USSC **FOUNDATION**

Traffic Safety Study

USSCF ON-PREMISE SIGNS / RESEARCH CONCLUSIONS

TRAFFIC SAFETY STUDY

AN EXAMINATION OF THE RELATIONSHIP BETWEEN SIGNS AND TRAFFIC SAFETY

A Research Project of The

UNITED STATES SIGN COUNCIL FOUNDATION

by

Albert M. Tantala, Sr., P.E.
Peter J. Tantala, P.E.
Michael W. Tantala, Ph.D. Candidate

of

TANTALA ASSOCIATES
CONSULTING ENGINEERS
4903 Frankford Avenue, Philadelphia, Pennsylvania 19124-2693
T: 215.289.4600 - F:215.288.1885 - E: mail@tantala.com
http://www.tantala.com

Recommended citation: Tantala, A. *et al.*, "Traffic Safety Study: An examination of the relationship between signs and traffic safety", Tantala Associates, Consulting Engineers, Philadelphia, Pennsylvania. Funded by the United States Sign Council, November 2003.

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UNITED STATES SIGN COUNCIL FOUNDATION

This research study, which examines the relationship between roadside signs and traffic safety, was published by the United States Sign Council Foundation as part of the Foundations's on-going effort to provide a verifiable body of knowledge concerning sign usage within the built environment.

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The United States Sign Council Foundation
211 Radcliffe Street, Bristol, Pennsylvania 19007-5013
215-785-1922 www.usscfoundation.org

EXECUTIVE SUMMARY

The **purpose** of this study is to examine the relationship between roadside signs and traffic safety. This study was funded by a grant from the United States Sign Council (USSC) as part of the Council's on-going effort to provide a verifiable body of knowledge concerning sign usage within the built environment.

The first part of this study establishes statistical ***correlation coefficients*** between roadside signs and accidents along the New Jersey Turnpike. This study considers various situations, with and without interchange bias. 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.

The **results** of this study indicate the following:

- *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 -0.098 to +0.219). **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 -0.026 to +0.194). **These data reinforces the premise that no statistical relationship between signs and accidents exists.** The data also strongly suggest that no causal relationship between signs and accidents exists.
- 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 and increased. **These measures indicate no statistically significant changes in accident occurrences after the installation of another 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**. 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*.

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1. GENERAL COMMENTS

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.

This study examines the relationship between signs and traffic safety, and evaluates the correlation between signs and accidents for particular roads and conditions.

2. OBJECTIVE

The purpose of this study is to examine the relationship between roadside signs and traffic safety.

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 S*patial Comparison* part.

3. 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*.

A. 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.

(1) 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

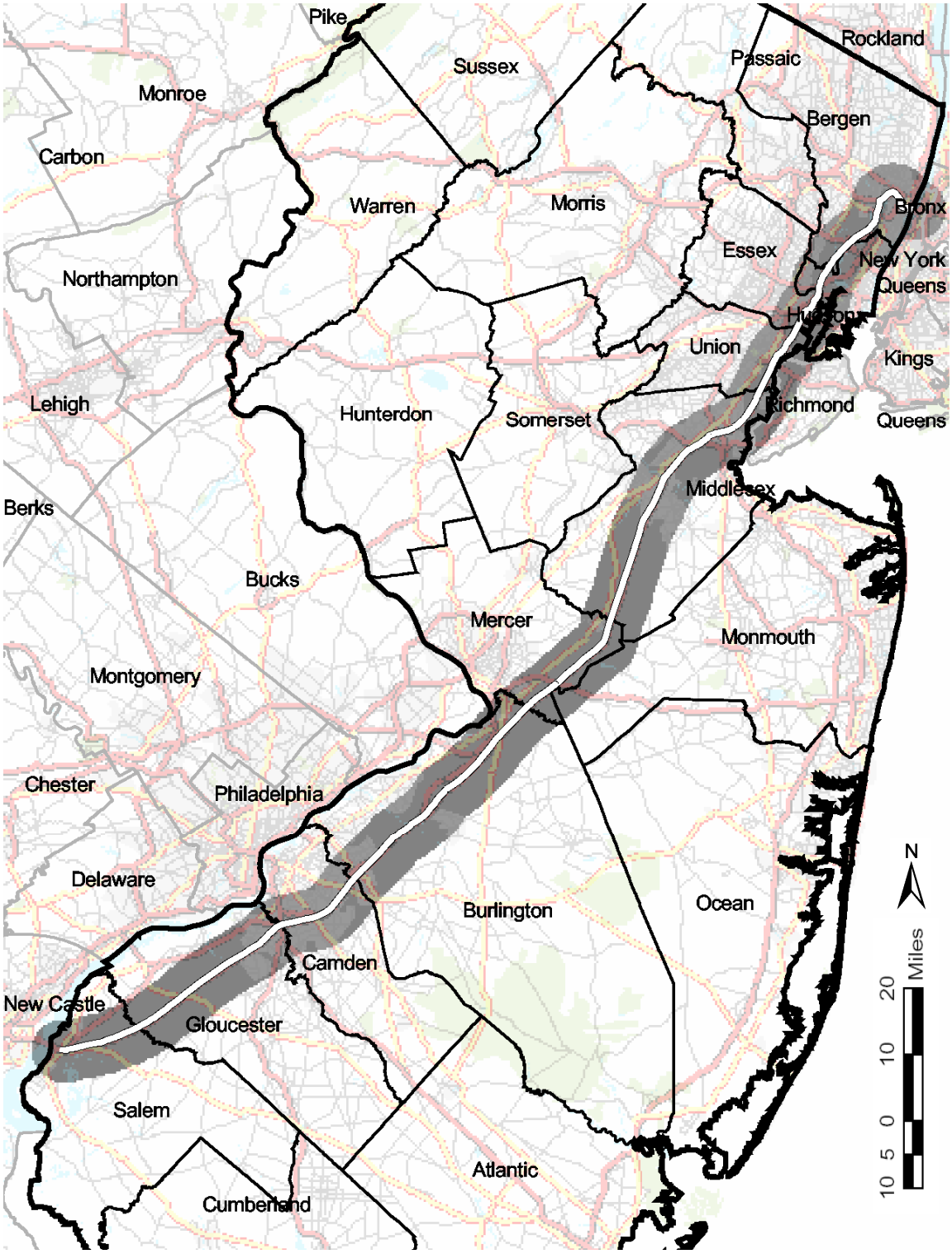


Figure 1. New Jersey Turnpike

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.

(2) Signs

Several types of signs exist along the Turnpike, including advertising signs, directional signs, informational signs, emergency signs, markers, *inter alia*. Figure 2 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 3 (each solid dot represents a sign); the signs are individually identified in Appendix A.1, and 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.

Figure 2. Typical Signs along the New Jersey Turnpike

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 3, 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. Figure 4 is a typical data sheet. Appendix A.1 provides detailed survey information.

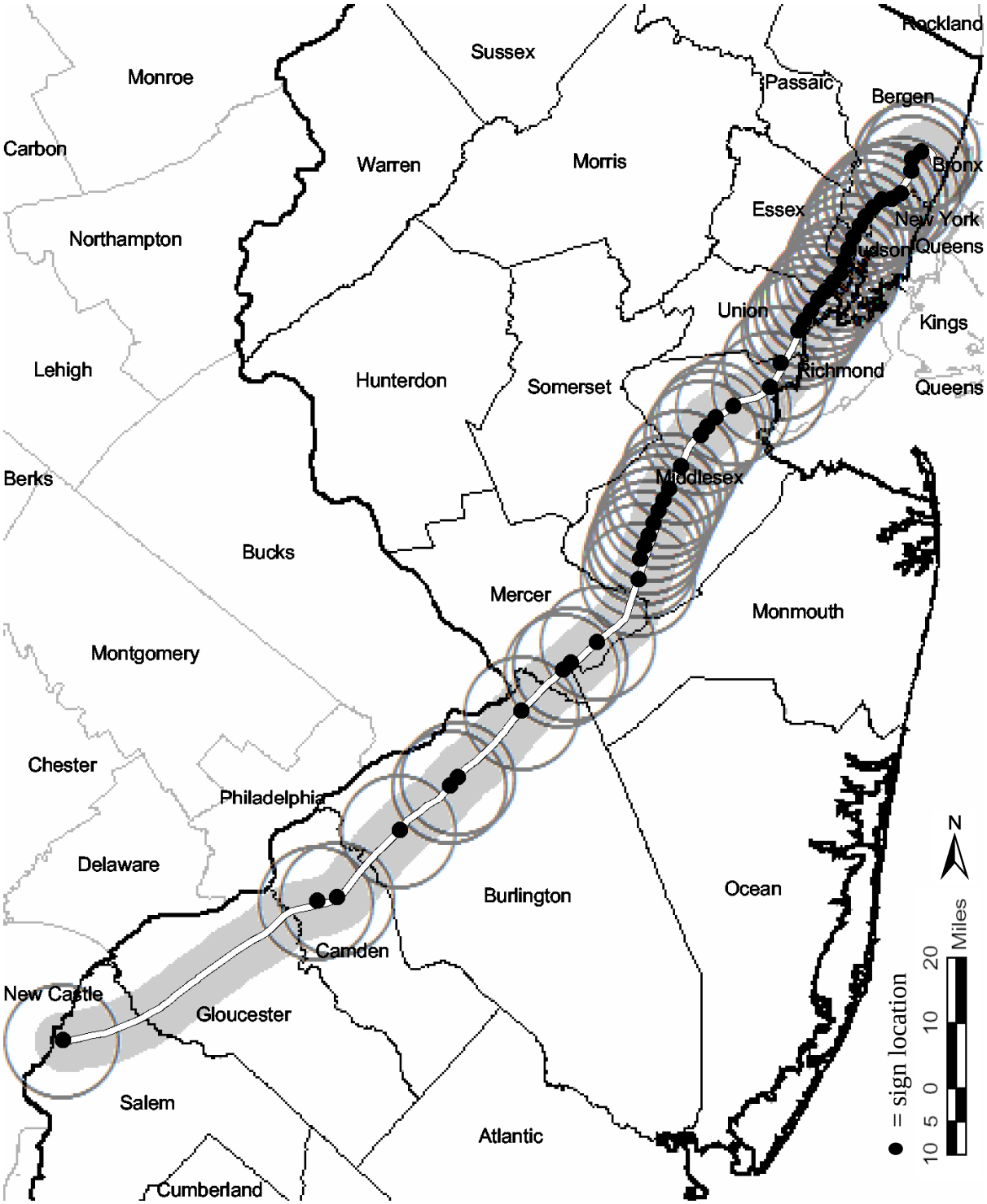


Figure 3. Sign-Location Plan

Sign ID:	14
Milemarker:	70.35
Direction	North with North Read
Use:	Non-Accessory
Type:	Single Face
Dimensions:	14' x 48'
Illumination:	External
Copy:	Fennelley Real Estate

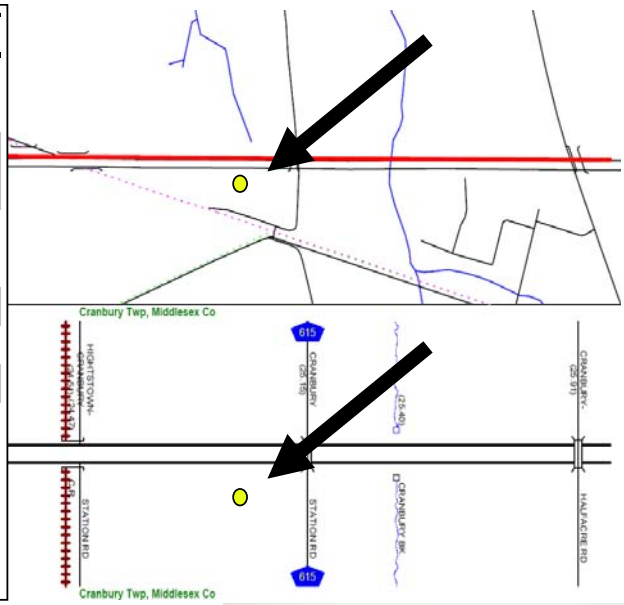


Figure 4. Typical Sign-Location Data

(3) 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. 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*.

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

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.

B. 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 *sub*set 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*. 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.

(1) 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:

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

where s_i is the i*th* 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.] Individual locations of certain signs are shown in Appendix A.1 of this study (with aerials, photographs, diagrams and sign characteristics).

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 5. 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 6. Figures 5 and 7 show similar data in the form of a mapped, density plot for sign and accident data along the Turnpike between 1998 and 2001. Comparisons of other histograms and density plots illustrating the differences in sign densities accident along the Turnpike for accidents representing each individual year between 1998 and 2001 are shown in Appendix A.3.

Our basis for evaluating the relationship between sign locations and accident locations is the *correlation coefficient*. The *correlation coefficient* (ρ) between sign density, S^D, and accident density, A^D, may be calculated using:

