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An Examination of the Relationship between Signs and Traffic Safety

by

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ABSTRACT
The purpose of this study is to examine the relationship between roadside signs and traffic safety. The first part of this study establishes statistical correlation coefficients between roadside signs and accidents along the New Jersey Turnpike (for more than four years of data and about 23,000 accidents). This study considers various situations, with and without bias from turnpike interchanges. The results are analyzed for a variety of commonly accepted scenarios relating accident density to sign-density (the number of signs), to Viewer Reaction Distance (how far from a sign the driver is potentially within the "influence" of a sign), and to sign proximity (how far the accident is from the nearest sign). The second part of this study examines the incidence of traffic accidents at a specific, recently installed sign and for a period of time both before and after the installation of the sign. After the installation of a specific, roadside sign at a Pennsylvania intersection, the traffic volume increased, the APV (accident rate) decreased, the maximum number of accidents in any given day or week decreased. The results of this study strongly conclude that roadside signs have no statistical influence on the occurrence of accidents. These analyses also strongly suggest that no causal relationship between signs and accidents exists. Geospatial and geostatistical methods are used rigorously.

Key Words: Signage, Traffic Safety, Accidents, Correlation, GIS

INTRODUCTION

The United States has millions of miles of roads, highways, streets, and other traveled ways used for the navigation of motor vehicles. Virtually all of these roads have some type of signage associated with them, whether the signs are directional, informational, regulatory, identifying, advertising, or other types. Signs are necessary in order to promote efficient navigation, to disseminate vital wayfinding or safety information, to identify locations or destinations, to regulate traffic, to advertise, etc. For these functions, signs and roads are inseparable. Unfortunately, traffic accidents on roads also occur in the millions annually. Accidents may be attributable to many factors, including poor road conditions, driver ability, traffic volume, distractions, *inter alia*. Although advertising signs account for only a small percentage of all signs along roads, advertising signs are often viewed as the chief cause of distraction-related accidents. For this reason, advertising signs are heavily regulated, even though the relationship between signs and traffic safety has not been comprehensively established (*1*).

This study examines the relationship between signs and traffic safety, and evaluates the correlation between signs and accidents for particular roads and conditions. The study examines two situations which involve signs and traffic. In the first situation, a highway with roadside signs is selected and studied, including analysis of sign location, road conditions, traffic-accident locations, *inter alia*, for the purpose of determining if traffic accidents are more prevalent at or near existing signs. This part of the study is called the Sign-Accident Correlation part. Statistical correlation coefficients are used as the basis for comparison of the results. In the second situation, the location of a recently installed sign is identified, and the incidence of traffic accidents near the sign is examined, for a time period both before and after the installation of the sign, for the purpose of establishing whether traffic accidents occurred more frequently in the presence of the sign. This part of the study is called the Spatial Comparison part.

SIGN-ACCIDENT CORRELATION

The purpose of the Sign-Accident Correlation part of the study is to examine whether traffic accidents occur more frequently at or near signs on a specific roadway. Essentially, the Sign-Accident Correlation is a comparison of the location of signs and the location of accidents. These two sets of data are quantitatively compared using correlation coefficients.

Methodology

The procedure employed in this study involves collecting accident information for a given road, analyzing and assembling the information into useful data, identifying where advertising signs are located along the road, statistically analyzing the data by comparing the sign locations and the accident locations, and calculating correlation coefficients for these sets of data.

Road

The roadway examined in this part of the study is the New Jersey Turnpike. The New Jersey Turnpike (Turnpike) was selected over other thoroughfares, for many reasons conducive to the study. The Turnpike, shown in Figure 1, is generally oriented northbound-southbound, is a limited-access highway servicing the entire state of New Jersey and through traffic, is operated by the New Jersey Turnpike Authority, and is proximate to several metropolitan areas, including

New York City and Newark at its northern end, the state capital of Trenton near its central portion, and Philadelphia near its southern portion. The Turnpike is 113.8 miles long, and extends from the George Washington Bridge (New York State) at its north terminus, to State Route 130 near the Delaware Memorial Bridge (State of Delaware) at its south terminus (mile marker 0). The Turnpike also includes a 6.55-mile spur to its west which allows traffic to and from the Pennsylvania Turnpike. This study does not include the spur portion of the Turnpike.

The Turnpike is a limited-access, toll highway, with 18 entrances/exits (interchanges) along its length; the average distance between interchanges is approximately five miles. Most of the road is divided, with five lanes of traffic in each direction; the northern portion of the highway is further divided, with traffic in each direction segregated into "cars only" and "car and truck" traffic lanes. The posted speed limit along the entire Turnpike is 65 miles per hour. Signage along the Turnpike is strictly regulated, and is subject to local permitting procedures, in addition to state and Turnpike Authority approval.

Signs

Several types of signs exist along the Turnpike, including advertising signs, directional signs, informational signs, emergency signs, markers, *inter alia*. Figure 1 shows typical signs along the Turnpike. This study examines only advertising signs, and only those signs which are intended to principally advertise to traffic on the Turnpike.

The studied signs are graphically located in Figure 1 (each solid dot represents a sign); the signs include both accessory (on-premise) and non-accessory (off-premise) signs. All the signs are freestanding structures, and almost all are double-faced, advertising to northbound and southbound traffic. Almost all the signs are either internally or externally illuminated; only a few are not illuminated. The number of studied signs is 123: 72 located to the east side of the Turnpike and 51 to the west side of the Turnpike. Twenty-one signs are accessory, 102 are non-accessory, and one sign had its head removed and was temporarily only a sign upright.

The following assumptions are made concerning the signs.

- Because approximately 94% of the signs (116 of the 123) advertise to both northbound and southbound traffic, or have faces generally perpendicular to the traffic lanes, this study assumes that each of the studied signs has the potential to impact traffic safety on both northbound and southbound traffic within the view (or viewer-reaction) distance of the signs.
- Because approximately 92% of the signs (113 of the 123) are illuminated, this study assumes that all signs are illuminated and visible at all times. This study also assumes that each of the studied signs existed during the years for which traffic accidents were examined.

The location of the signs was determined from field-investigation, by identifying the mile marker location (one tenth mile) of each sign; these locations are graphically located in Figure 1, the Sign-Location Plan. The Sign-Location Plan shows that the northern portion of the Turnpike has the highest density of signs, that the central portion has a low to moderate sign density, and that the extreme southern portion has very few signs. Straight-line diagrams, aerial photographs, GIS information, and field-data are used to analyze the location and characteristics of each sign.

