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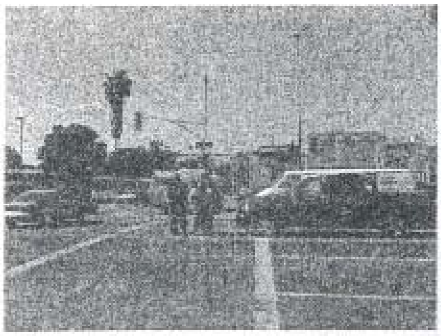

DEATH ON THE CROSSWALK A STUDY OF PEDESTRIAN-AUTOMOBILE COLLISIONS IN LOS ANGELES

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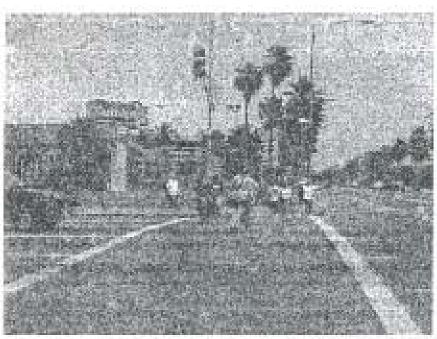

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Abstract

This research explores the spatial distribution of pedestrian-automobile collisions in Los Angeles and analyzes the social and physical factors that affect the risk of getting involved in such accidents. More specifically, this study investigates the influence of socio-demographic, land use, density, and traffic characteristics on pedestrian accident rates. We first provide an exploratory spatial and statistical analysis of pedestrian collision data in the city of Los Angeles to identify preliminary relationships between accident frequency and socio-demographic and land use characteristics at the census tract and block group levels. This aggregate level analysis also helps us identify major concentrations of pedestrian collision data which are used at a second stage of the research for more qualitative and detailed analysis of specific case studies of intersections with high frequency of pedestrian-automobile accidents. The study uses pedestrian accident data provided by the Los Angeles Department of Transportation, traffic volume data provided by Caltrans, socio-demographic data from the U.S. Census 2000, land use data from the Southern California Association of Governments (SCAG), and pedestrian volume and built environment data from fieldwork research.

Acknowledgment

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Introduction

On a summer afternoon in London in 1896, Ms. Bridget Driscoll stepped off the curb and into history as the first documented person in history to be killed by an automobile. The shocked investigators of the accident expressed the hope that such a horrible thing would never happen again (Roberts, 1998). More than a hundred years later, with millions of pedestrians having been killed by automobiles on both sides of the Atlantic, automobile casualties are no longer a novelty but a grim reality. Motor vehicles represent the leading cause of fatal unintentional injury in the U.S.[1] Nearly 6,000 pedestrians and cyclists are killed nationwide every year, and an additional 85,000-90,000 suffer from injuries inflicted upon them by a moving vehicle (National Highway Traffic Safety Administration, 2002).

What is more surprising in the above statistics is that walking represents an ever-declining mode of transportation in the U.S. The portion of people walking to work has dropped by 26% between 1990 and 2000 (Surface Transportation Policy Project, 2002). It has been estimated that presently Americans make fewer than 6% of their trips on foot, yet more than 13% of all traffic fatalities are pedestrians (Jackson and Kochtitzky, 2001). Some states score much worse than others in pedestrian fatalities. According to researchers "the most dangerous metropolitan areas for walkers are newer, sprawling, southern and western communities where transportation systems are more focused on the automobile at the expense of other transportation options" (Jackson and Kochtitzky, 2001). California has become one of the most dangerous states in the nation for pedestrians, with pedestrian deaths accounting for 20% of all traffic-related fatalities (Corless and Ohland, 1999). California is home to five of the twenty metropolitan areas in the U.S. with the highest pedestrian death rates (Surface Transportation Policy Project, 1998). Southern California leads all the state regions in pedestrian fatalities, and the Los Angeles SMSA with 354 pedestrian fatalities in 2000, tops the grim list of most dangerous California counties for pedestrians (Corless and Ohland, 1999; Martin, 2002).

Pedestrian accidents are not equally distributed throughout a metropolitan area. Some neighborhoods have higher rates of pedestrian casualties than others. Similarly, some population groups are more prone to being hit by a car than others. This research explores the spatial distribution of pedestrian accidents in Los Angeles to better understand the link between socio-demographic and physical characteristics of neighborhoods and pedestrian casualties. Based on the findings the study also articulates a series of strategies and policies for a safer environment for pedestrians.

Causes of Pedestrian-Automobile Collisions: Brief Literature Review

The field of accident studies has investigated the role of a number of factors in the causation of pedestrian accidents. In general, we can categorize these factors in four categories: 1) the social and behavioral characteristics of drivers and victims; 2) road design characteristics;

[1] In 1998, the first five causes of unintentional fatal injury in the US were: Motor vehicles (43,501 deaths), falls (16,274 deaths), poisoning (10,255 deaths), drowning (4406 deaths), and choking (3515 deaths) (National Safety Council, 2001).

3) traffic and parking characteristics; and 4) area characteristics, i.e. the social, physical and land use characteristics of neighborhoods.

A number of studies have explored the social and behavioral characteristics of drivers and pedestrians involved in collisions (California DMV Research Studies, 1999). Some studies have used multiple regression models to predict the propensity of drivers to cause an accident based on their gender, age, and prior driving record (Hurrington and McBride, 1970; Peck and Kuan, 1983). In general, such studies found that male drivers had a higher rate than female drivers of getting involved in fatal accidents. Differences in gender, age, driving experience, and sobriety have been shown to be significantly linked to fatal pedestrian accidents. A study that analyzed pedestrian fatalities in New York City from 1994 to 1997 found that younger drivers (19-34 years of age) caused 48% of the deaths. The study found that 91% of the drivers involved in these accidents were men and only 9% were women, even though women accounted for an estimated 25% of vehicle miles driven on NYC streets. Interestingly, drunk driving was not a major factor in these New York City accidents, as only 4% of the drivers were found to be under the influence of drugs or alcohol (Komanoff, 1999).

Studies analyzing the socio-demographic characteristics of victims have found that children and the elderly are the two age groups most vulnerable to pedestrian-automobile collisions (National Safety Council, 1994; Retting et al. 2004). In a study of motor vehicle accidents in Honolulu, Levine et al. (1995a) found that 28.8% of the victims were children under 15, while 15.4% of the victims in pedestrian accidents were seniors. The aforementioned study of pedestrian casualties in New York City found that one fifth of all traffic fatalities under the age of 16 were pedestrians, while older New Yorkers accounted for 35% of the victims (Komanoff, 1999). Nationwide, elderly pedestrians accounted for 17% of all pedestrian fatalities in 2002 (NCSA, 2002). Even though studies have documented that fewer children are now walking than in the previous decades, pedestrian injury remains the second leading cause of unintentional injury-related death among children ages 5-14 (Surface Transportation Policy Project, 2002). While the proportions of children and the elderly that fall victims to the car are different for different geographic regions, these two groups comprise the greatest number of all pedestrian accidents relative to their share of population (Corless and Ohland, 1999)[2].

Child pedestrian accidents tend to happen in residential areas, and often in non-arterial roads, near a child's home (Sharples et al. 1990; Petch and Henson, 2000), and on the journey to school[3]. Behavioral factors (e.g. overactivity) and the length of exposure in public spaces have been associated with child injuries. However, for collisions involving children, environmental influences have been found to be more significant than behavioral factors (Corless and Ohland, 1999). Even though the total annual number of fatalities of children walking or biking to school

[2] This is even more pronounced in countries other than the U.S. In the U.S. walking has declined significantly and children are usually driven or bused to school. In Scotland, where walking to school is more common, child pedestrian casualties made up 46% of all pedestrian casualties in 1997 (Scottish Executive, 2001)

[3] The number of children walking to school has declined significantly in the U.S. over the last decades. It is estimated that less than 1% of children ages 7-15 are currently riding their bicycles to school, a decrease of more than 60% since the 1970s (New York Times, 1999)

represents only 16% and 6% respectively of the total annual student fatalities on the journey to school, on a per mile basis, school-aged bicyclists have the highest injury and fatality rates, followed by school-aged pedestrians (TRB, 2002).

The traffic engineering field has examined the relationship of road characteristics (e.g. type of road, lane width, pavement characteristics, intersection geometry, street lighting, existence of marked crosswalks, availability of raised medians, etc.) and pedestrian accidents. A study of pedestrian accidents in Seattle found that the highest number of such accidents (54%) occurred on main arterials, followed closely by minor arterials (39%) (Walgren, 1998). Studies have also explored how the presence of marked sidewalks in uncontrolled locations (with no traffic lights) affects pedestrian collision rates. A recent study found that in high traffic multi-lane streets marked crosswalks were associated with higher pedestrian crash rates (FHA, 2002). A series of traffic management and traffic calming measures (traffic light signalization, speed bumps, crossing guards, woonerfs, etc.) have been studied in efforts to reduce pedestrian accidents (Institute of Transportation Engineers, 1998; Federal Highway Administration, 1994).

Studies have explored the relationships between pedestrian crashes and traffic and parking characteristics. A significant relationship has been found between traffic volume and the number of accidents (Levine et al. 1995a; Roberts et al. 1995; Jackson and Kochtitzky, 2001). Traffic speeds have also been associated with increased risk of injury to pedestrians (Jacobsen et al. 2000). High density of curb parking is often associated with increased numbers of pedestrian accidents (Roberts et al. 1995), for the reason that parked cars were impairing the visibility of incoming traffic. However, this might be a spurious correlation because it is also likely that many cars are parked in high-activity areas with a lot of pedestrians. As expected, pedestrian exposure has been typically associated with accident risk. However, because of lack of data on pedestrian volumes most studies have not been able to include this important variable in their analysis, or have used general proxies.

Finally, a set of studies has examined the relationship between pedestrian accidents and the social and physical characteristics of neighborhoods. Researchers have found a relationship between an area's social deprivation and lack of affluence and pedestrian accidents (Scottish Executive, 2001). Child pedestrian injuries occur significantly more often in poor neighborhoods with restricted access to play space and dangerous streets with high traffic (Rivara and Barber, 1985; Corless and Ohland, 1999). This finding seems to hold true not only for children but also for adults. In a study that examined the relationship between an area's social characteristics and road accident casualties in Scotland, Abdalla et al. (1997) found that the rate of road traffic accident casualties per 10,000 residents was above the region's rate in the most deprived areas, and below the region's rate in the most affluent areas. A California study that examined the relationship of ethnicity of California children and pedestrian accidents in 1996, found that Latino and African American children, presumably living in some of the state's most disadvantaged neighborhoods, were disproportionately represented among all pedestrian fatalities and injuries relative to their share of the population (Corless and Ohland, 1999). Similarly, a study that examined pedestrian safety data between 1990 and 2000 found that during that period black children had a pedestrian death rate more than twice that of white children (Safe Kids Campaign, 2002). Statewide hospitalization records from California show that

Latinos and African Americans are most at risk of being hit by a car.[4] A recent study has speculated that "the link between pedestrian deaths and ethnicity is due to the fact that Latinos and African-Americans are more likely to walk, bike and/or take public transportation, resulting in greater exposure to the dangers of the street" (Surface Transportation Policy Project, 2002).

While the relationship between pedestrian accident risk and the socio-demographic characteristics of neighborhoods is not disputed, certain physical and land use factors may be also augmenting the risk of accidents for pedestrians. A small number of studies have indicated that much. Investigating the significance of particular land uses, Levine et al. (1995b) found that the number of schools and bars in a blockgroup predicted the number of pedestrian crashes, along with the population and employment variables. The same researchers found that the number of miles of freeway ramps and access roads, and the number of miles of major arterials in a neighborhood were positively related to the number of crashes occurring. Some researchers have found high child accident rates to be associated with neighborhoods which lack open spaces, back yards, and play areas, have high numbers of on-street parking, long and straight streets, and heavy vehicular traffic (Preston, 1976; Petch and Henson, 2000). Walgren (1998) discovered that in Seattle 89% of the high accident locations were within 150 feet of a bus stop, while 90% of such locations were within 70 feet of a crosswalk. Most of the accidents occurred at intersections without a traffic light. A study by the Santa Ana Unified School District found that more than half of the city's 72 pedestrian accidents during the first six months in 1998 involved children walking near schools (Los Angeles Times, 1999).

Population density is another local area characteristic that has been found to have a positive correlation with pedestrian casualties. Graham and Glaister (2003) found, however, that in extremely dense urban areas there is a decrease in the expected collision rates. They reasoned that this may be due to the low traffic speeds of vehicles in highly congested areas.

What is the importance and effect of the different variables described in the literature on the occurrence of pedestrian accidents in Los Angeles? Are particular neighborhoods more susceptible to pedestrian accidents than others? To address these questions we will now turn to our empirical study.

Pedestrian Accidents in the City of Los Angeles

Using data on pedestrian accidents for the City of Los Angeles along with demographic, land use, traffic and built environment characteristics we have investigated the spatial distribution of pedestrian accidents in the city as well as the influence on accidents of neighborhood socio-demographic, density, land use, and traffic characteristics.

Data on all vehicle accidents which occurred in the City of Los Angeles from 1994 through 2001 was obtained from the Los Angeles Department of Transportation (LADOT).

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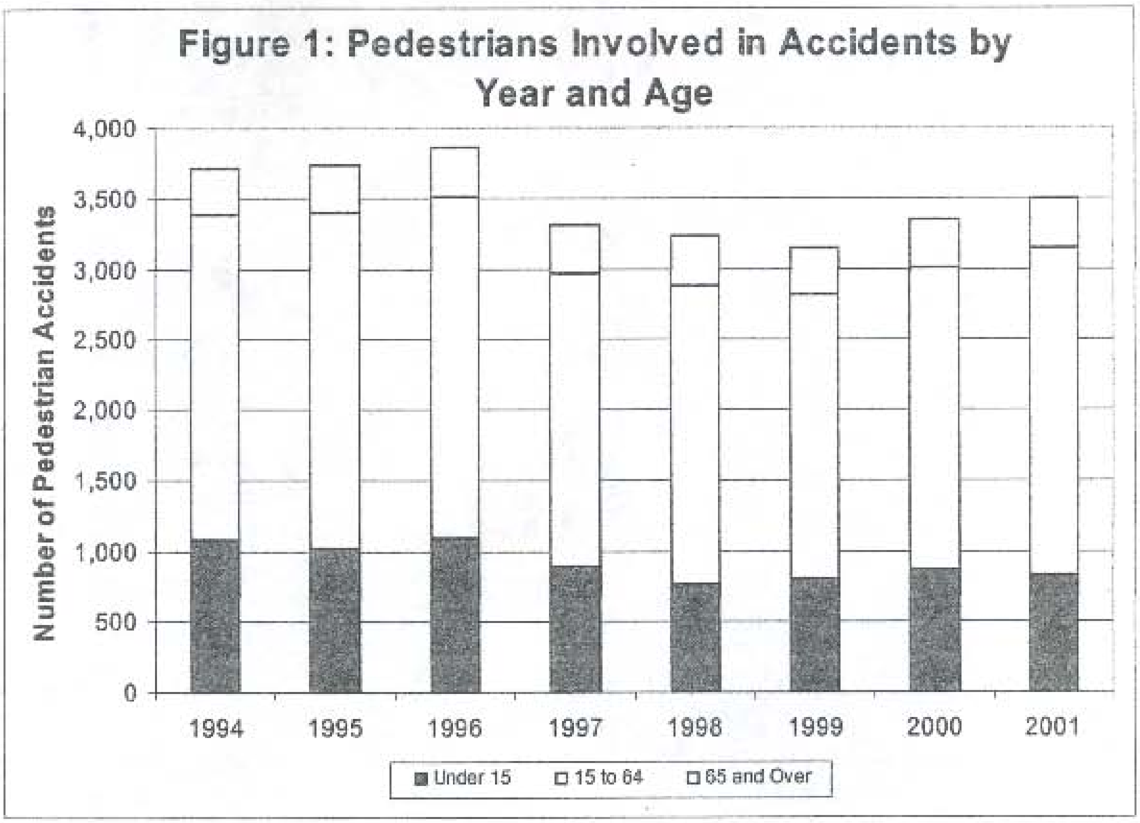
[4] In 1999-2000, Latinos comprised 38% of pedestrian fatalities and hospitalized injuries even though they constituted 30% of the state's population. African Americans comprised 12% of pedestrian fatalities and hospitalized injuries, while constituting only 7% of the state's population. In contrast, Caucasians made up 51% of the state's population but only 39% of the pedestrian fatalities and hospitalized injuries (STPP, 2002).

Pedestrian accidents accounted for 6 to 7% of all traffic accidents each year of the study period for a total of 25,683 accidents.[5] Due to multiple injuries per accident, the actual number of pedestrians involved was slightly higher at 27,835. Figure 1 shows variation in the numbers of pedestrians involved in accidents per year over the study period (which ranged from a high of 3,861 pedestrians in 1996 to a low of 3,142 in 1999). There were 619 pedestrian fatalities during this time period and 4,066 injuries rated as severe. The remaining accidents were classified as with "visible injury" (about 50%) or "complaint of pain" (about 30%). As with national data the absolute number of pedestrian accidents declined from 1996 to 1999, but started rising again since 2000. Accidents involving children under the age of 15 have declined from a high of about one-third of the total pedestrian accidents in 1996 to one-fourth in the most recent year of the data, 2001.[6] The proportion of pedestrian accidents involving seniors (65 and over) has remained fairly constant at 9 to 10% of the total pedestrian accidents. More males than females are involved in pedestrian accidents (almost 60% male).



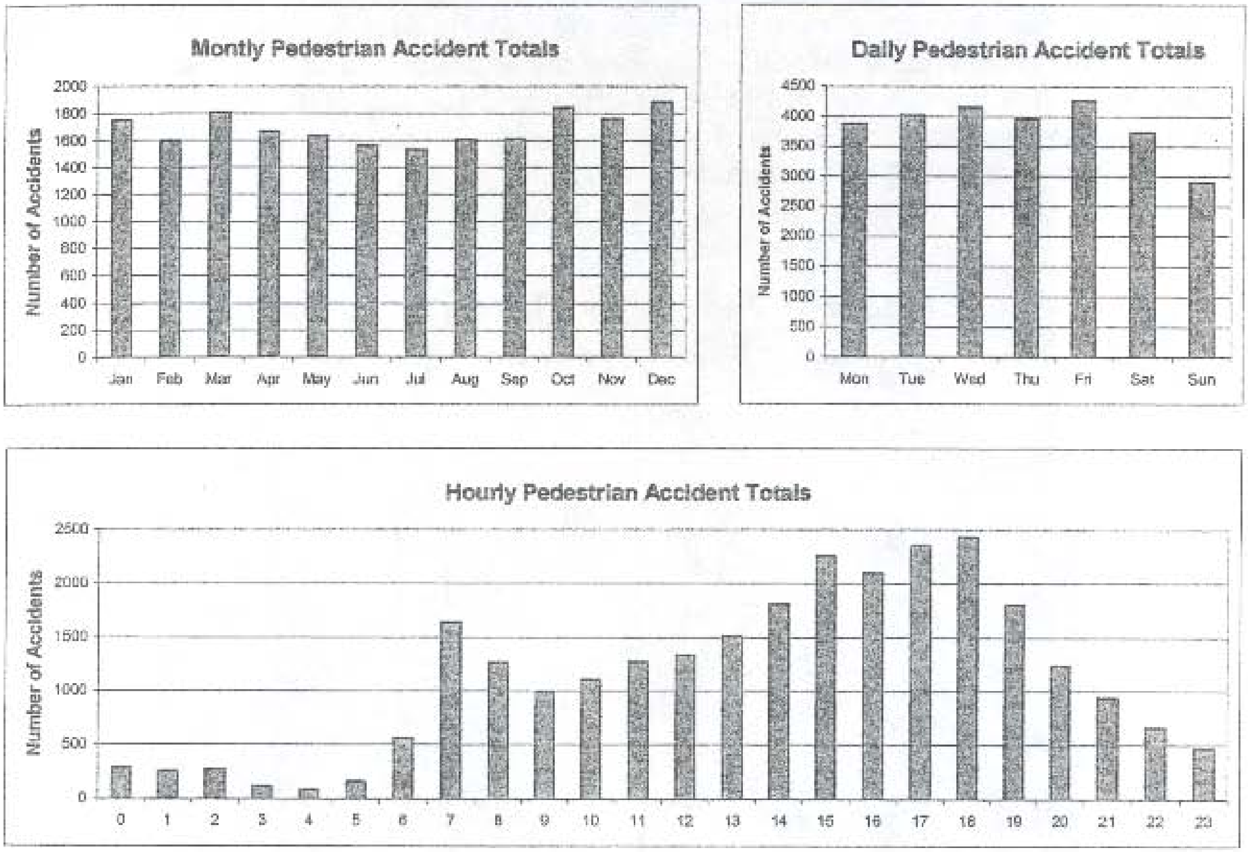
Source: Los Angeles Department of Transportation

[5] The percent of vehicle accidents involving pedestrians declined by about a percentage point between 1997 and 2001.

