilities for non-work destinations

[3] Cambridge Systematics (undated), San Francisco Travel Model Development. Draft Final Report.

- Average parking costs in the residence and work zones
- Parking availability in the residence and work zones, measuring the difficulty to find parking space required by the household.

The variables that were retained after testing are listed in Figure 15 below, along with the co-efficients and T-statistics obtained. Variables listed are those that were both possible to forecast and added to the explanatory power of the model.

Note that the model takes three parts. The number of households that own one, two or three or more vehicles are forecast separately. The base alternative is that a household has no vehicle available.

The coefficient refers to the effect of each individual variable on vehicle availability. The larger the coefficient, the greater the influence of that variable, although this will also depend on the units of each variable (e.g. number of people, minutes, thousands of dollars).

The T-statistic refers to the confidence that a particular variable does have an influence on vehicle availability. A T-statistic of 1.645 or more equates to 90% confidence that the variable does have an influence. A T-statistic of 1.960 or more equates to 95% confidence.[4]

As can be seen from Figure 15, the key factors that influence vehicle availability in San Francisco, according to the model, are:

- **Household income.** This variable is highly significant. The higher the income, the greater the probability of having more vehicles available.
- **Household size and composition.** More adults in a household, particularly working adults, will increase the probability of having more vehicles availability. However, the effect is less for adults aged 18-24.
- **Auto and transit travel times.** Travel times to work by automobile, and the ratio of transit to auto level of service, influence vehicle availability.
- **Parking.** The cost of parking at work, and the availability of parking at home (both on-street and off-street), each influence vehicle availability.
- **Home zone vitality index.** This index is a measure of the pedestrian environment. It affects the probability of a household having two or more vehicles available, but not a single vehicle.
- **Density.** Along with income, density was the most significant variable tested. The higher the density, the lower the probability of having more vehicles available.

[4] Note that a T-statistic below these critical values does not automatically imply that a variable should be removed from the model, if the sign is correct and there are strong reasons to believe that it should be retained.

Figure 16 San Francisco vehicle availability model

	One vehicle		Two vehicles		Three or more vehicles	
Variable	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic
Household variables						
Household income (000)	0.0262	5.8	0.0366	7.5	0.0398	6.8
2 adults in household	0.642	3.7	1.924	7.7	0.806	2.1
3 adults in household			1.874	6.0	1.917	4.5
No. adults over 3 in household			0.714	2.9	1.005	2.9
FT workers in household	0.361	2.6	0.490	2.9	0.946	4.6
PT workers in household			0.722	3.3	1.293	4.4
No. household members 18-24	-0.317	-2.1	-0.381	-2.2	-0.381	-2.2
Level of service variables						
Max auto time to work (min.)	0.0144	2.3	0.0273	4.0	0.0273	4.0
Transit/auto accessibility ratio	-0.128	-0.5	-0.641	-2.0	-0.641	-2.0
Work zone parking cost ($)	-0.250	-2.0	-0.359	-2.3	-0.832	-3.3
Locational variables						
Home zone parking availability	-0.469	-1.8	-0.469	-1.8	-0.469	-1.8
Home zone vitality index			-0.218	-1.6	-0.432	-1.9
Density (households within half mile)	-0.145	-5.5	-0.185	-4.9	-0.310	-4.3
Constants						
Residual constant	0.909	1.4	-0.527	-0.7	-1.324	-1.6

Source: Cambridge Systematics, San Francisco Travel Model Development.

Location Efficiency Modeling

This study, by the Institute for Location Efficiency, analyzed the 1099 Travel Analysis Zones in the San Francisco metropolitan area, to test vehicle availability and vehicle use against a wide range of potential explanatory variables.[5] The aim was to identify households that were less likely to incur the costs of vehicle ownership, so that they might qualify for a cheaper 'Location Efficient Mortgage'.

Vehicles available per household was treated as a dependent variable, with data taken from the 1990 Census. The independent, explanatory variables this was tested against are shown in the table below.

[5] Holtzclaw, John (2000), Smart Growth – As seen from the air. Paper presented at the Air and Waste Management Association Annual Meeting and Exhibition, Salt Lake City. The paper describes the results of the Location Efficiency Study, sponsored by the Natural Resources Defense Council, the Center for Neighborhood Technology and the Surface Transportation Policy Project.

Figure 17 Variables tested in location efficiency model

	Measure(s)	Data source
Density	Households/residential acre Population/acre Population/residential acre	Census, regional planning organizations
Income	Household income Per capita income	Census
Household size	Persons/household	Census
Transit accessibility	Zonal transit density[6] Number of jobs accessible by transit	Calculated from transit agencies/MPO data
Center proximity	Number of jobs within 30 minute drive	Metropolitan Transportation Commission
Local shopping	Number of service and retail jobs per developed area within the zone	Census
Pedestrian/bike friendliness	Index, based on scale of street grid, housing age (as a proxy for sidewalks, narrow street, slower traffic and buildings closer to the sidewalk), traffic calming, pedestrian conditions and bike facilities	Calculated from census and other sources

Many of these variables proved to be highly correlated with each other, particularly density, transit, local shopping, center proximity and pedestrian/bicycle friendliness. This made it difficult for the separate influences to be disentangled, according to the researchers, but meant that density to some extent captures the effect of these other variables.