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

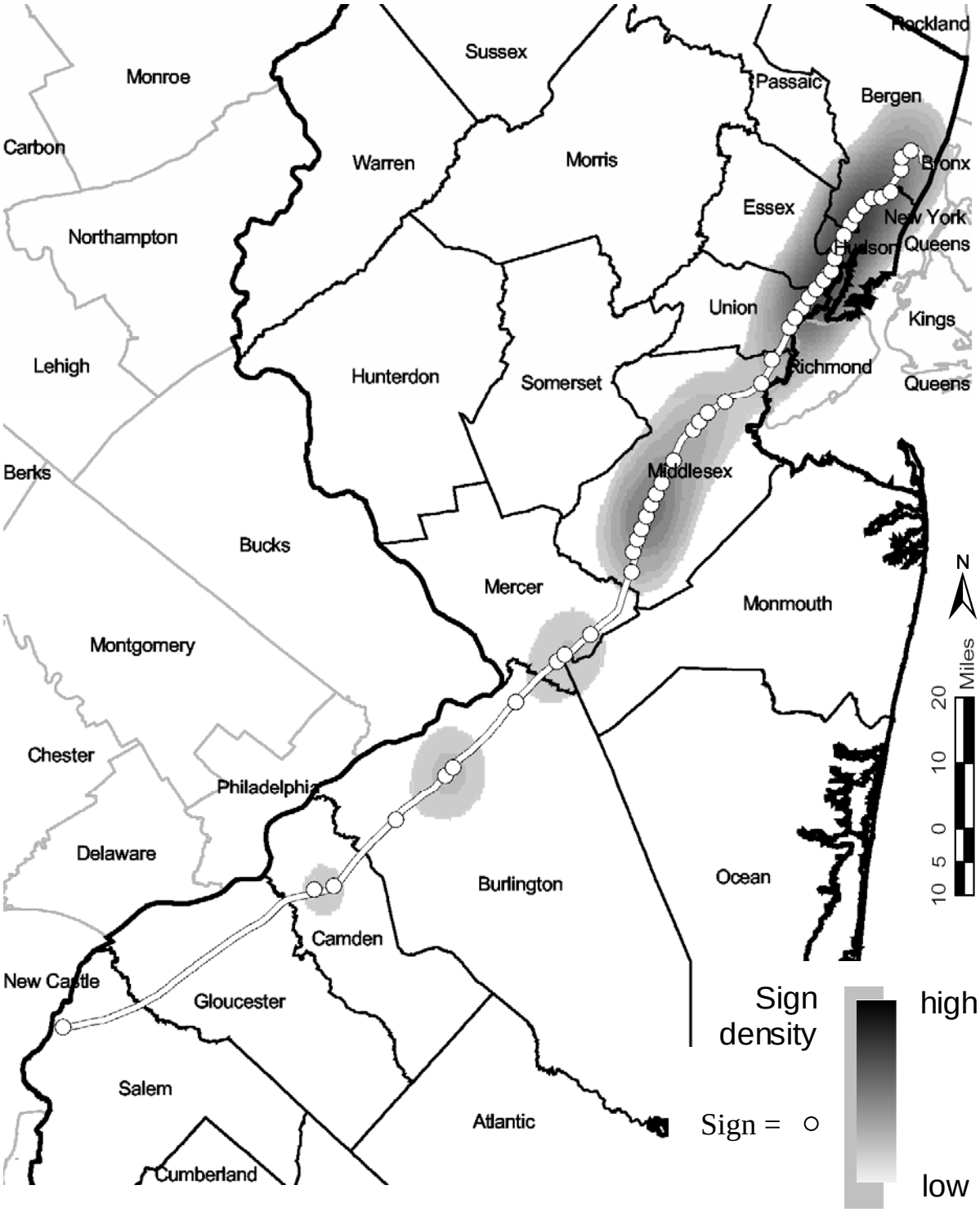


Figure 5. Sign Density

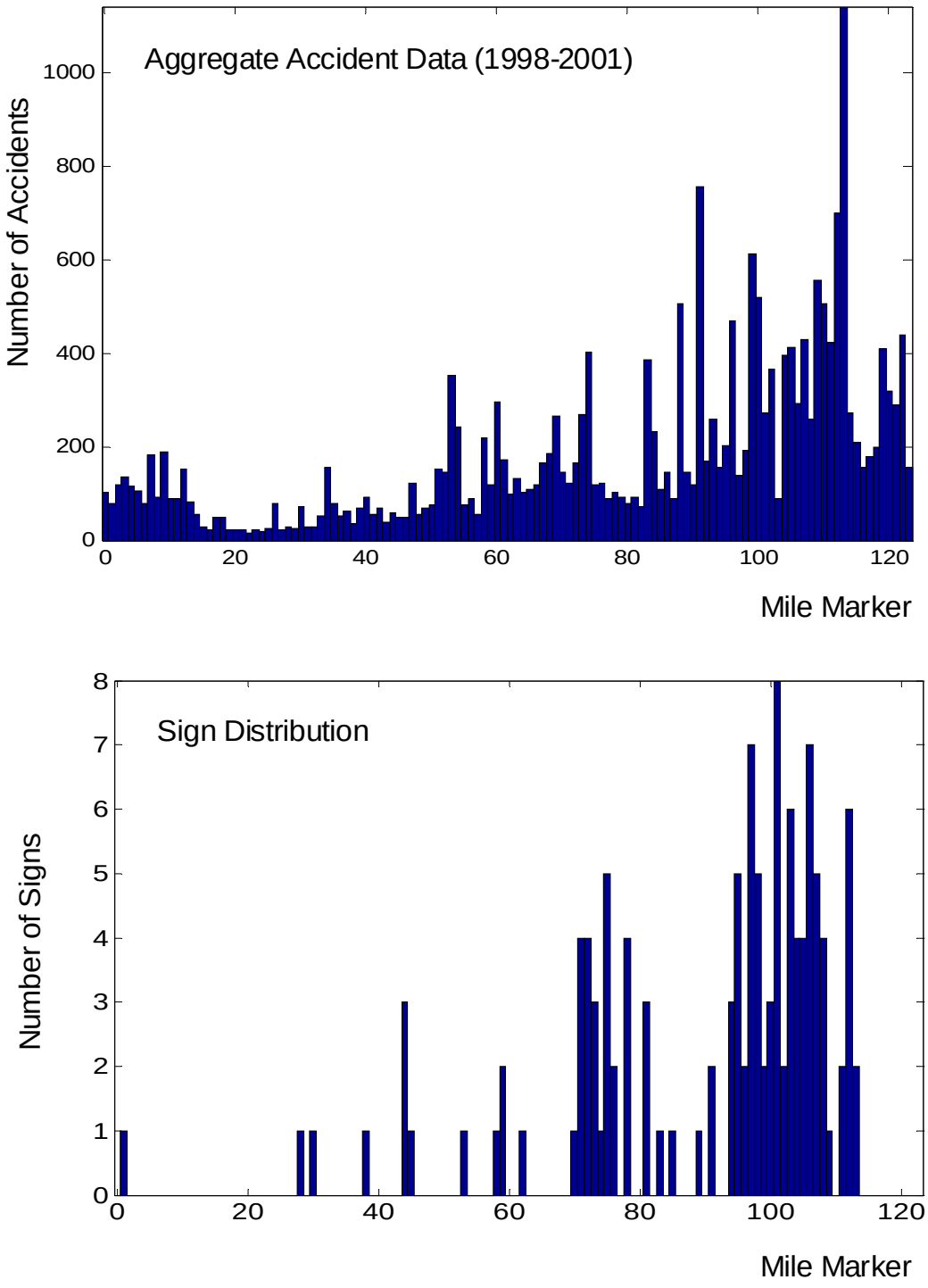


Figure 6. Comparison of Accidents with Sign Locations by Mile Marker

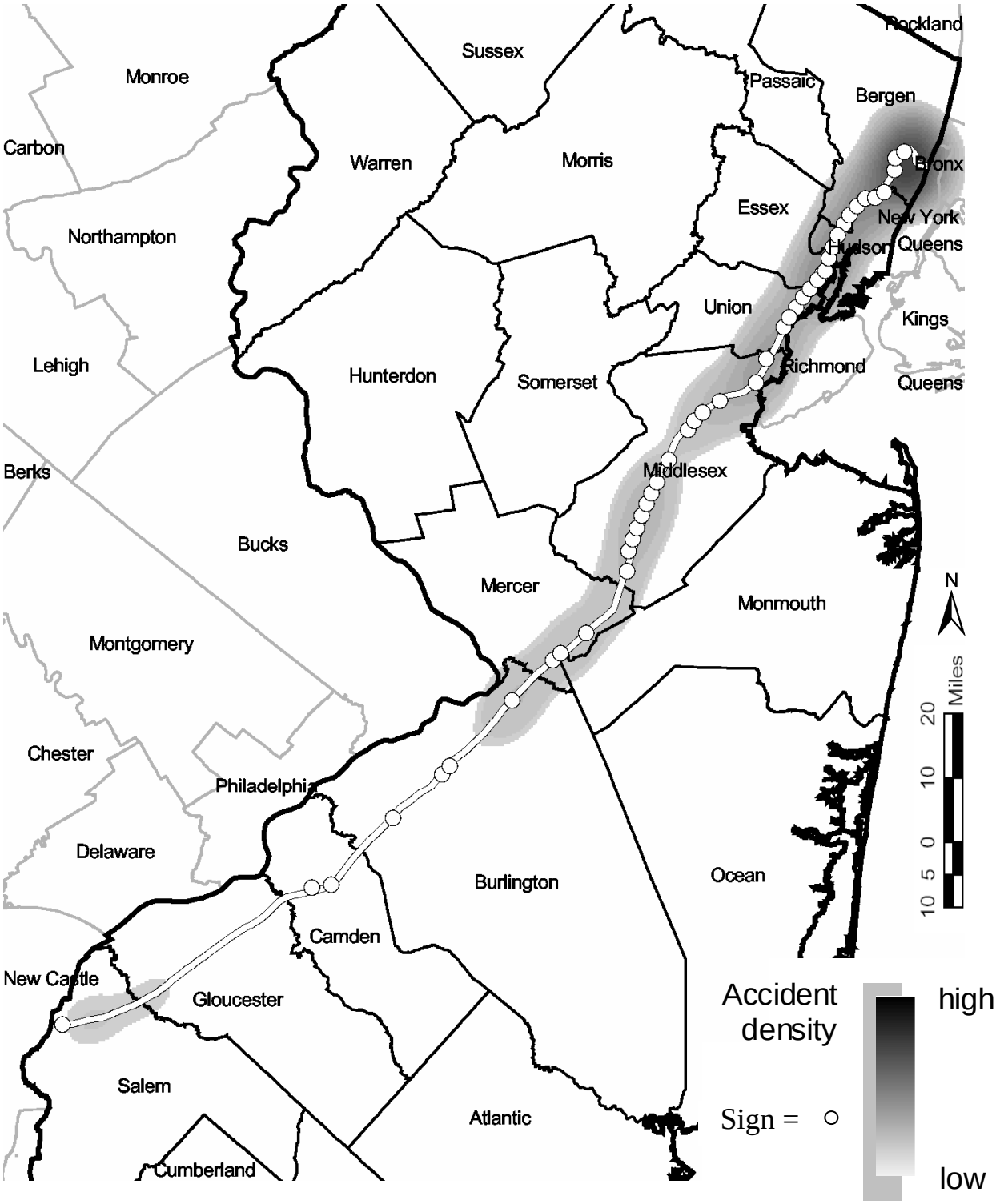


Figure 7. Aggregate Accident Density for 1998-2001

The *correlation coefficients* with their corresponding data are shown in Table 2 for the individual and aggregate years between 1998 and 2001, and from data plotted in Appendix A.2. These coefficients range from -0.098 to +0.219. Figure 8 shows commonly accepted interpretations of *correlation coefficients* and visual scatter plots to emphasis what various *correlation coefficients* might represent (Ang, 1975). To provide another sense of the value of *correlation coefficients*, Figure 9 shows historically observed *correlation coefficients* for a variety of other relationships. 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, and are calculated using data plotted in Appendix A.2.

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 Viewer 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

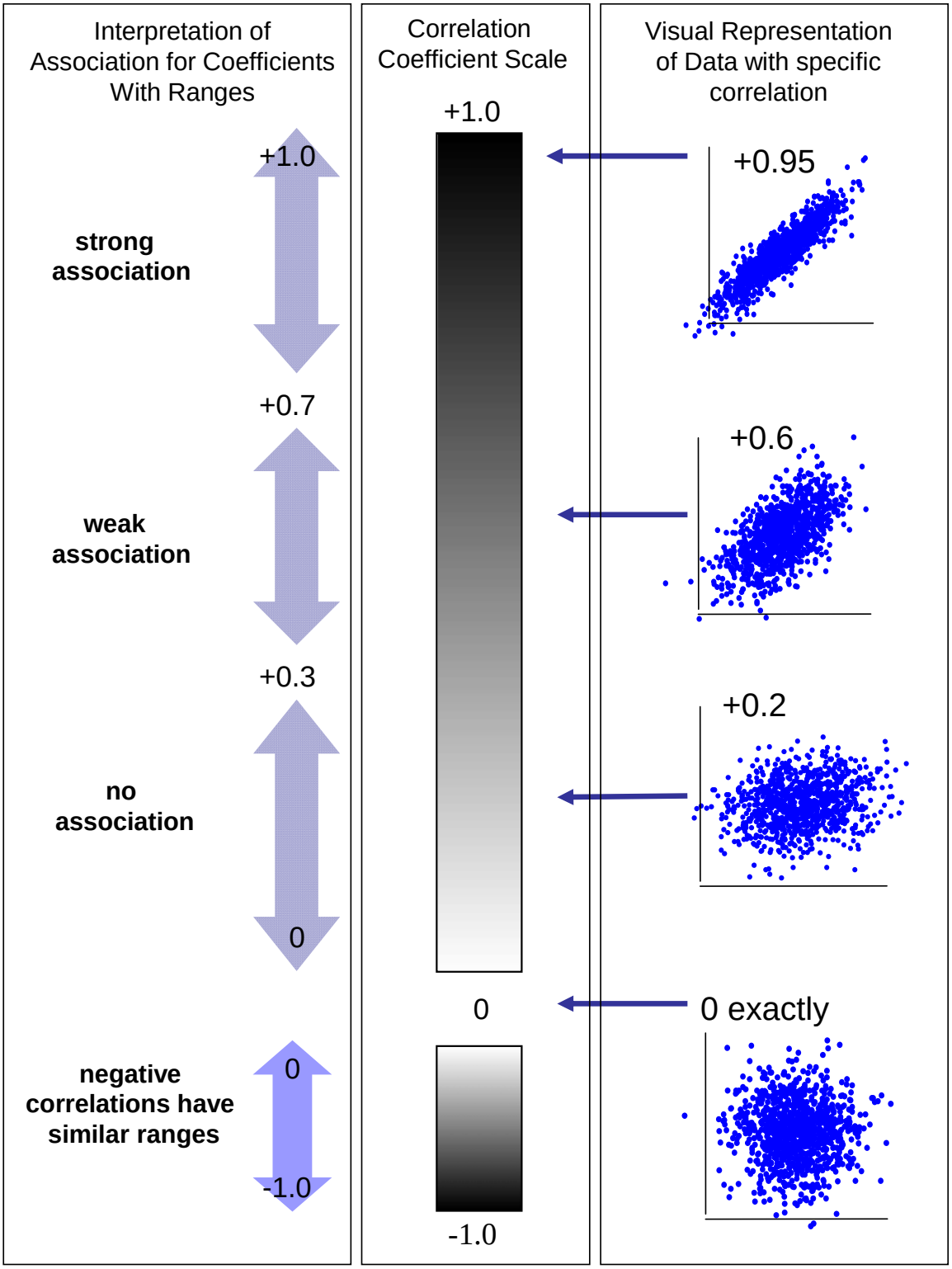


Figure 8. Visual Interpretations of *Correlation Coefficients*

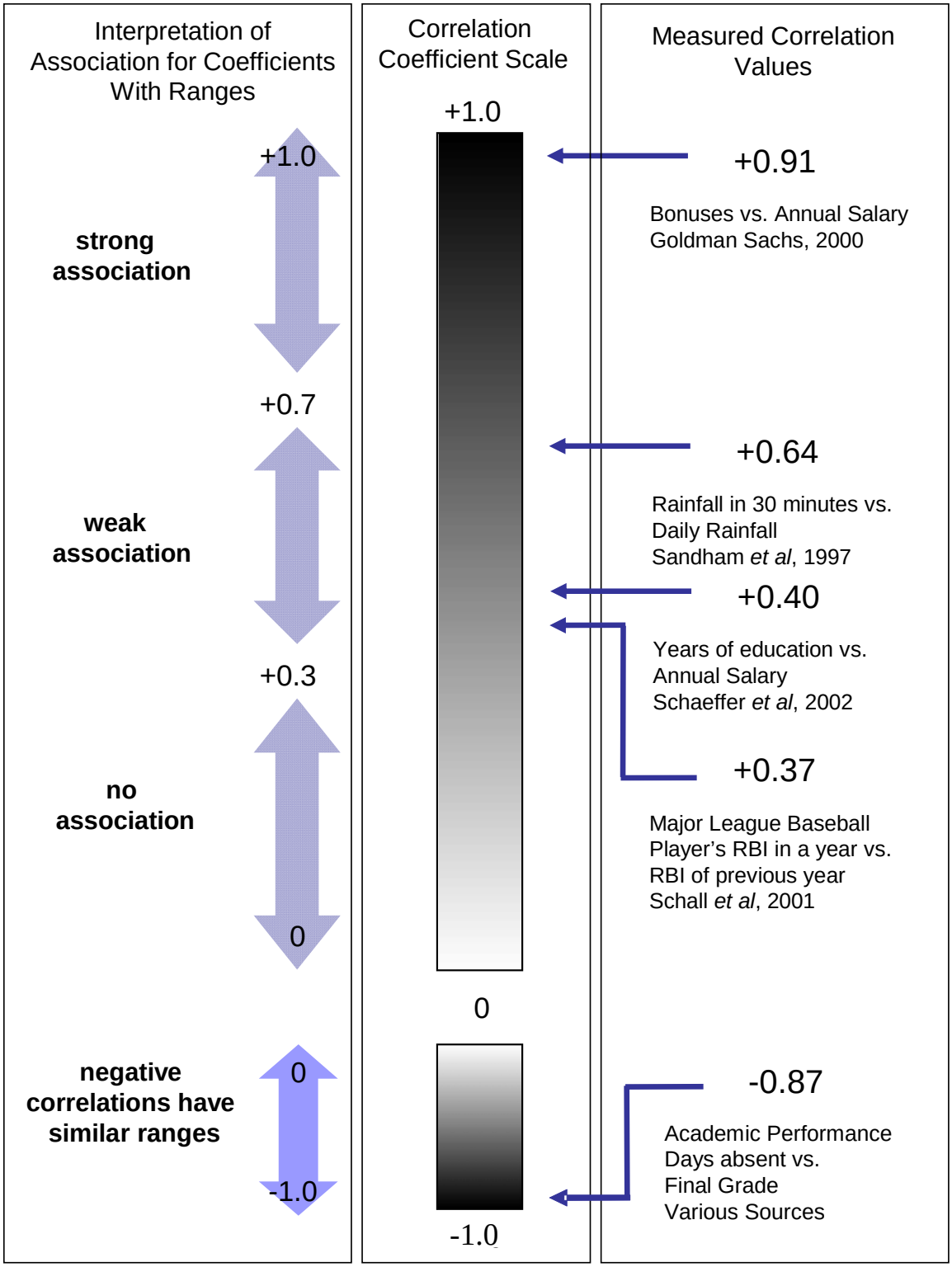


Figure 9. Actual *Correlation Coefficients* for Various Relations

(2) 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 (*USSC*, reference), 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

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

where d_m is the distance to the nearest sign location for m*th* 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

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

where s_i is the i*th* 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, and is calculated from data plotted in Appendix A.2.

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.

(3) 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:

$$\left\{ P_m \;=\; \left| d_m - m \right|,\; m \;=\; 0,\; 0.1,\; \cdots\;,\; M \right\}$$

where d_m is the distance to the nearest sign location for m*th* mile marker and M is the total length of the Turnpike in miles.

The *correlation coefficients* between sign proximity indices, P, and accident density, A^D, 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. These *correlation* coefficients are calculated using data which is plotted in Appendix A.2. Table 2 shows *correlation coefficients* excluding interchange bias 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.

C. 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*.

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. 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 10, 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 11 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.