Traffic Accidents

Currently, more than 650,000 vehicles travel the New Jersey Turnpike each day. Traffic accident records for the Turnpike are available for certain time periods (*10*). Accidents have been recorded since the Turnpike's completion in 1951 by either the New Jersey Turnpike Authority or the New Jersey State Police. However, only accident data for the past ten years is readily obtainable or computerized. Detailed analysis and assembly of the data indicates that the only years for which reliable accident data is available, are 1998, 1999, 2000, and 2001. Data for 2002 are not available. The total number of accidents for each of these years is listed in Table 1. In all, 22,971 accidents were included in this study. Only reported accidents are part of the study, and all data was obtained from either the New Jersey Turnpike Authority, the New Jersey State Police, and the New Jersey Department of Transportation. For each year, the accident data is segregated by mile marker (one tenth mile), and listed by the number of accidents which occurred at or near each mile marker. Listing the data in this fashion allows a parallel tabulation of sign-location by mile marker, and the subsequent comparison of these parallel sets of data.

Analysis

As stated, both the accident data and the sign locations are assembled, or listed, by mile marker, in order to form a basis for their comparison. Three comparisons of these variables are completed, including a comparison of

- Accident-Density and Sign-Density,
- Accident-Density and Viewer Reaction Distance, and
- Accident-Density and Proximity to Signs.

The above three comparisons are made for each of the four, examined years, and for the aggregate of the four years. A quantitative measure of how well the data compared is obtained by using a statistical correlation coefficient. The results of the correlation coefficient analysis and a discussion of correlation coefficients are in the Results section of this study.

This study also examines a subset of traffic-accident data to assess its relationship to signage. Correlation coefficients are calculated with the same accident data, however excluding those accidents and signs near Turnpike interchanges (entrances/exits) within one mile (½ mile on each side of an interchange). Accident data near Turnpike interchanges have the potential to bias the results, because drivers undertake additional tasks such as lane changes, accelerating/decelerating, negotiating directions, attention to others undertaking additional tasks, *inter alia* (*4*). These added factors could bias and dilute a study of accident data when compared to typical conditions of straight driving without sources of potential distraction.

Accident Density and Sign Density

This study defines accident density as the number of accidents per mile marker (every tenth of a mile). The terms number of accidents and accident density are used interchangeably. The sign density, S_m^D, is defined as the number of signs per mile, and is determined using a moving average of the number of signs at each mile marker with a "window" size of one mile, and may be expressed by:

$$\left\{ S_m^D = \sum_{i=1}^{Q} \left[s_i \middle| m - 0.5 \le s_i \le m + 0.5 \right],\ m = 0,\ 0.1, \cdots,\ M \right\} \tag{1}$$

where s_i is the *ith* sign's mile marker location, and Q is the number of signs observed along M, which is the total length of the Turnpike in miles. [The vertical line after s_i in the above equation means "given that", and is not an absolute value symbol.]

The sign density, that is, the average number of signs per mile, varies along the length of the Turnpike, and is shown graphically in Figure 1. The sign density varies from 0 to 9 signs per mile. If a noticeable correlation between signage and accidents exists, then we would expect a significantly larger number of accidents in areas with relatively high sign densities. Histograms illustrating the differences in sign densities and accidents along the Turnpike for data from 1998 to 2001 are shown in Figure 2. Figures 1 and 3 show similar data in the form of a mapped, density plot for sign and accident data along the Turnpike between 1998 and 2001. Our basis for evaluating the relationship between sign locations and accident locations is the correlation coefficient (*6,7,8*). The correlation coefficient (ρ) between sign density, S^D, and accident density, A^D, may be calculated using:

$$\rho = \frac{\sum_m (A_m^D - \bar{A}^D)(S_m^D - \bar{S}^D)}{\sqrt{\sum_m (A_m^D - \bar{A}^D)^2 \sum_m (S_m^D - \bar{S}^D)^2}},\ m = 0,\ 0.1, \cdots,\ M \tag{2}$$

The correlation coefficients with their corresponding data are shown in Table 2 for the individual and aggregate years between 1998 and 2001. These coefficients range from -0.098 to +0.219. Figure 4 shows commonly accepted interpretations of correlation coefficients and visual scatter plots to emphasis what various correlation coefficients might represent (*2*). The Correlation coefficients excluding interchange bias are shown with their corresponding data in Table 2 for the individual and aggregate years between 1998 and 2001.

Accident Density and Viewer Reaction Distance (VRD)

Accident density, A_m^D, was previously defined as the number of accidents per mile marker (every tenth of a mile). Viewer Reaction Distance (VRD) is a measure of the distance in which a driver has time to "notice" or react to a sign which is in the driver's field of vision. The VRD is the distance to a sign in which the driver is potentially within the "influence" of a sign. Analogously, Viewer Reaction Time (VRT) is the time a driver is within the "influence" of a sign. Reasonable values for VRD were previously determined in previous studies (*5*), and are a function of the driver's speed. The posted speed limit on the Turnpike is 65 mph; this approximately corresponds with a VRD of approximately 0.2 miles and a VRT of 10 seconds. This study uses a binary index, V_m^{VRD}, to represent if a given mile marker is within the VRD, and is represented as

$$\left\{ V_m^{VRD} = \begin{cases} 1, & d_m \le VRD \\ 0 & \text{otherwise} \end{cases},\ m = 0,\ 0.1, \cdots,\ M \right\} \tag{3}$$

where d_m is the distance to the nearest sign location for *mth* mile marker, VRD is 0.2 (the viewer reaction distance corresponding to a 10 second VRT at the 65 mph on the Turnpike), and M is the total length of the Turnpike in miles. The index d_m is defined as

$$\left\{d_m = \min\left(\left\{|s_i - m|, i = 0,1,\cdots,Q\right\}\right),\ m = 0,\ 0.1,\cdots,\ M\right\} \quad (4)$$

where s_i is the ith sign's mile marker location and Q is the number of signs observed.

The correlation coefficient between accident density, A^D, and viewer reaction distance, V^{VRD}, is calculated similar to that which was previously defined. These correlation coefficients are shown with their corresponding data in Table 2, for the individual and aggregate years between 1998 and 2001. Correlation coefficients excluding interchange bias are also shown with their corresponding data in Table 2 for the individual and aggregate years between 1998 and 2001. Correlation coefficients are determined for data that are within 0.2 miles of the nearest sign, based on the previous discussion of Viewer Reaction Distance. If a noticeable correlation exists between signage and accidents, then we would expect significant changes in the number of accidents occurring 0 to 0.2 miles from any sign.