[6] Children under 15 makeup about 23% of the total population in the City of Los Angeles according to 2000 census data and about 10% of the population is over 65.

A temporal analysis of accident data reveals that accidents are more frequent in late fall and winter (Figure 2). Fewer accidents occur on Saturdays and Sundays than weekdays, presumably because there are fewer automobiles on the road. The peak accident period coincides with the afternoon and morning rush hours (with a major peak between 2 and 7 p.m. and a shorter morning peak between 7 and 8 a.m.)

Figure 2: Pedestrian Accident Totals by Time



An analysis of the location of pedestrian accidents shows that about 40% of them occurred in marked crosswalks at intersections (see Table 1). Twenty-eight percent of accidents took place when pedestrians were "jay-walking" or crossing the road where there was no marked crosswalk. In an additional 12% of the cases, the pedestrian was walking in or along the road as opposed to crossing the road. Almost 20% of the accidents occurred off the road on sidewalks, parking lots, driveways, etc. This percentage breakdown in location of pedestrian accidents was fairly consistent across the years of the study.

Table 1:	Location of Pedestrian Accident				
Year	Intersection Crosswalk	Other Crosswalk	No Crosswalk	In Road	Not in road
1994	38%	2%	30%	12%	19%
1995	38%	2%	29%	12%	19%
1996	38%	1%	30%	12%	19%
1997	39%	1%	28%	12%	20%
1998	41%	2%	28%	11%	18%
1999	40%	1%	27%	11%	21%
2000	42%	1%	27%	11%	19%
2001	40%	2%	26%	13%	21%
TOTAL	40%	1%	28%	12%	19%

Spatial Analysis of Pedestrian Accidents

Accidents involving pedestrians were geo-coded, mapped and aggregated to the census tract and census block level for spatial analysis.[7] Point data representing pedestrian accident incidents was overlaid on socio-demographic and land use characteristics at the regional level to explore visually (using GIS technology) the relationship between the density of pedestrian accidents and the presence of certain socioeconomic, land use, traffic and pedestrian variables (see Table 2). Year 2000 census data at the tract and block group level provided socio-demographic characteristics for the analysis. Land use data was obtained from the Southern California Association of Governments (SCAG) for 2001. This data was re-categorized and aggregated at the census tract and block group level into nine land use codes.

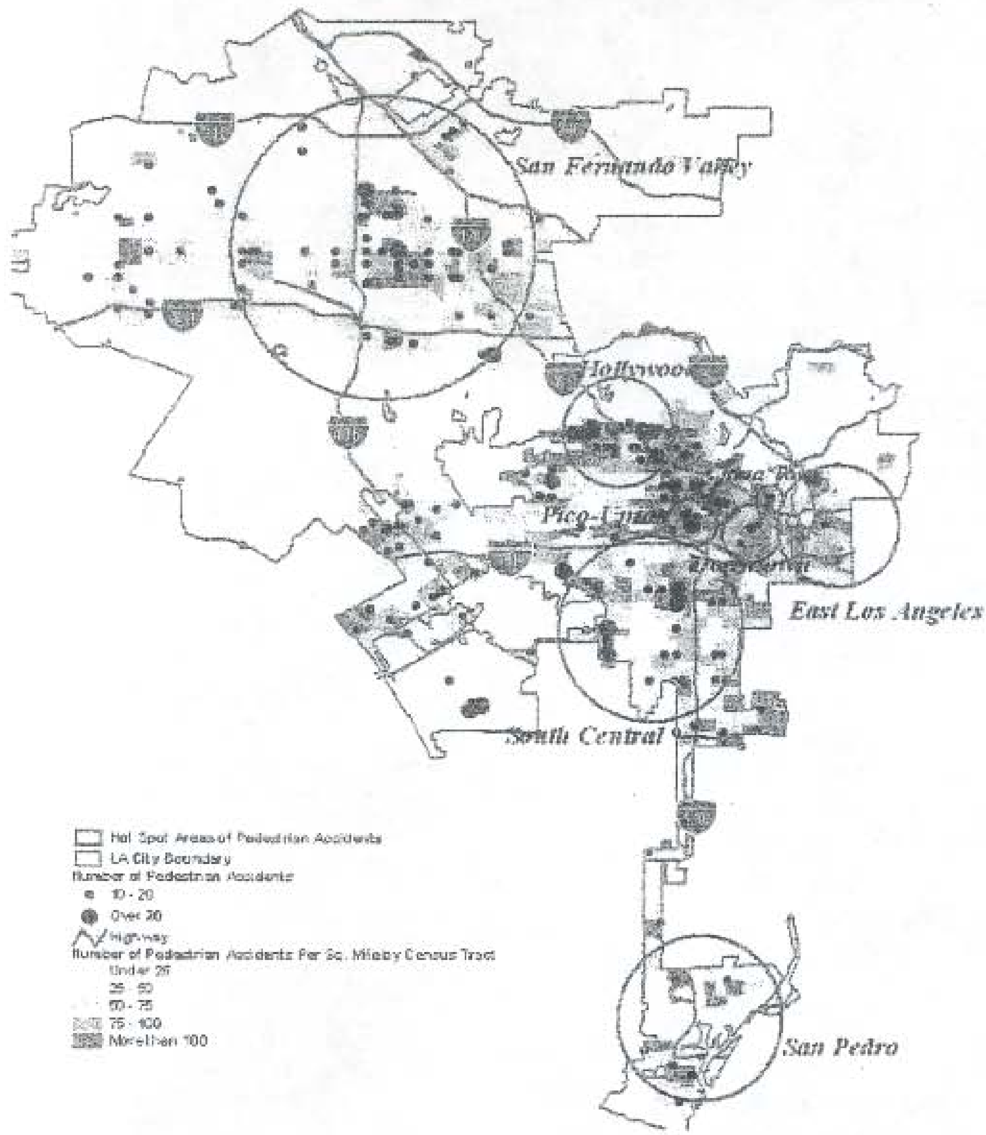
Table 2: Data Types and Sources
Macro Level (census tract or block group)
Socio-Economic Variables (2000, US Census)
Age
% Children (< 15)
% Elderly (>65)
Gender
Ethnicity
Income (% Below Poverty)
Education
Vehicles per HH
Average HH Size
Land Use Variables (2000, SCAG)
% Vacant
% Open Space
% Industry
% Educational Facilities
% Public Facilities
% Commercial
% Low Density Residential
% Medium-High Density Residential
Traffic/Pedestrian Variables
Total Population (2000, US Census)
Population Density
Average Annual Daily Traffic (2000, Caltrans)
Road Density (2000, Tiger File)

[7] Ninety-seven percent of accidents were successfully geo-coded resulting in a total of 24,784 accidents used in the study.

Concentrations of accidents must be normalized relative to "at risk" population (pedestrian and vehicle traffic levels) in order to determine accident rates. However, there exists no good data source on pedestrian trips. Therefore, we experimented with proxy variables such as population density and traffic volume as surrogates for pedestrian density in order to adjust the distribution of pedestrian accidents for the "at risk" population in our hot-spot analysis. Average annual daily traffic counts for local streets in the City of Los Angeles were obtained from the California Department of Transportation (Caltrans). Vehicle traffic levels seem to be a reasonable proxy for pedestrian traffic. The Tiger File for Roads (2000, Census Bureau) was used to calculate road density per spatial unit.

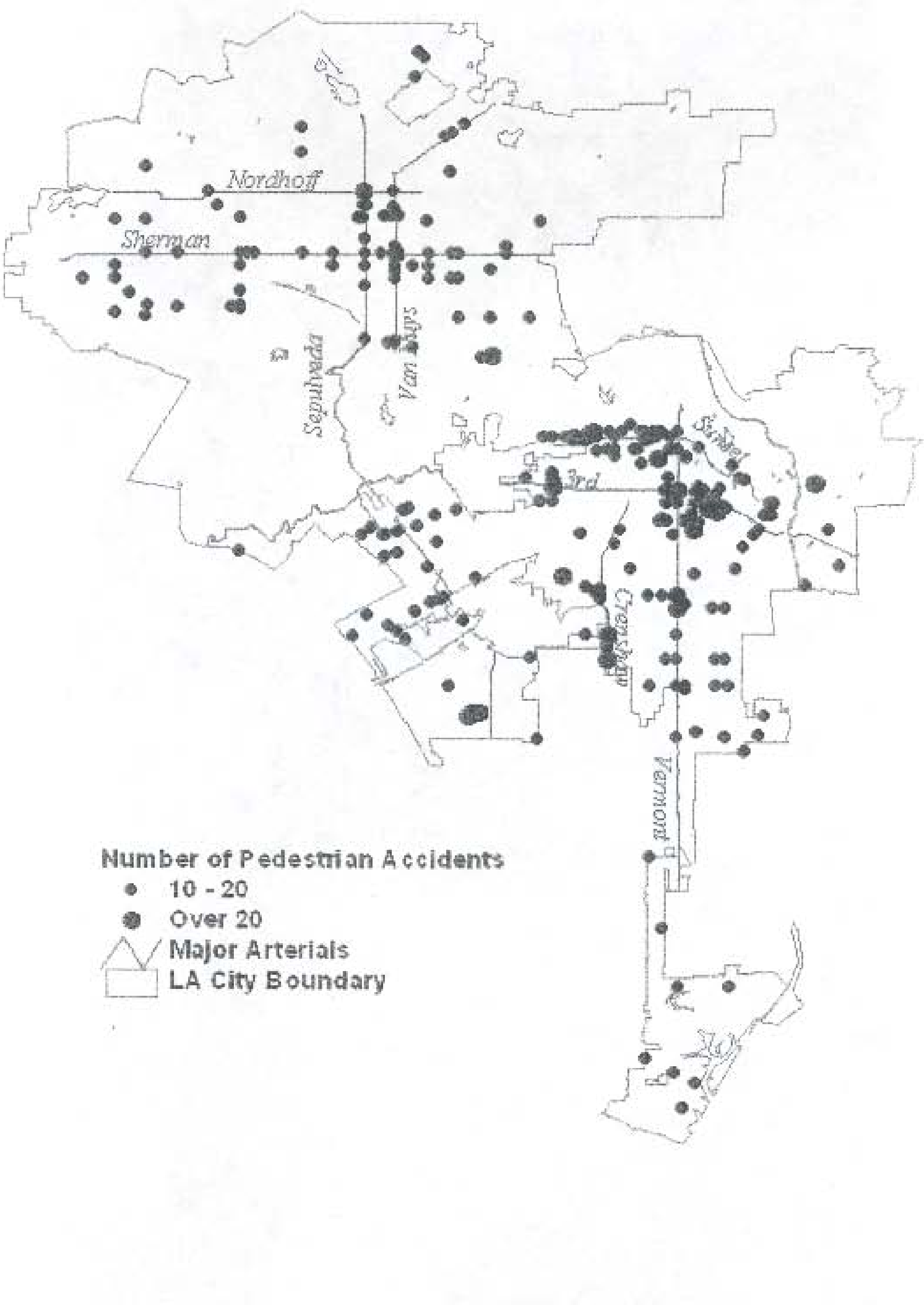
The map in Figure 3 shows pedestrian accidents per square mile by census tract for the City of Los Angeles. We can observe a wide variation in accident density at the tract level.

Figure 3: Pedestrian Accidents per Square Mile



A clustering of accidents can be seen in the map in Figure 4 where the larger dots represent intersections with over 20 accidents and the smaller, 10 to 20 accidents. As expected, we see many accident sites following a linear pattern along major arterials.

Figure 4: Density of Pedestrian Accidents



Zooming into the central area of Los Angeles, including the southern section of the San Fernando Valley, Figures 5 shows a visual correlation between the distribution of pedestrian accidents and the percent Latino population

Figure 5: Pedestrian Accidents and Percent Latino

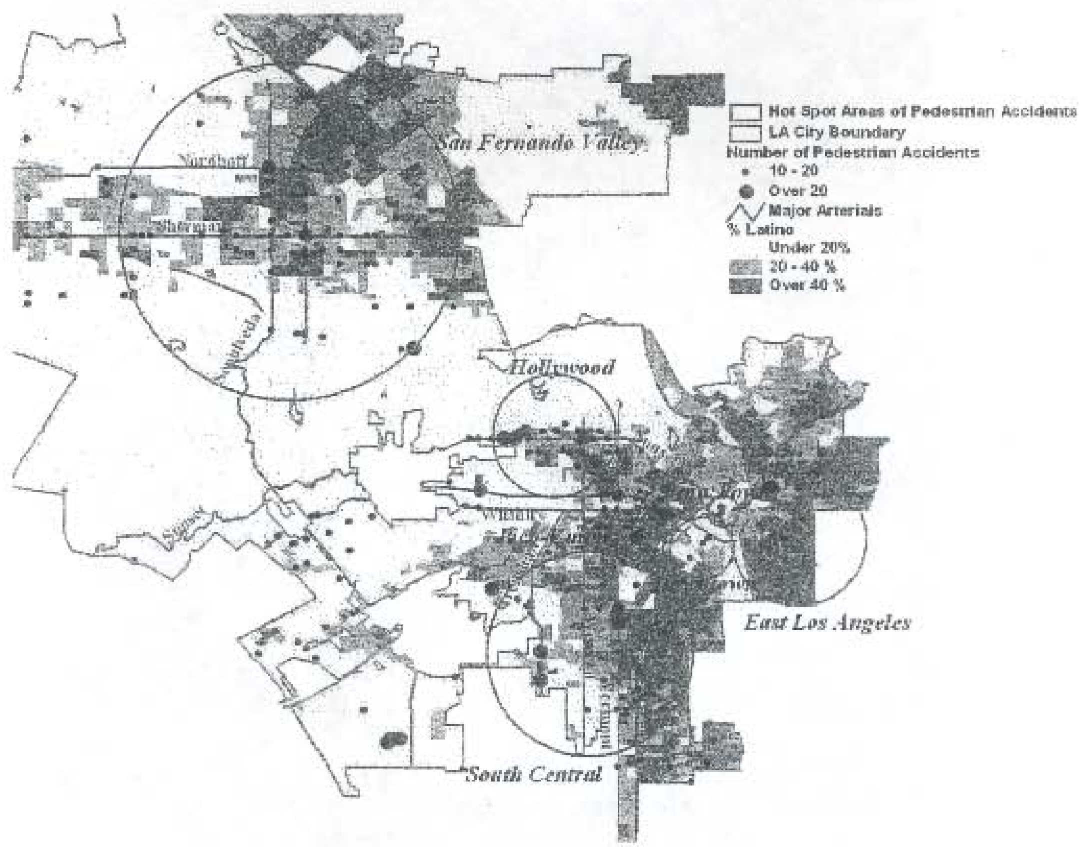


Figure 6 shows visually a correlation between the distribution of pedestrian accidents and the percentage of the population which falls below poverty

Figure 6: Pedestrian Accidents and Percent below Poverty

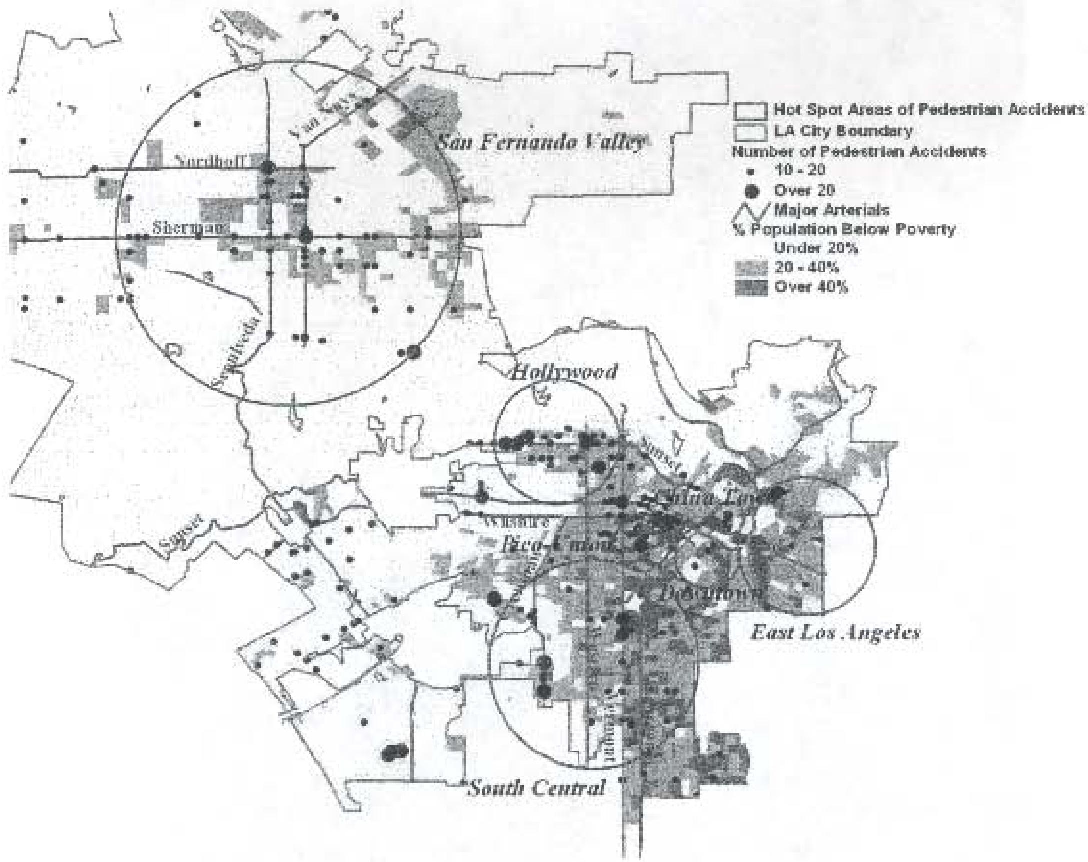


Figure 7 shows visually a correlation between the distribution of pedestrian accidents and the percentage of commercial land use.