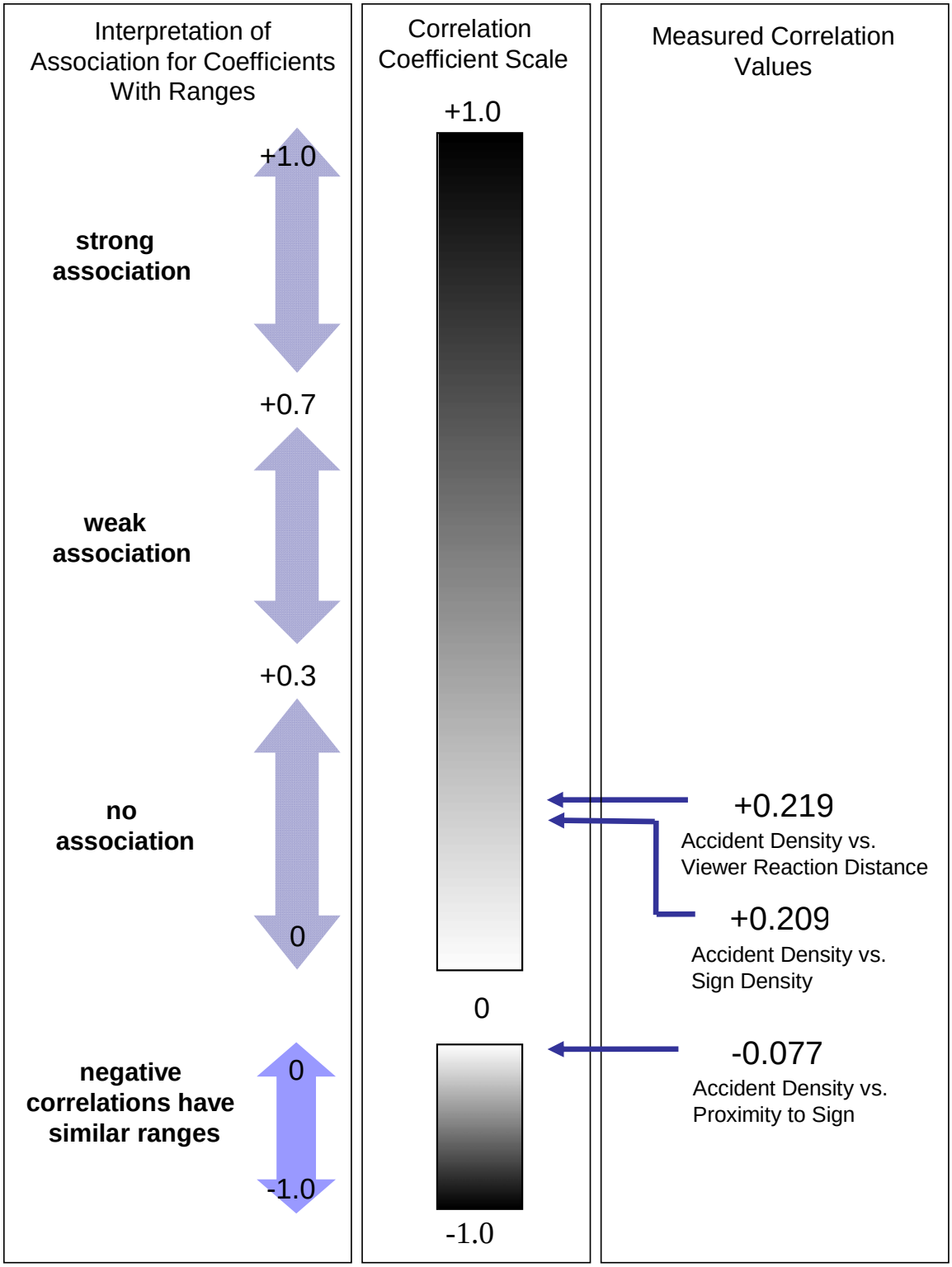


Figure 10. Calculated *Correlation coefficients* with Interchange Bias

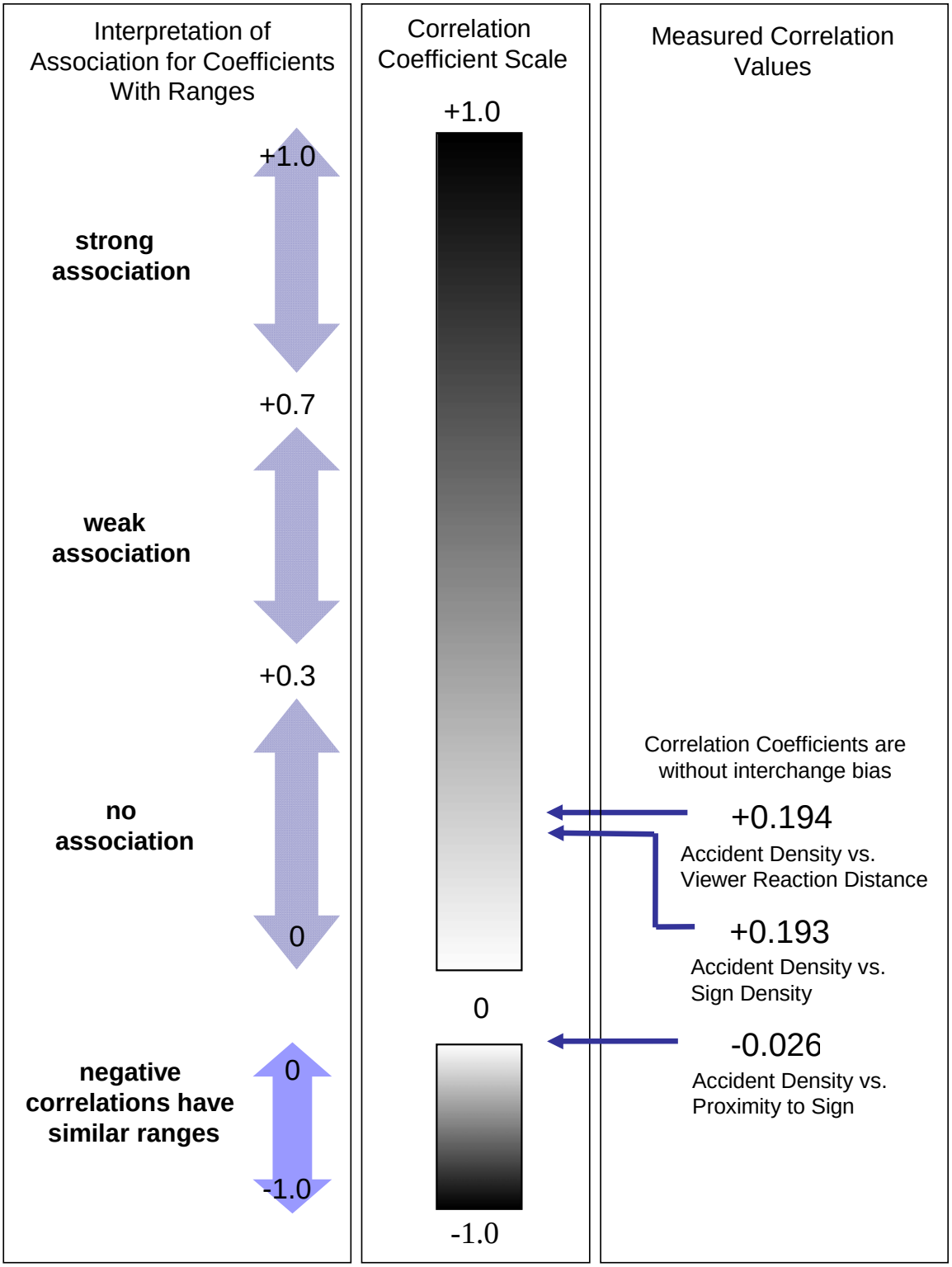


Figure 11. Calculated *Correlation coefficients* without Interchange Bias

4. SPATIAL COMPARISON

A. 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.

(1) 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. Figure 12 shows the area, the intersection, and the sign. The sign was installed on or about January 28, 2002.

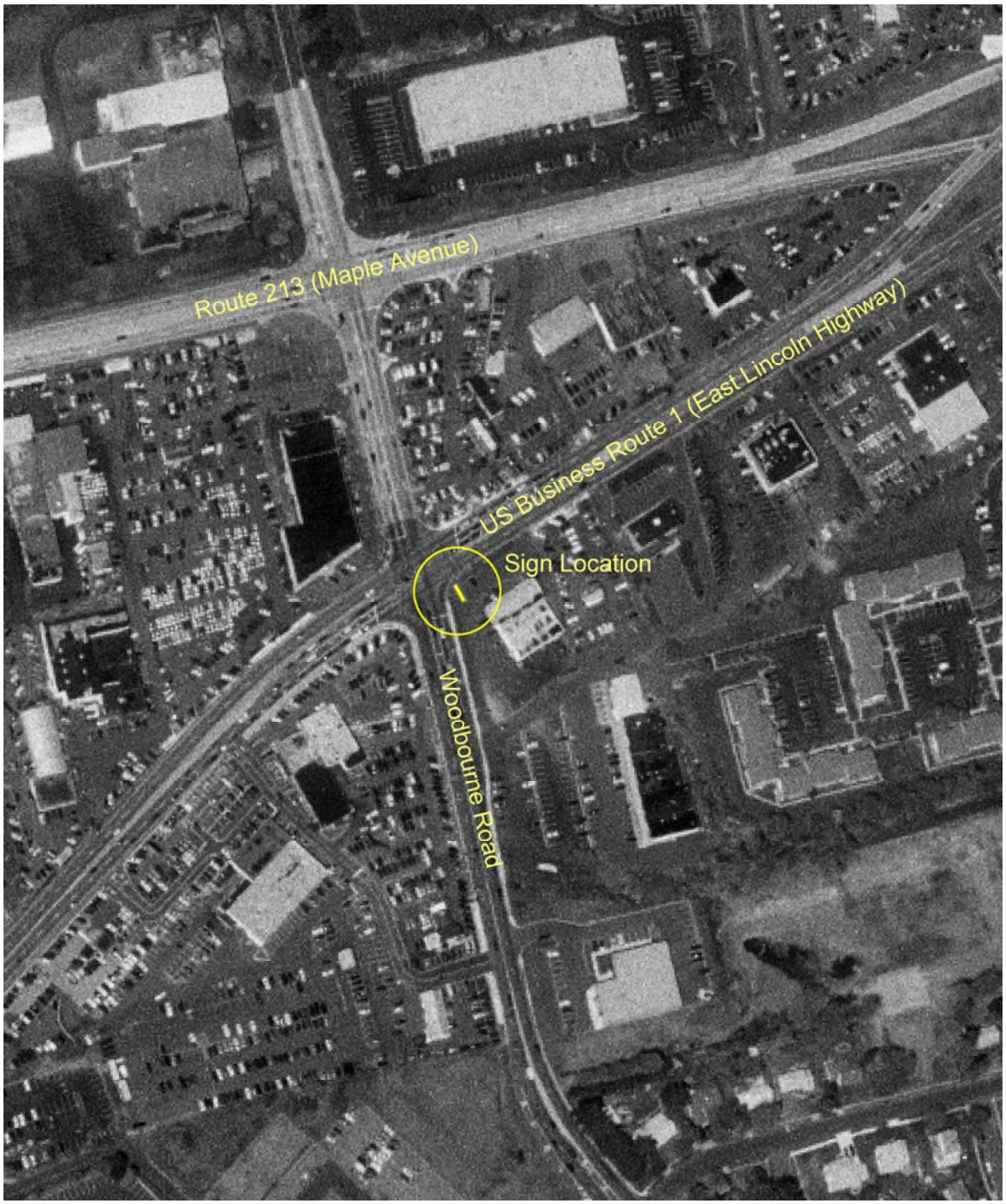


Figure 12. Aerial Photograph of Sign at the Lincoln Highway and Woodbourne Road

(2) 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. Figure 13 shows photographs of the sign.

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.

Figure 13. Photographs of Sign at the Lincoln Highway and Woodbourne Road

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 and compiled in Appendix A.2.

Table 3. Traffic Accidents at the Lincoln Highway and Woodbourne Road Intersection

	Prior to Sign (before 28Jan02)	After Sign (after 28Jan02)	Totals
the Lincoln Highway	35	33	68
Woodbourne Road	33	27	60
Totals	68	60	128

B. 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.

(1) Accidents-per-Volume (APV) Ratios

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

$$\text{APV} = \frac{\text{Number of accidents}}{\text{Annual Traffic Volume}}$$

Table 4 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.

Table 4. Accidents, Volume and APV at Woodbourne Road Intersection

	Prior to Sign (before 28Jan02)	After Sign (after 28Jan02)	% change
No. of Accidents	68	60	-11.8%
Average Traffic Volume	6,935,000	7,300,000	+5.3%
APV	0.00098%	0.00082%	-16.3%
Equivalent	1 in 101,985	1 in 121,666	

(2) Histogram Comparison

Using the summarized, *PennDOT,* accident-report data in Appendix A4, we show in Figure 14, 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. Similar histograms for the separate roads are shown in Figures 15(A) and 15(B). 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. 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.

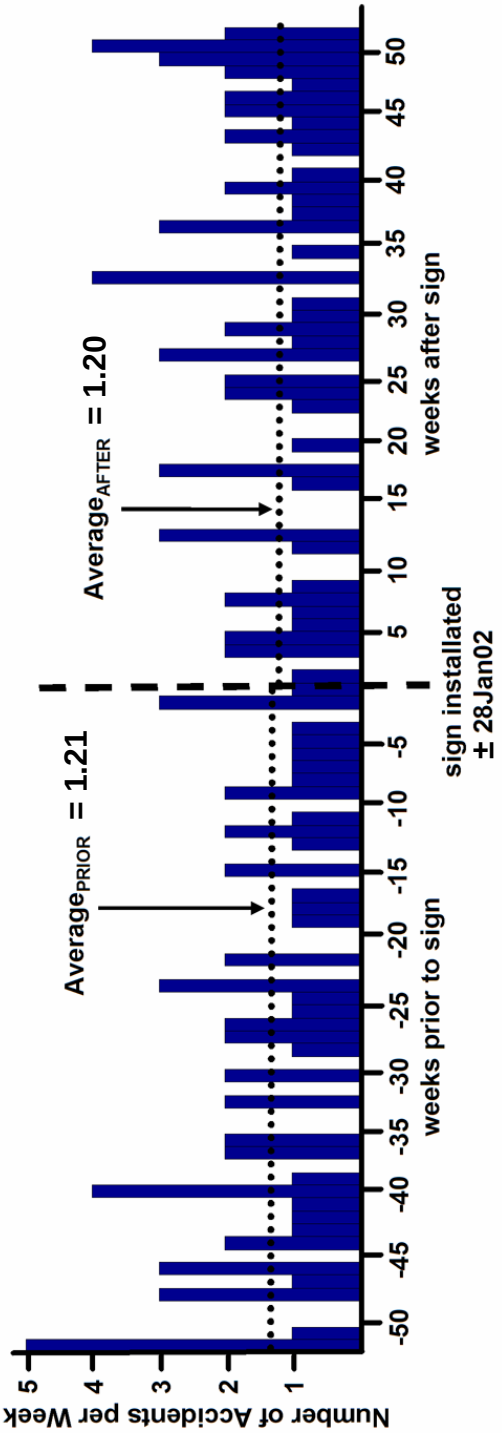
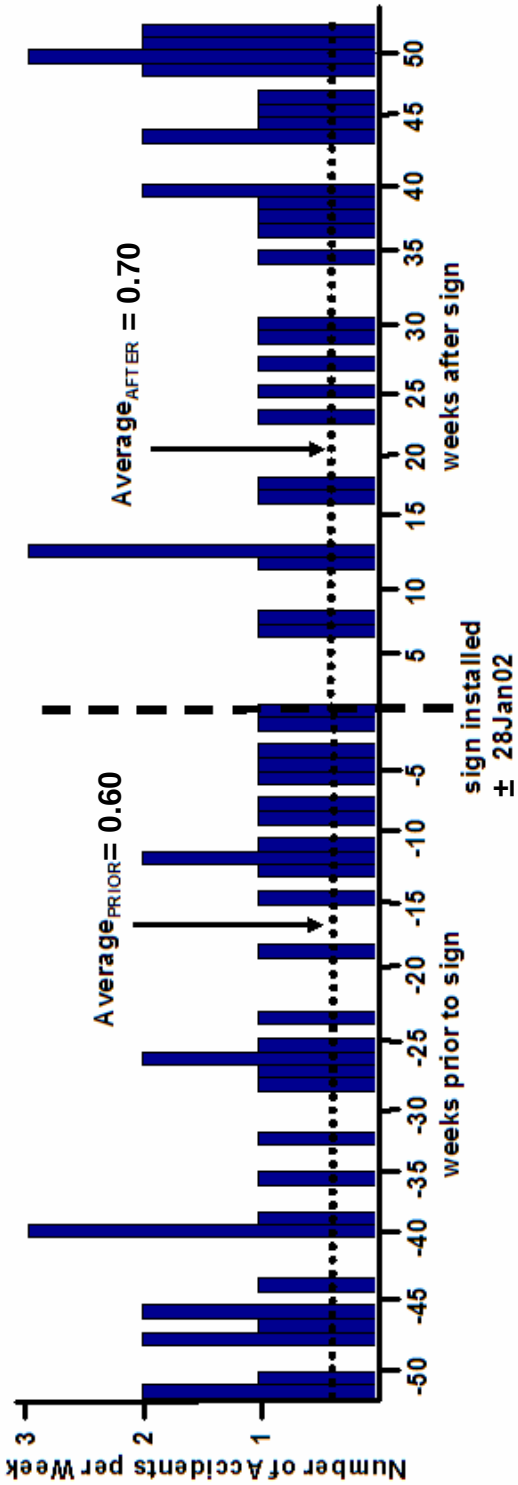


Figure 14. Composite Weekly Histogram of the Lincoln Highway and Woodbourne Road Intersection Accidents in 2001-2002

A.