For San Francisco (as well as the other metropolitan areas studied, Chicago and Los Angeles), the variables which explained the most variance in vehicles/household were:

- net residential density (Hh/RA)
- per capita income ($/P)
- household size (P/H)
- zonal transit density (Tr)

[6] This is defined as the daily average number of buses or trains per hour times the fraction of the zone within ¼ mile of each bus stop (or ½ mile of each rail or ferry stop or station), summed for all transit routes in or near the zone.

These were incorporated into a model, which could predict 90.2% of the variation in vehicles per household. The equation is:

$$\frac{Veh}{Hh} = 4.722\left(22.520 + \frac{H}{RA}\right)^{-0.3471}\left(1 - e^{-\left(0.000112\frac{\$}{P}\right)^{1.2386}}\right)\left(1 + 1.0519\frac{P}{H}\right)\left(Tr + 60.312\right)^{-0.2336}$$

$\frac{Veh}{Hh}$ = Vehicles per household $\quad \frac{H}{RA}$ = Households per residential acre

$\frac{\$}{P}$ = Per capita income $\quad \frac{P}{H}$ = Persons per household $\quad Tr$ = Zonal Transit Density

Residential density and transit density are raised to negative powers, meaning that doubling density or doubling transit density results in a fixed decrease in vehicle availability.

Household size has a linear relationship with vehicle availability.

Income increases vehicle availability, but by lesser increments as income increases. It levels off at $40,000, as there is a limit to the number of vehicles a person would want to own.

Modelling changes in density, income, household size and transit accessibility

The Location Efficiency Study model above can be used to predict the influence of density, income, household size and transit accessibility on vehicle availability, while holding all other factors constant.

Density

Figure 17 below shows the projected impact of changing densities on vehicle availability in the San Francisco Bay Area, while holding income, household size and transit accessibility constant at the levels in the Market/Octavia study area. (Note that factors subsumed in the density variable, such as local shopping, will also vary.) The three lines show the projections for three different income levels[7]: a base case of 1990 income levels in the Market/Octavia study area[8], and income levels 25% higher and lower than this base case.

Density in the Market/Octavia study area is around 35 households per residential acre. For comparison, the Tenderloin has 80-150 households per residential acre, Hayes Valley (the

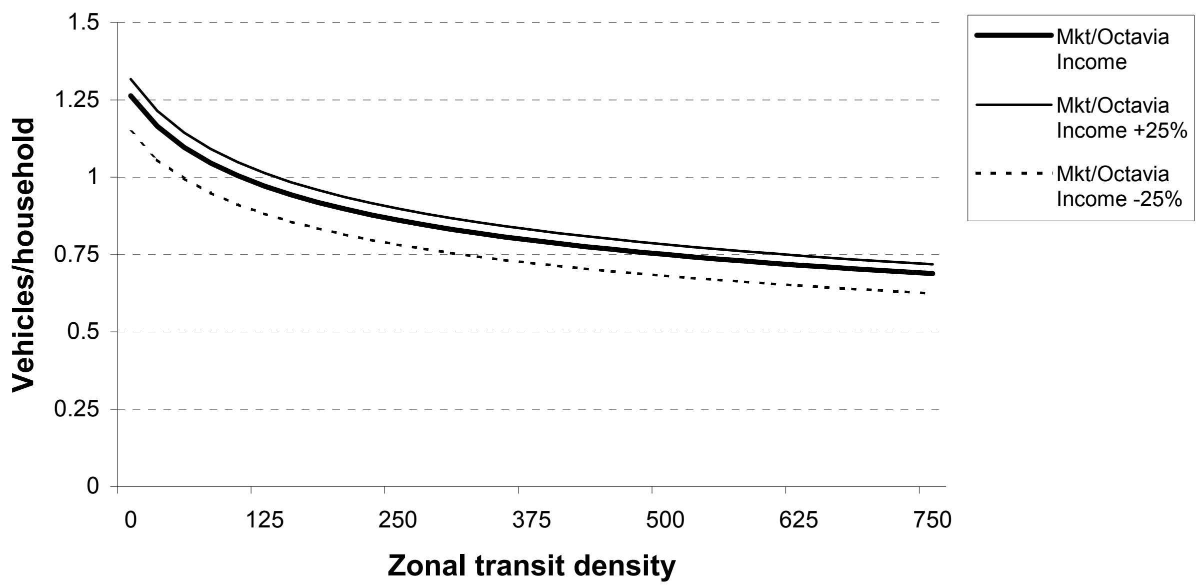
[7] Note that the model is calibrated to use 1989 income levels.
[8] Defined as Travel Analysis Zone 62.

area immediate west of Van Ness and north of Oak) 77, the western Russian/Nob Hill area around 50, Mission Dolores and the Upper Haight just under 45, and the Outer Sunset 10-14. Figure 3 shows residential densities in San Francisco.

Note that the measure of density used only includes residential land. Thus while overall densities may be low in an area, if only a small part of the land is used for housing and that housing is built at high densities, residential density may still be high.

As can be seen from the chart, doubling residential density in the Market/Octavia area from 35 to 70 households per residential acre would be likely to reduce vehicle availability from 0.93 vehicles per household to 0.79, while holding income, transit density and household size constant.

Figure 18 Effect of residential density on vehicle availability



Source: Calculated from Holtzclaw (2000).