Figure 7: Pedestrian Accidents and Commercial Land Use

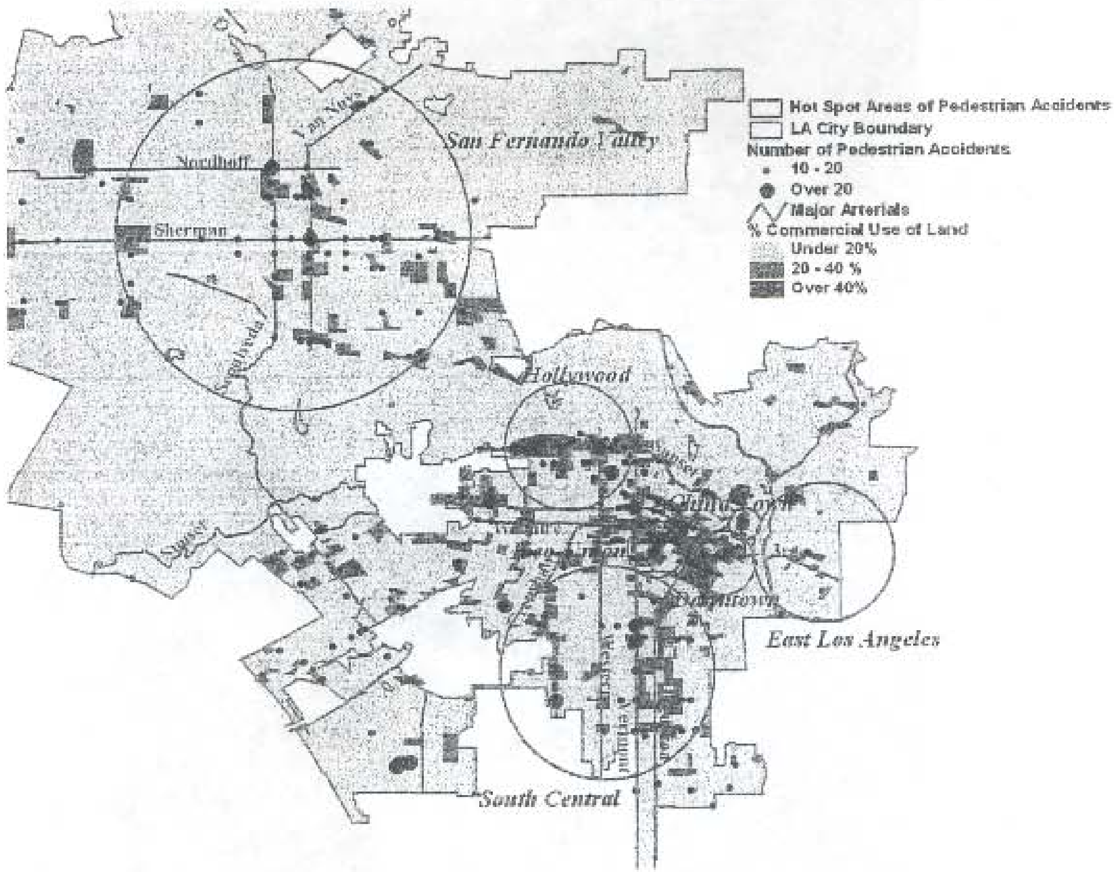
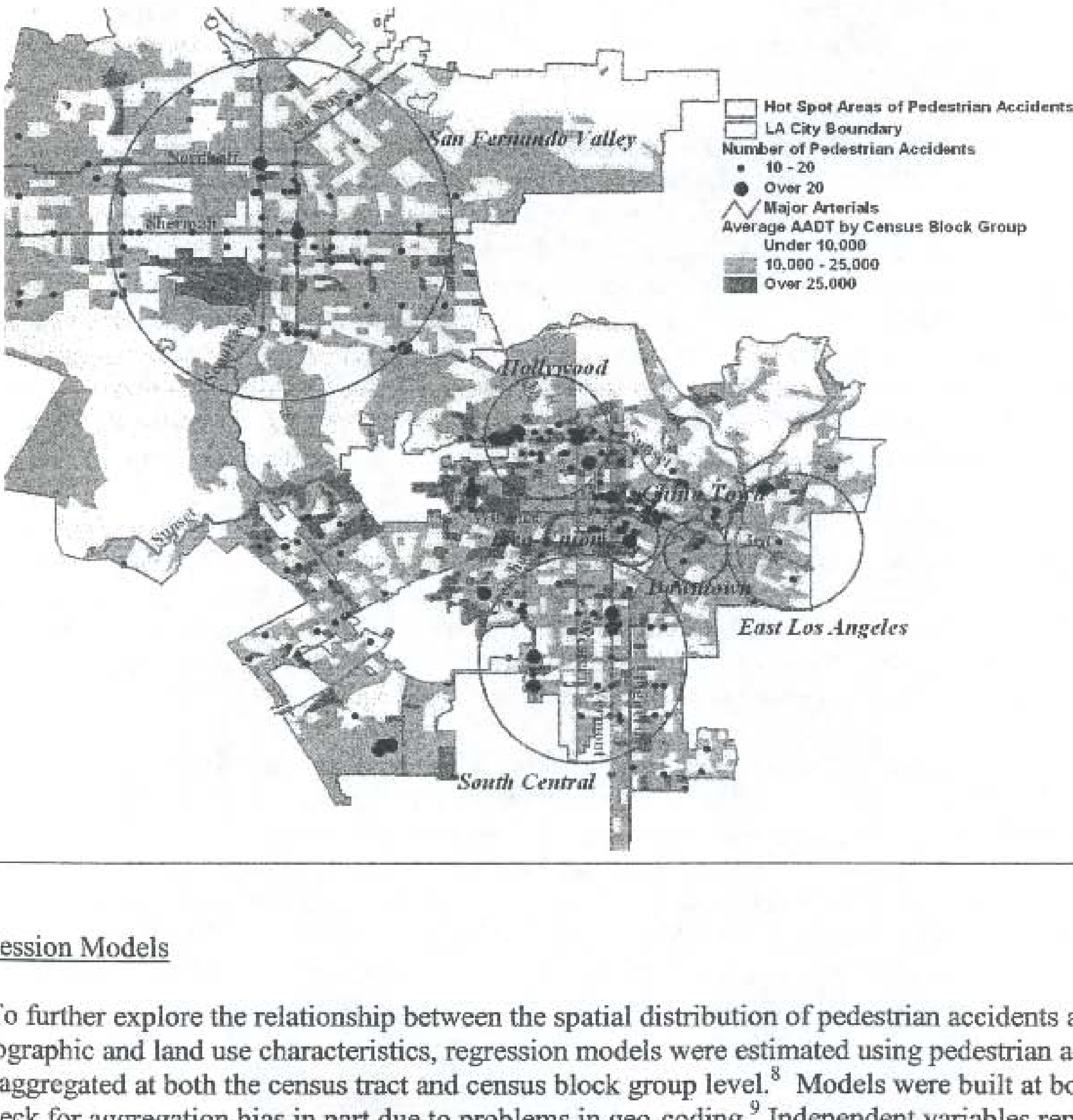


Figure 8 shows visually a correlation between the distribution of pedestrian accidents and the level of average daily traffic. We see "hot spots" of pedestrian accidents in the Hollywood area, South Central Los Angeles, the Pico Union area, East Los Angeles, and Chinatown, locations with large low income and/or minority populations.

Figure 8: Pedestrian Accidents and Average Daily Traffic



Regression Models

To further explore the relationship between the spatial distribution of pedestrian accidents and demographic and land use characteristics, regression models were estimated using pedestrian accident data aggregated at both the census tract and census block group level.[8] Models were built at both levels to check for aggregation bias in part due to problems in geo-coding.[9] Independent variables representing three different factors were tested in the models (see Table 2):

[8] There are 893 census tracts and 2611 census block groups used in the study.

[9] Approximately 20 percent of the geo-coded pedestrian accidents were located on the border of a spatial unit since boundaries are generally determined by roads, so the actual assignment of accidents to a census tract or block group can be arbitrary. If socio-demographic or land use characteristics of the two spatial

Socio-demographic characteristics of the population of each spatial unit which include age, gender, ethnicity, income, education, household size, and vehicles per household.

1. Land use characteristics of the spatial unit which are measured as the percent of area in each of the following nine categories: vacant land, open space, industrial, educational facilities, public facilities, commercial, low density residential, and medium and high density residential.

2. Variables related to identifying "at risk" population for normalization of accidents. For each spatial unit (census tract or block group), variables include total population, population density, average annual daily traffic (AADT) on local streets, and road density (length of road per square mile).

The dependent variable used in the regression models is the number of pedestrian accidents in each spatial unit. The average number of pedestrian accidents is about 24 per census tract, ranging from zero to 191 accidents (note the census tract containing the LA airport which recorded 338 pedestrian accidents was eliminated from the analysis). Ninety percent of the tracts had 50 or fewer accidents. At the census block group level, the average is 8 pedestrian accidents per block group. Most block groups have fewer than 20 accidents with no accidents recorded for 422 block groups. However, three block groups recorded over 100 accidents, more than most census tracts. Two of these block groups were bounded by a freeway in South Central LA and had some of the highest average daily traffic counts[10] and minority populations. The third block group was close to the harbor area in San Pedro but exhibited no extreme values in terms of traffic, socio-economic or land use characteristics.

Since the dependent variable is measured as non-negative count data, ordinary least squares regression was not appropriate for our analysis so the Negative Binomial Regression specification was selected (see Graham and Glaister (2003) for a more detailed discussion of this model specification for a similar analysis).[11] The negative binomial model predicts the expected number of accidents per spatial unit, where the coefficients on the independent variables represent the percentage change in the expected number of accidents for a unit change in an independent variable.

The results of the final models are shown in Table 3. We see quite similar results for the two different levels of spatial aggregation with respect to the sign and significance of the coefficients. Regression coefficients on all variables which represented some aspect of density of population at risk (i.e. population, population density, average annual daily traffic (ADDT), and road density) were statistically significant. As total population and average AADT increase, expected numbers of accidents also increase. The coefficient on road density was also positive; however, the best fit included a quadratic term, indicating that the number of accidents increased as a higher percent of the spatial unit is covered by roads, but at a diminishing rate. The coefficients on population density (which also included a quadratic term) are more difficult to explain as they indicate a negative relationship with pedestrian accidents when all other variables are held constant. This phenomenon was also noted in the model by

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units adjacent at such a boundary are significantly different, regression coefficients can be affected by arbitrary assignment of accidents.

[10] Although averaged annual daily traffic counts did not include freeway traffic, heavy traffic may be due to freeway access.

[11] The Negative Binomial model was selected rather than the Poisson model since the variance of the accident count data was greater than the mean.

Graham and Glaister (2003). They suggest a possible explanation for this effect, "where population densities are higher, the use and speed of vehicles are more stringently controlled by the density of traffic lights, pedestrian crossings, road design and speed restrictions," thus leading to fewer pedestrian accidents. We would caution that population density is highly correlated with the residential land use variables included in the model (r = 0.7 between population density and the percent medium and high density residential) so problems of multi-collinearity may be present.

Table 3: Negative Bionomial Regression Models to Predict Pedestrian Accident Counts

	Census Block Group Model		Census Tract Model	
Independent Variable	Coef.	Std. Error	Coef.	Std. Error
Population	3.97E-04	3.17E-05 ***	1.70E-04	2.15E-05 ***
Population Density	-2.60E-05	7.15E-06 ***	-5.44E-06	1.13E-06 ***
Population Density^2	1.59E-10	9.08E-11 *	3.90E-10	1.35E-10 ***
% Below Poverty	7.91E-01	2.18E-01 ***		
% Latino			5.21E-01	1.92E-01 ***
Avg. Vehicles/HH	-3.86E-01	8.27E-02 ***	-6.23E-01	1.19E-01 ***
ADDT	5.14E-06	2.58E-06 **	4.56E-06	8.10E-07 ***
Road Density	3.24E-02	1.54E-02 **	1.51E-01	1.67E-02 ***
Road Density^2	-4.13E-04	3.00E-04	-2.88E-03	3.81E-04 ***
% Vacant	-1.25E+00	2.77E-01 ***	-5.93E-01	2.60E-01 **
% Educational	6.82E-01	3.21E-01 **	1.04E+00	3.38E-01 ***
% Public	7.53E-01	4.78E-01	2.91E-01	5.36E-01
% Industrial	1.60E-01	2.37E-01	-4.27E-01	2.84E-01
% Commercial	1.78E+00	2.55E-01 ***	1.68E+00	3.40E-01 ***
% Low Density Residential	-4.19E-01	1.85E-01 **	-3.99E-01	1.56E-01 ***
% Medium & High Density Residential	-1.36E-01	2.33E-01	8.77E-01	2.26E-01 ***
Constant	1.57E+00	2.71E-01 ***	1.47E+00	3.06E-01 ***
Dispersion Parameter	0.9346	0.0316 ***	0.5019	0.0263
Log Likelihood at Zero	-7718		-3570	
Log Likelihood at Convergence	-7641		-3501	
AIC	6.107		7.917	
BIC	-4215.045		1082.931	

* significant at .10 level
** significant at .05 level
*** significant at .01 level

There was also considerable multi-collinearity amongst the final set of census variables selected to represent socio-demographic factors of the population: age, gender, ethnicity, poverty, household size and vehicles per household (see Tables 4 and 5). For example, there is a strong correlation between percent children under 15 in a spatial unit and the percent Latino population as well as the percent of the population below poverty and the percent Latino population. As a result, only one of the demographic variables along with the vehicle ownership variable was included in each of the final regression models. At the census block group level, the percent of the population below poverty was the strongest socio-demographic predictor variable while in the census tract model, percent Latino was the most significant socio-demographic variable. The coefficients on these variables in each model were positive, supporting the assumption that pedestrian accidents are more likely to occur in low income, minority neighborhoods once other aspects of risk are controlled for. The coefficient on the average number of vehicles per household indicated a negative relationship with pedestrian accidents – as more vehicles are available, pedestrian accidents decrease. We hypothesized that more vehicles in the household could be an indication of decreased pedestrian activity, and hence less exposure to the risk of pedestrian accidents.

Table 4: Correlation Coefficients at the Census Block Group Level

Variable	% Children	% Latino	% Below Poverty	Avg. HH Size	Avg. No. Vehicles/HH
% Children		0.69	0.47	0.79	-0.14
% Latino	0.69		0.62	0.76	-0.38
% Below Poverty	0.47	0.62		0.41	-0.67
Avg. HH Size	0.79	0.76	0.41		0.03
Avg. No. Vehicles/HH	-0.14	-0.38	-0.67	0.03	

Table 5: Correlation Coefficients at the Census Tract Level

Variable	% Children	% Latino	% Below Poverty	Avg. HH Size	Avg. No. Vehicles/HH
% Children		0.77	0.43	0.86	-0.14
% Latino	0.77		0.64	0.81	-0.45
% Below Poverty	0.43	0.64		0.40	-0.78
Avg. HH Size	0.86	0.81	0.41		0.06
Avg. No. Vehicles/HH	-0.14	-0.45	-0.78	0.06	

Of particular interest to our study was the significant relationship between land use and pedestrian accidents. We observed more pedestrian accidents in areas with educational facilities and higher percentages of commercial land use. In the census tract model, medium and high density residential land use also contributed positively to accident prediction. Accident counts were lower in areas with vacant land, industrial uses and low density residential (i.e. negative regression coefficients).

Case Studies of High-Accident Intersections

To further explore the effects of land use and built environment features on pedestrian accidents we conducted qualitative case study research at the urban block level. From the spatial analysis outlined previously we selected hot spots of pedestrian accidents for further case study research by identifying intersections that seemed to involve the highest levels of pedestrian risk.[12] Risk was measured both in terms of the total number of pedestrian accidents and an exposure index calculated by dividing the number of pedestrian accidents by the maximum average annual vehicle traffic on the intersecting streets (a surrogate measure for population at risk). We were also interested in studying diverse geographic and social contexts. Therefore, in addition to the primary factor of risk, other factors which influenced our case study selection included geographical and socio-economic diversity of the neighborhoods where the high-risk intersection was located. A total of twelve intersections were selected for in-depth study of the physical characteristics of the neighborhood. Table 6 summarizes the number of accidents from 1994-2001, exposure index, traffic characteristics, and most frequent days and times when accidents occurred at each intersection.

TABLE 6: Selection Criteria for Case Study Intersections

	Intersection	# of Accidents	Exposure*	Average Annual Daily Traffic		Most Frequent	
				NS	EW	Time	Day
1	VERMONT & 3RD	37	0.830	46,628	42,556	3-6pm	RF
2	FAIRFAX & 3RD	34	0.949	29,073	42,556	12-3pm	F
3	SUNSET & WESTERN	33	1.060	35,256	27,021	3-6pm	R
4	CRENSHAW & SLAUSON	30	0.866	36,590	32,724	12-3pm	Sun,T
5	DALY & N. BROADWAY	29	1.099	n/a	26,385	6-9am	F
6	MARTIN LUTHER KING JR. & VERMONT	26	0.860	23,066	37,425	3-6pm	WR
7	NORDHOFF & SEPULVEDA	25	0.789	30,521	32,821	3-6pm	Sat
8	SHERMAN WAY & VAN NUYS	22	0.719	36,281	24,885	3-6pm	M
9	ALVARADO & 6TH	22	0.480	45,873	45,833	12-3pm	Sun
10	LEMON GROVE & WESTERN	20	0.692	56,082	1,750	12-3pm	F
11	FLORENCE & SAN PEDRO	19	0.986	14,436	24,113	3-6pm	Sat
12	CATALINA & 3RD	16	0.728	1,400	42,555	6-9pm	M
	TOTAL	313				3-6pm	F

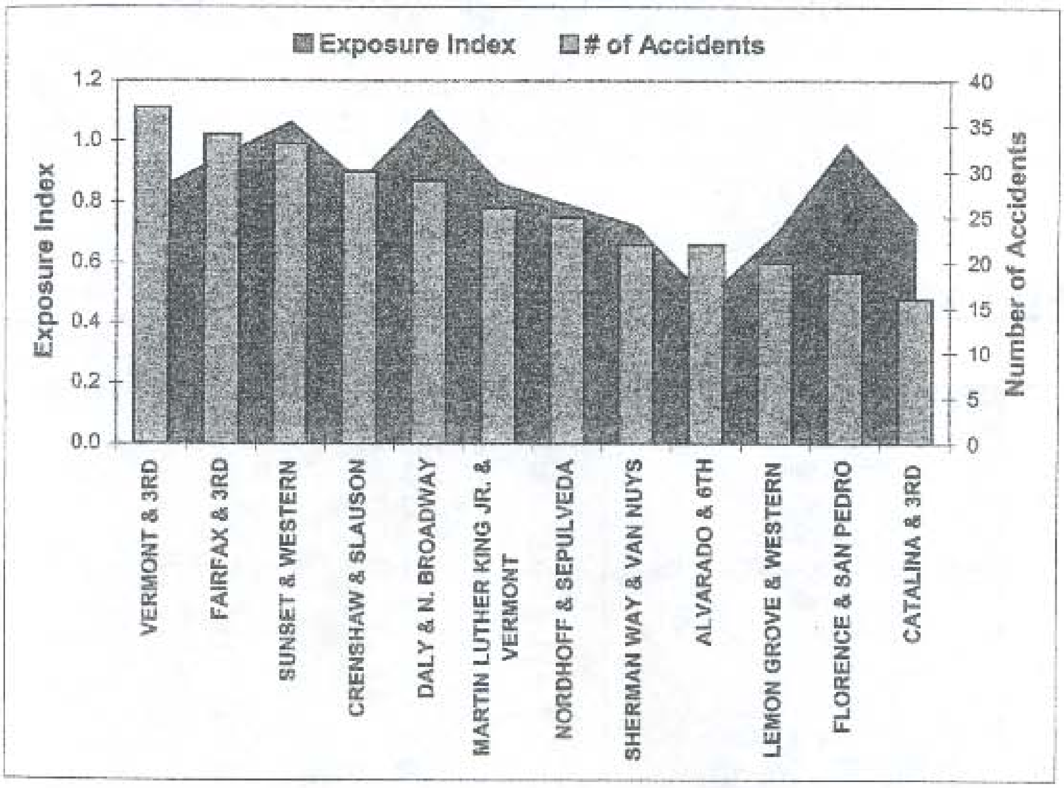
*Calculated as # of Accidents divided by average of NS and EW average annual daily traffic * 1000

---

[12] A large number of accidents occurred during the study period at the Los Angeles airport (LAX). These accidents were excluded from our analysis because they did not occur at a typical intersection.