B.

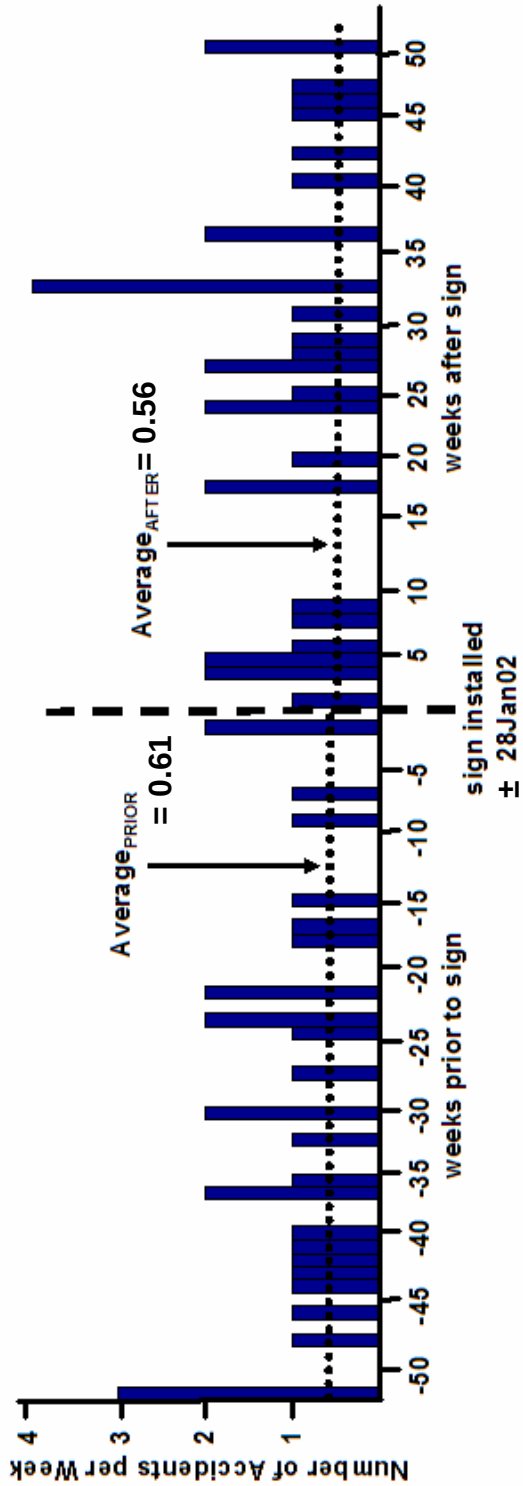


Figure 15. Weekly Histogram of (A) Woodbourne Road and (B) the Lincoln Highway Intersection Accidents in 2001-2002

C. 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 5. 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.

Table 5. Spatial Comparison Results

	Prior to Sign (before 28Jan02)	After Sign (after 28Jan02)
Accidents	68	60
APV	0.00098%	0.00082%
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

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.

5. 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.

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*.

DEFINITIONS

Accessory sign - A sign relating in its subject matter to the lot or tract on which it is located, or to products, accommodations, services or activities on the premises on which it is located

Accident Density - the number of accidents per mile marker (every tenth of a mile) along a road or highway

Accidents-per-Volume (APV) Ratio - A quantitative measure of traffic safety for a specified road or portion of road, which is the ratio of the number of accidents to the annual traffic volume

Correlation Coefficient – a statistical measure of the "association" between two sets of data

Interchange Bias – the potential for additional tasks which drivers undertake at interchanges/intersections to contribute to the occurrence of an accident. These additional tasks may include lane changes, accelerating/decelerating, negotiating directions, attention to others undertaking additional tasks, *inter alia*.

Limited-Access Highway - a highway especially designed for through traffic and over, from or to which owners or occupants of abutting land or other persons have no right or easement or only a limited right or easement of access, light, air, or view by reason of the fact that their property abuts on such limited access highway or for any other reason

Non-accessory - A sign other than an accessory sign

DEFINITIONS (continued)

Sign - Any privately owned permanent or temporary device, placard, painting, drawing, poster, letter, word, banner, pennant, insignia, trade flag, or representation used as or which is in the nature of an advertisement, announcement, or direction which is on a public way or on private property within public view of a public way

Sign Density – the number of signs per mile marker (every tenth of a mile) along a road or highway

Viewer Reaction Distance (VRD) - 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. A posted speed limit of 65 mph usually corresponds to a VRD of approximately 0.2 miles.

Viewer Reaction Time (VRT) – a measure of the time during which a driver is within the "influence" of a sign. A posted speed limit of 65 mph usually corresponds to a VRT of approximately 10 seconds.

REFERENCES

Ang, A., W. Tang, Probability Concepts in Engineering Planning and Design, John Wiley and Sons, Inc., 1975.

Federal Highway Administration, "Safety and Environmental Design Considerations in the Use of Commercial Electronic Variable-Message Signage", Report No. FHWA/RD-80/051, 1980.

Garber, N. and L. Hoel, Traffic and Highway Engineering, PWS Publishing, 2nd edition (Revised Printing), 1999.

Garvey, P, Thompson-Kuhn, B, & Pietrucha, M., "Sign Visibility Research and Traffic Safety", United States Sign Council, 1996.

Harr, M., Reliability Based Design in Civil Engineering, General Publishing Company, Ltd., 1987.

Modarres, M., M. Kaminsky, V. Krivtsov, Reliability Engineering and Risk Analysis: A Practical Guide, Marcel Dekker, Inc., 1999.

Montgomery, D., G. Runger, N. Hubele, Engineering Statistics, John Wiley & Sons, Inc., 1998.

National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce, Historical Weather Data for Pennsylvania, 2001 and 2002.

New Jersey Turnpike Authority, the New Jersey State Police, and the New Jersey Department of Transportation, New Jersey Turnpike Accident data for 1998 to 2001 obtained from New Jersey Government Records Council under the Open Public Records Act, (ORPA), 2003.

O'Connor, P., Practical Reliability Engineering, Heyden and Sons, Inc., 1981.

PennDOT, Bureau of Planning and Research, Transportation Planning Division in Cooperation with the FHWA, 2001 Traffic Volume Map for Bucks County, Pennsylvania, 2000 and 2001.

Township of Middletown, Bucks County, Pennsylvania, "Building and/or Zoning Permit" No. 20004, Issued 28Jan02.

APPENDICES

APPENDIX A.1: Sign Survey of the New Jersey Turnpike

APPENDIX A.2: Comparison of Sign Data with Number of Accidents for 1998-2001

APPENDIX A.3: Accident and Sign Density Figures

APPENDIX A.4: Compiled Accident Data from *PennDOT* Police Accident Reports for the Lincoln Highway and Woodbourne Road Intersection

APPENDIX A.1

Sign Survey of the New Jersey Turnpike

Sample Information Collected
Survey Data

Sign ID:	14
Milemarker:	70.35
Direction	North with North Read
Use:	Non-Accessory
Type:	Single Face
Dimensions:	14' x 48'
Illumination:	External
Copy:	Fennelley Real Estate

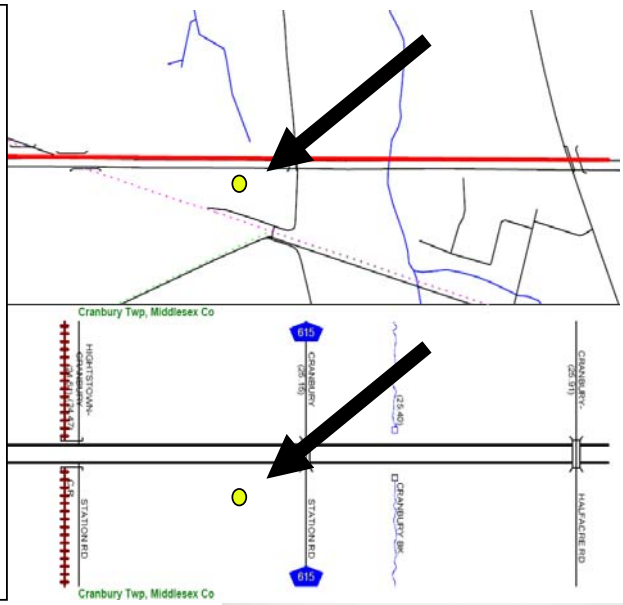


Figure A1-1. Sample Survey Data of Sign on New Jersey Turnpike

Sign ID	Milepost	Route Direction	Facing Direction	Faces DF/SF	Sign Shape V,F,T	Use A,NA	Dimensions of Face	Illumination	Owner	Owner Number	Page	Note
1	0.6000	S	NS	DF	V	NA	14x48	Y, Ext			Mike's Famous	
2	28.0000	N	?	?	?	?	?	?	?	?	?	Upright w/o head
3	30.2000	S	S	SF	F	NA	9x12	N			Sunoco	
4	38.3000	N	N	SF	F	NA	9x12	N			Sunoco	
5	44.3000	N	NS	DF	F	A	12x16	N			Howard Johnson's	
6	44.4000	N	NS	DF	F	A	12x16	N			West Hampton / Applebees	
7	44.5000	S	NS	DF	F	A	15x20	Y, Int			Econo lodge	
8	44.7000	S	NS	DF	F	A	15x20	Y, Int			Holiday Inn	
9	53.0000	S	NS	DF	V	NA	20x60	Y	Interstate		Volkswagen	
10	57.6500	N	N	SF	F	A	9x12	N			Sunoco	
11	58.7000	N	N	SF	F	A	9x12	N			Sunoco	
12	58.7000	S	S	SF	F	A	9x12	N			Sunoco	
13	62.4200	S	NS	DF	V	NA	20x60	Y			Sovereign Bank Arena	
14	70.3500	N	N	SF	F	NA	14x48	Y	Interstate	293c		
15	70.6000	S	NS	DF	F	NA	20x60	Y, Ext	Viacom		Raceway Park	
16	71.0900	N	S	SF	F	A	12x40	N			Cushman and Wakefield	
17	71.1500	N	N	SF	F	A	12x40	N			Cushman and Wakefield	
18	71.2500	N	PERP	SF	F	A	12x9	N			Armkl LLS Med	
19	71.6500	S	S	DF	F	A	12x9	Y, Int			Sunoco	
20	72.2000	S	NS	DF	V	NA	14x48	Y, Ext	Viacom		Amerihealth	
21	72.4000	S	NS	DF	V	NA	14x48	Y, Ext	Elray		Holiday Inn	
22	72.5000	N	NS	DF	V	NA	14x48	Y, Ext	Viacom		Nestea	
23	72.6000	S	NS	DF	V	NA	14x48	Y, Ext	Elray		Full Body Health	
24	72.9000	S	NS	DF	V	NA	14x48	Y, Ext	Viacom		Monmouth Park Racetrack	
25	73.1700	S	NS	DF	V	NA	14x48	Y, Ext	Clear Channel		Jack Daniels	
26	74.2500	S	N	SF	F	A	12x30	Y, Ext			Forsgate Ind Comp	
27	74.7300	N	NS	DF	V	NA	14x48	Y, Ext	Clear Channel	032115		
28	74.9400	N	NS	DF	V	NA	14x48	Y, Ext			Lexus	
29	75.0000	S	NS	DF	V	NA	14x48	Y, Ext	Matrix		Maint Soln	
30	75.2300	S	NS	DF	V	NA	14x48	Y, Ext	Matrix		Air Natl Guard	
31	75.2700	N	NS	DF	V	NA	14x48	Y, Ext	Carole		NJ Lot	
32	75.9000	S	PERP	SF	F	A	14x48	N			Local 825	
33	76.2000	N	NS	DF	V	NA	14x48	Y, Ext	Carole		Apple Vaca	
34	77.5300	N	N	SF	F	NA	12x9	N			Sunoco	
35	77.9000	N	NS	DF	V	NA	14x48	Y, Ext	Matrix		Open Road	
36	78.1000	N	NS	DF	V	NA	14x48	Y, Ext	Matrix		Open Road	
37	78.3000	N	N	SF	F	NA	12x9	N			Sunoco	
38	80.8000	N	NS	DF	V	NA	14x48	Y, Ext	Morel		Hilton	
39	80.9700	N	NS	DF	V	NA	14x48	Y, Ext	Morel		Read Hebrew	
40	81.5000	N	NS	DF	V	NA	14x48	Y, Ext	Carole		Brian Tracy	
41	83.1000	N	NS	DF	V	NA	14x48	Y, Ext	Next Media	077	Nestea	
42	85.1000	N	NS	DF	V	NA	14x48	Y, Ext			Hellen Ind Parks	
43	88.8000	N	NS	DF	V	NA	14x48	Y, Ext	Clear Channel	032103	SUV	
44	90.6000	S	NS	DF	V	NA	14x48	Y, Ext	Next Media		Wegman's	
45	91.2000	MID	N	SF	F	NA	12x9	N			Sunoco	
46	93.6000	S	NS	DF	V	NA	12x40	Y, Ext	Viacom		Verizon	

Figure A1-2. Sample of Survey Data of Signs on New Jersey Turnpike

APPENDIX A.2

Comparison of Sign Data with Number of Accidents for 1998-2001

Sign Density and Number of Accidents
Distance with VRD and Number of Accidents
Distance to Nearest Sign and Number of Accidents

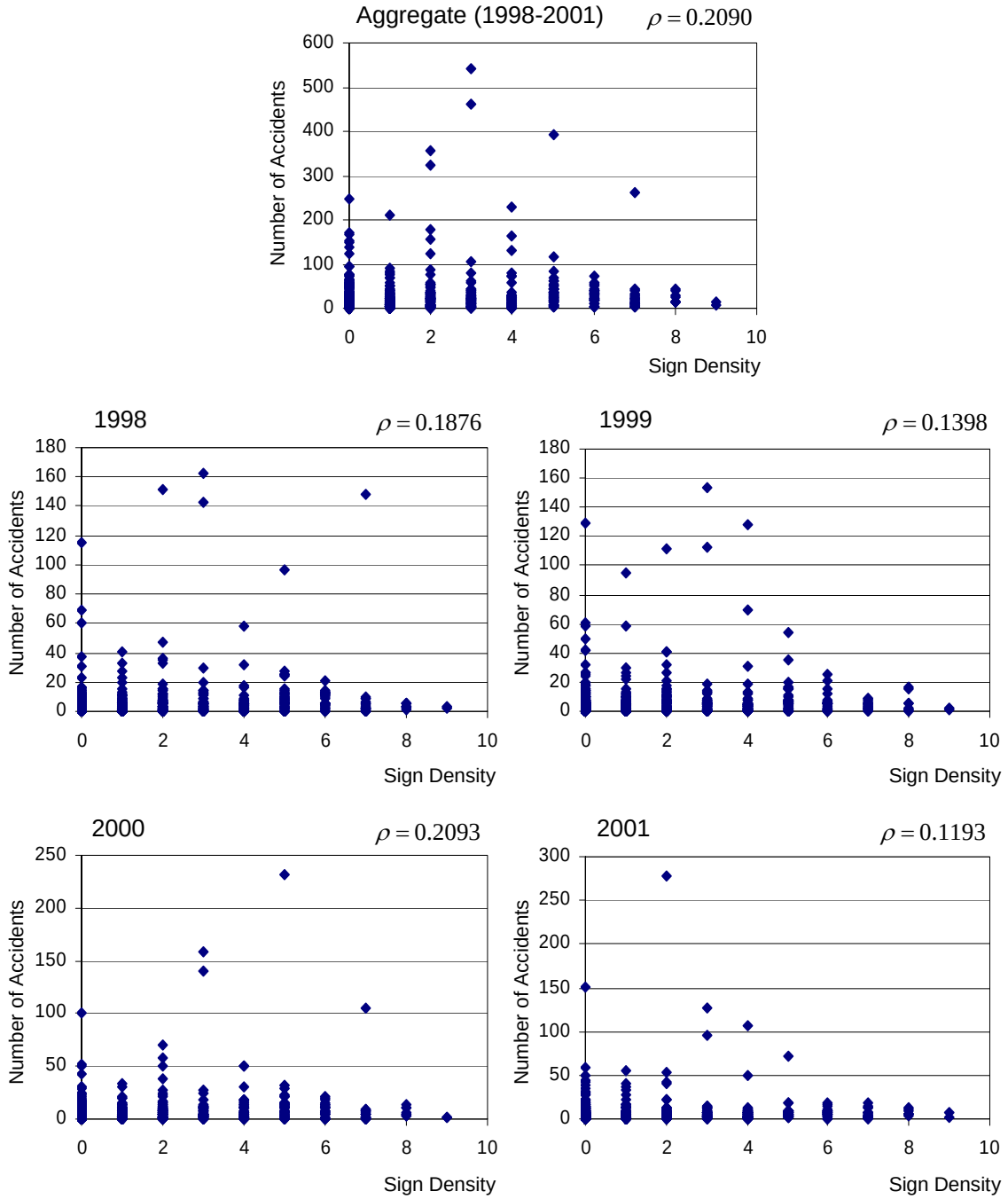


Figure A2-1. Aggregate (1998-2001) Sign Density and Number of Accidents with Interchange Bias