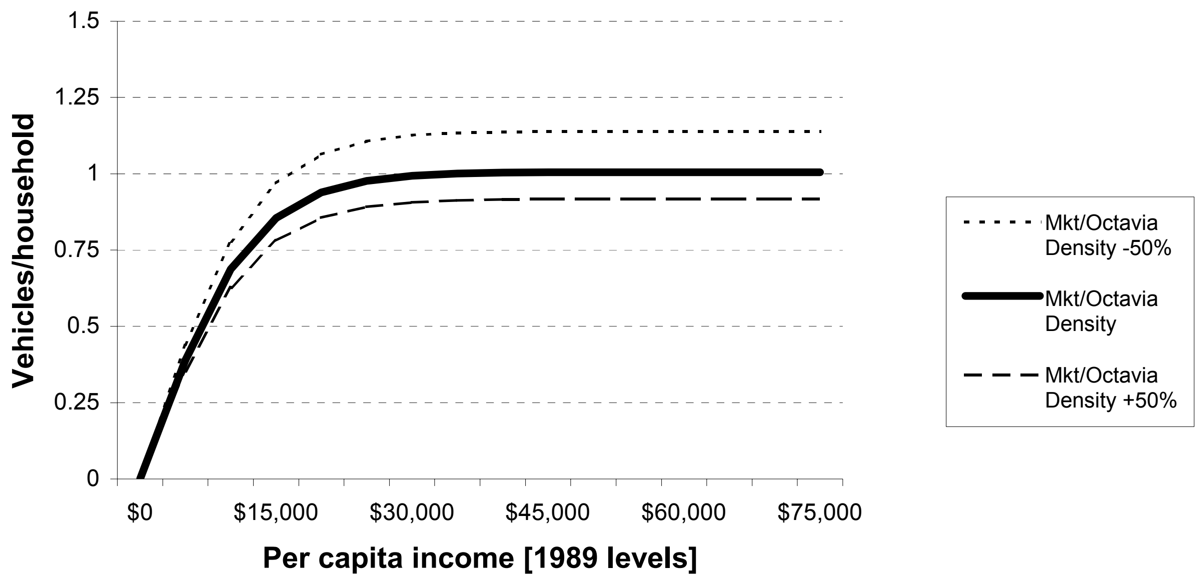
Income

Figure 18 below shows the projected impact of changing incomes on vehicle availability in the San Francisco Bay Area, while holding density, household size and transit accessibility constant at the levels in the Market/Octavia study area. The three lines show the projections for three different density levels: a base case of densities in the Market/Octavia study area, and density levels 50% higher and lower than this base case.

As can be seen, rising per capita incomes are associated with rising vehicle availability, but only up to levels of around $30,000 per year. Above this level, income has little impact. Note that the model is calibrated to use 1989 incomes, for which data is available in the 1990 Census.

Mean per capita income in the Market/Octavia study area in 1989 was $19,615. Raising this by just under 25% to $24,500 would be likely to raise vehicle availability rates from 0.93 to 0.97 vehicles per household. Reducing them by just over 25% to $14,700 (for example in conjunction with more affordable housing) would be likely to reduce vehicle availability rates from 0.93 to 0.85 vehicle per household.

Figure 19 Effect of income on vehicle availability



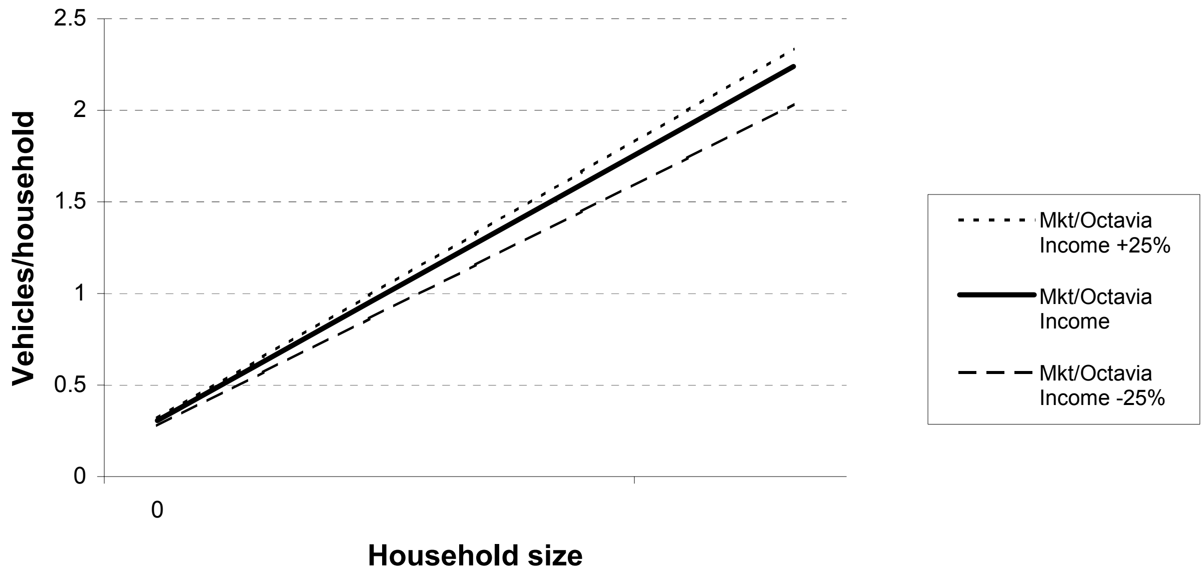
Source: Calculated from Holtzclaw (2000).