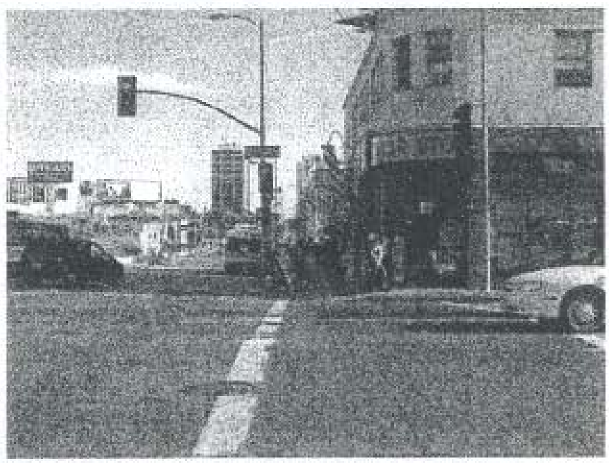
Intersections toward the top of the list of Table 6 led all the intersections in the City of Los Angeles in terms of numbers of accidents (Vermont & 3rd and Fairfax & 3rd had more accidents than any other intersection in the city of Los Angeles) while those toward the bottom were included because of their high exposure rates as well as for reasons of diversity (Florence & San Pedro and Catalina & 3rd). The neighborhood around Catalina and Third, for example, has more residential land use than other areas studied while the Florence and San Pedro neighborhood is primarily non-white with 38 percent of the population living below poverty and 36 percent under the age of 15. Figure 9 compares the case study intersections in terms of number of accidents and exposure index, while the next pages give a brief visual profile of the twelve intersections. A map for each intersection was also created showing the location of each pedestrian accident.

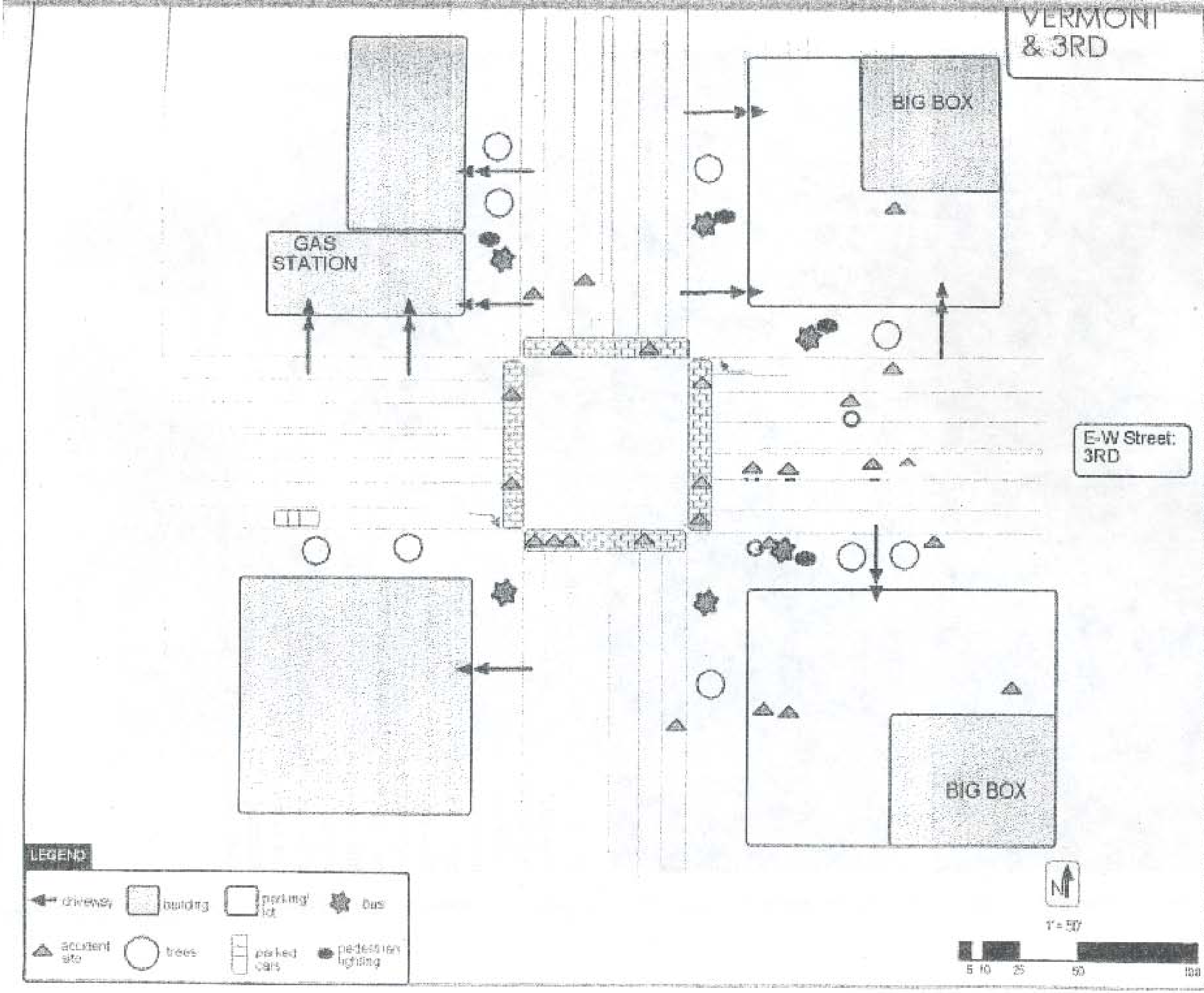
Figure 9: Exposure Index (Area) versus Number of Accidents (Bars)



Vermont & 3rd

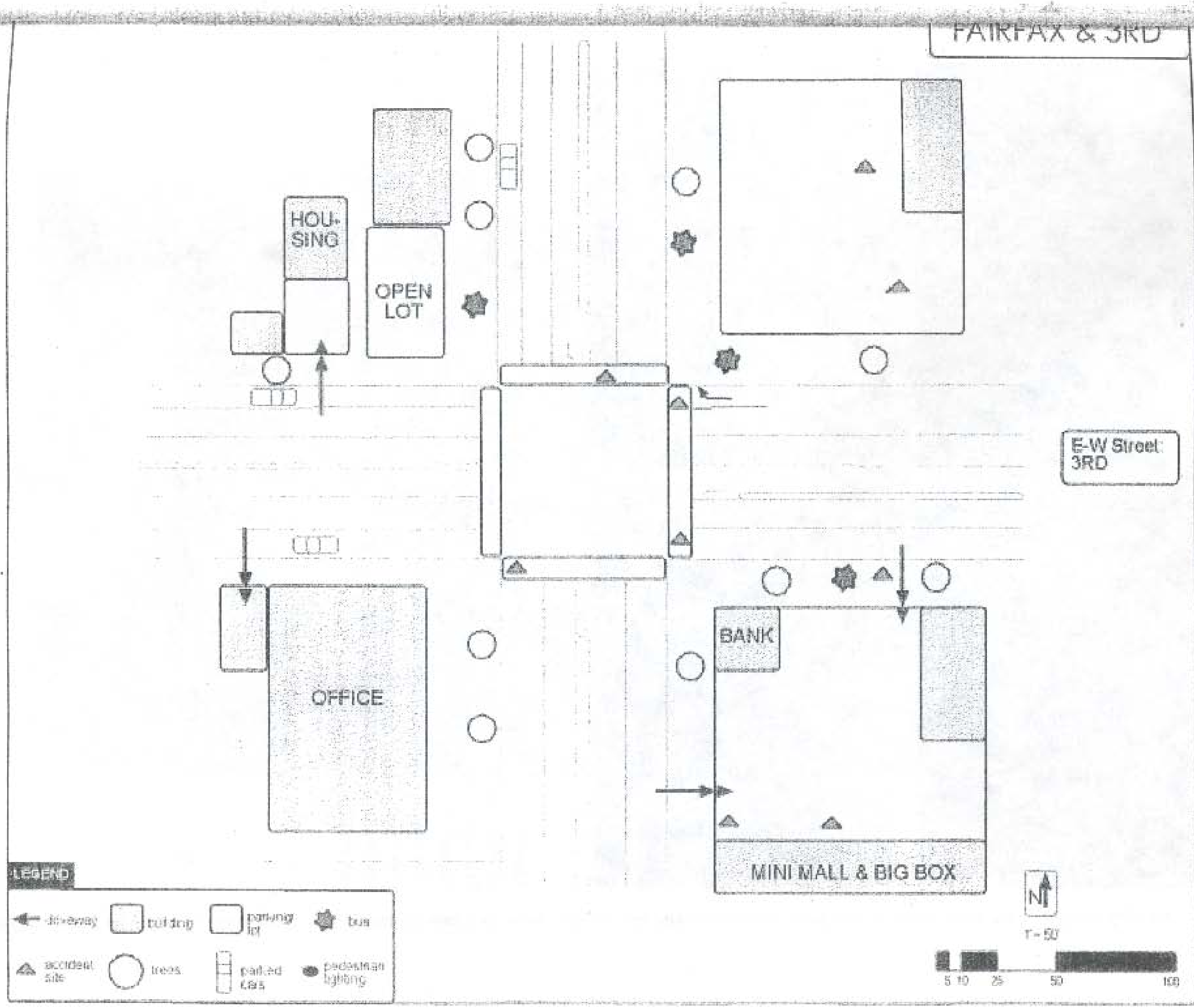
This intersection had the highest levels of pedestrian and vehicular traffic and the highest combined level of NS and EW average annual daily traffic. It also had the greatest number of pedestrian accidents and the second highest observed number of pedestrians crossing the intersection per 5 minute interval. There was a lively atmosphere with vendors on street corners and at supermarket parking lots. Bus stops were heavily used on all four corners with crowds of passengers getting off and on or waiting for the bus. A higher proportion of accidents at this intersection occurred while a vehicle was backing up (24% versus 13% for all intersections combined).




VERMONT
& 3RD
BIG BOX
GAS
STATION
E-W Street:
3RD
BIG BOX
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
1" = 50'
5 10 25 50 100

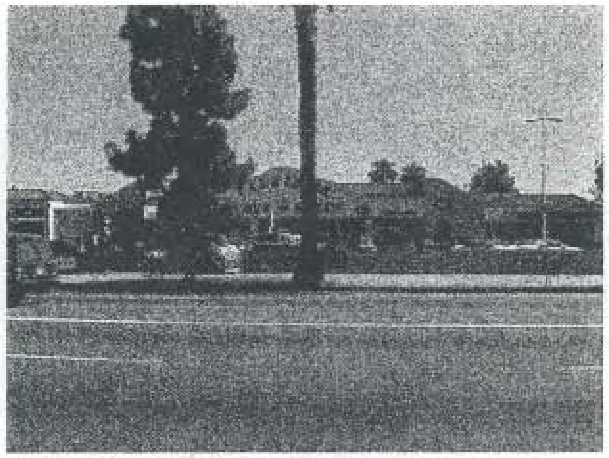
<u>Fairfax & 3rd</u>

This intersection is the site of the historic Farmer's Market which has been expanded with the development of a new shopping center, "the Grove." Of all the intersections studied, this one had the highest percentage of elderly (52%) and female (73%) victims. Field observations indicated a large number of elderly pedestrians in the area, but very few pedestrians of color. The neighborhood is primarily non-Hispanic White (92%) with a high proportion of elderly (twice the city proportion). Three-fourths of the accidents occurred off the road and one-third involved the automobile backing up. This is a major intersection for bus lines, but there are no bus shelters.

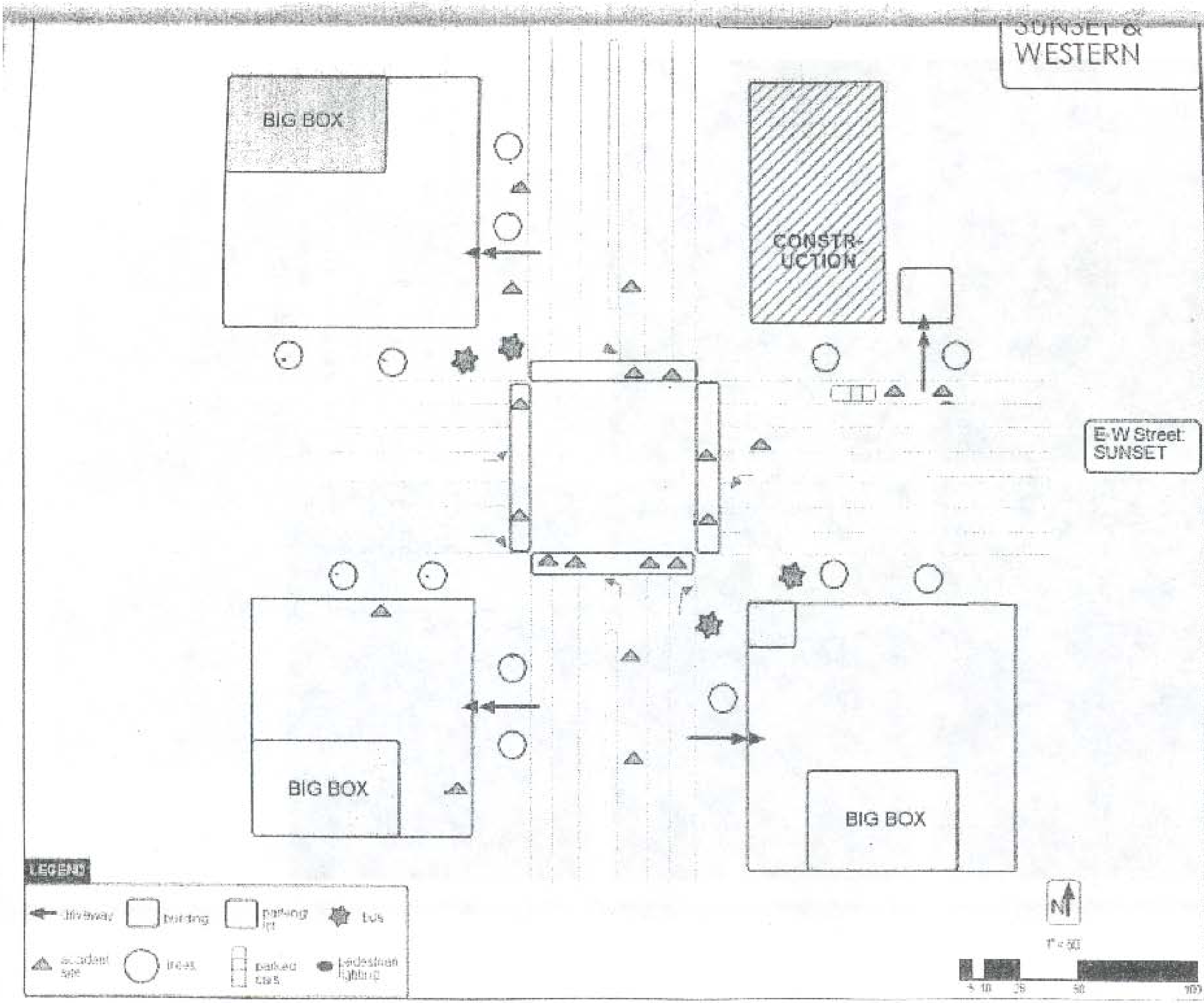


FAIRFAX & 3RD
HOU-
SING
OPEN
LOT
OFFICE
BANK
MINI MALL & BIG BOX
E-W Street:
3RD
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
1" = 50'
5 10 25 50 100