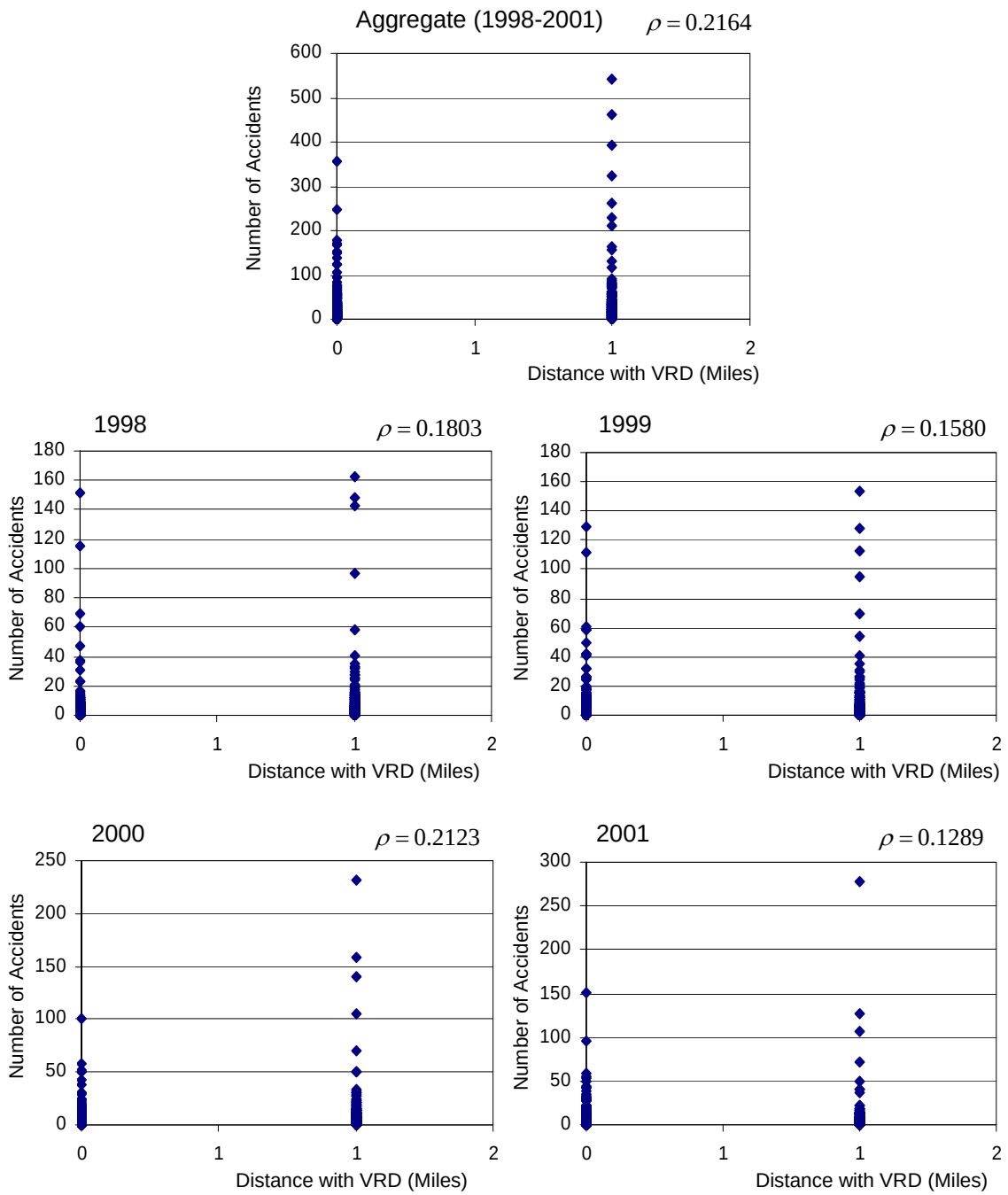


Figure A2-2. Aggregate (1998-2001) Distance with VRD and Number of Accidents with Interchange Bias

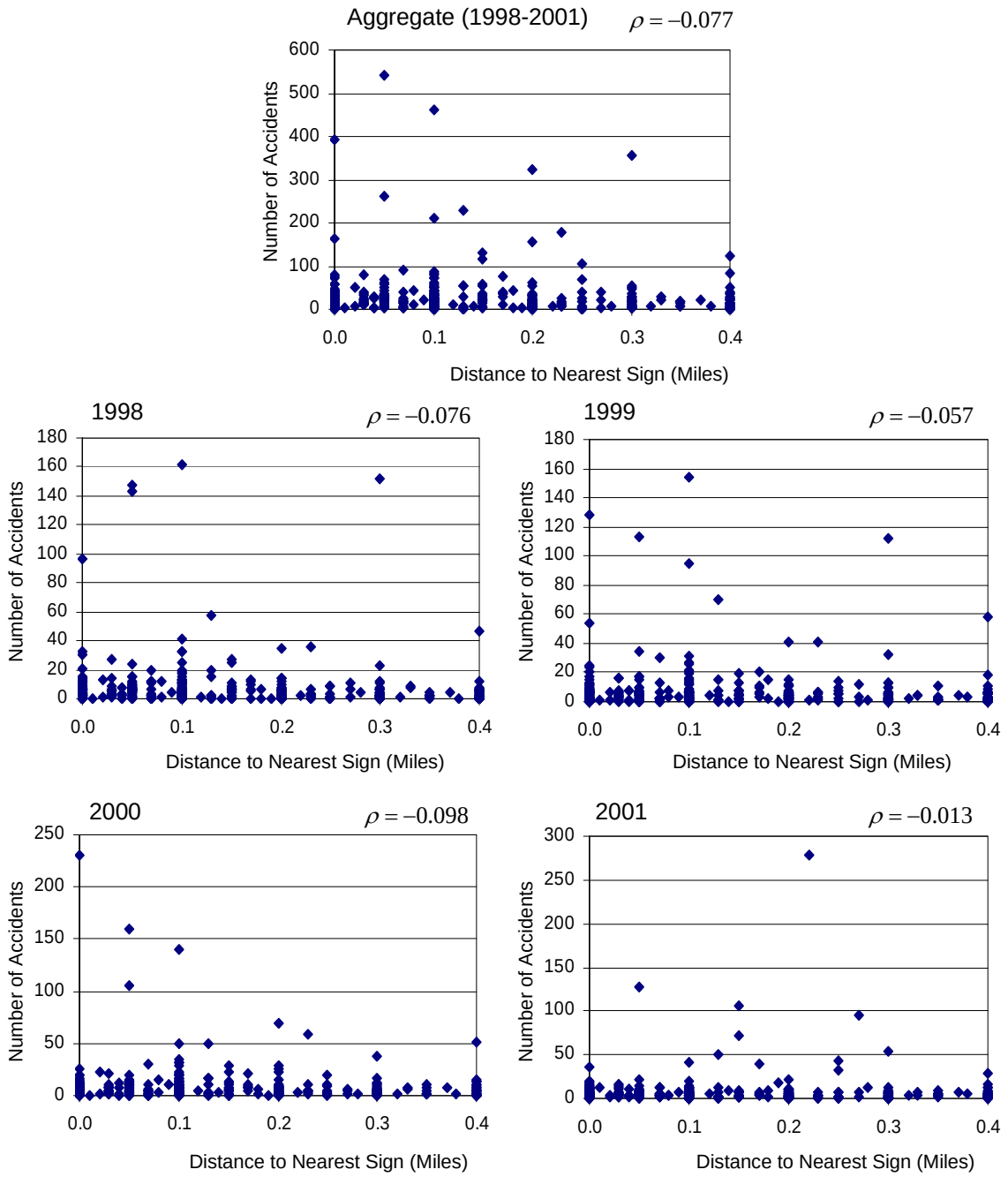


Figure A2-3. Aggregate (1998-2001) Distance to Nearest Sign and Number of Accidents with Interchange Bias

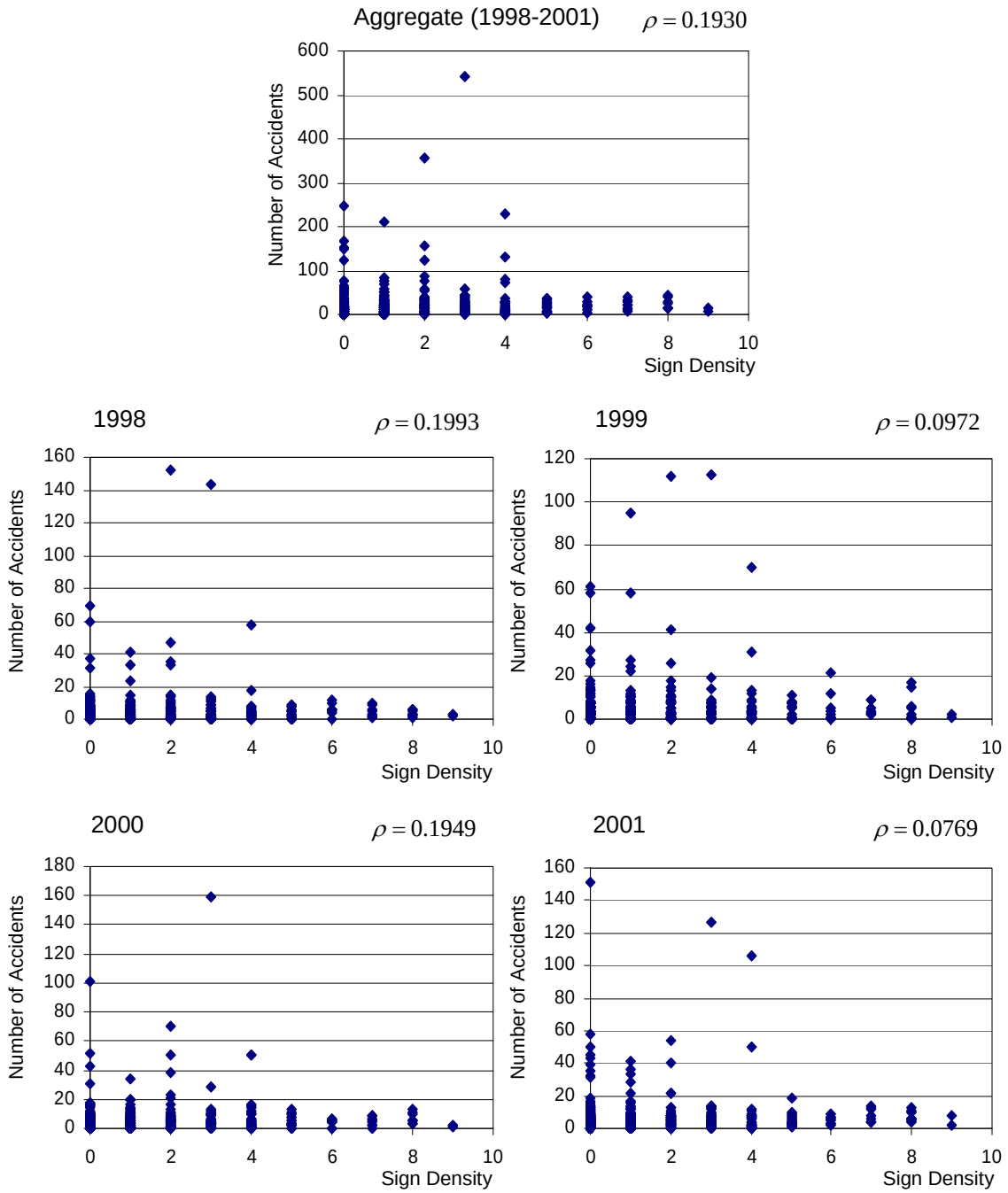


Figure A2-4. Aggregate (1998-2001) Sign Density and Number of Accidents without Interchange Bias

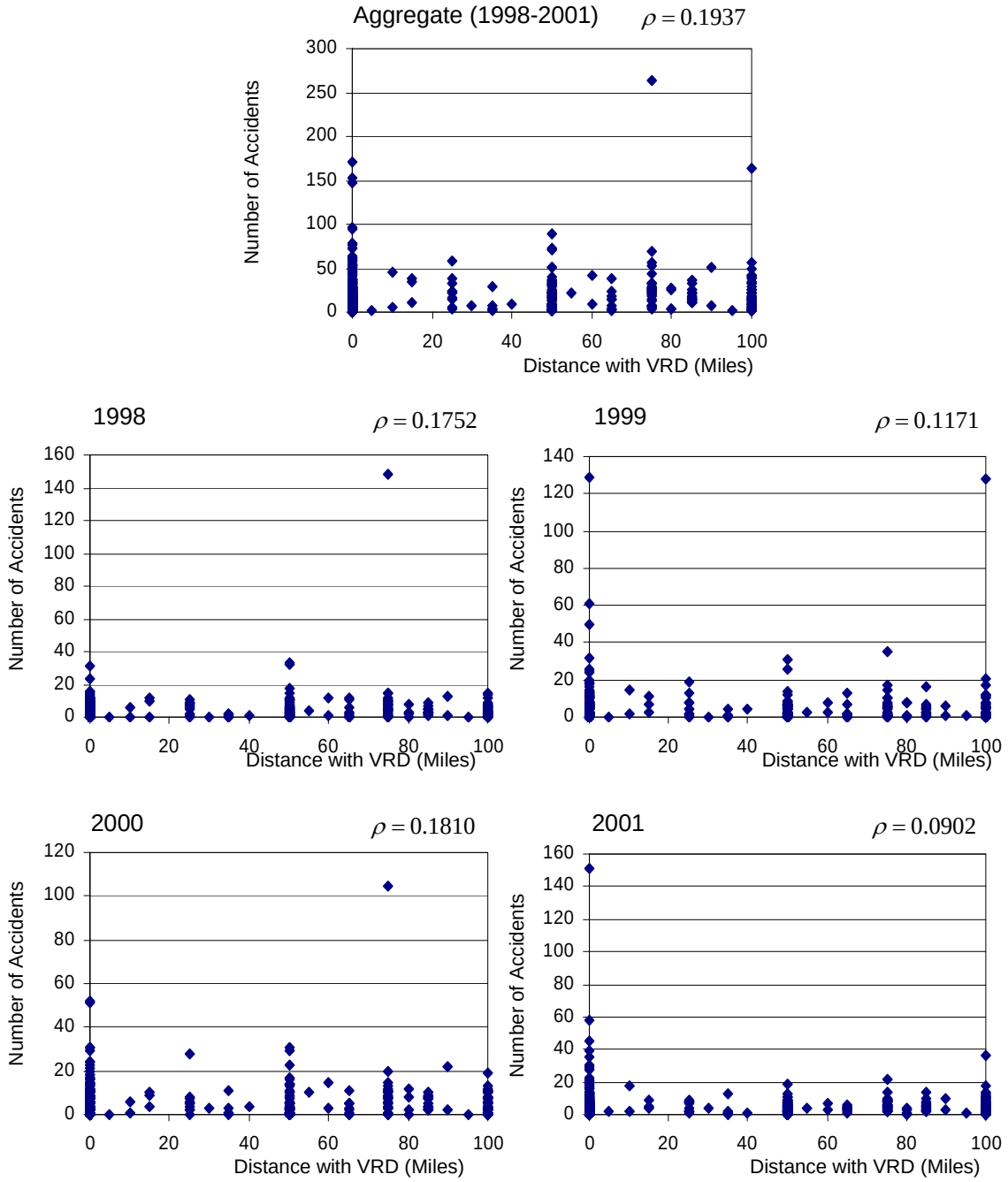


Figure A2-5. Aggregate (1998-2001) Distance with VRD and Number of Accidents without Interchange Bias