Household size

Figure 19 below shows the projected impact of changing household sizes on vehicle availability in the San Francisco Bay Area, while holding density, income and transit accessibility constant at levels in the Market/Octavia study area. The three lines show the projections for three different density levels: a base case of incomes in the Market/Octavia study area, and income levels 25% higher and lower than this base case.

The figure shows a simple straight-line relationship between household size and vehicle availability. According to the 1990 census, mean household size in the Market/Octavia study area was 1.95. Increasing this by 25% to 2.44 (for example through providing more family housing) would be likely to increase vehicle availability from 0.93 to 1.09 vehicles per household. Reducing this by 25% to 1.46 would be likely to reduce vehicle availability from 0.93 to 0.78 vehicles per household.

Figure 20 Effect of household size on vehicle availability



Source: Calculated from Holtzclaw (2000).

Transit accessibility

Figure 20 below shows the projected impact of changing transit accessibility on vehicle availability in the San Francisco Bay Area, while holding density, income and household size constant at levels in the Market/Octavia study area. Transit accessibility is defined as zonal transit density – the daily average number of buses or trains per hour times the fraction of the zone within ¼ mile of each bus stop, or ½ mile of each rail or ferry stop or station), summed for all transit routes in or near the zone.

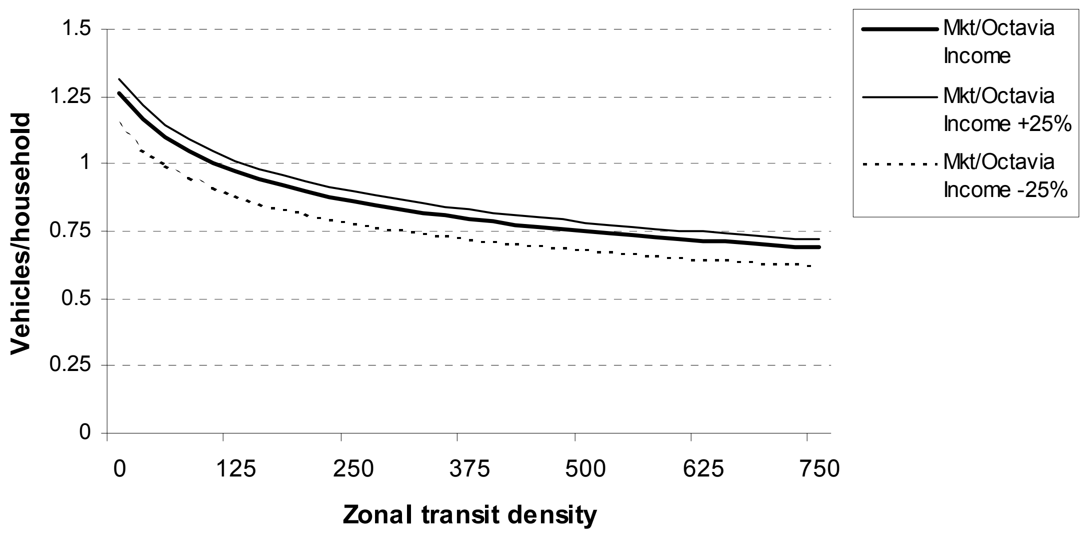
The three lines show the projections for three different density levels: a base case of incomes in the Market/Octavia study area, and income levels 25% higher and lower than this base case.

Figure 21 shows the impact on vehicle availability, if transit accessibility in the Market/Octavia study area were to be like that in another part of the city. The figure does not show vehicle availability in these areas – it shows the likely vehicle availability assuming the density, income levels and household sizes of Market/Octavia, but the transit accessibility of another part of the city.

As can be seen from the figures, increasing transit service levels by 25%, to the levels of lower Nob Hill at Van Ness and Geary, would be likely to reduce vehicle availability from 0.93 to 0.87 vehicles per household. Reducing transit service to the levels of the Upper Haight or Union Street would be likely to increase vehicle availability from 0.93 to 0.97 vehicles per household.