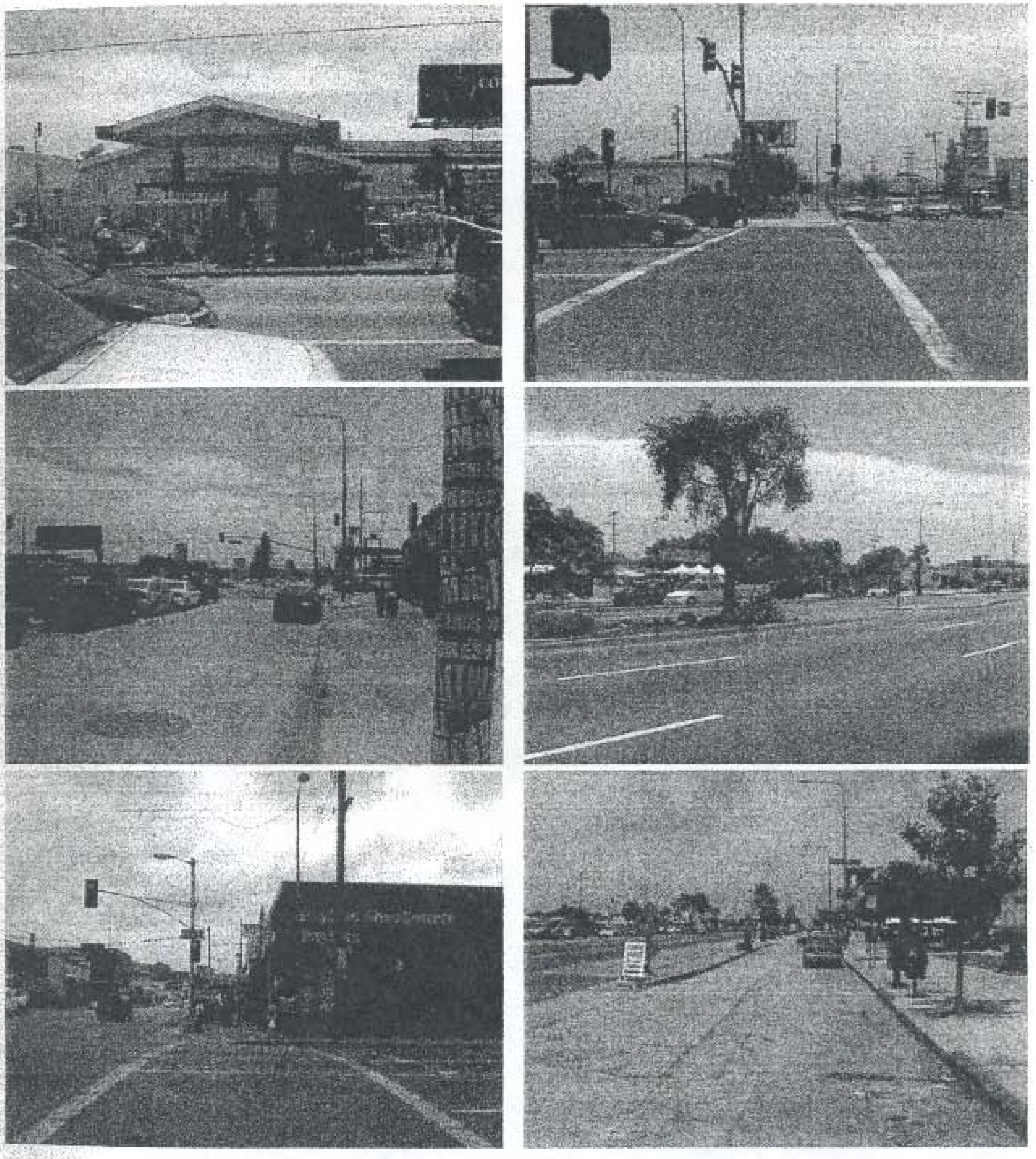
Sunset & Western



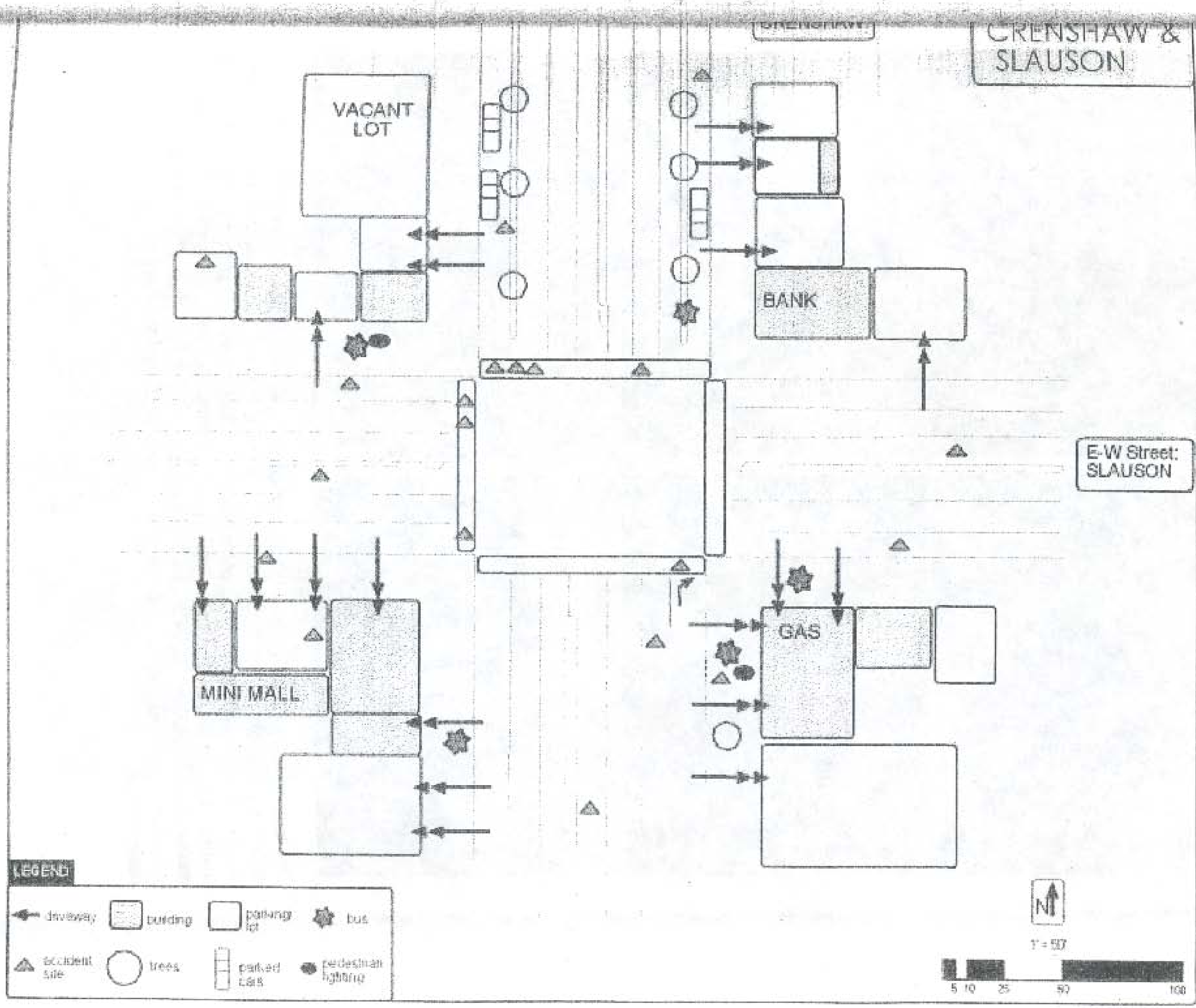
This is an automobile-oriented intersection with three lanes of traffic in all directions (excluding left and right turn lanes). Riders disembark from buses at unmarked stops. A higher than normal percentage of pedestrian accidents occurs off the road or when making a right turn. There is noticeable overgrown foliage that obstructs the vision of drivers when making a right turn. A higher percentage of pedestrian victims are elderly and female. The poverty rates in this neighborhood are double the average rate for the City of Los Angeles.


SUNSET &
WESTERN
E-W Street:
SUNSET
BIG BOX
CONSTR-
UCTION
BIG BOX
BIG BOX
N
1" = 50'
5 10 25 50 100
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting

Crenshaw & Slauson

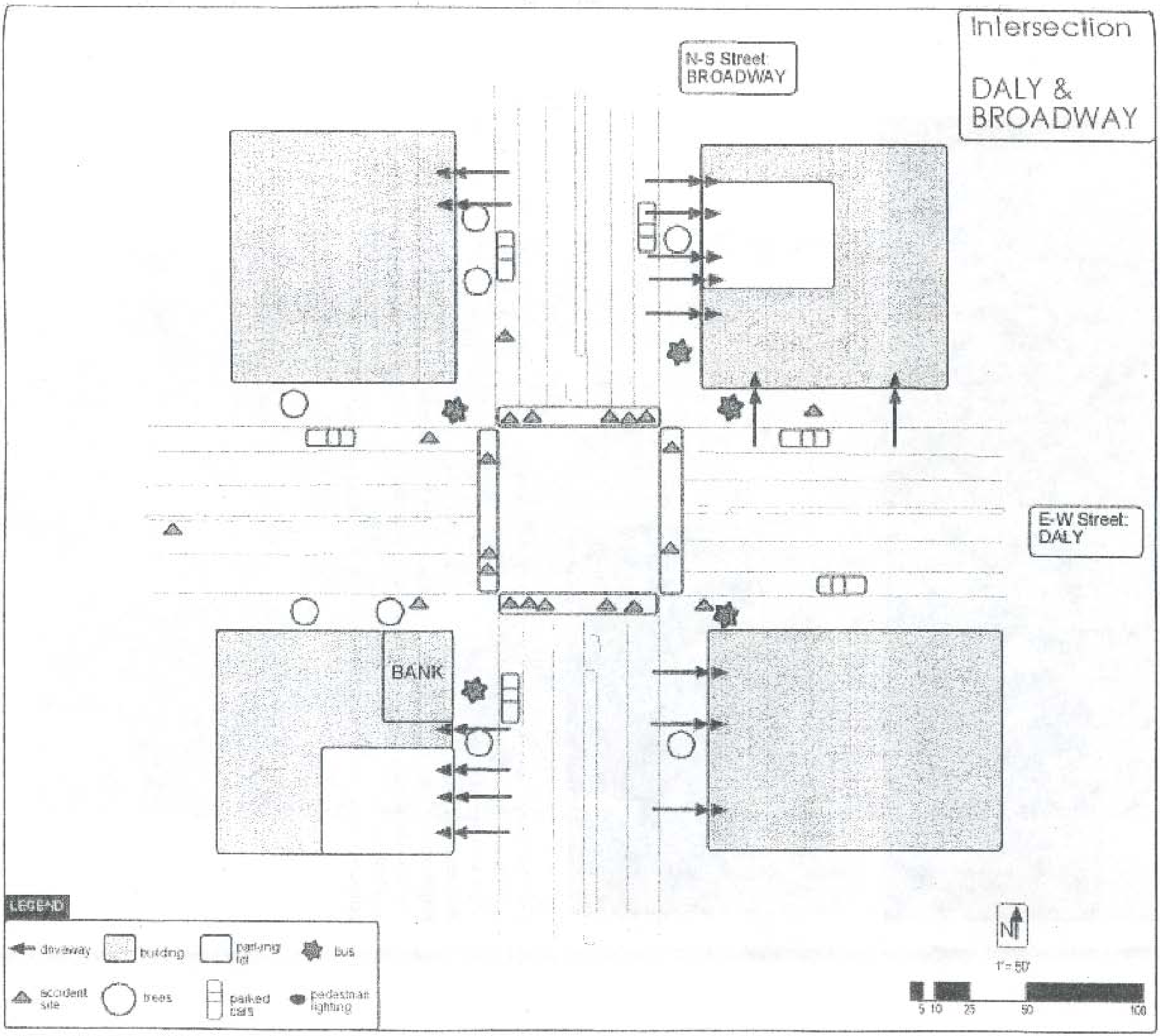


This intersection, in a predominantly white neighborhood, had a higher proportion of fatal accidents as well as male victims. None of the accident victims were children and only one was over 65. A lower percentage of accidents occurred at the crosswalk than in the other intersections studied. The intersection has an unusual street configuration with secondary lane separated by a median from the main street. This leads to merging traffic and pedestrians crossing the secondary lane to reach buses which stop at the median. Illegal u-turns by vehicles were also observed here.

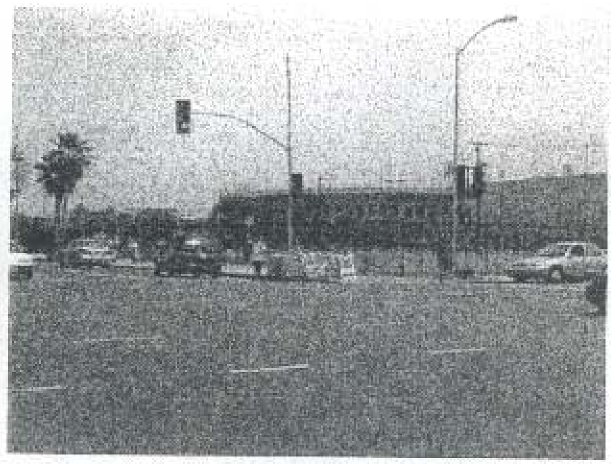

CRENSHAW & SLAUSON
CRENSHAW
E-W Street: SLAUSON
VACANT LOT
BANK
GAS
MINI MALL
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
N
1" = 50'
5 10 25 50 100

Daly & N. Broadway

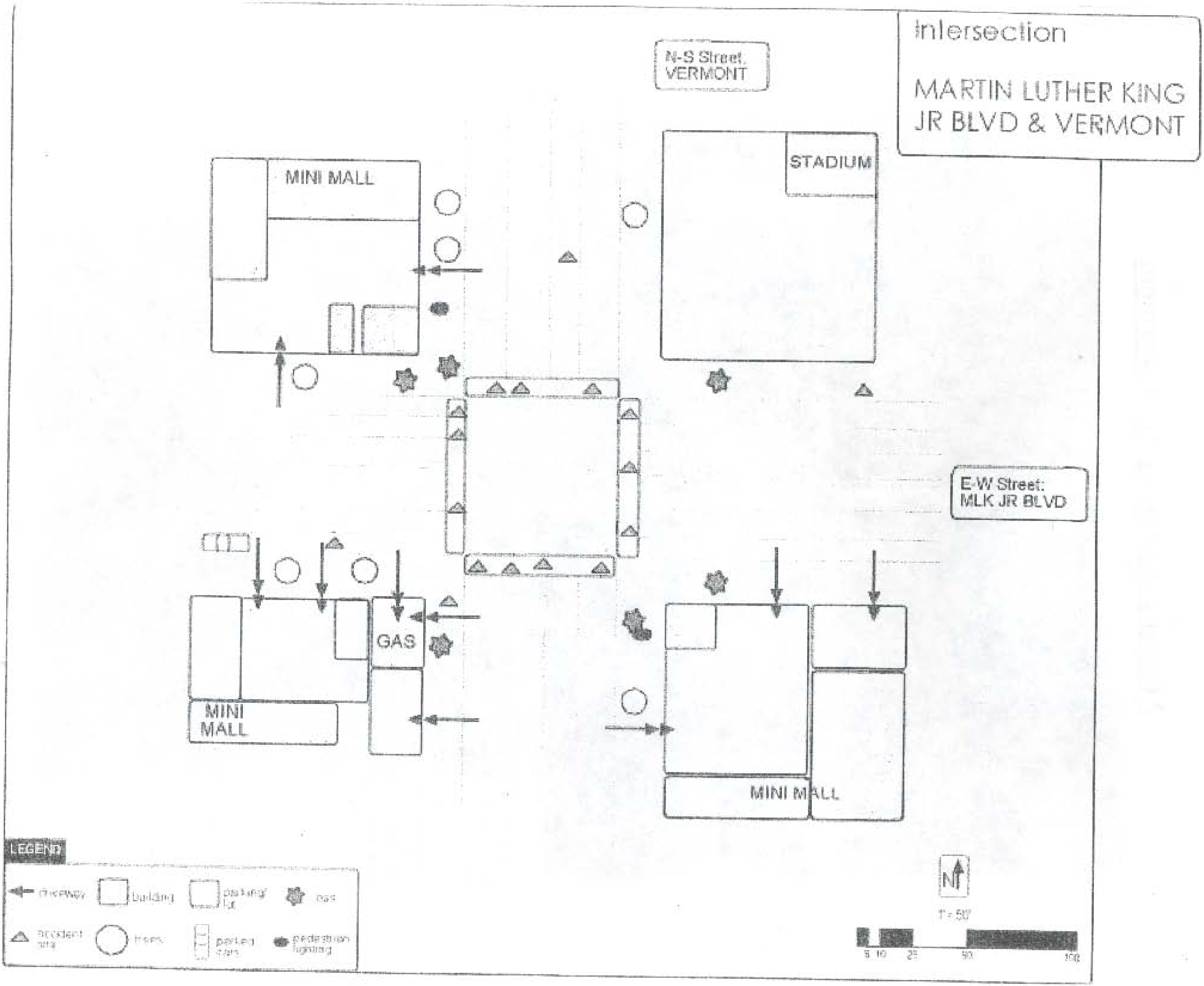
This intersection had the highest exposure index. Poverty rates in this neighborhood are very high (double the city average).A higher proportion of accidents happened at the crosswalk and while vehicles were making a left turn. There were fewer severe accidents here than at the other intersections studied, but a higher percentage of accidents involved children and females. The neighborhood has a much higher proportion of children than the City of Los Angeles (almost double). The presence of an elementary school in the neighborhood as well as a peak time accident rate between 6 and 9 a.m. indicates that most of the accidents are related to school pedestrian traffic since most local businesses are not open before 9:00 am.


Intersection
DALY & BROADWAY
N-S Street: BROADWAY
E-W Street: DALY
BANK
N
1" = 50'
5 10 25 50 100
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting

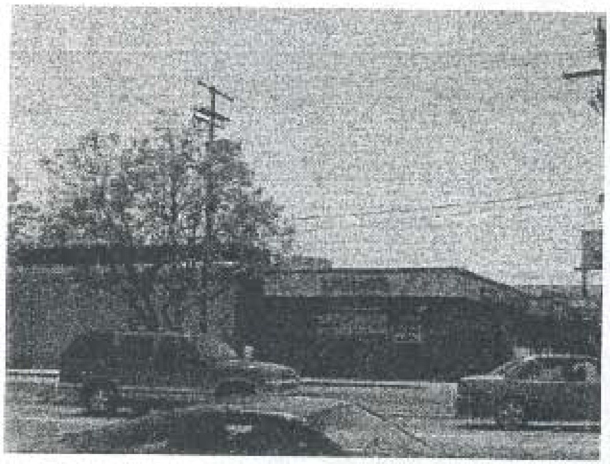
Martin Luther King Jr. & Vermont



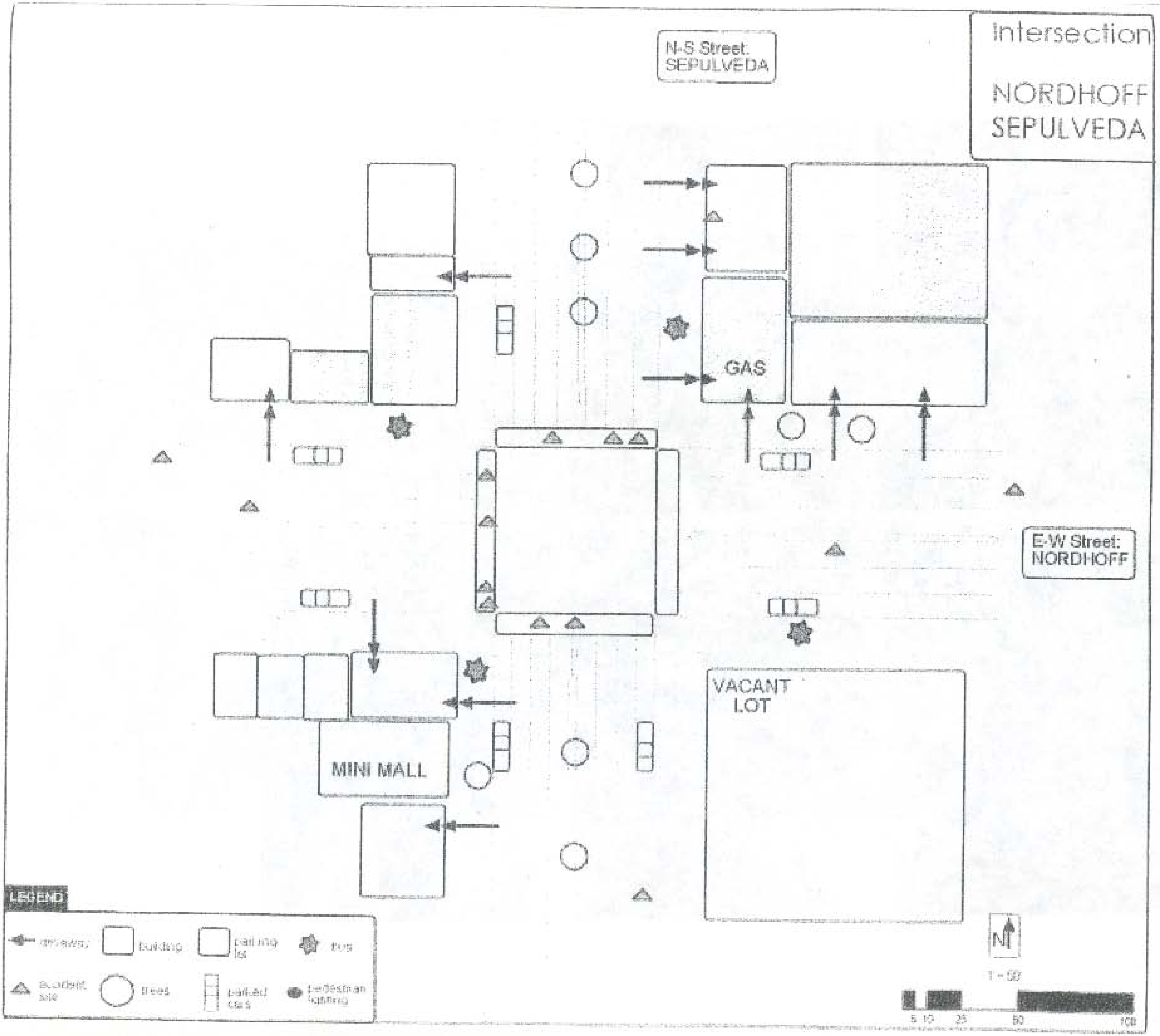
The poverty rate of this neighborhood, which is bounded by Exposition Park and the Swim Stadium to the north, is more than double that of the City of Los Angeles, and the highest of all twelve intersection neighborhoods studied. This intersection had the highest number of pedestrians crossing per five minute interval. This may explain why a higher proportion of accidents occur at the crosswalks here than at the other intersections studied. Higher numbers of teenagers were victims of pedestrian-automobile accidents here. There is a high school in the area and large numbers of teenagers were observed hanging out on the sidewalks.