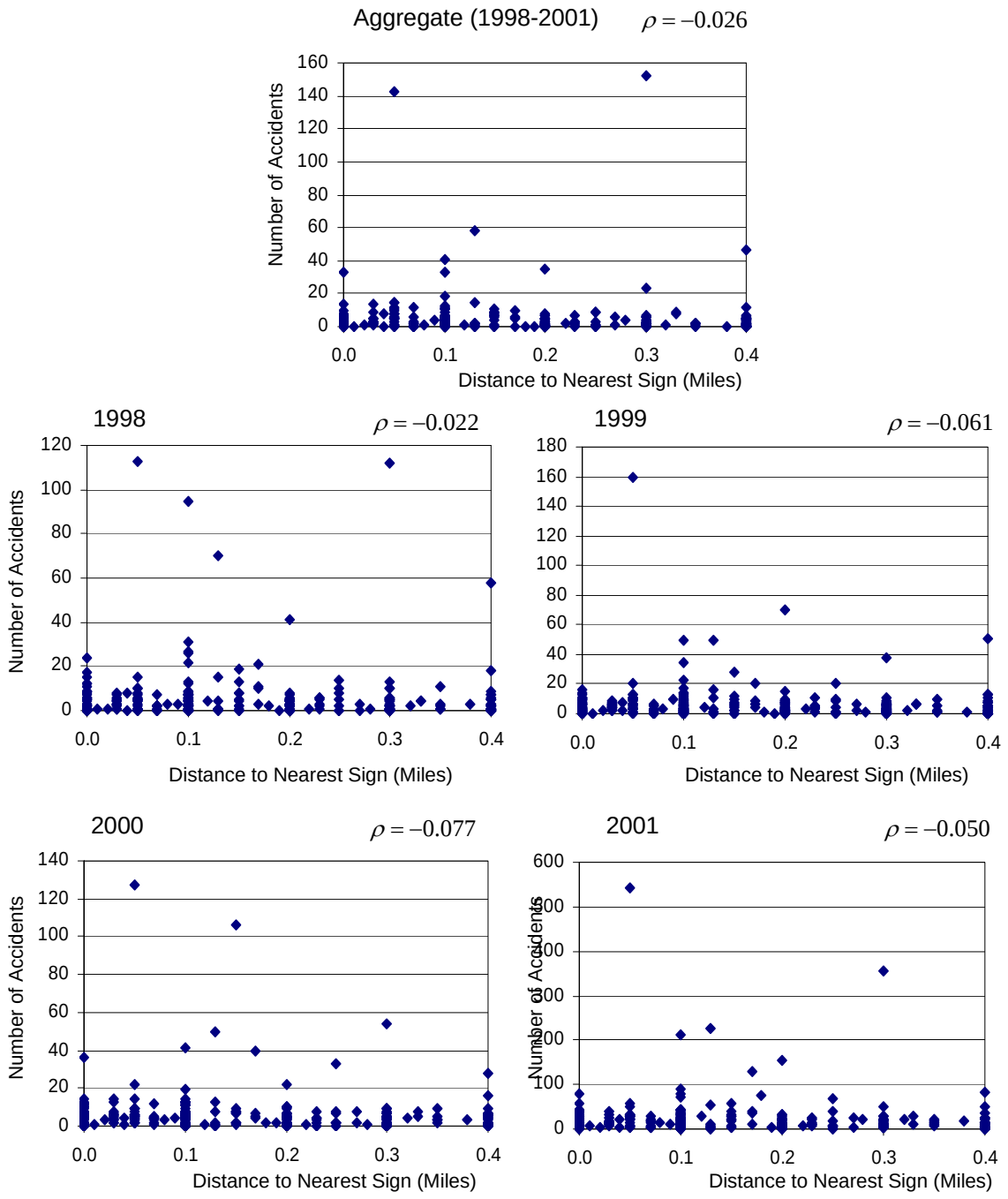


Figure A2-6. Aggregate (1998-2001) Distance to Nearest Sign and Number of Accidents without Interchange Bias

APPENDIX A.3

Accident and Sign Density Figures

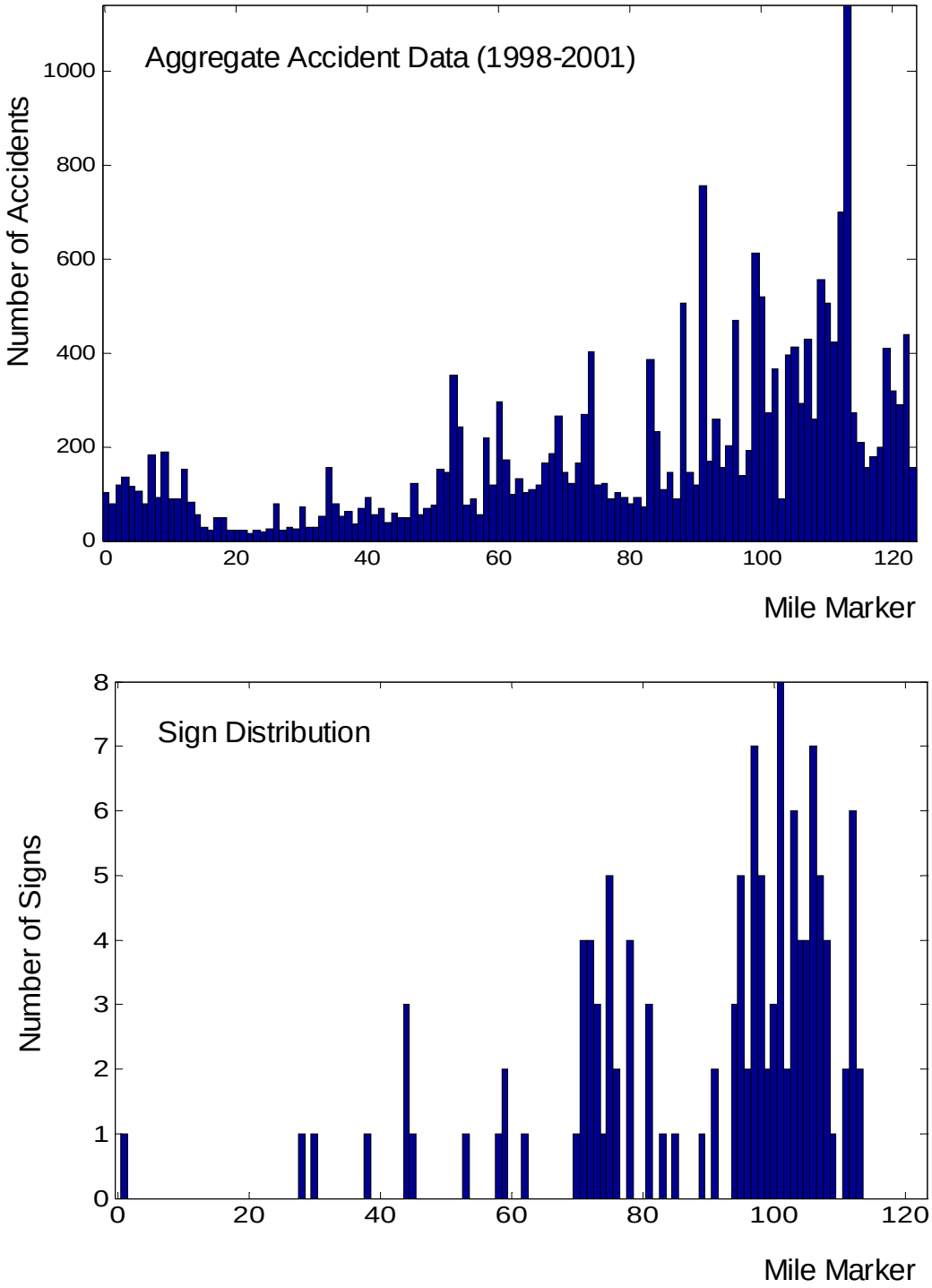


Figure A3-1. Comparison of 1998-2001 Accidents with Sign Locations by Mile Marker

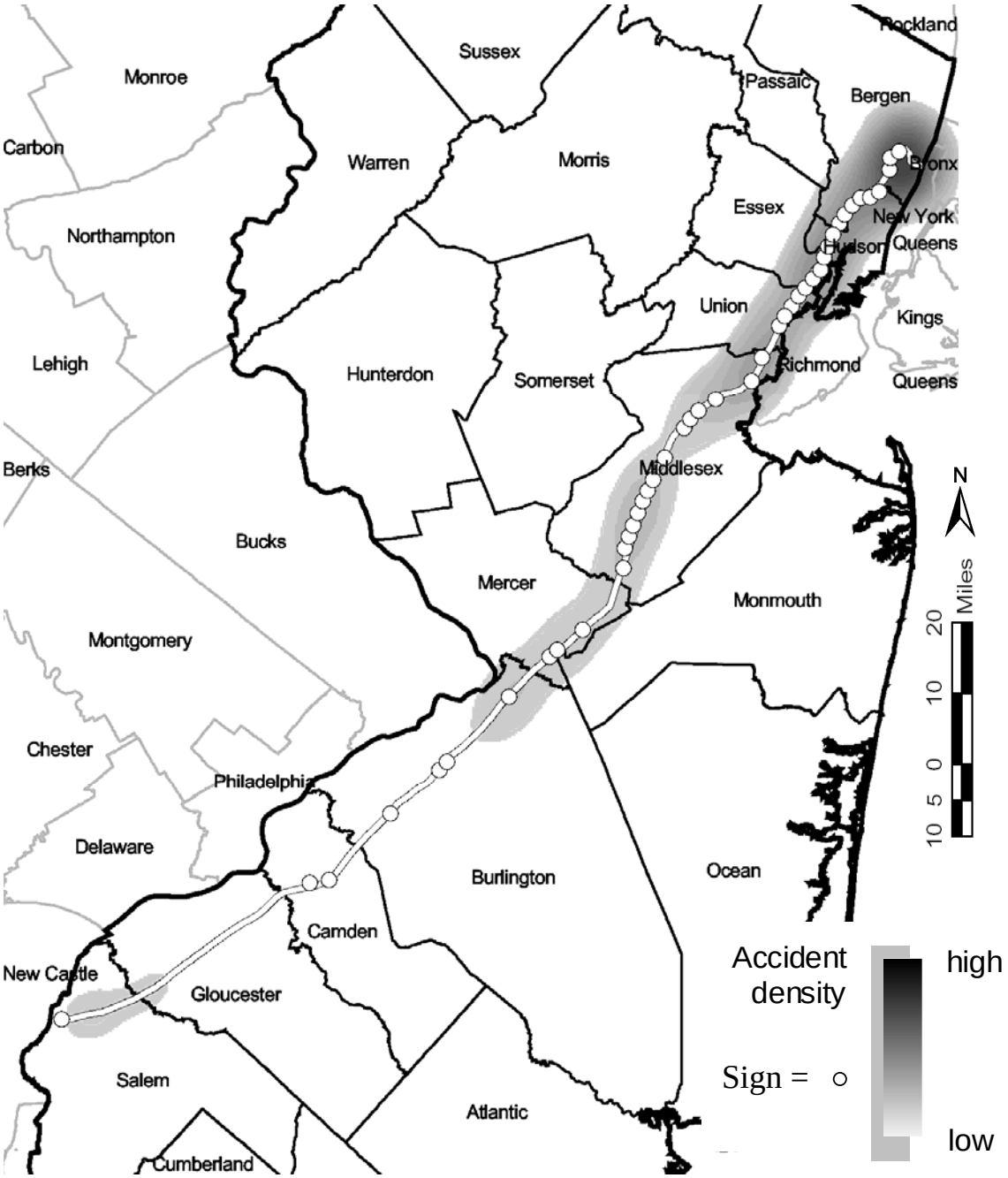


Figure A3-2. Aggregate Accident Densities (1998-2001)