Number of Accidents and Proximity to Signs

Accident density, A_m^D, was previously defined as the number of accidents per mile marker (every tenth of a mile). An index, P_m, is used to represent proximity to signage, and is simply the distance from a individual mile marker to the nearest sign. P_m may be expressed by:

$$\left\{P_m = |d_m - m|,\ m = 0,\ 0.1,\ \cdots,\ M\right\} \quad (5)$$

where d_m is the distance to the nearest sign location for mth mile marker and M is the total length of the Turnpike in miles. The correlation coefficients between sign proximity indices, A^D, and accident density, V^{VRD}, are similar to that previously defined. Table 2 shows these correlation coefficients with their corresponding data for the individual and aggregate years between 1998 and 2001. If a noticeable correlation exists between signs and accidents, then we would expect more accidents at locations which are closer to signs.

Correlation coefficients are determined for data that are within 0.4 miles of the nearest sign. Based on previous discussion of Viewer Reaction Distance (VRD), 0.4 miles is twice the 0.2 mile VRD value. If a noticeable correlation exists between signs and accidents, then we would expect significant changes in the number of accidents between the 0 and 0.2 mile range and the 0.2 and 0.4 mile range, and the correlation coefficient would be large (close to ±1.00). However, these correlation coefficients are actually close to zero, indicating almost statistical independence, or no relationship or tendency for signs to influence traffic accidents. Further, when interchange bias is excluded, these correlation coefficients move closer to zero, again strongly suggesting no causal relationship.

Results

Our results seek to evaluate if road signs have an influence on the occurrence of traffic accidents. As discussed, a useful measure of compliance ("association") between two sets of data (signs and traffic accidents) is the correlation coefficient (*6,11*). If the variables "tend" to go up and down together, then the correlation coefficient will be positive. If the variables "tend" to go up and down in opposition with each other, the correlation coefficient will be negative. By definition, a correlation coefficient can be no larger than +1, and can be no smaller than -1. Values at or near +1 indicate a perfect one-to-one correlation, and values at or near -1 indicating perfect inverse correlation. Values at or near zero indicate statistical independence of one set of data with respect to the other. Statistically, a correlation coefficient of 0.7 or smaller is considered to indicate "weak" correlations, at best, and does not indicate much difference from correlation coefficients of zero (*6*). It is important to note that correlation is not necessarily causation, even though it may be an indicator. Table 2 lists the correlation coefficients obtained for the relationships examined in this study, namely:

- Accident Density and Sign Density,
- Accident Density and Viewer Reaction Distance, and
- Accident Density and Proximity to Sign.

As seen in Table 2 and Figure 5, the correlation coefficients for accident density and sign density are all statistically low, with coefficients ranging from +0.140 to +0.209. When signs and accidents within one-half mile of interchanges are excluded, almost all of the coefficients are lower, and range from +0.077 to +0.199. Each of these coefficients indicates zero to extremely weak correlation between the locations of signs and the locations of accidents. As shown in Figure 6 when interchange bias is excluded, the coefficients are generally closer to zero, further suggesting that no statistical or causal relationship between sign density and accident density exists.

The correlation coefficients results for accident density and Viewer Reaction Distance (VRD) vary between +0.129 and +0.220. These coefficients are low, are close to zero, and correspondingly indicate less than marginal or no correlation between signs and accidents. Again, the coefficients are lower with the exclusion of interchange bias, further suggesting a lack of relationship or dependence between signs and accidents.

Each of the correlation coefficients for accident density and proximity to the sign is negative, indicating that a slight inverse correlation exists regarding sign locations relative to the location of accidents. In other words, the accident rate was higher at locations farther from the nearest sign, but only slightly. These negative coefficients are also close to zero, and we must, therefore, conclude statistical independence. Also of note is the fact that the correlation coefficients are relatively consistent from year to year within each category. No large increases or decreases in the coefficients exist from year to year. This consistency positively influences the confidence in the study results.

SPATIAL COMPARISON

Methodology

The purpose of this Spatial Comparison part of this study is to examine the incidence of traffic accidents at an intersection at a specific, recently installed sign and for an equal period of time before and after the installation of the sign, and to determine if traffic accidents occurred more frequently or less frequently with the presence of the sign. Sign data are statistically compared using histograms and average accident-per-volume (APV) ratios for one year before the sign was installed and for one year after the sign was installed. It should be emphasized that there were no other, substantial changes at the intersection where this selected sign is located, other than the installation of the selected sign, a slight increase in traffic volume, and the winter snowfall.

Location

The selected sign is near the Oxford Valley Mall in Middletown Township, Bucks County, Pennsylvania. The sign is at the northeast corner of the Lincoln Highway (U.S. Business Route 1) and Woodbourne Road. The intersection is controlled by a traffic light. The sign was installed on or about January 28, 2002 (*13*).

Sign

The selected sign is a free-standing, double-face, accessory (on-premise) structure with two uprights. Each sign face is rectangular, measures 6 feet high by 15 feet wide, and has a sign-face area of 90 square feet. The top of the sign is approximately 25 feet above the grade adjacent to the sign. The sign faces are internally illuminated and include an electronic-message-panel display. The sign faces are oriented approximately perpendicular to the Lincoln Highway, and are intended to principally advertise to traffic on the Lincoln Highway, and secondarily advertise to traffic on Woodbourne Road. The findings at this location are particularly relevant because of the dynamic nature of the sign itself which, as noted, contains a high-contrast electronic-message-panel. Animation of this feature was observed to include varied aspects of simulated movement including scrolling, wipe-on, wipe-off, blending, and rapid copy variations involving different messages in a constantly changing mode of operation (*3*).

Traffic Accidents

At the Lincoln Highway and Woodbourne Road intersection, the Pennsylvania Department of Transportation (PennDOT) recorded an average, daily traffic-count of 18,500 vehicles in 2001 and 20,000 vehicles in 2002. Data were obtained from police accident reports which were provided by PennDOT for a period of one year before, and one year after, the sign installation at this intersection (*12*). At this intersection, 68 accidents occurred in 2001, which is prior to the installation of the sign, and 60 accidents occurred after the sign installation, which approximately represents a one in a hundred thousand chance of an accident at this intersection based on average traffic volumes. The number of accidents for this part of the study is listed in Table 3.