Intersection
MARTIN LUTHER KING JR BLVD & VERMONT
N-S Street: VERMONT
E-W Street: MLK JR BLVD
STADIUM
MINI MALL
MINI MALL
MINI MALL
GAS
LEGEND
driveway
building
parking lot
gas
accident site
trees
parked cars
pedestrian lighting
N
1" = 50'
5 10 25 50 100

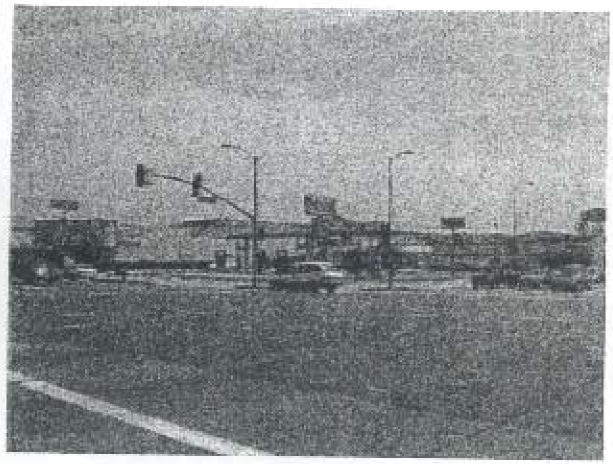
Nordoff & Sepulveda



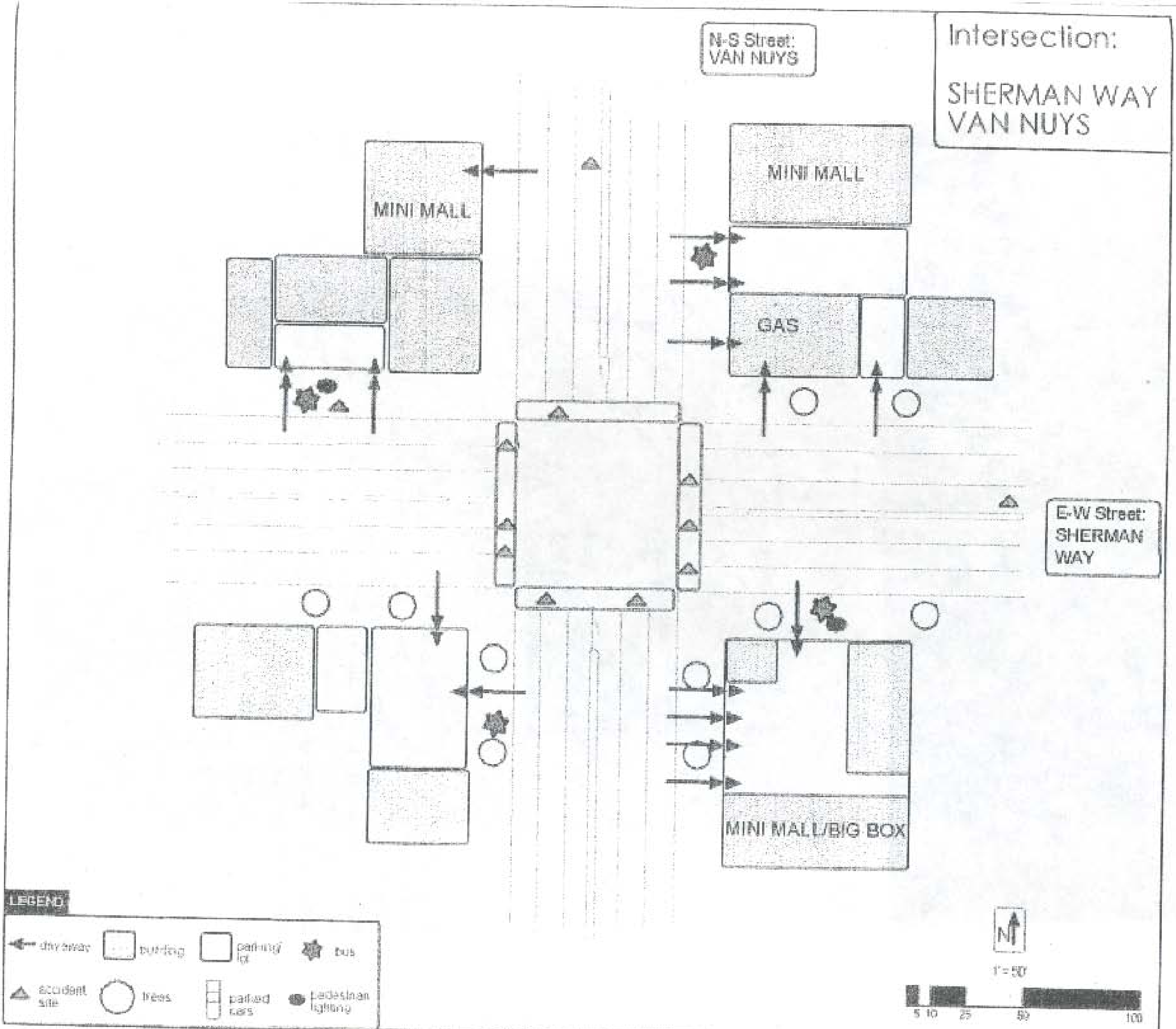
This intersection is on a major through fare to the 405 Freeway and little pedestrian activity was observed. One-third of the pedestrian accident victims were not at the crosswalk when the accident occurred. The neighborhood has more than twice the percentage of children than the City of Los Angeles, which could account for the high proportion of children involved in pedestrian accidents as well has the high proportion of fatal accidents.


Intersection
NORDHOFF
SEPULVEDA
N-S Street:
SEPULVEDA
E-W Street:
NORDHOFF
GAS
VACANT
LOT
MINI MALL
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
1 = 50
5 10 25 50 100

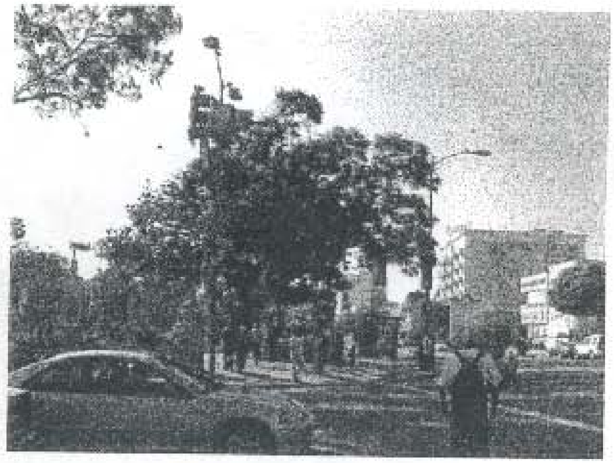
Sherman Way & Van Nuys

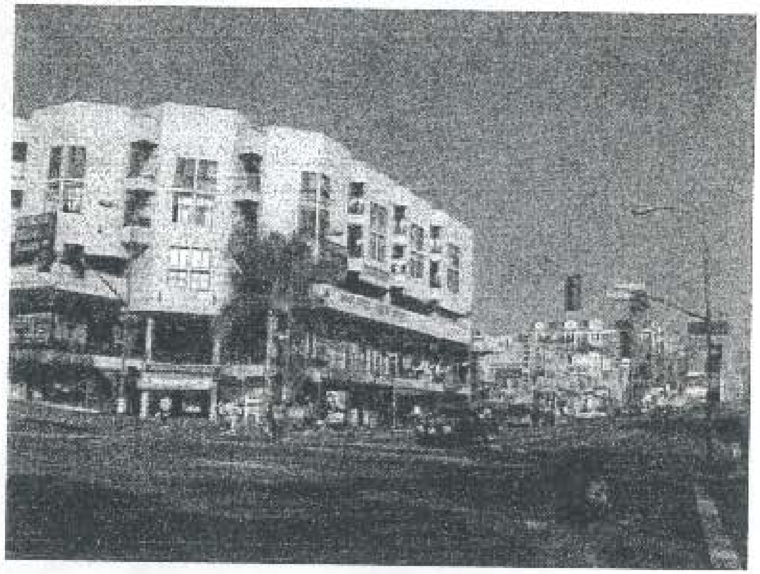


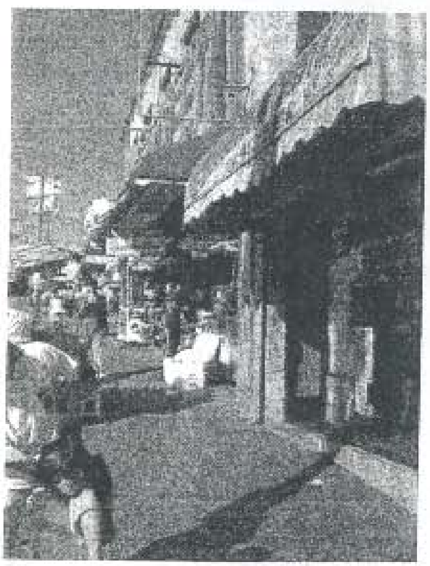
This is an automobile-oriented intersection with seven lanes of traffic and additional vehicular traffic coming in and out of the driveways of commercial establishments. Mini-malls are located on three corners of the intersection. Pedestrians were observed to be impatient with a walk signal which seemed to alternate with every other light and were observed running to catch the bus or crossing without a signal. The percentage of accidents resulting in severe injuries is higher at this intersection, perhaps due to high traffic speeds. A larger proportion of accidents occurred when the auto was proceeding straight.


Intersection:
SHERMAN WAY
VAN NUYS
N-S Street:
VAN NUYS
E-W Street:
SHERMAN
WAY
MINI MALL
MINI MALL
GAS
MINI MALL/BIG BOX
LEGEND
driveway
building
parking/
lot
bus
accident
site
trees
parked
cars
pedestrian
lighting
N
1" = 50'
5
10
25
50
100

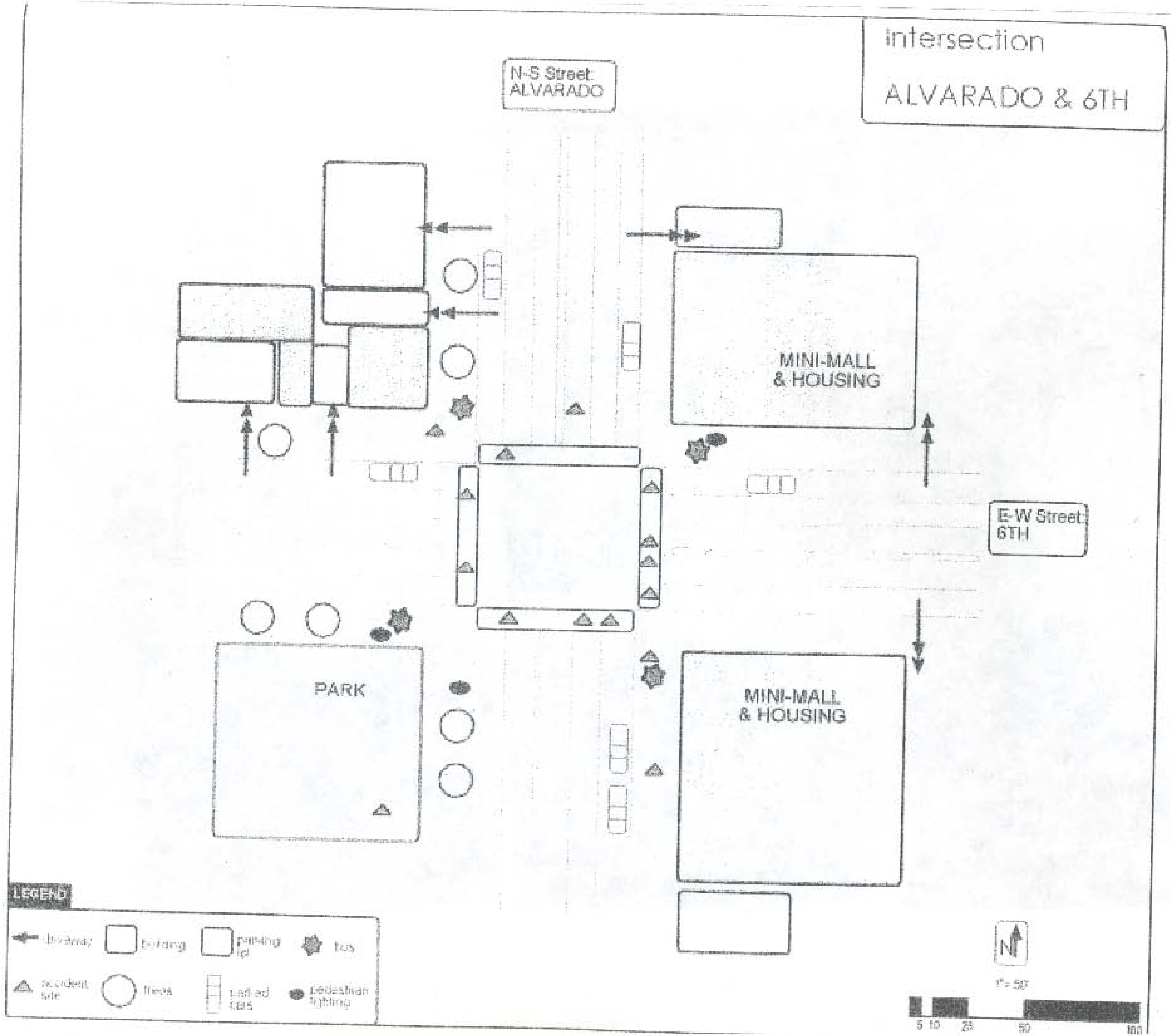
Alvarado & 6th



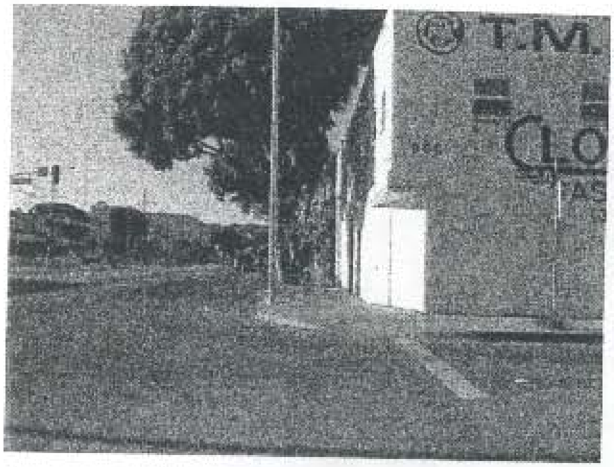


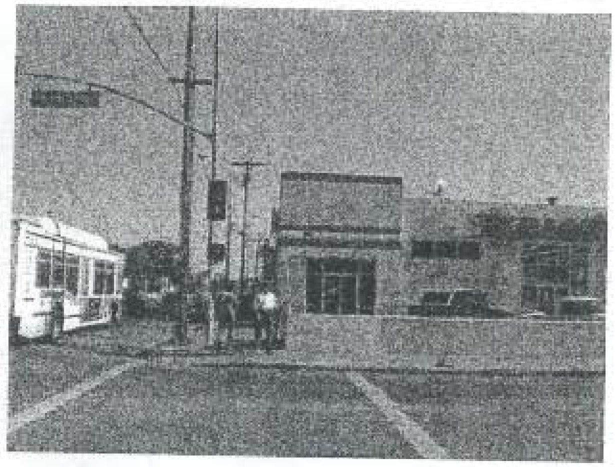


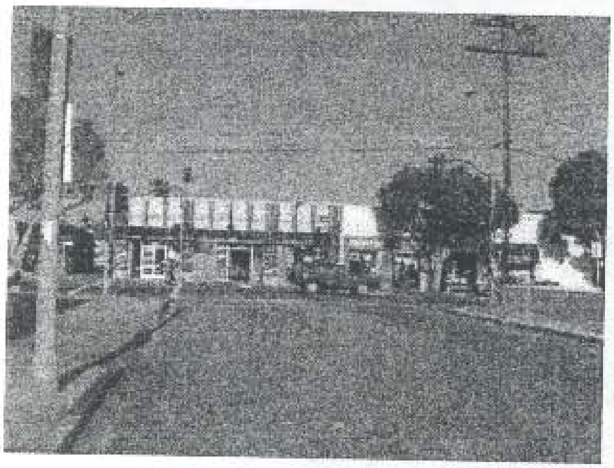
This intersection, which borders MacArthur Park, is vibrant with high numbers of pedestrians. Large mixed use projects occupy the four corners of the intersection. There are higher accident rates for children and males here. A higher proportion of males live in this neighborhood than in the City of Los Angeles as a whole. Males also seem drawn to the soccer fields of MacArthur Park. About three-fourths of the accidents involved vehicles proceeding straight. Sixty percent of the accidents occurred with pedestrians were crossing at the crosswalk. This intersection has a rather low exposure index. The high numbers of accidents are likely due to the high numbers of pedestrians present.


intersection
ALVARADO & 6TH
N-S Street:
ALVARADO
E-W Street:
6TH
MINI-MALL
& HOUSING
MINI-MALL
& HOUSING
PARK
LEGEND
driveway
building
parking lot
bus
accident site
trees
padded taxis
pedestrian lighting
N
1" = 50'
5 10 25 50 100