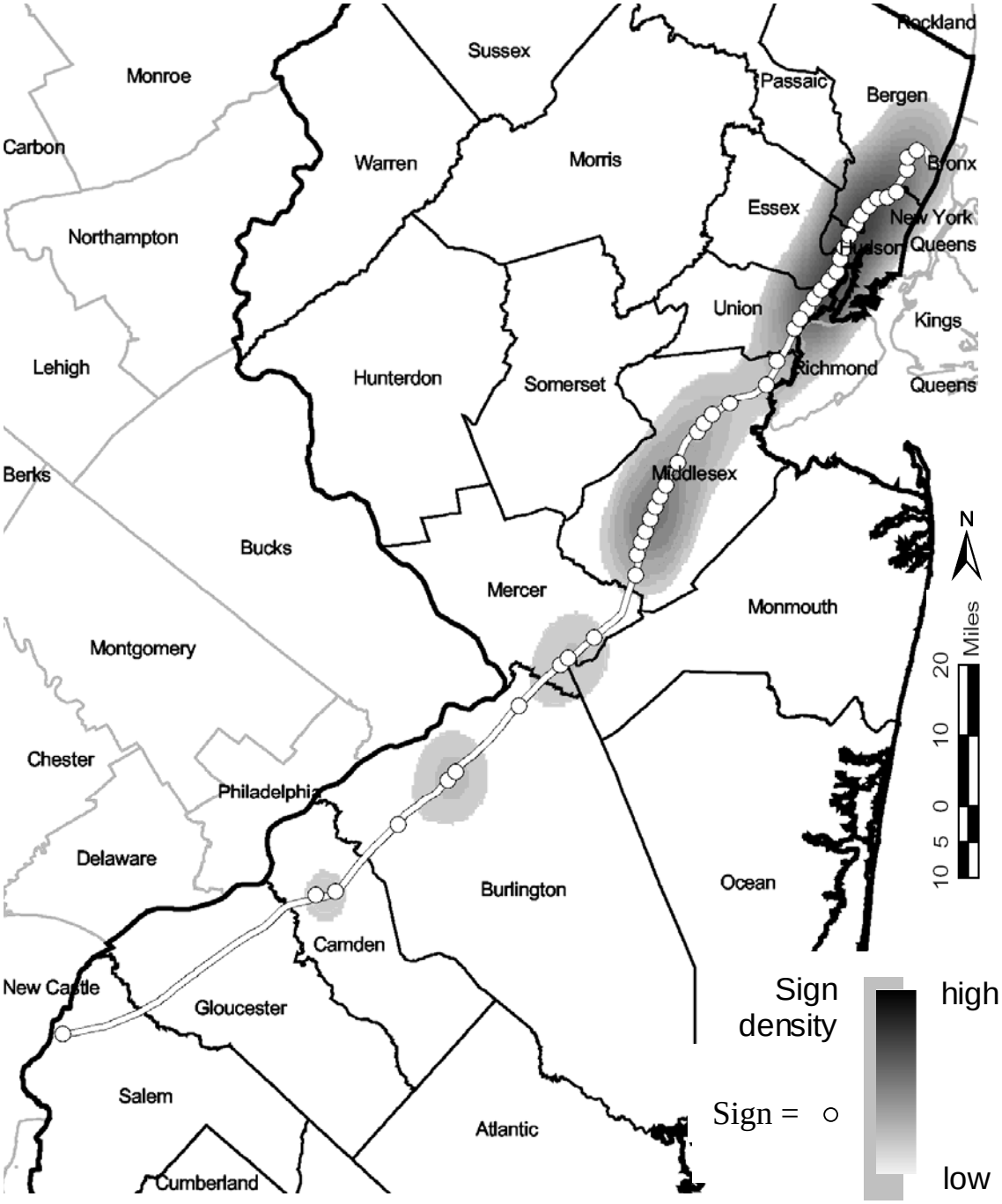


Figure A3-3. Sign Density

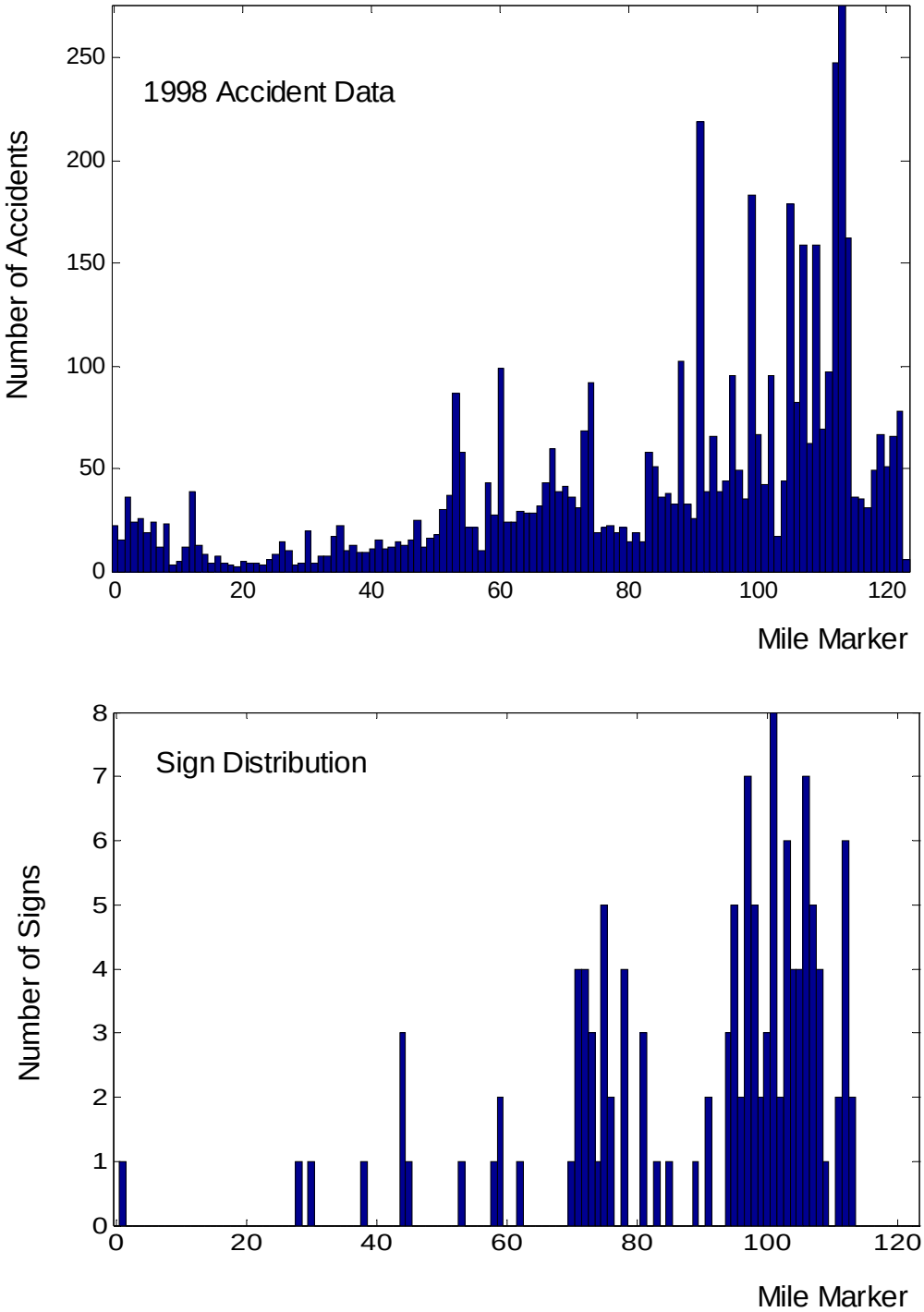


Figure A3-4. Comparison of 1998 Accidents with Sign Locations by Mile Marker

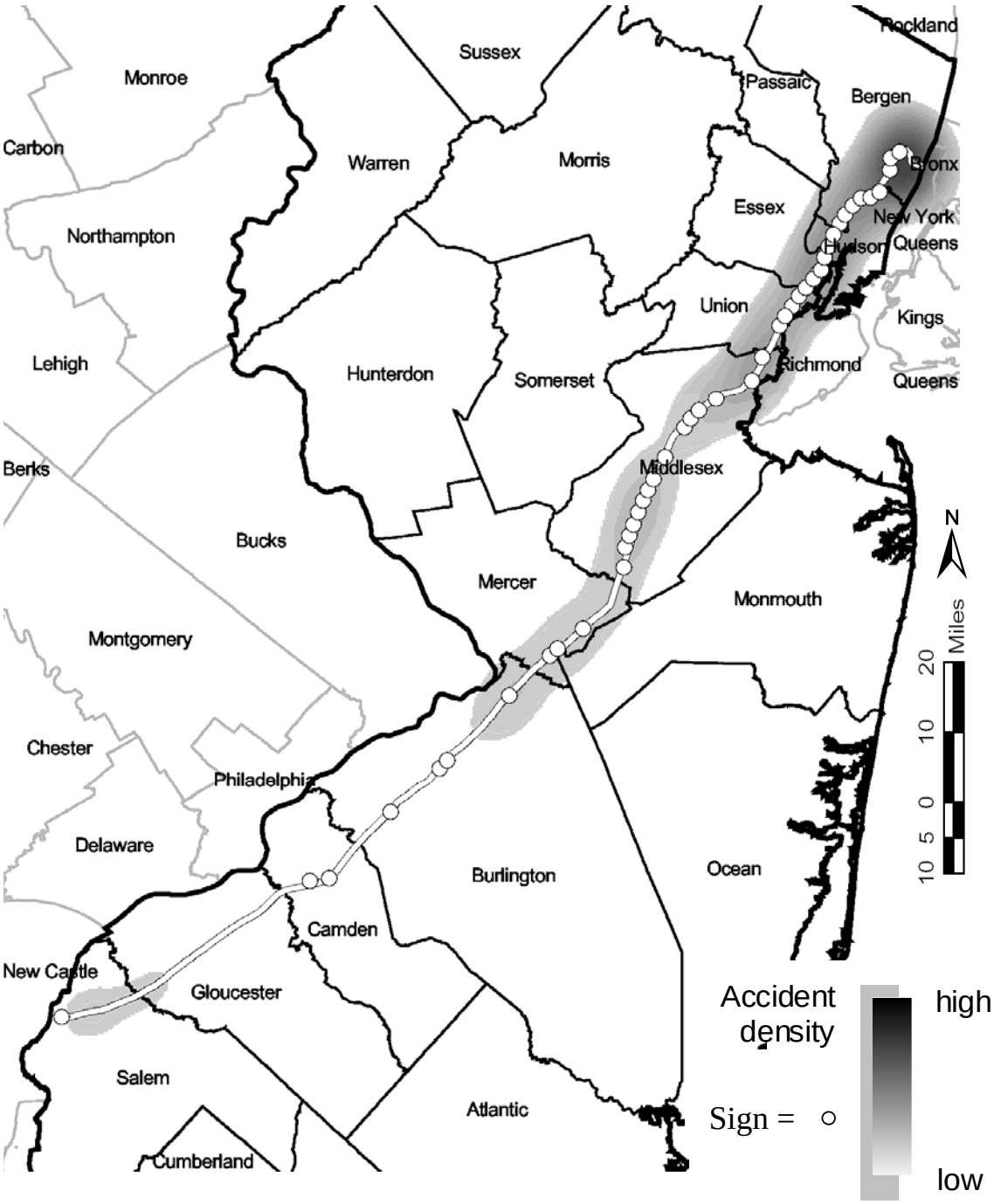


Figure A3-5. Accident Density for 1998

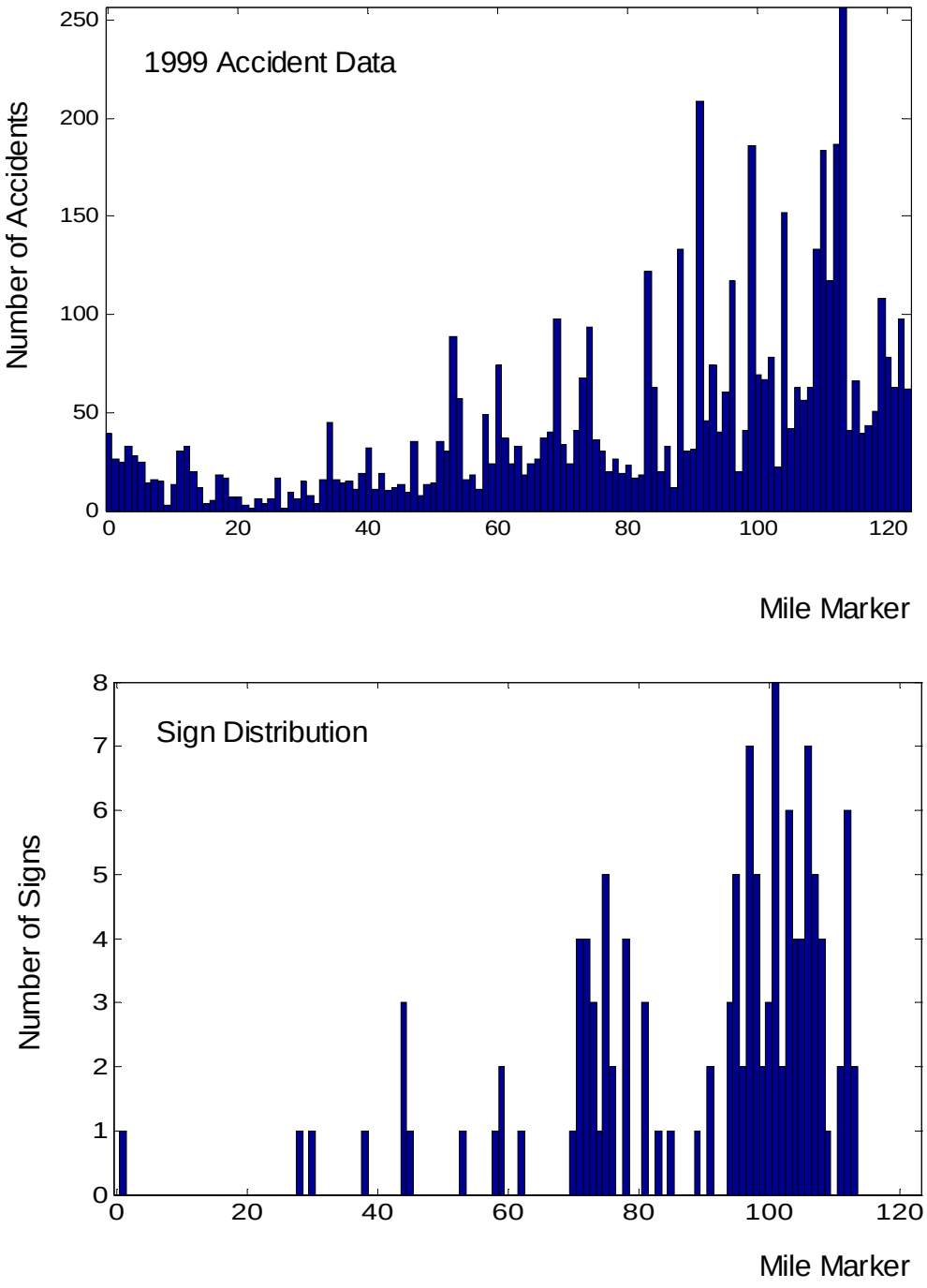


Figure A3-6. Comparison of 1999 Accidents with Sign Locations by Mile Marker

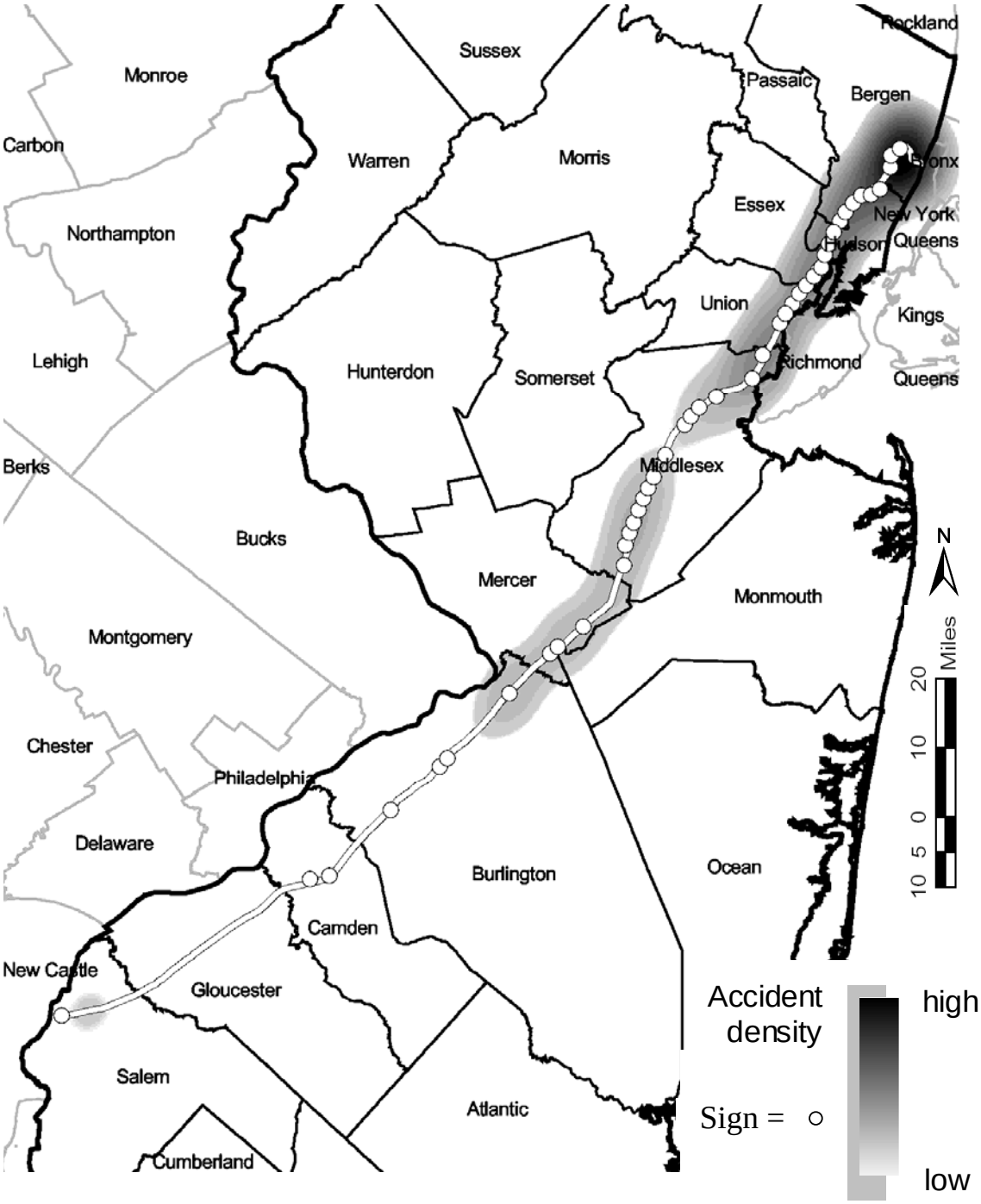


Figure A3-7. Accident Density for 1999

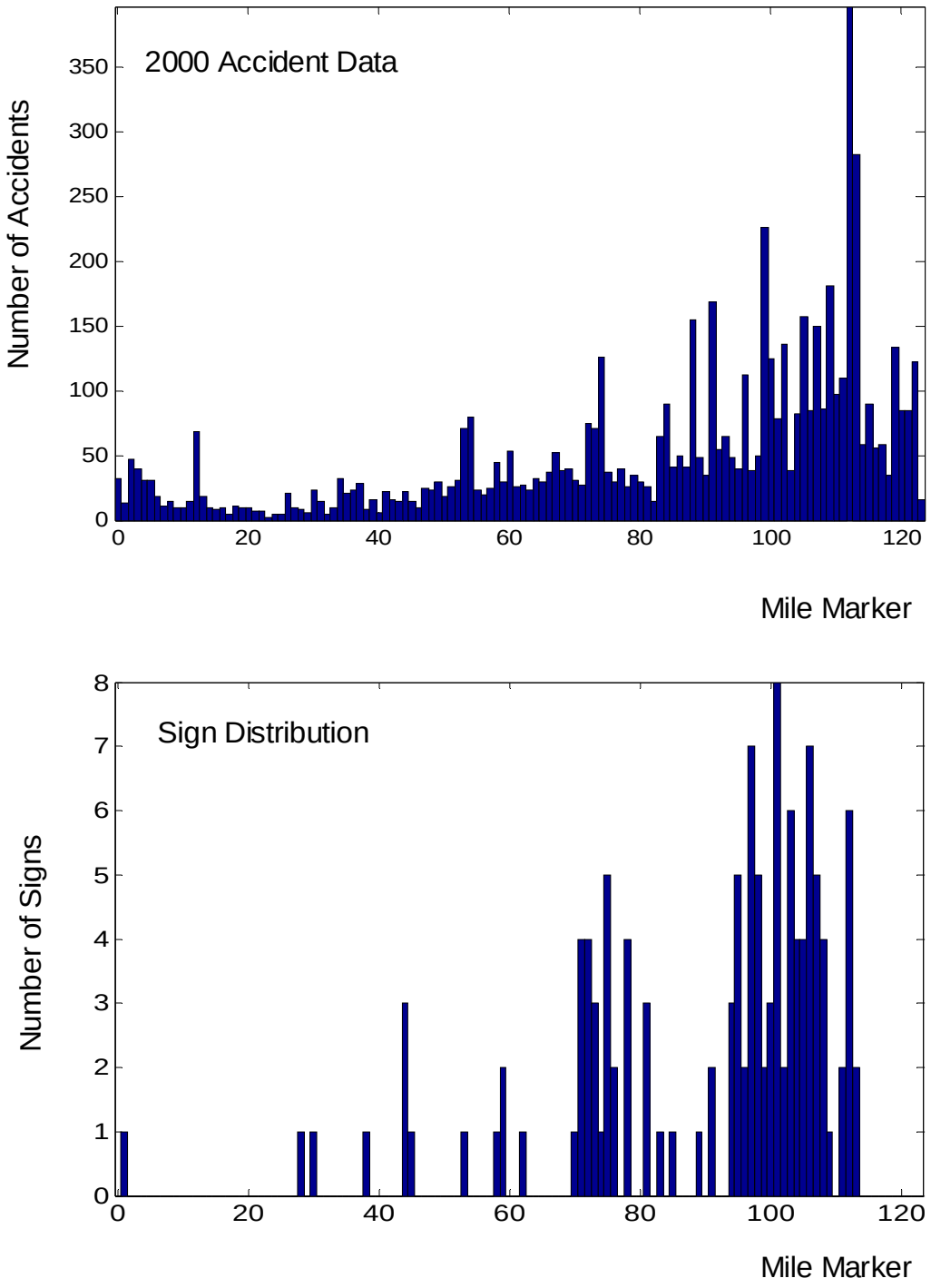


Figure A3-8. Comparison of 2000 Accidents with Sign Locations by Mile Marker

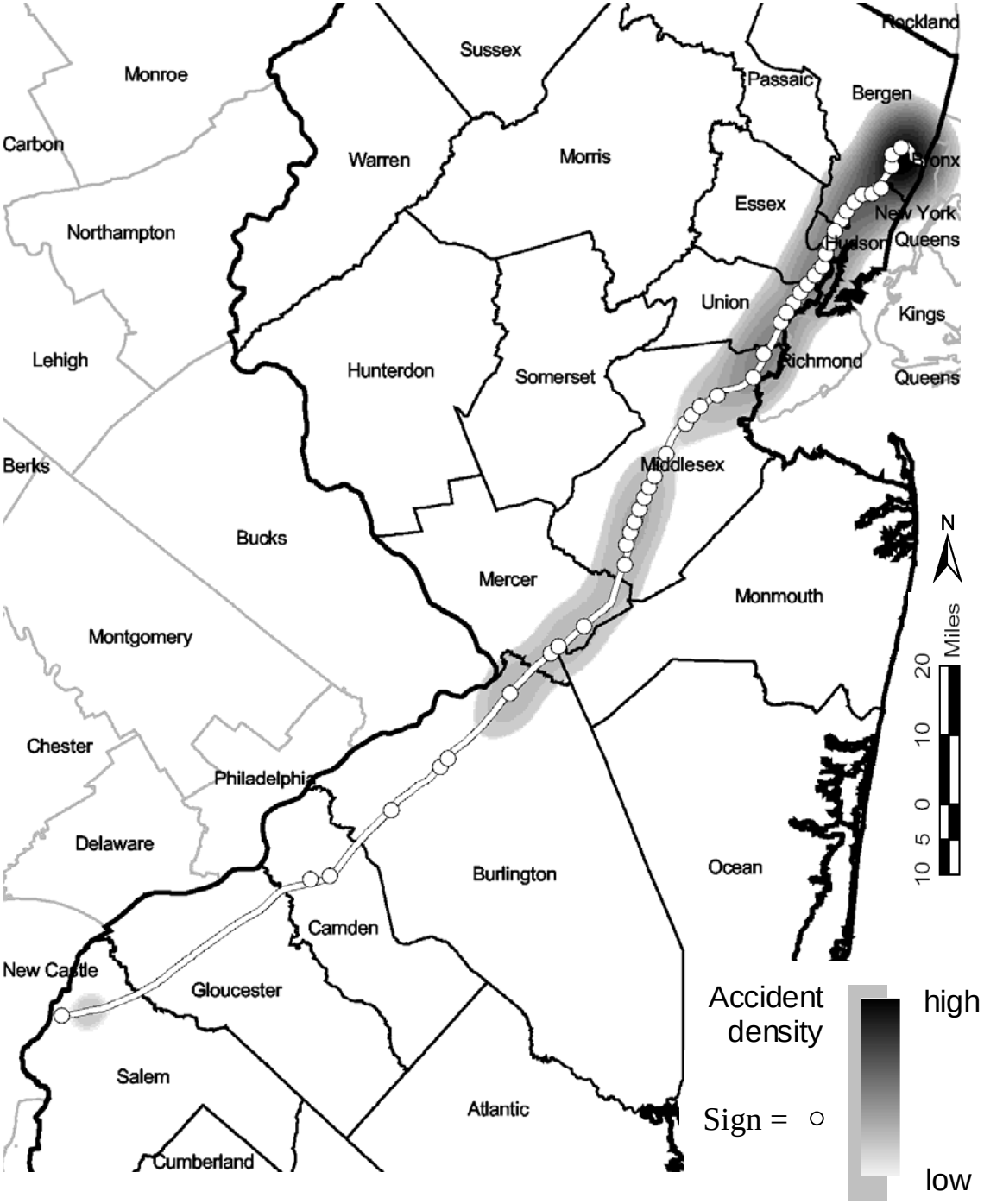
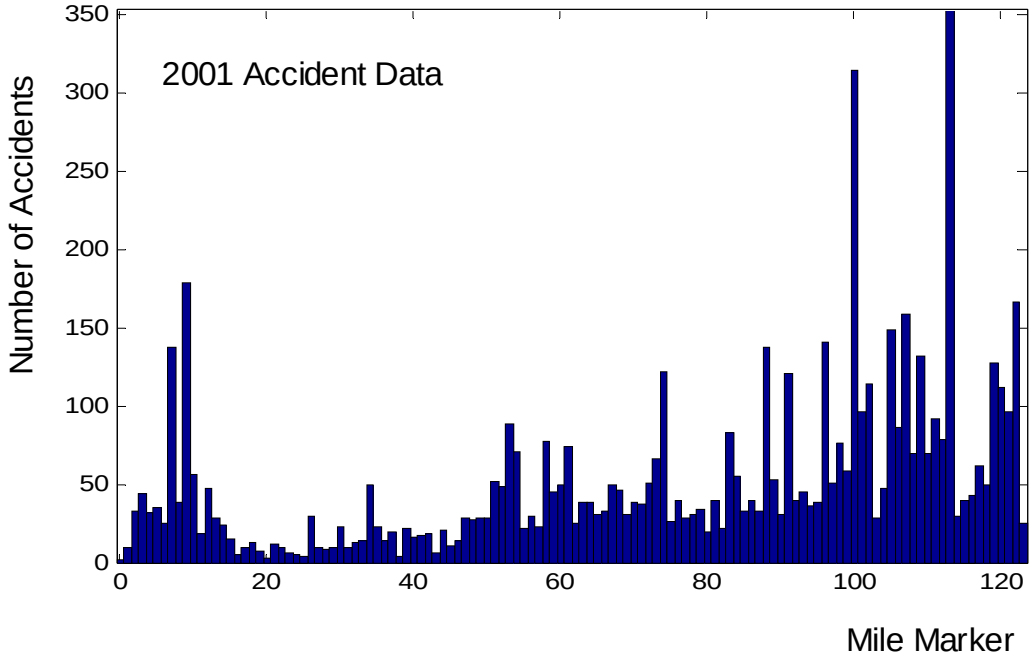


Figure A3-9. Accident Density for 2000



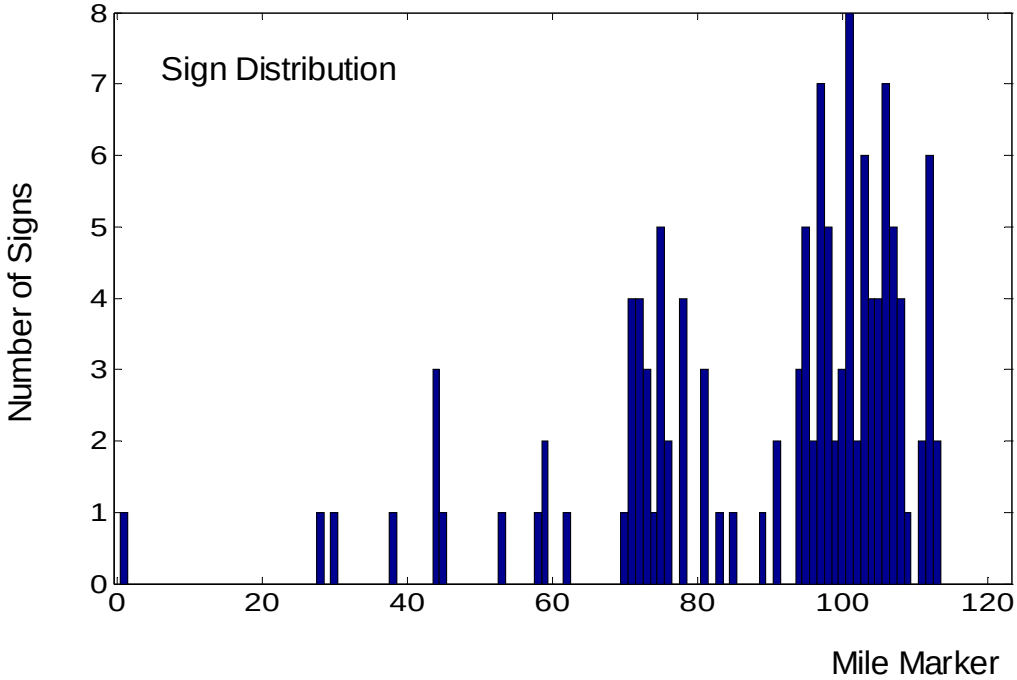


Figure A3-10. Comparison of 2001 Accidents with Sign Locations by Mile Marker

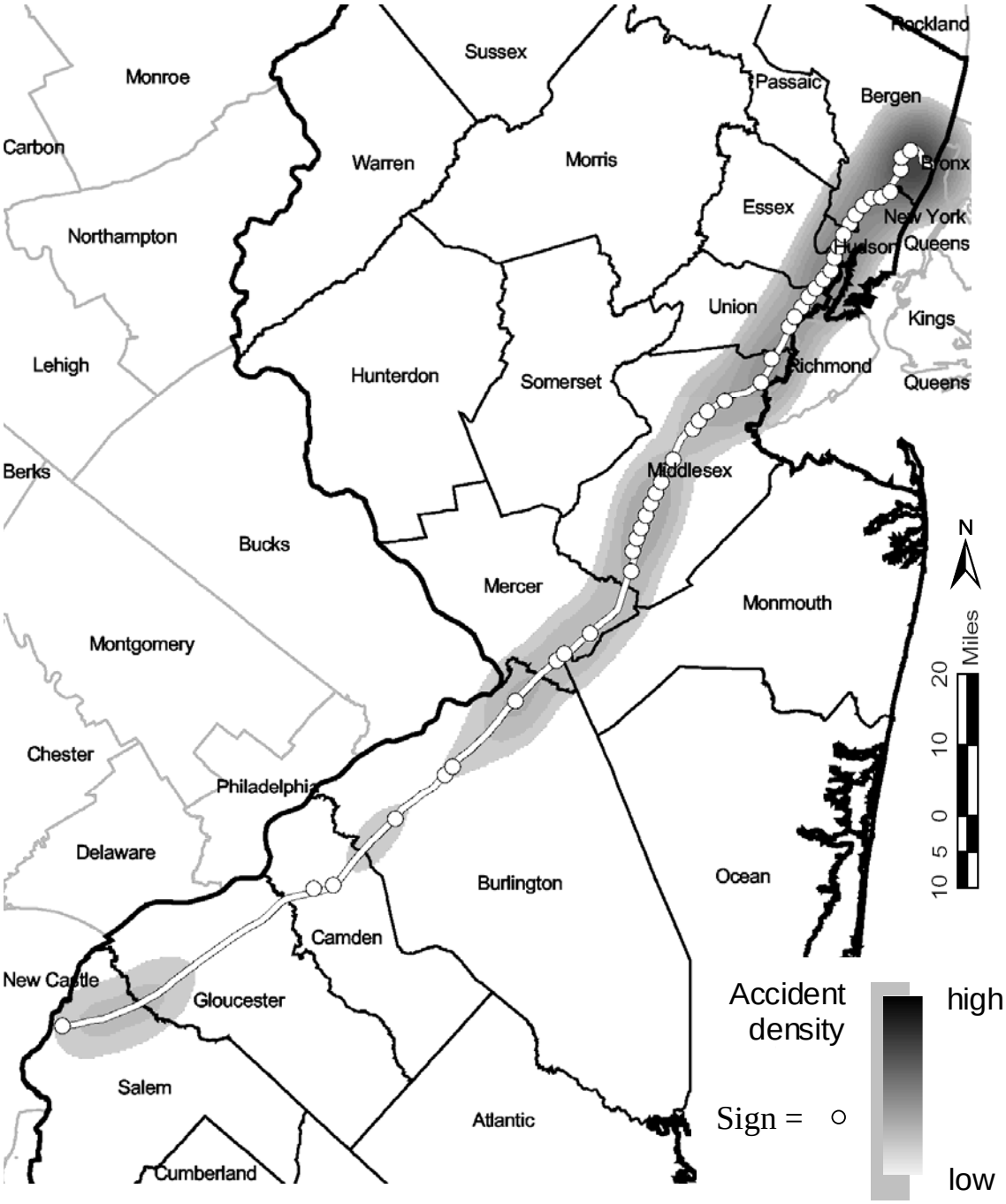


Figure A3-11. Accident Density for 2001

APPENDIX A.4

Compiled Accident Data from *PennDOT* Police Accident Reports for the Lincoln Highway and Woodbourne Road Intersection

2001 Accidents			2002 Accidents		
No.	Date of Accident	Principal Location	No.	Date of Accident	Principal Location
1	1/2/01	Woodbourne Road	64	1/3/02	Woodbourne Road
2	1/2/01	Woodbourne Road	65	1/15/02	South Woodbourne Road
3	1/5/01	East Lincoln Highway	66	1/21/02	South Woodbourne Road
4	1/6/01	East Lincoln Highway	67	1/25/02	South Woodbourne Road
5	1/6/01	North Woodbourne Road	68	1/27/02	South Woodbourne Road
6	1/13/01	East Lincoln Highway	69	1/31/02	South Woodbourne Road
7	1/31/01	South Woodbourne Road	70	2/5/02	East Lincoln Highway
8	2/3/01	East Lincoln Highway	71	2/13/02	South Woodbourne Road
9	2/5/01	East Lincoln Highway	72	2/18/02	East Lincoln Highway
10	2/7/01	East Lincoln Highway	73	2/23/02	South Woodbourne Road
11	2/15/01	South Woodbourne Road	74	3/14/02	East Lincoln Highway
12	2/18/01	East Lincoln Highway	75	3/19/02	East Lincoln Highway
13	2/18/01	East Lincoln Highway	76	3/23/02	East Lincoln Highway
14	2/28/01	East Lincoln Highway	77	3/23/02	East Lincoln Highway
15	3/2/01	South Woodbourne Road	78	4/19/02	East Lincoln Highway
16	3/10/01	South Woodbourne Road	79	4/23/02	South Woodbourne Road
17	3/16/01	South Woodbourne Road	80	4/25/02	East Lincoln Highway
18	3/21/01	South Woodbourne Road	81	4/29/02	South Woodbourne Road
19	3/31/01	East Lincoln Highway	82	5/8/02	South Woodbourne Road
20	3/31/01	East Lincoln Highway	83	5/28/02	East Lincoln Highway