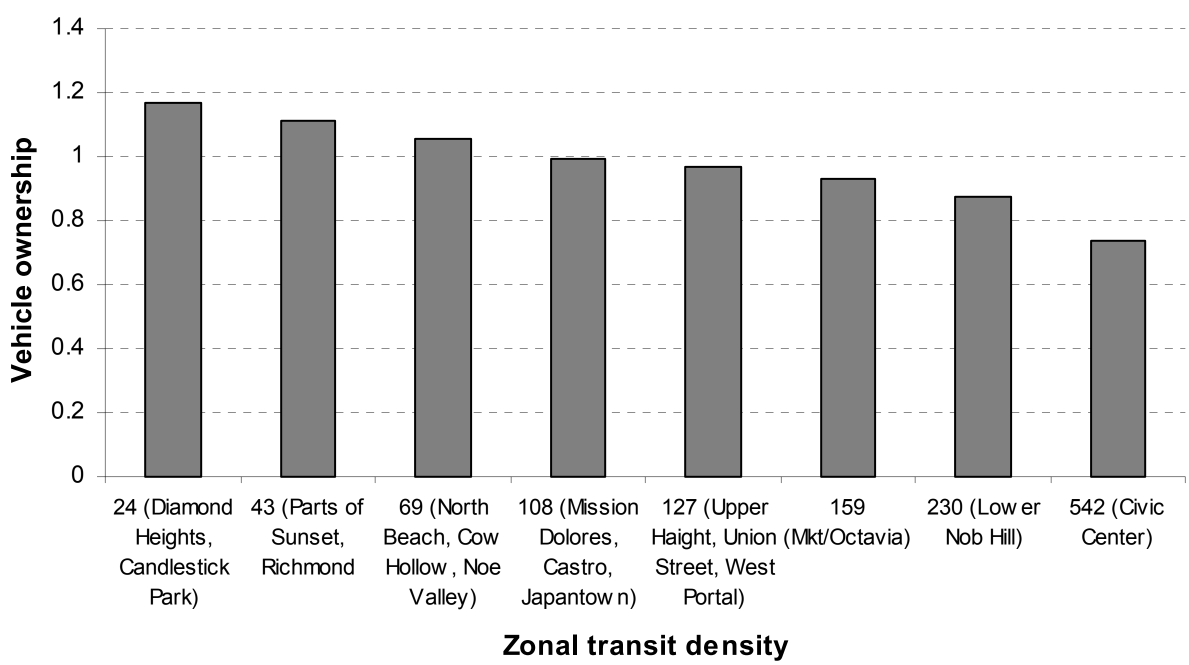
Figure 22 shows the transit accessibility for various parts of the city, based on Travel Analysis Zones (which are roughly similar to census tracts in San Francisco).

Figure 21 Effect of transit accessibility on vehicle availability

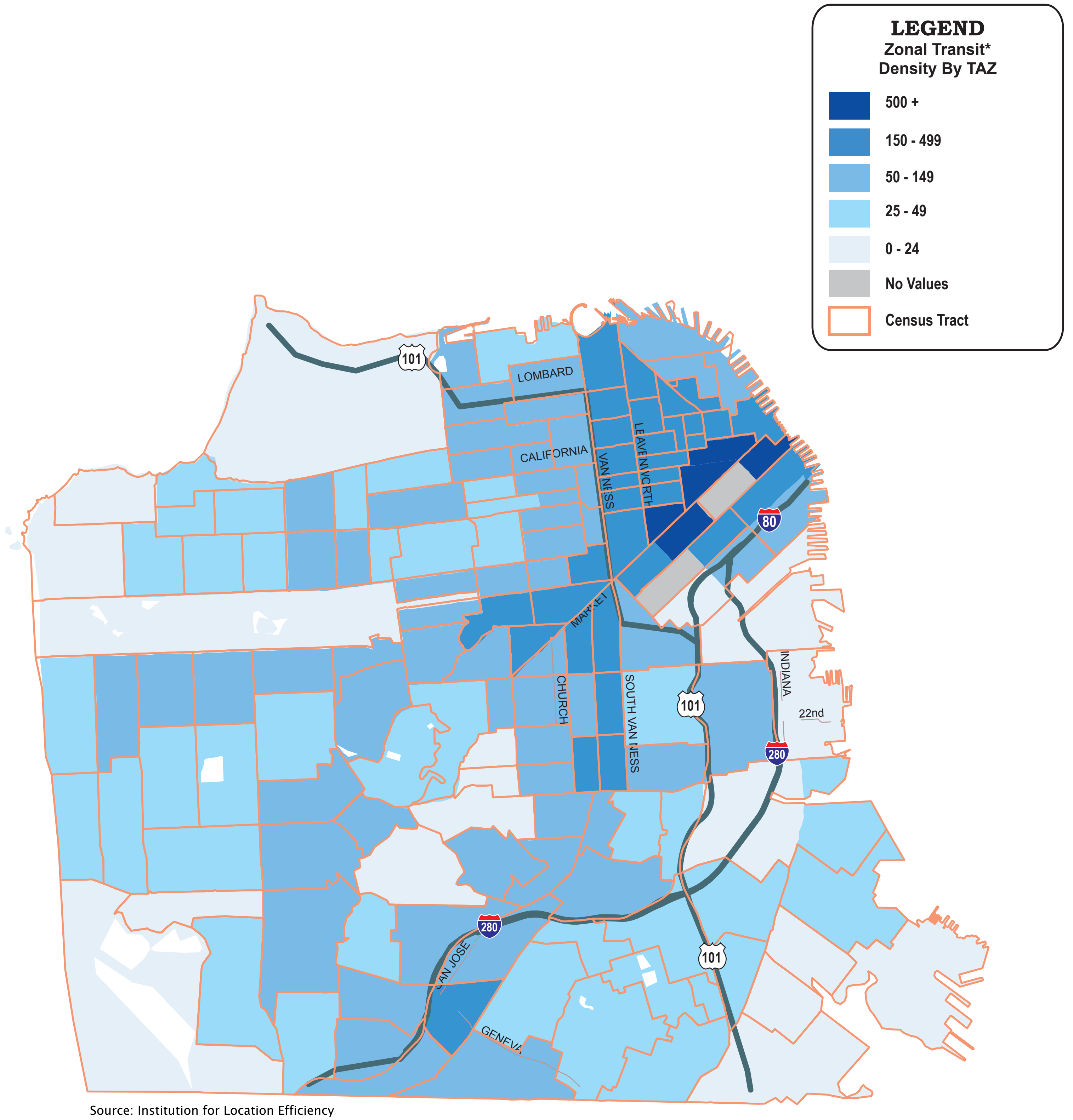


Source: Calculated from Holtzclaw (2000).