Analysis

The accident data assembled for this part of the study are based on the proximity to the sign and on when the accident occurred. To examine how this one specific intersection is impacted by the introduction of a sign, comparisons were made of

- changes in traffic accidents-per-volume (APV) ratios, and
- histograms of the accident data on a temporal basis.

Accidents-per-Volume (APV) Ratios

A quantitative measure of comparing traffic safety is to use accidents-per-volume (APV) ratios (*4*). The APV ratio is calculated by

$$APV = \frac{\text{Number of accidents}}{\text{Annual Traffic Volume}} \quad (6)$$

Table 3 summarizes accidents, annual traffic volumes and APV ratios for the sign at the Lincoln Highway and Woodbourne Road intersection for 2001 and 2002. The number of accidents decreased 11.8% from 2001 to 2002; the traffic volume also increased by 5.3%. If we compared the APV ratios, then the accident rate decreased by 16% after the introduction of the sign at this intersection.

Histogram Comparison

Using the summarized, PennDOT, accident-report data (*12*) we show in Figure 7, the composite distribution of accidents before and after the installation of the sign (on or about January 28, 2002) as a weekly histogram for the Lincoln Highway and Woodbourne Road intersection. A comparison of the histograms of accidents (on either a weekly or a daily basis) at the intersection in 2001 (before sign installation) and in 2002 (after sign installation), indicates no substantial change in accident patterns. The peak number of accidents on any given week decreased from 5 to 4, after the introduction of the sign at the intersection; the peak number on any given day decreased from 3 to 2. The number of accident-free days increased from 42 to 43; the number of accident-free weeks remained the same at 15. Based on the data, no significant change in accident occurrences can be attributed to the introduction of this roadside sign. It should also be noted that the later months of 2002, the year after the installation of the sign, had significantly greater snowfall (*9*). This additional snowfall could be an influencing factor of why the accident occurrence rates were not less than they already are (relative to those in 2001). This is evident because there are slightly more accidents in the winter months (generally weeks 40 to 52) of 2002 than in the rest of the year.

Results

The results suggest that roadside signs in and of themselves have no influence on the occurrence of traffic accidents. The most useful measures of traffic-accident occurrence at any specific location (APV, peak daily accidents, peak weekly accidents, accident free days and accident free weeks) are evaluated and compiled in Table 4. After the introduction of this roadside sign, traffic volume increased, the APV (accident rate) decreased, the peak number of accidents on any given day or week decreased, the number of accidents-free days increased, and the number of accident-free weeks remained the same. These measures indicate no statistically significant changes in accident occurrences after the introduction of the roadside sign at this busy intersection.

The number of accidents was relatively steady from 2001 to 2002. No large increases or decreases occurred in the values from year to year. With the exception of a new sign, there were no other changes at this intersection. No new buildings, changes in lane/intersection topography, zoning or traffic-light signalization/timing were introduced. The analysis reinforces the results of the Sign-Accident Correlation part of this study, that roadside signs in and of themselves have no influence on the occurrence of traffic accidents.

CONCLUSIONS

The results of this study strongly conclude that roadside signs have no statistical influence on the occurrence of accidents. The following are the conclusions of this study.

- Correlation coefficients are statistical measures of the "association" between two sets of data, such as signs and traffic accidents. The correlation coefficients developed in this study consistently confirm, for more than four years of data (about 23,000 accidents), that the coefficient values are generally close to zero (between -0.070 and +0.220).

- The correlation coefficients establish that no statistical relationship between signs and accidents exists. These correlation coefficients also strongly suggest that no causal relationship between signs and accidents exists.
- Turnpike interchanges have the potential to unfairly bias the results because drivers undertake additional tasks, such as lane changes, accelerating/decelerating, and negotiating directions. If the data near Turnpike interchanges is excluded, then the correlation coefficients converge even more closely to zero (between -0.030 to +0.194).
- The interchange bias-free correlation coefficients further reinforce the premise that no statistical relationship between signs and accidents exists. These data also strongly suggest that no causal relationship between signs and accidents exists.
- After the installation of the specific, roadside sign at a Pennsylvania intersection, the traffic volume increased, the APV (accident rate) decreased, the maximum number of accidents in any given day or week decreased and the number of days without accidents increased.
- After the installation of the specific, roadside sign at a Pennsylvania intersection, histogram analysis indicates no statistically significant changes in accident occurrences after the installation of the roadside sign at this busy intersection.

The results of this study strongly conclude that roadside signs have no statistical influence on the occurrence of accidents. These analyses also strongly suggest that no causal relationship between signs and accidents exists. Traffic accidents may be much more likely attributable to, and strongly correlated with, other factors, such as driver fatigue, poor road conditions, driver abilities, traffic volume, legitimate distractions, *inter alia*.

ACKNOWLEDGEMENTS

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LIST OF TABLES

LIST OF FIGURES

TABLE 1. Number of Traffic Accidents on the New Jersey Turnpike

Year	Number of Accidents
1998	5,122
1999	5,348
2000	6,204
2001	6,297
Total	22,971

TABLE 2. Correlation Coefficient Results

Comparison	1998	1999	2000	2001	Aggregate 1998-2001
Accident Density and Sign Density	+0.188	+0.140	+0.209	+0.119	+0.209
without interchange bias	+0.199	+0.097	+0.195	+0.077	+0.193
Accident Density and View Reaction Distance	+0.180	+0.158	+0.212	+0.129	+0.219
without interchange bias	+0.175	+0.117	+0.181	+0.090	+0.194
Accident Density and Proximity to Sign	-0.076	-0.057	-0.098	-0.013	-0.077
without interchange bias	-0.022	-0.061	-0.077	-0.050	-0.026

TABLE 3. Accidents, Volume and APV at Woodbourne Road Intersection

Measure	**Prior to Sign** (before 28Jan02)	**Prior to Sign** (before 28Jan02)	
			Total
Traffice Accidents			
on the Lincoln Highway	35	33	68
on Woodbourne Road	33	27	60
Totals	68	60	128
			% change
At Intersection			
Total Accidents	68	60	-11.8%
Average Traffic Volume	6,935,000	7,300.000	+5.3%
APV	0.00098%	0.00082%	-16.3%
APV Equivalent	1 in 101,985	1 in 121,666	