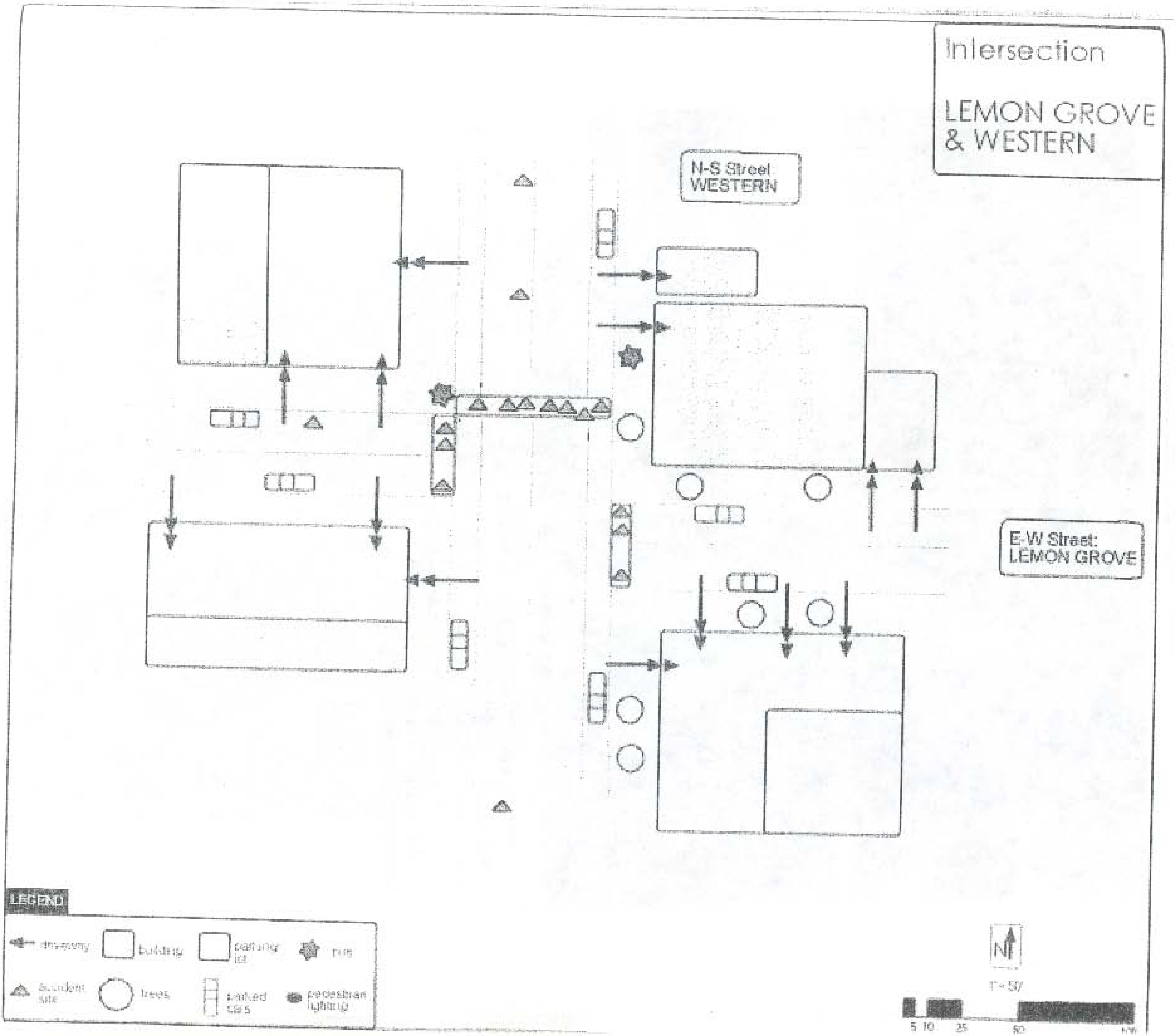
Lemon Grove & Western



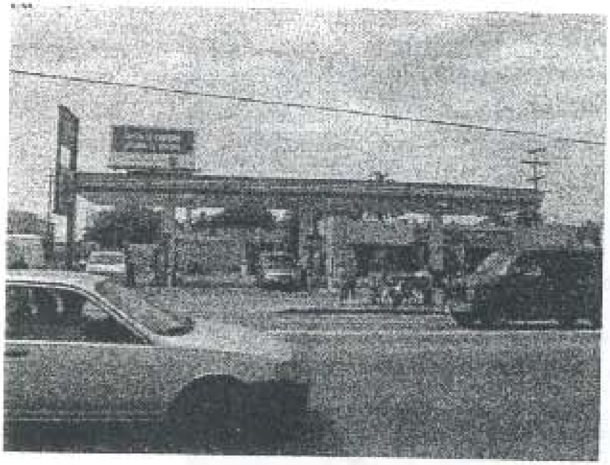


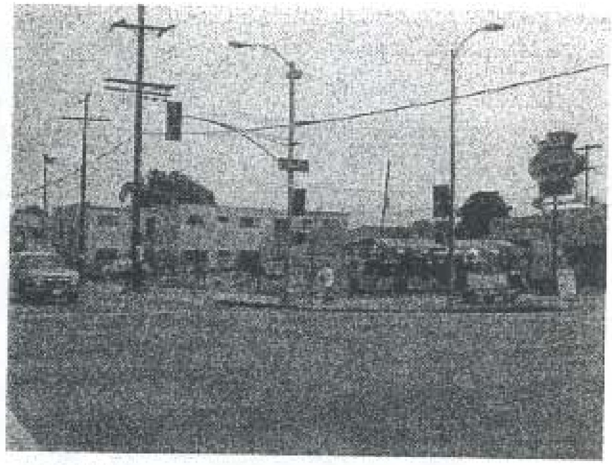


This intersection has a number of small/open front commercial establishments, while the rest of the neighborhood is primarily residential. Lemon Grove is a smaller street that jobs as it crosses Western (does not continue straight through). The traffic light at the intersection only serves pedestrians crossing on the northwest side, so jay walking is common. Seventy-five percent of the accidents here occurred at the intersection crosswalk. Little pedestrian traffic was observed at this intersection. A high percentage of victims were children or male.

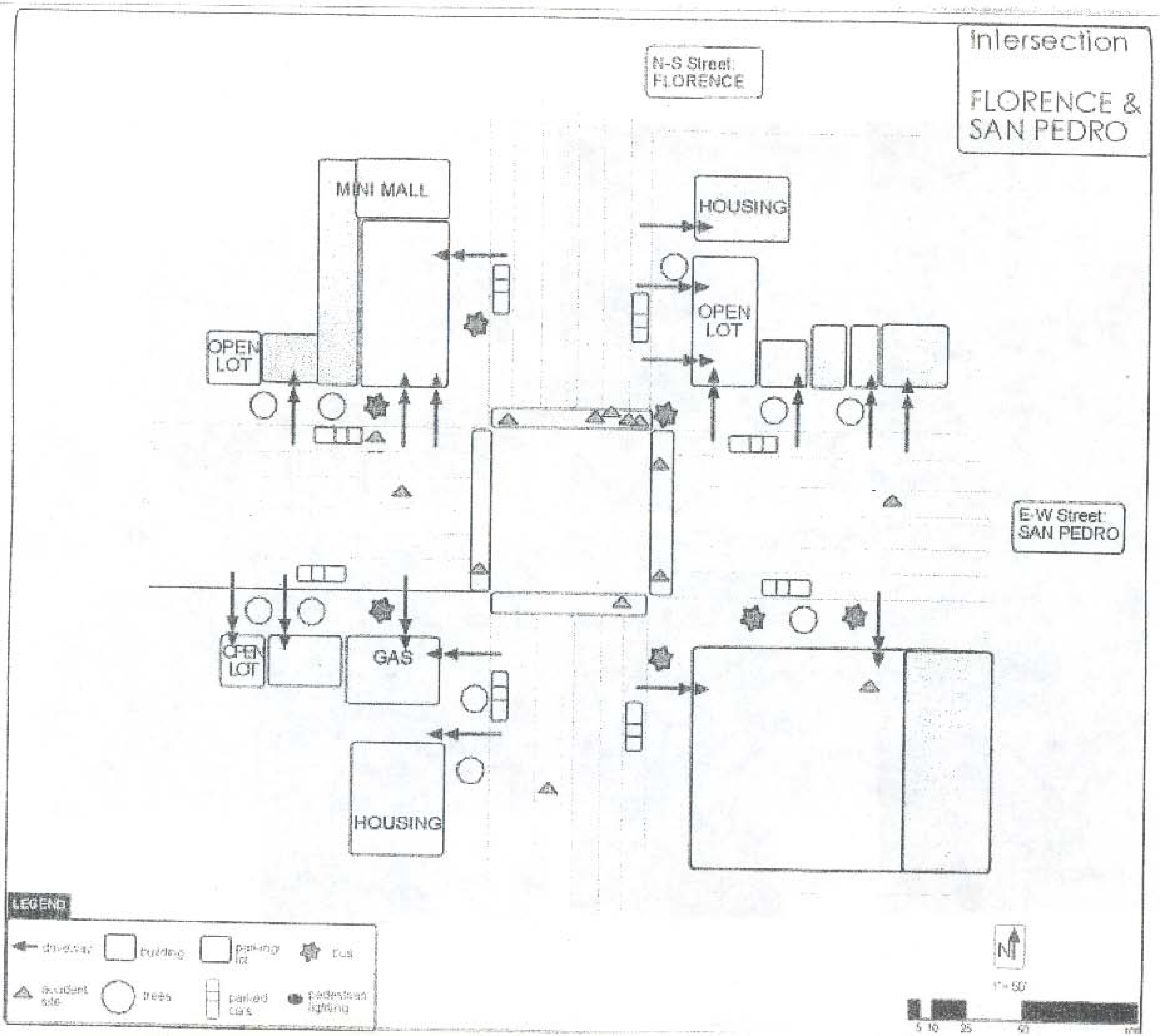

Intersection
LEMON GROVE
& WESTERN
N-S Street:
WESTERN
E-W Street:
LEMON GROVE
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
N
1" = 50'
5 10 25 50 100

Florence & San Pedro



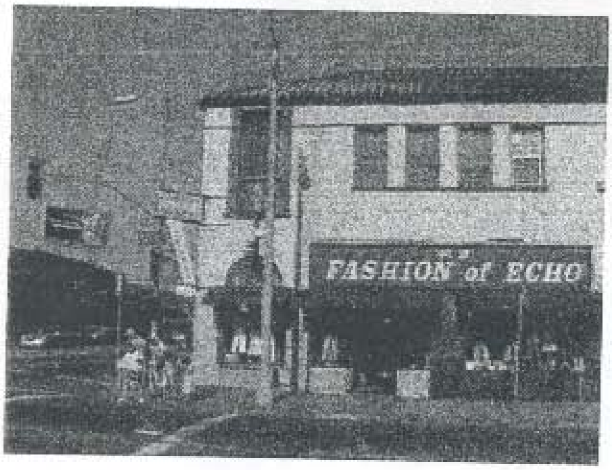


This is an automobile-oriented intersection with street parking on all segments. There are numerous vacant/open lots with one used as a vendor area. There is an auto repair shop with autos on the sidewalk and a general lack of upkeep and disorder in the area. Just over one-fourth of the victims were elderly and 70 percent ware male. There is a high proportion of children in the neighborhood (more than double the proportion in the city of Los Angeles), as well as a high percent of population below poverty.



Intersection
FLORENCE & SAN PEDRO
N-S Street: FLORENCE
E-W Street: SAN PEDRO
MINI MALL
OPEN LOT
HOUSING
OPEN LOT
GAS
OPEN LOT
HOUSING
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
N
1" = 50'
5 10 25 50

Catalina & 3rd



There is a significant amount of multi-family residential land use near this intersection with blocks transitioning to residential neighborhoods about 60 feet from the intersection. Sidewalks become narrower at this point and there are numerous driveways. However these do not generate as much traffic flow as driveways in the commercial/retail areas. Vendors at the corners create some obstacles to walking. Valet parking for a nearby restaurant provokes commotion and valets noted that a good deal of jaywalking occurs although it was not observed during the observation periods. A higher proportion of accidents occurred when crossing outside of a crosswalk and when the vehicles were making a right turn.

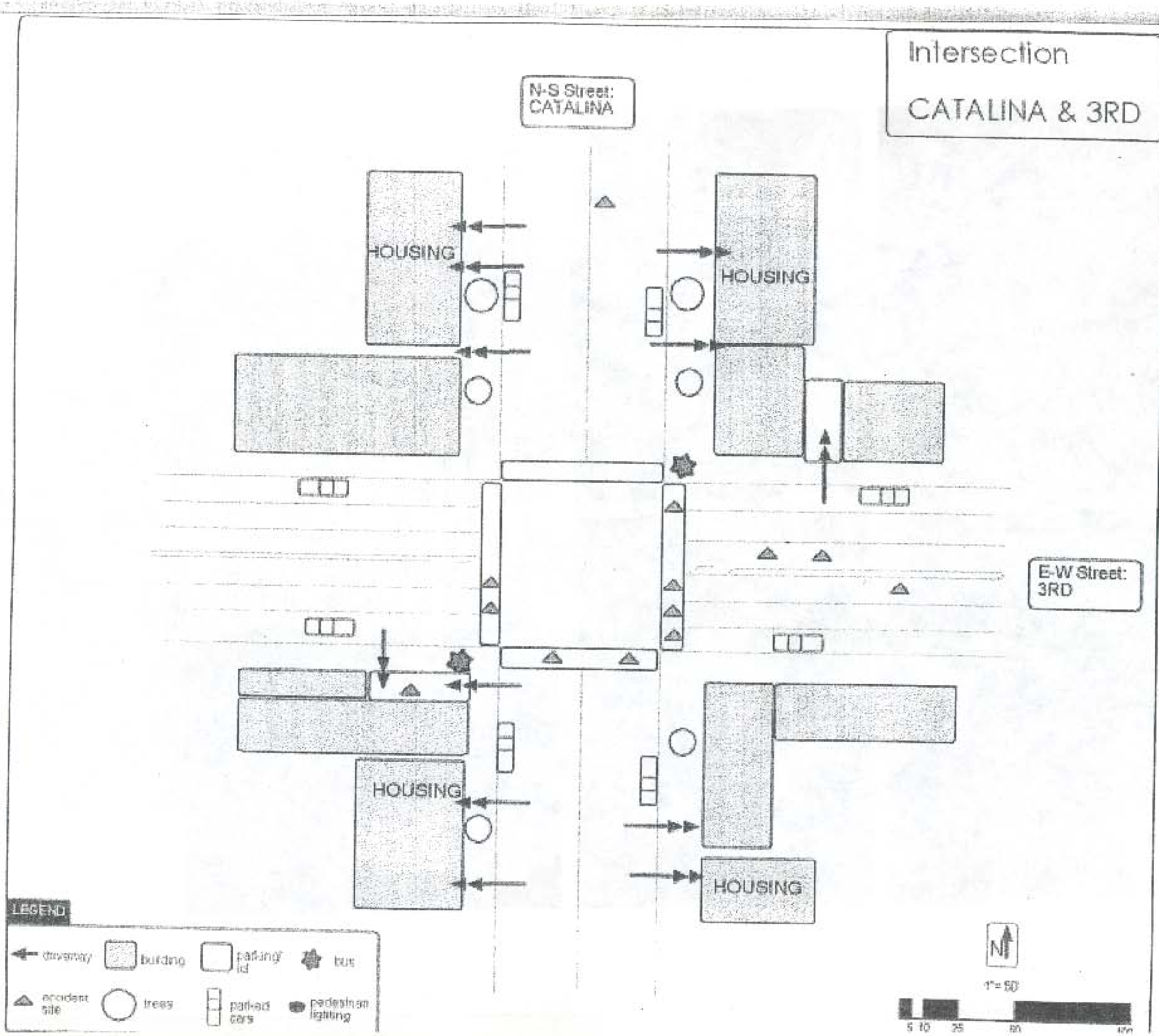

Intersection
CATALINA & 3RD
N-S Street: CATALINA
E-W Street: 3RD
HOUSING
HOUSING
HOUSING
HOUSING
LEGEND
driveway
building
parking lot
bus
accident site
trees
parked cars
pedestrian lighting
N
1" = 50'
5 10 25 50

Table 7 compares the demographics of the case study intersection neighborhoods to those for the City of Los Angeles. All but three of the case study neighborhoods have a higher poverty rate than the City as a whole. In fact, the poverty rate for six of the twelve intersections is twice that of the City (around 40% versus 22% for the City). The only high-accident intersection with poverty rates significantly lower than those of the City's and of the other neighborhoods' studied was Fairfax and Third. This intersection is located in a primarily white neighborhood with a large elderly population. This intersection has the second highest number of pedestrian accidents and the most involving elderly (three times the elderly accident rate for the City) and female casualties (almost three-fourths of the victims were female compared to 43% for all accidents in the City). The vast majority of the case study neighborhoods had significantly higher proportions of minority populations than the city averages. Indeed, only two case study neighborhoods had a higher proportion of white residents than the city-wide 30 percent: Fairfax & 3rd which is 71% white and Sunset and Western which is 28% white. Most of the case study neighborhoods have significantly higher population densities than the City as a whole.

Table 7: Demographics of Intersection Neighborhoods

Intersection		Demographics of Neighborhood					
		Age (%)		% NH White	% Hispanic	% Below Poverty	Pop. Density
		Under 15	Over 65				
1	VERMONT & 3RD	18%	5%	9%	41%	34%	20,047
2	FAIRFAX & 3RD	8%	16%	71%	8%	12%	6,567
3	SUNSET & WESTERN	19%	7%	28%	49%	43%	20,312
4	CRENSHAW & SLAUSON	24%	11%	1%	27%	19%	7,852
5	DALY & N. BROADWAY	28%	8%	2%	55%	42%	15,558
6	MARTIN LUTHER KING JR. & VERMONT	30%	6%	1%	64%	41%	5,883
7	NORDHOFF & SEPULVEDA	32%	5%	11%	69%	31%	13,088
8	SHERMAN WAY & VAN NUYS	27%	9%	20%	58%	23%	12,932
9	ALVARADO ST. & 6TH	20%	18%	12%	64%	40%	22,314
10	LEMON GROVE & WESTERN	23%	11%	16%	67%	31%	25,265
11	FLORENCE & SAN PEDRO	36%	5%	0%	72%	38%	14,408
12	CATALINA & 3RD	23%	5%	6%	59%	39%	70,107
LA	CITY OF LOS ANGELES	23%	10%	30%	47%	22%	7,350

Below City of Los Angeles Value

About the same as City of Los Angeles Value

Above City of Los Angeles Value

Significantly above City of Los Angeles Value

Tables 8 and 9 give statistics on the pedestrian and vehicle actions at the time of the accident. Overall we see that 40 percent of pedestrian accidents in Los Angeles occur while the pedestrian is crossing at an intersection crosswalk, this percentage is significantly higher for a number of the case study intersections. For example, three-fourths of the accidents at Lemon Grove & Western and over 60 percent of the accidents at Martin Luther King Jr. & Vermont occurred when the pedestrian was in an intersection crosswalk. At Fairfax and 3rd (the site of the shopping center Grove) almost three-fourths of the accidents did not occur in the road, but in parking lots or driveways, and more than a third (35%) of these accidents occurred when a vehicle was backing up

TABLE 8: Pedestrian Action and Severity of Accident

	Intersection	# of Accidents	Pedestrian Action: Crossing in Crosswalk – At Inter-section	Pedestrian Action: Crossing in Crosswalk – Not At Inter-section	Pedestrian Action: Crossing NOT in Cross-walk	Pedestrian Action: In Road	Pedestrian Action: Not in Road	Severity of Accident: Fatal or Severe	Severity of Accident: Visible Injury
1	VERMONT & 3RD	37	41%	3%	16%	11%	[illegible]	8%	43%
2	FAIRFAX & 3RD	34	12%	12%	3%	0%	74%	18%	35%
3	SUNSET & WESTERN	33	30%	0%	18%	9%	42%	9%	45%
4	CRENSHAW & SLAUSON	30	27%	0%	20%	13%	40%	32%	37%
5	DALY & N. BROADWAY	29	59%	7%	10%	3%	21%	10%	34%
6	MARTIN LUTHER KING JR. & VERMONT	26	62%	0%	8%	4%	[illegible]	8%	62%
7	NORDHOFF & SEPULVEDA	25	40%	8%	32%	4%	16%	24%	44%
8	SHERMAN WAY & VAN NUYS	22	45%	0%	23%	5%	27%	23%	50%
9	ALVARADO & 6TH	22	59%	0%	9%	5%	27%	14%	64%
10	LEMON GROVE & WESTERN	20	75%	5%	10%	10%	0%	15%	40%
11	FLORENCE & SAN PEDRO	19	53%	0%	26%	5%	16%	[illegible]	63%
12	CATALINA & 3RD	16	50%	0%	38%	6%	6%	13%	38%
LA	CITY OF LOS ANGELES	27,835	40%	1%	28%	12%	19%	17%	56%

Below City of Los Angeles Value

About the same as City of Los Angeles Value

Above City of Los Angeles Value

Significantly above City of Los Angeles Value

Table 9: Vehicle Action

	Intersection	# of Accidents	Vehicle Action: Proceeding Straight	Vehicle Action: Making Right Turn	Vehicle Action: Making Left Turn	Vehicle Action: Backing-Up	Vehicle Action: Other
1	VERMONT & 3RD	37	43%	8%	11%	[illegible]	14%
2	FAIRFAX & 3RD	34	44%	12%	3%	35%	6%
3	SUNSET & WESTERN	33	39%	21%	3%	15%	21%
4	CRENSHAW & SLAUSON	30	43%	13%	17%	7%	20%
5	DALY & N. BROADWAY	29	38%	10%	28%	7%	17%
6	MARTIN LUTHER KING JR. & VERMONT	26	50%	12%	12%	12%	15%
7	NORDHOFF & SEPULVEDA	25	40%	16%	12%	12%	[illegible]
8	SHERMAN WAY & VAN NUYS	22	[illegible]	14%	5%	5%	14%
9	ALVARADO & 6TH	22	73%	[illegible]	0%	5%	0%
10	LEMON GROVE & WESTERN	20	75%	0%	5%	0%	20%
11	FLORENCE & SAN PEDRO	19	74%	0%	[illegible]	5%	5%
12	CATALINA & 3RD	16	50%	31%	0%	6%	13%
	TOTAL	313	50%	13%	10%	13%	14%

Below % for all Case Study Intersections

About the same as % for All Case Study Intersections

Above % for all Case Study Intersections

Significantly above % for All Case Study Intersections

For all case study intersections we conducted a systematic and detailed fieldwork analysis and photographic documentation at the urban block level to collect variables associated with street design and traffic as well as urban form and land use. Table 10 summarizes the street characteristics of the case study intersections. All street intersection accommodated two-way traffic, and all had traffic lights and marked crosswalks. Variations were observed in the duration of the green light. While generous crossing time was allowed at Alvarado and Sixth, an intersection with high proportion of elderly population, Fairfax and Third, another intersection with high number of elderly pedestrians, had a very brief duration of the green light.