Figure 22 Vehicle availability with transit accessibility



Source: Calculated from Holtzclaw (2000).



*Zonal Transit is defined as the daily average number of buses or trains per hour times the fraction of the zone within .25 mile of each bus stop (or .25 mile of each rail or ferry stop or station), summed for all transit routes in or near the zone.

Figure 23 **Transit Accessibility, San Francisco**

Parking Demand and Affordable Housing

This study by the San Francisco Planning Department[9] reviewed evidence from census data, surveys of residential developments and telephone surveys on parking demand associated with affordable housing developments. It also conducted a survey of those living in affordable housing units; respondents represented about 45% of family/working adult affordable units constructed in the city between 1982 and 1992.

Figure 23 below summarizes the results from this survey. Vehicle ownership in affordable ownership multiple-bedroom housing was found to be similar to the overall city rate of 1.4 vehicles per unit for the downtown perimeter, and 1.5 per unit for representative outlying neighborhoods. It should be noted however, that parking spaces are usually provided at no price to the residents of these developments.

Vehicle ownership in affordable rental housing was much lower. This was attributed largely to differences in income between renters and home owners. Figure 24 shows vehicle ownership by income level, for those living in affordable housing.

Figure 24 Vehicle ownership in affordable housing

Type of affordable housing	No autos	One auto	Two autos	Three or more autos	Average number of autos
Rental housing					
Studio/1bdrm	45.7%	47.8%	4.3%	2.2%	0.45/unit
2+bdrm	23.1%	64.4%	9.6%	2.9%	0.92/unit
Ownership housing					
Studio/1bdrm	26.3%	57.9%	15.8%	0.0%	0.89/unit
2+bdrm	5.7%	52.9%	37.6%	3.8%	1.39/unit

Source: Planning Department (1992).

[9] San Francisco Department of City Planning (1992), Parking Demand for Affordable Housing in San Francisco.

Figure 25 Vehicle ownership with income levels in affordable housing

Vehicle ownership	Very low income (50% of median)	Lower income (60% of median)	Low income (80% of median)	Median income	Moderate income (120% of median)
No autos	50%	35%	14%	7%	3%
One auto	43%	59%	59%	65%	39%
Two autos	7%	5%	25%	24%	51%
Three or more autos	0%	0%	0%	4%	7%

Note: Income ranges at the time of the survey: Very low income = $22,800 or less; Lower income = $22,801-$27,360; Low income = $27,361-$36,480; Median income = $36,481-$45,600; Moderate income = $45,601-$55,000.

Source: Planning Department (2000).

Market Study – Parking Provision and Housing Price[10]

This study examined the relationship between parking provision and the cost of owner-occupied housing in San Francisco. While it does not directly relate to vehicle ownership, it is useful to consider the effect that parking provision has in increasing house prices.

The researchers examined 28 census tracts in six San Francisco neighborhoods with demographic characteristics, such as income, household size and racial composition, that were fairly typical of the city as a whole: North Beach, Haight-Ashbury, Duboce Triangle, Russian Hill, Noe Valley and the Castro.

Real estate transaction data on 232 housing units sold in 1996 were linked with census data on neighborhood characteristics, to build a model that was able to assess the effects of off-street parking on sale prices. Single-family units and condominiums were modeled separately. The hedonic model took the form of:

Home value = f(unit size, unit structure, unit age, architectural style, off-street parking availability, neighborhood median income level and neighborhood racial composition).

According to the model, the inclusion of parking spaces significantly increases the selling price of units. Only the size of the unit and the number of bathrooms are more closely associated with sales price.

The differences in sale values are shown in the table below. As can be seen, parking adds 12-13% to the cost of the average home in San Francisco.

[10] Jia, Wenyu and Wachs, Martin (1998), Parking requirements and housing affordability: a case study of San Francisco. University of California Transportation Center, Working Paper UCTC No. 380.

Figure 26 Housing prices with and without parking

	Single-family unit	Condominium
With off-street parking	$394,779	$303,856
Without parking	$348,388	$256,053
Difference	11.8%	13.0%

Source: Jia and Wachs (1998).

Neighborhood Comparisons: Income, Density, Transit, Location and Vehicle Availability

Many studies have shown the importance of income in influencing vehicle availability. However, many neighborhoods in San Francisco show that other factors are important in determining the rate of vehicle ownership. In the City, as neighborhoods become denser, more mixed-use, closer to jobs and with access to higher quality transit, vehicle ownership falls regardless of income. The typical examples of are Nob and Russian Hills. However, the Market/Octavia area is a good case in point as well.

To illustrate this point, we have paired census tract data of tracts with similar incomes at different locations in the City. Along with income we have shown average vehicle ownership rates (aggregately and by owners and renters), as well as Zonal Transit Density (a proxy for transit service quality discussed earlier) and density. The pairings are shown in Figure 27. Each of these pairings show that vehicle ownership varies significantly by location at many different income levels. The areas with significantly lower vehicle ownership rates are closer to downtown, have significantly higher Zonal Transit Densities, and higher residential densities. Some specific observations for each area are below.