TABLE 4. Spatial Comparison Results

Measure	**Prior to Sign** (before 28Jan02)	**Prior to Sign** (before 28Jan02)
Accidents	68	60
APV	0.00098%	0.00082%
APV Equivalent	1 in 101,985	1 in 121,666
Peak Daily Accidents	3	2
Peak Weekly Accidents	5	4
Accident Free Days	42	43
Accident Free Weeks	15	15

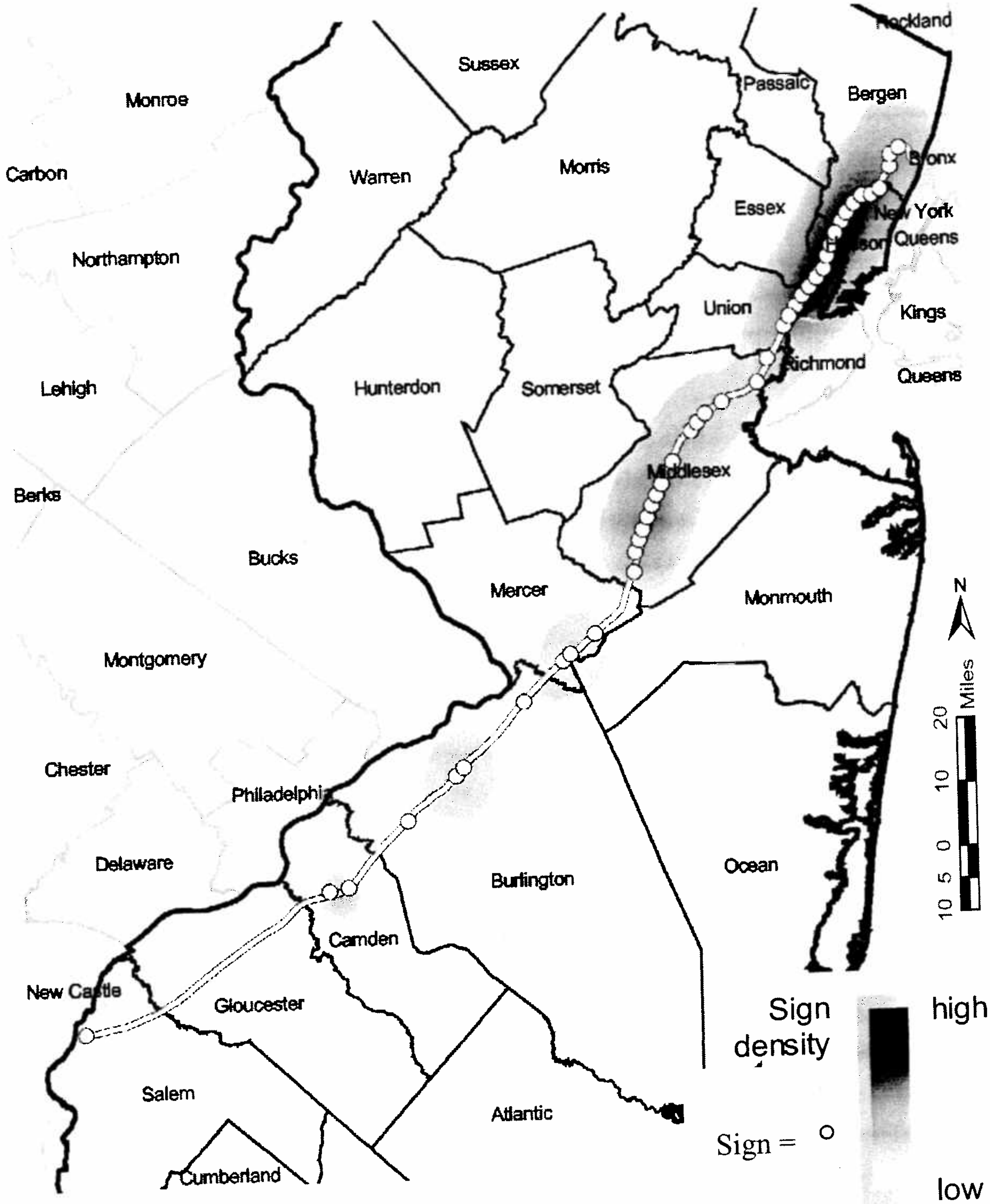

FIGURE 1. New Jersey Turnpike, Sign-Location Plan, and Sign Density

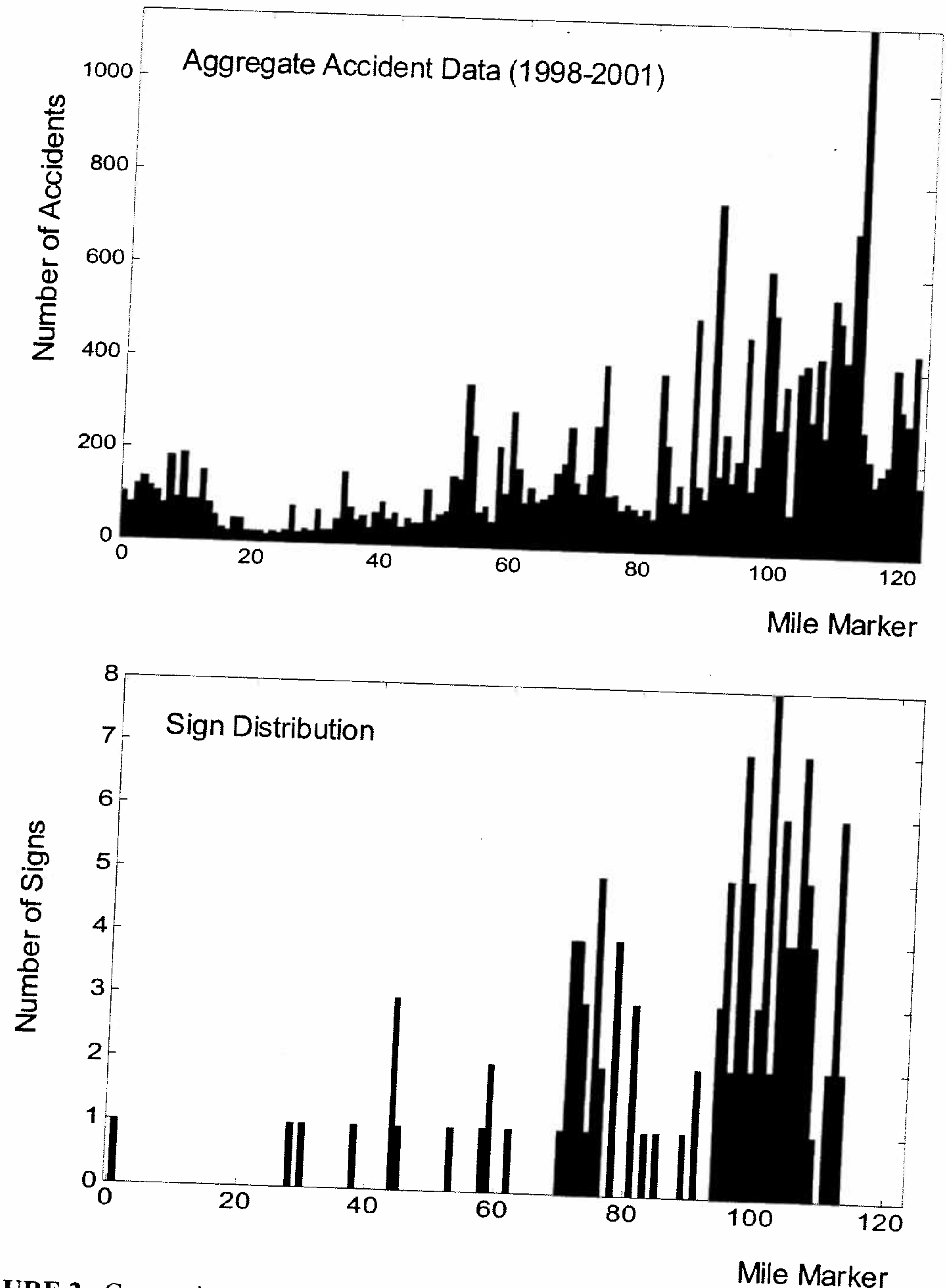

FIGURE 2. Comparison of Accidents with Sign Locations by Mile Marker

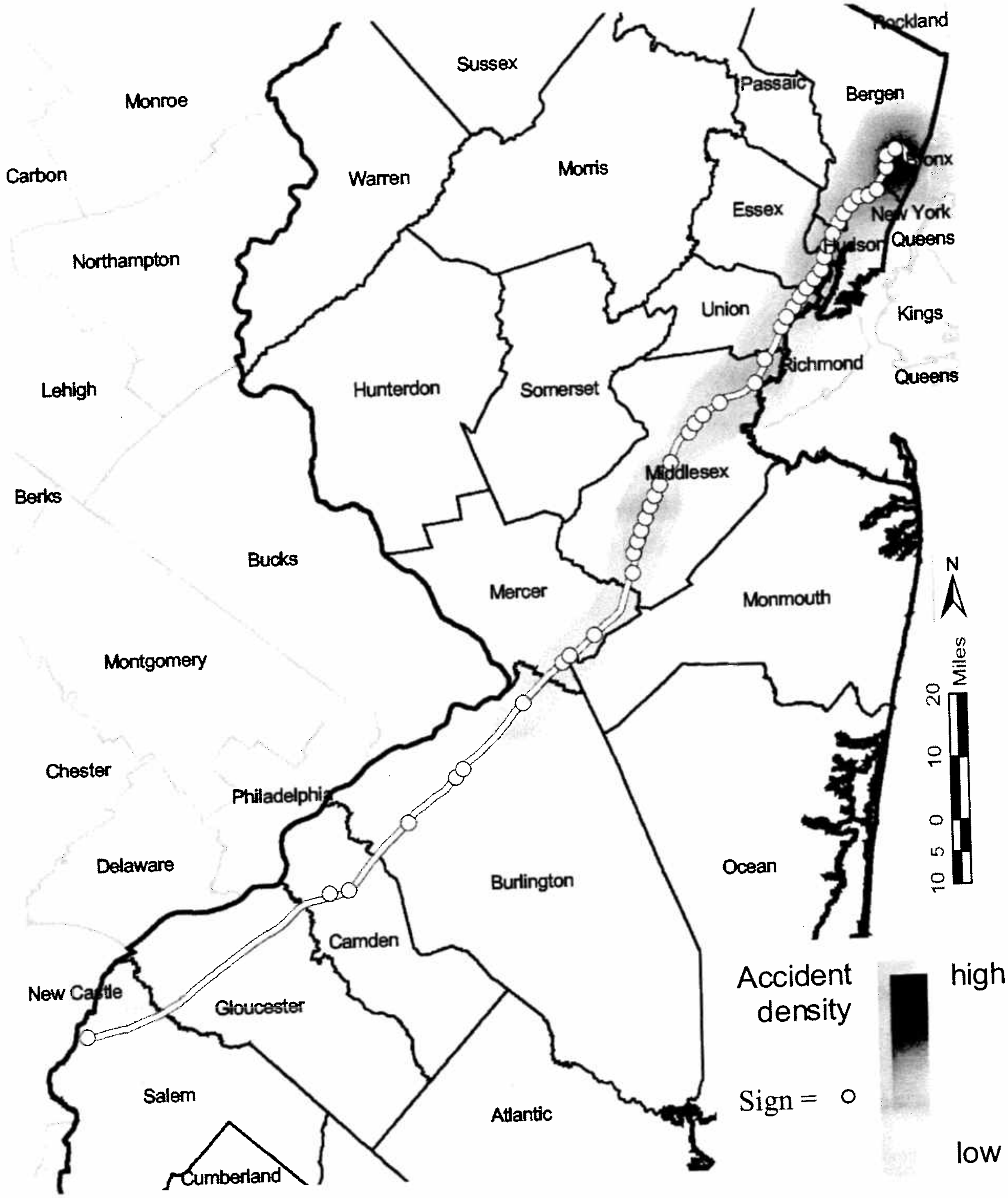