TABLE 10: Street Characteristics of Intersections

Street Characteristics	Vermont & 3rd		Fairfax		Sunset		Crenshaw		Daly		MLK	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
Number of Lanes	3	3	2	2	2	2	3	2	2	2	2	3
Direction	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way
Median	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Turning												
U-turn Allowed	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes/No	Yes	Yes	Yes	Yes
Right on Red OK	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Right turn lane	No	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	No
Left turn OK	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Left turn lane	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Marked Crosswalk	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Traffic Light	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green (sec.)	27	20	8	6	28	24	5	5	6	20	27	20
Flashing (sec.)	36	29	21	27	30	35	15	30	18	31	43	28

Street Characteristics	Nordoff		Sherman Way		Alvarado		Lemon Grove		Florence		Catalina	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
Number of Lanes	3	2	3	3	2	2	2	1	4	4	1	2
Direction	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way	2-way
Median	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Turning												
U-turn Allowed	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Right on Red OK	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Right turn lane	No	No	No	No	No	No	No	No	No	No	No	No
Left turn OK	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Left turn lane	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes
Marked Crosswalk	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Traffic Light	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green (sec.)	5	18	10	7	35	35	34	6	15	22	3	15
Flashing (sec.)	18	30	15	22	42	42	38	17	24	29	12	19

Table 11 summarizes sidewalk characteristics of the twelve intersections that may have an impact on the occurrence of pedestrian-automobile accidents. Most of the intersections had a significant pedestrian presence on the sidewalk. Pedestrian counts for five- minute intervals gave average counts that ranged from a low of 24 pedestrians at Daly and Broadway to a high of 421 pedestrians at Martin Luther King and Vermont. The median number was 100 pedestrians per five minutes. A common characteristic shared by ten intersections was the very large number of driveways interrupting the sidewalk. Automobiles coming in and out of the driveways represented hazards for pedestrians on the sidewalks. All intersections had adequate traffic and pedestrian warning signs and street lighting, but pedestrian lighting on the sidewalks was absent from more than half of the intersections. Visibility for pedestrians and motorists was evaluated on a scale from 1 (lowest) to 5 (highest). None of the intersections scored very high (above 3) for motorist visibility, and only one intersection (Crenshaw and Slauson) scored above the average for pedestrian visibility. A number of visual impairments, including parked cars, shrubbery, and stopped buses on the street and sidewalk impairments (vendors, wares, construction) were observed in many of the high-accident intersections. The situation was further aggravated by the fact that sidewalk widths ranged from narrow to average.

TABLE 11: SIDEWALK CHARACTERISTICS OF INTERSECTIONS

Sidewalk Characteristics	Vermont & 3rd	Fairfax	Sunset	Crenshaw	Daly	MLK	Nordoff	Sherman Way	Alvarado	Lemon Grove	Florence	Catalina
Width (ft.)	Average	Average	Average	Average	Average	Narrow	Narrow	Average	Narrow	Narrow	Narrow	Average
# of Driveways	9	4	4	19	18	10	14	14	14	15	18	12
Pedestrian Counts/5 min.	251	147	99	100	24	423	63	137	63	30	53	182
Pedestrian Warning Sign	6	8	8	6	7	8	8	8	8	5	8	8
Street Lighting	14	19	17	18	17	18	21	21	21	12	19	11
Pedestrian Lighting	8	0	2	6	0	5	0	5	0	0	0	0
Visibility (1 to 5)												
Pedestrian	3	3	3	4	3	3	2	3	2	3	2	1
Motorist	2	3	2	2	3	1	2	2	2	3	3	2
Visual Impairment (1 to 5)												
Shrubbery	4	5	5	4	4	4	2	5	2	3	4	3
Parked Cars	1	2	1	3	4	1	5	1	5	5	5	5
Stopped Buses	4	3	3	4	3	4	3	2	3	2	4	2
Other	2	1	2	1	1	1	1	2	1	2	2	1
Sidewalk Impediments												
Vendors	3	1	1	3	1	1	1	1	1	1	1	2
Wires	2	1	1	1	1	1	1	1	1	1	1	1
Construction	3	1	2	1	1	1	1	1	1	1	1	1
Other	5	4	5	5	5	4	4	4	4	2	4	4
Jaywalking	1	1	0	7	0	0	1	1	1	0	0	1
Mid-block crossing	0	1	0	1	0	0	0	0	0	0	0	3

Finally, Table 12 identifies certain urban form and land use characteristics of the twelve intersections. Most of the high-accident intersections are in commercial areas with a multitude of small and large retail stores and surface parking lots. While the average lot length in Los Angeles is 600 feet ten intersections have much longer lots, a fact that may induce pedestrians to cross the street at mid-block. Other notable elements include many bus lines and bus stops, which attract transit riders and pedestrian activity at the intersection. At eight of the twelve sites one or more bus stops were very close to the intersection. Stopped buses at these sites represented visual impairments for pedestrians trying to cross at the crosswalk.

TABLE 12: Urban Form and Land Use Characteristics of Intersections

Urban Form & Landuse	Vermont & 3rd	Fairfax	Sunset	Crenshaw	Daly	MLK	Nordoff	Sherman Way	Alvarado	Lemon Grove	Florence	Catalina
Block Length (ft.)	700	1200	650	800	1200	1200	1200	800	700	1200	1200	1250
Multi-Family Housing	1	1	0	0	1	0	1	0	2	3	3	13
Single-Family Housing	0	0	0	0	0	0	0	0	0	3	0	0
Commercial											0	
Small/open Front	11	21	1	14	28	11	9	28	42	19	9	18
Small/closed Front	13	2	3	5	16	8	5	3	2	5	4	4
Large/open Front	0	8	1	0	1	0	1	0	2	1	0	0
Large/closed Front	4	3	3	0	6	2	3	2	3	3	3	1
Other non-residential											0	
Mini mall	0	1	1	2	1	2	2	3	2	1	1	2
Major shopping center	0	1	0	1	0	0	0	0	0	0	0	0
Big Box	2	2	3	0	0	0	0	0	0	0	0	0
Office	0	1	0	0	1	0	0	0	1	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0
Banks	2	1	0	1	1	2	0	0	1	0	0	0
Gas stations	1	0	0	1	0	2	1	1	0	0	2	0
Alcohol selling	5	6	4	4	2	2	3	3	0	0	6	4
Parks/playgrounds	0	0	1	0	0	1	0	0	1	0	0	0
Vacant Buildings	1	1	0	0	3	0	0	2	1	0	1	0
Vacant lots											0	
Fenced	0	1	1	3	0	0	1	0	0	0	2	0
Unfenced	0	0	0	0	0	0	0	0	0	0	0	0
Parking												
Surface	4	5	6	8	5	8	5	7	2	7	7	3
Structures	1	0	0	0	1	0	0	0	0	0	0	0
Curb	1	3	1	1	5	1	7	2	5	7	7	5
Bus stops												
# of bus lines	12	11	9	12	10	13	4	16	6	2	8	3
# stops close to intersect.	0	1	2	0	2	1	0	0	4	1	2	2
# of bus riders at stop	58	35	46	37	4	123	24	44	25	2	12	11

Policies and Strategies for Safe Walking

Our study showed that certain Los Angeles neighborhoods are more vulnerable than others as their residents have a higher risk of getting involved in pedestrian collisions. It was clear from the GIS analysis that pedestrian accidents were concentrated in a number of hotspots regionally, which included the areas of East Los Angeles, South Central Los Angeles, Hollywood, Pico Union, and Chinatown. As expected within these areas accidents tend to concentrate along high-traffic arterials. The study also found that more pedestrian accidents were encountered in low-income Latino neighborhoods, in neighborhoods with high traffic levels and higher percentages of street space. Certain land uses, in particular schools and commercial establishments, seem to generate more risk for pedestrian collisions.

Findings from the case study analysis seemed to confirm the findings of the spatial analysis, mainly that most high pedestrian accident intersections tend to be in neighborhoods with high-poverty rates and minority populations. Additionally, a close look at the micro-environment surrounding these intersections showed that certain urban form characteristics may also contribute to the more frequent occurrence of accidents at these intersections. Long blocks with multiple driveways, visual impairments for motorists and pedestrians, and relatively low levels of pedestrian lighting may make walking a rather unsafe activity at these intersections.

Our empirical findings help us articulate specific recommendations for making neighborhoods safer from walking.

- *Conduct an annual safety audit to identify high-risk neighborhoods and hot spots of traffic accidents.* The uneven spatial distribution of accidents in the metropolitan area and their concentration in certain neighborhoods and hot spots makes it imperative that particular attention is given to these neighborhoods and high-risk intersections. A "safety audit" by municipal departments of transportation can identify annually the "worst offenders" in each municipality -- the spots with the highest numbers of accidents. A series of measures that target the redesign of unsafe crossings, traffic mitigation, and education and information campaigns for safe walking can then specifically target these high-risk neighborhoods.

- *Provide the appropriate infrastructure for safe walking.* At a minimum, the provision of a physical infrastructure for pedestrianism (sidewalks, pedestrian overpasses, crosswalks, etc.) is a necessary but not sufficient precondition for safe walking. Sidewalks should be wide enough and without obstructions so that pedestrians are not forced to walk on the street. In areas with high pedestrian activity and long blocks, mid-block crossings with traffic signals should be provided. Since a significant number of accidents in high-risk neighborhoods occur in uncontrolled crossings, the installation of new technological devices at some crossings with in-pavement flashing lights automatically activated by pedestrian presence should also be considered. Particular attention should be given to pedestrian visibility through appropriate lighting, and motorist visibility through frequent pruning of foliage. Additionally, parking restrictions in certain areas as well as the encouragement of diagonal parking should be considered. A number of pedestrian accidents occur because of jaywalking as pedestrians are "darting out" to the street in front of parked buses. Bus stops should be relocated further back from crosswalks so that crosswalks are behind and not in front of stationary vehicles.

- *Mitigate the effects of traffic.* As shown in Table 13, both design and policy interventions can be utilized to mitigate the effects of traffic and make neighborhoods safer for pedestrians. Efforts to reduce the volume of automobiles often focus on the encouragement of alternative modes of traffic, by providing the infrastructure and policy incentives for the adoption of these modes, and by making the use of private automobiles more expensive. An integrated and continuous pedestrian network that connects points of origin with popular destinations should be in place before we can observe major modal changes. Unfortunately, very few U.S cities can boast such a network. At the metropolitan scale, the accommodation of carpools and buses on special lanes can offer some incentives to drivers to switch modes. Such efforts have only had modest success in reducing automobile travel. Scholars have argued that pricing mechanisms (e.g. congestion parking, gasoline taxes, high license fees, etc.) that make the use of automobile more expensive have a better chance to promote alternative transportation modes; however, such mechanisms often do not enjoy wide public support in the U.S.

A variety of innovative design means have been utilized by municipalities in Europe, and more recently in Canada and the U.S in an effort to slow down traffic speeds in residential neighborhoods and near schools and public places. Such measures, often called *traffic calming,* seek to reduce the negative effects of automobiles, alter driver behavior, and improve conditions for pedestrians and cyclists (Lockwood, 1997). Traffic calming devices are designed to be self-enforcing, although their effectiveness varies according to the particular measures employed. The principal measures fall into four categories: 1) vertical deflections (speed bump and humps, raised intersections); 2) horizontal deflections (chicanes, bends, and deviations; 3) road narrowing (through neckdowns, chokers, and bulbs); and 4) medians, central islands, and traffic circles (FTA, 1994; Kim and Smith, 1999).

Case studies of the effect of traffic calming on pedestrian and bicycle travel in Northern Europe have shown that it increases walking, slows vehicular traffic, and decreases pedestrian accidents (Eubank-Ahrens, 1987; Tolley 1989, 1993). In the U.S. a number of cities, such as Palo Alto and Santa Monica in California, Portland, Seattle, and New York City have implemented different versions of traffic calming programs, reporting good results. Seattle, for example, reported a 77% reduction in traffic crashes after implementing a city-wide traffic calming program (NHTSA, 2003).

Table 13: Design and Policy Interventions to Mitigate the Effects of Traffic

Target	**Objective**	**Physical Planning and Design Actions**	**Policy Actions**
Motorists	Manage/regulate vehicular traffic	Traffic control devices: Traffic signals Roadway signs Crosswalks, Pavement markings	- Enforcement of traffic regulations - Fees and penalties for non-complying drivers
	Reduce vehicular traffic volume	Infrastructure accommodating alternative modes: Sidewalks, paths, trails Bike lanes Busways Carpool lanes	-Make use of private automobile more expensive through gasoline and parking prices, license fees and other taxes. -Congestion pricing
	Reduce traffic speed	Traffic Calming Devices: - Vertical deflections - Horizontal deflections - Road narrowing - Central islands and medians Creation of cul-de-sacs	Designation of slow speed areas: - Woonerfs - School safety zones - Home zones
Pedestrians	Increase of safety for pedestrians	Provide physical infrastructure for pedestrians (sidewalks, crosswalks, lighting) Upkeep sidewalks and eliminate sidewalk obstructions	-Preferential treatment of non-motorized modes when they intersect with motorized modes. - Crossing aids for school children - Escort to school programs - Enforcement of helmets
	Educate, inform about dangers of traffic		Training programs for children about safe travel, walking and biking.

- *Customize pedestrian infrastructure according to the specific needs of area residents.* Municipalities enforce a traffic code that seeks to manage and regulate traffic through the use of traffic control devices such as traffic signals and lights, stop signs, pavement markings, and crosswalks. These devices provide a basic level of protection for pedestrians, but to be more effective they should be customized to the specific needs of particular neighborhoods. For example, examining the effectiveness of crosswalks, Koepsel et al. (2002) found that they did little to protect older pedestrians, giving them only a false sense of security. When no traffic signal or stop signs were present, marked crosswalks were associated with 3-6 fold increase in risk. Crosswalks should be designed taking into consideration the age and other characteristics of pedestrians and should be avoided at intersections with high-traffic speeds, poor illumination, and insufficient visibility for drivers (Runge and Cole, 2002). For neighborhoods with high concentrations of elderly pedestrians crossing time should be extended to allow slower pedestrians to finish crossing. Additionally, refuge islands in the median of wide two-way streets and curb extensions to reduce crossing distance should be considered.

- *Educate children and parents, particularly in immigrant neighborhoods.* While the redesign of pedestrian facilities is one way to enhance pedestrian safety, there are some pedestrian crashes that can be avoided through education and enforcement. Programs such as the *Safe Routes to School,* have been initiated in Western Europe and the United Kingdom, but have been increasingly applied to different school districts in the U.S. as well. They involve a series of educational and physical measures to create safe routes to school, including identification and mitigation of hazards along the main routes to school, encouragement of safe cycling, restrictions on vehicle speeds, and other traffic calming measures (NHTSA, 2003). Pilot programs conducted in 1995 in ten British schools resulted in an increase of cycling and walking, reductions in child road casualties by 32%, and reductions in car use by 12-17% (SUSTRANS, 2003).

Finally, the implementation of education and information strategies, and age-appropriate, training programs have been pursued by various school districts, non-profit coalitions and community activists in an effort to make the streets safer for pedestrian travel and cycling. A program that has attracted national attention and admiration is the *Injury Free Coalition for Kids* established in 1988 by Dr. Barbara Barlow of the Harlem Hospital Injury Prevention Program. The coalition renovated 45 playgrounds in Harlem, replacing dangerous or drug-infested lots with safe play spaces. The project hired mothers from Harlem to act as administrators, sponsored anti-violence counseling and street smart workshops, and resulted in a 55% reduction in injuries requiring hospitalization and 36% reduction in motor vehicle and bicycle injuries, compared to the pre-intervention period. The Harlem Hospital Injury Prevention Program. also established the *Safety City Program* that teaches street safety to all 3rd grade children who practice on a model street constructed on their school's playground. The program has been expanded to the *Mobile Safety City Program,* which visits schools in New York City training all 3rd graders (Durkin et al., 1999).

- *Mobilize neighborhood social capital.* Neighborhoods with strong social capital have initiated a number of interventions that rely on volunteerism, neighborhood watch, and community policing to make the trip to and from school safe. Volunteers have acted as crossing aids for busy intersections on the route to school. Model programs, such as the *Walking School Bus,* or *Bike Train,* involve adult volunteers who accompany children to school, stopping at designated locations where children can join the "bus" or "train" at prearranged times. (Wethmore, 2001). The greater numbers of children who compose the walking bus are more visible to motorists and provide an additional safety factor. Two notable programs in Southern California that rely on social networks in the neighborhood are *Safe Corridors* and *KidWatch.* The first takes place in the city of Santa Ana and has volunteer parents patrol to and from school in high-traffic areas and where children have experienced problems with gangs. KidWatch is also a program designed to provide a safe trip to and from school for more than 8,200 children, in the West Adams neighborhood near the University of Southern California in Los Angeles. The program which is a partnership between residents, the university, the police, and five neighborhood schools, mobilizes more than 700 volunteers, who are committed to being alert during the time that children walk to or from school, performing different chores (sweeping sidewalks, watering their lawns) and informing the police of any danger (USC, 2003).

- *Mitigate the effect of certain land uses.* Consistent with the results of other studies, we also found that many pedestrian accidents tend to occur in the vicinity of schools. Every effort should be made to avoid locating schools along major arterials. Unfortunately, as Levine et al. (1995b) have shown, many schools are already built along high-traffic streets. In such cases, overpasses and underpasses should be provided for safe crossings. Additionally, the establishment of *safety zones* (20 mph) in the blocks surrounding the school should be considered. Our study also discovered a higher concentration of accidents in commercial areas. Many of these accidents take place because automobiles are engulfing pedestrian spaces and vice versa. Especially along commercial corridors multiple driveways of commercial establishments are constantly interrupting the sidewalk, creating an invasion of the pedestrian space by cars. In commercial spaces particular attention should be given in separating pedestrian and vehicular spaces, consolidating the number of driveways, and creating safe crossings for pedestrians.

In the summer of 1896 the first recorded pedestrian crash in history was an oddity, but in the century that followed crashes became painful and inherent parts of urban travel. Empirical studies including this one suggest that a variety of factors may be responsible for the occurrence of pedestrian accidents; they also find that some neighborhoods are more at risk than others because of their socio-demographic, physical, traffic, and land use characteristics. These characteristics need to be considered very carefully by transportation planners and municipalities so that policies and strategies can be customized to the specific needs of particular neighborhoods. Only then the walk to the school, the bus stop, the store or around the block may become safer.

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