Pair 1: Market/Octavia (Tract 162.98) vs. Bret Harte/Bayview (Tract 234)

- Both are low-income tracts, but the average household in the Bret Harte/Bayview tract has *three times* the vehicle availability of the Market/Octavia tract.
- Tract 162.98 is within a short walk from the jobs Civic Center and a longer walk to downtown, while Tract 234 is not near significant concentrations of jobs.
- The Market/Octavia tract is twice as dense as the Bayview tract and has better than ten times the transit service.

Pair 2: Market/Octavia (Tract 168.98) vs. South Mission District (Tract 229)

- While each has median incomes around $26,000, households in the nearby South Mission District average more that 50% higher levels of vehicle availability.
- Tract 168.98 has 30% higher residential density and a 118% higher Zonal Transit Density.

Figure 27 Comparisons of Neighborhood Characteristics – Paired By Income

Pair 1 / **Pair 2**

Market-Octavia (162.98)	Bret Harte/ Bayview (234)	Area (Census Tract)	Market-Octavia (168.98)	Sth Mission District (229)
$21,934	**$22,708**	**Median Income**	**$26,136**	**$26,083**
$23,798	$27,938	Average Income	$30,681	$32,652
Vehicles/HH		*Vehicles/HH*	Vehicles/HH	
0.46	**1.28**	**All**	**0.70**	**1.06**
0.44	0.80	Renters	0.64	0.90
1.25	1.80	Owners	1.13	1.55
281	20	Zonal Transit Density	159	73
16.7	7.2	HH/Total Acre	24.0	18.5

Pair 3 / **Pair 4**

Nob Hill (112)	South Bernal Hts. (254)	Area (Census Tract)	Russian/ Nob Hill (108)	Outer Richmond (477)
$32,042	**$32,268**	**Median Income**	**$36,217**	**$36,199**
$50,234	$39,537	Average Income	$50,025	$41,911
Vehicles/HH		*Vehicles/HH*	Vehicles/HH	
0.75	**1.25**	**All**	**0.74**	**1.26**
0.64	0.99	Renters	0.66	1.15
1.09	1.48	Owners	0.96	1.45
332	54	Zonal Transit Density	218	34
65.6	12.2	HH/Total Acre	42.3	18.6

Pair 3: Nob Hill (Tract 112) vs. South Bernal Heights (Tract 254)

- These tracts have similar median incomes; however, Nob Hill contains more very high-income households as shown by the 27% higher average income. Despite this, South Bernal households have available 67% more vehicles than Nob Hill.
- Nob Hill has major advantages in transit service (six times higher Zonal Transit Density) and density (five times higher households/residential acre.)

Pair 4: Russian/Nob Hills (Tract 108) vs. Outer Richmond (Tract 477)

- The highest income tracts, they still exhibit significant differences in vehicle availability. Renters in tract 477 average 74% greater levels of vehicle availability than those in tract 108.

- Tract 108 benefits from superior transit service (6.4 times greater Zonal Transit Density) and is a higher density area (2.3 times higher households/residential acre).

The wide differences in vehicle availability in these neighborhoods underscore that a one size fits all minimum parking requirement does not reflect reality in the City. The importance of location and neighborhood conditions (both existing and futures) cannot be ignored when considering how much parking should be included in new development.

Policy Implications & Discussion of Related Issues

The Market/Octavia Specific Plan is considering eliminating minimum parking requirements for housing and setting a maximum parking allowance of 1 space per unit.

The data from Market/Octavia certainly supports reductions in minimum parking requirements. Among its block groups, 26% to 79% of rental households live car free. The area is also a low to moderate-income area. Vehicle owners in the city tend to have higher incomes. Supplying housing and parking together assumes that new residents will own vehicles. Parking also increases the cost and price of housing leading to either deeper subsidies for affordable housing (not available in Market/Octavia due to Proposition E restrictions) or more up market housing. **Therefore, building each new housing unit with a new parking space would not reflect the behavioral characteristics of the community. Abundant housing with parking would likely be a catalyst for gentrification.**