FIGURE 3. Aggregate Accident Density for 1998-2001

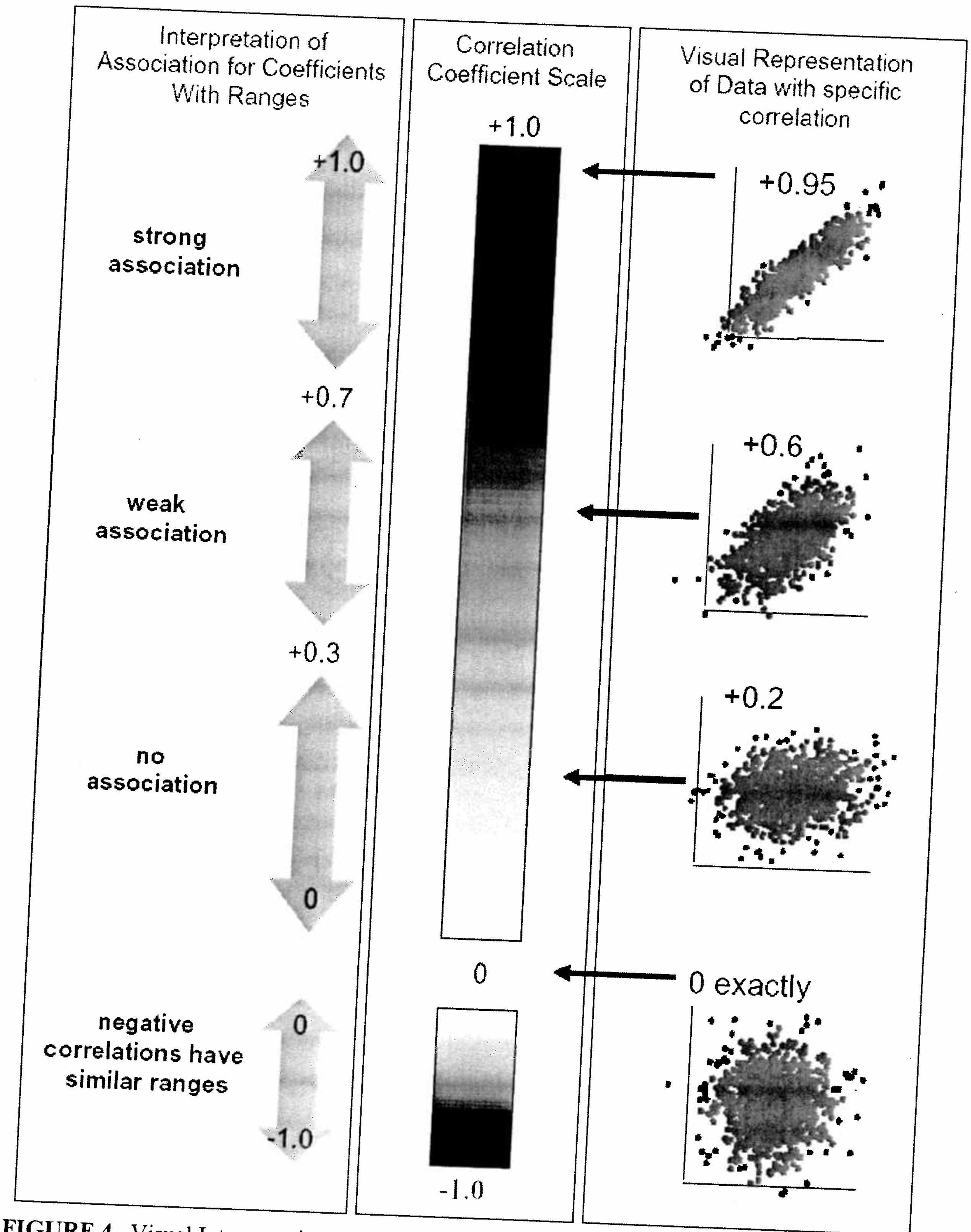

FIGURE 4. Visual Interpretations of Correlation Coefficients

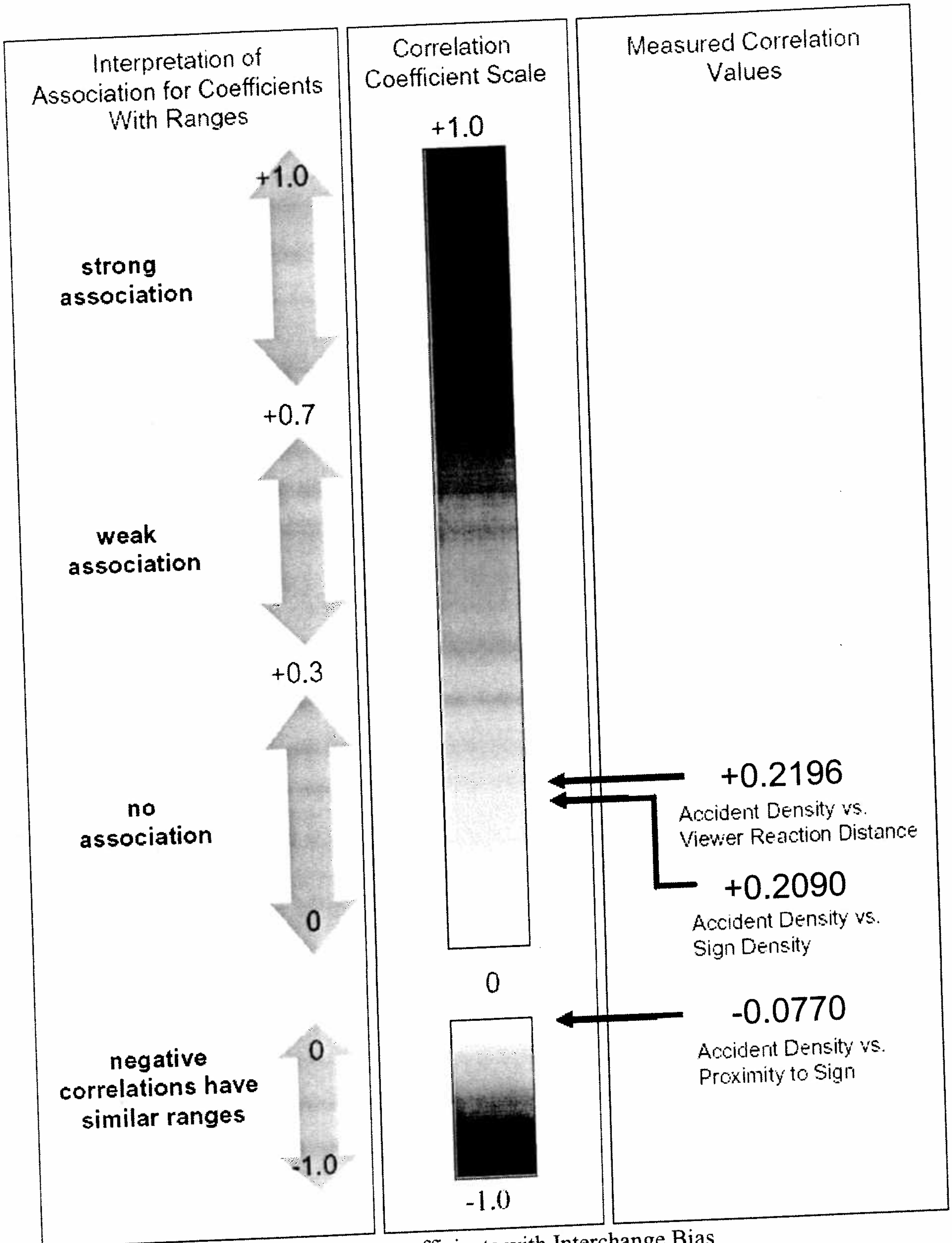

FIGURE 5. Calculated Correlation coefficients with Interchange Bias