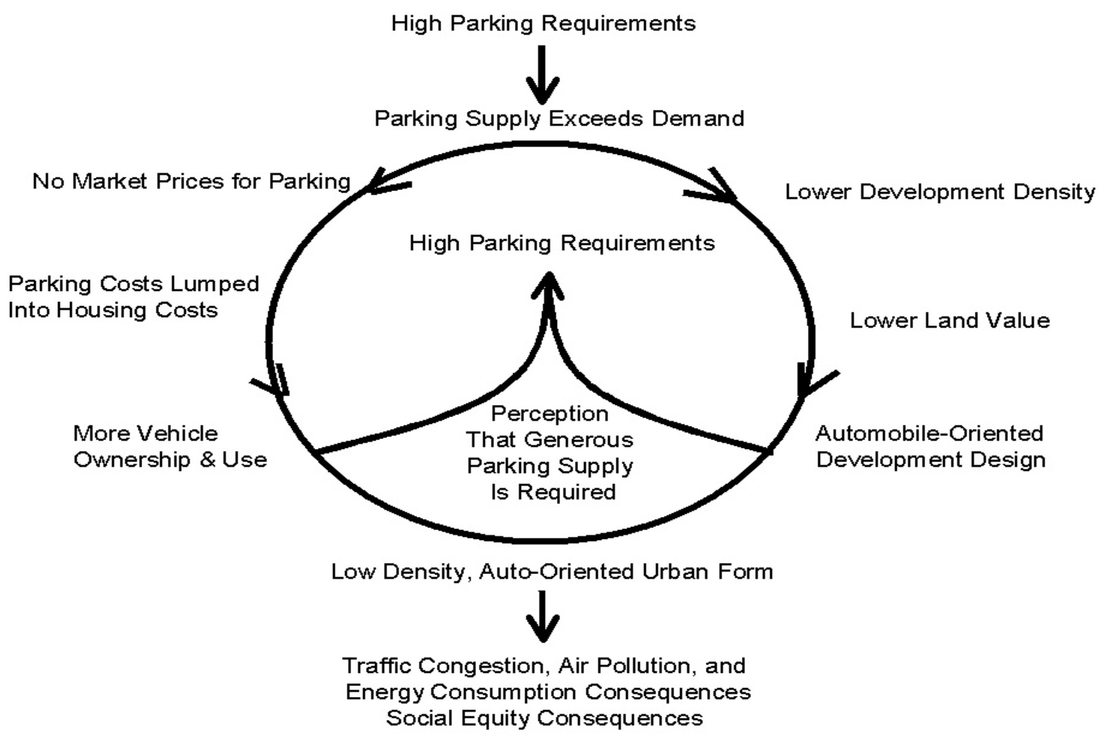
There is also evidence that parking supply is a key cause of vehicle ownership. While this is very difficult to establish directly from data, the patterns outlined in this paper point to parking supply being a key issue. Some researchers feel that the significance of density explaining vehicle ownership rates is connected to the fact that it is costly (either in hassle or in needing to rent a garage space) to park a vehicle in older, denser urban areas.[11] The areas of Nob Hill, Russian Hill, Market/Octavia and others with low vehicle ownership were built up before it was common and required to provide a parking space for each housing unit. **Therefore, requiring the provision of parking with the development of housing is a self-fulfilling prophecy, generating vehicle ownership. Housing built with less or no parking can be the reverse, attracting households who will live without a vehicle.**

Requiring the supply of parking with housing can distort the market for vehicles leading to unnaturally high rates of vehicle ownership. This happens because high minimum parking

[11] Schimek, Paul. 1996. Household Motor Vehicle Ownership and Use: How Much Does Residential Density Matter? Washington DC: National Research Council, Transportation Research Board.

requirements create a plentiful supply of parking. As a result and despite its high cost, the parking is given away for free. This hides the true cost of vehicle ownership in parking. In housing, the result is that parking costs are "bundled" into the costs of a housing unit, whether or not the parking is used at all. All households have no choice but to pay for the parking, whether they use none, one, two or three vehicles. With a large portion of car ownership paid for and apparently free, a choice not to own a vehicle is nearly irrational. (The cyclical impact of parking supply on auto-dependence is shown in Figure 27.) Disrupting the market for parking and creating incentives for vehicle ownership and driving run contrary to the Transit-First philosophy of the City. **Therefore, minimum parking requirements in Market/Octavia higher than the natural rate of vehicle ownership will disrupt the market for parking and thus vehicles leading to unnatural rates of vehicle ownership.**

Figure 28 When Cities Over Require Parking[12]



Taking this line of reasoning further, if parking supply influences vehicle ownership both directly and through its influence on the price of parking, controlling the supply of parking can be used as a form of transportation system management. In the Market/Octavia study area, the local street network is at capacity due to its location near Civic Center and the nearby freeway access. Many regional trips have a segment in the area. Thus it is imperative to minimize the number of vehicle trips generated by the new development

[12] Adapted from Willson, Richard. Suburban Parking Requirements. 1995. Journal of the American Planning Association, Vol. 61, No. 1:29-42.

intended in the Market/Octavia Specific Plan. Capacity expansion of the street network (through street widenings) is impossible, thus new trips could cause the system to break down and exacerbate the environmental impact of development and transportation. **Therefore, new development with little or no parking will keep parking prices high and vehicle ownership and usage low. Instead, walk trips, bike trips and transit trips will be generated, which can be accommodated by the sidewalks or by transit improvements. Maximum parking requirements are appropriate in the Market/Octavia area.**

The implicit assumption of analyzing vehicle availability is that it represents demand for vehicles and thus parking in housing. As argued above, this ignores the role of supply and price in influencing demand. Again, restricting supply increases the cost of parking and influences the level of vehicle consumption. The current policy of mandating supply sends an economic message that vehicle ownership and usage is encouraged. Restricting supply sends the opposite message that transportation alternatives are encouraged. Sending this message is particularly possible in San Francisco today. This is because with the advent of City CarShare, not owning/leasing a car does not mean one does not have access the transportation benefits of one.

In summary, parking provision in the Market/Octavia area should respond to the conditions of the area. It should not be based on a blanket citywide requirement that does not reflect the character of the community or transportation realities (high quality transit service and no excess capacity in the street network). New development with high levels of parking supply will distort the market for parking, increase vehicle availability in the area, generate new vehicle trips, and thus have a significant negative impact on environmental quality. Development with minimal parking will generate walk, bike and transit trips which can be accommodated without negative environmental impact.