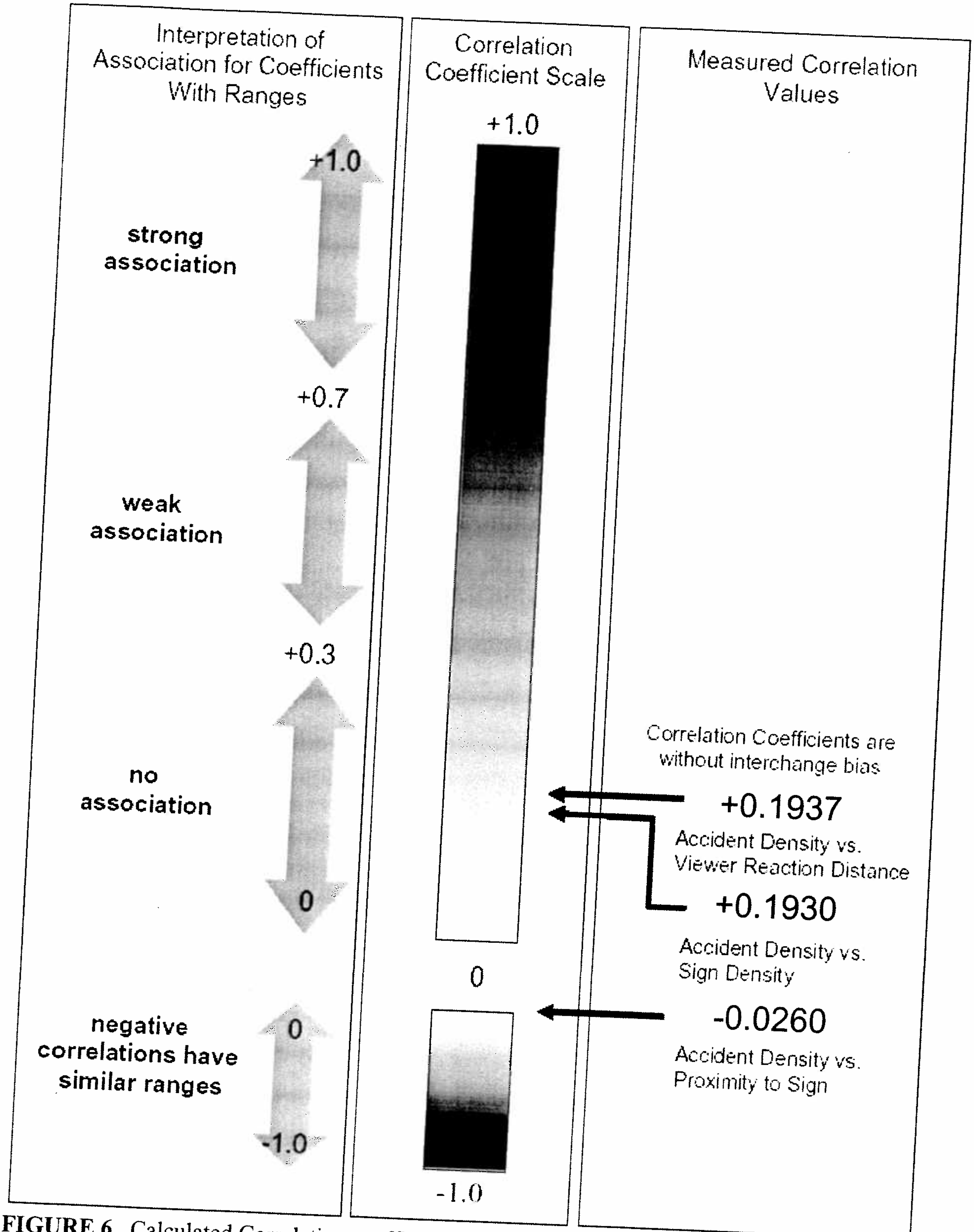

FIGURE 6. Calculated Correlation coefficients without Interchange Bias

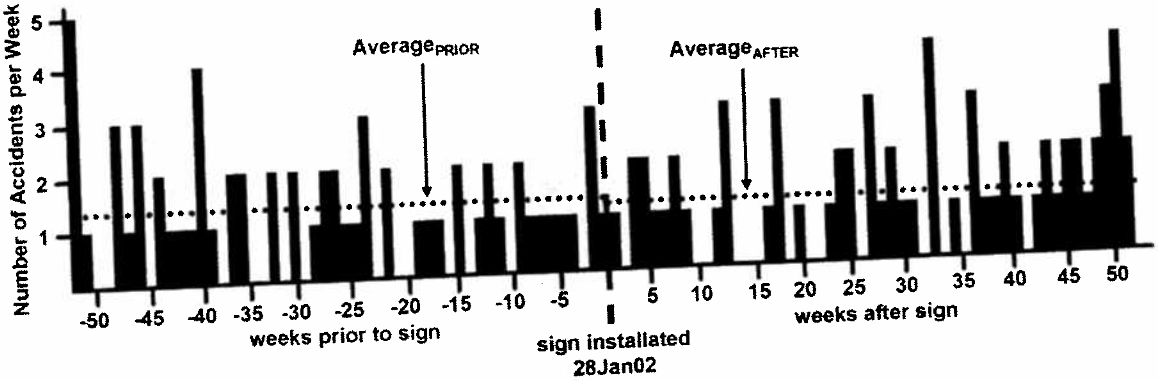

FIGURE 7. Composite Weekly Histogram of Woodbourne Road and the Lincoln Highway Intersection Accidents in 2001-2002