21	3/31/01	South Woodbourne Road	84	6/5/02	South Woodbourne Road
22	4/1/01	East Lincoln Highway	85	6/6/02	South Woodbourne Road
23	4/6/01	East Lincoln Highway	86	6/11/02	North Woodbourne Road
24	4/22/01	South Woodbourne Road	87	6/11/02	East Lincoln Highway
25	4/23/01	South Woodbourne Road	88	6/25/02	South Woodbourne Road
26	4/26/01	South Woodbourne Road	89	6/27/02	East Lincoln Highway
27	4/27/01	East Lincoln Highway	90	7/1/02	North Woodbourne Road
28	5/19/01	South Woodbourne Road	91	7/3/02	North Woodbourne Road
29	5/19/01	East Lincoln Highway	92	7/10/02	East Lincoln Highway
30	5/30/01	South Woodbourne Road	93	7/14/02	South Woodbourne Road
31	5/31/01	South Woodbourne Road	94	7/22/02	East Lincoln Highway
32	6/17/01	East Lincoln Highway	95	7/27/02	South Woodbourne Road
33	6/21/01	South Woodbourne Road	96	8/8/02	Woodbourne Road
34	6/23/01	East Lincoln Highway	97	8/8/02	South Woodbourne Road
35	7/1/01	East Lincoln Highway	98	8/9/02	South Woodbourne Road
36	7/2/01	East Lincoln Highway	99	8/10/02	South Woodbourne Road
37	7/6/01	East Lincoln Highway	100	8/23/02	East Lincoln Highway
38	7/14/01	North Woodbourne Road	101	9/4/02	Woodbourne Road
39	7/19/01	South Woodbourne Road	102	9/6/02	East Lincoln Highway
40	7/20/01	South Woodbourne Road	103	9/9/02	Woodbourne Road
41	7/20/01	East Lincoln Highway	104	9/12/02	East Lincoln Highway
42	8/2/01	North Woodbourne Road	105	9/23/02	East Lincoln Highway
43	8/2/01	Woodbourne Road	106	9/24/02	East Lincoln Highway
44	8/24/01	East Lincoln Highway	107	9/28/02	East Lincoln Highway
45	8/29/01	South Woodbourne Road	108	10/3/02	South Woodbourne Road
46	9/9/01	South Woodbourne Road	109	10/18/02	North Woodbourne Road

Figure A4-1. 2001 and 2002 Compiled Accident Data from *PennDOT* Police Accident Reports at the Lincoln Highway and Woodbourne Road Intersection

2001 Accidents

No.	Date of Accident	Principal Location
47	9/19/01	East Lincoln Highway
48	9/19/01	South Woodbourne Road
49	10/8/01	East Lincoln Highway
50	10/11/01	East Lincoln Highway
51	10/14/01	East Lincoln Highway
52	10/18/01	East Lincoln Highway
53	10/31/01	East Lincoln Highway
54	10/31/01	South Woodbourne Road
55	11/9/01	East Lincoln Highway
56	11/15/01	South Woodbourne Road
57	11/23/01	East Lincoln Highway
58	11/29/01	East Lincoln Highway
59	12/10/01	East Lincoln Highway
60	12/19/01	East Lincoln Highway
61	12/20/01	South Woodbourne Road
62	12/22/01	East Woodbourne Road
63	12/26/01	East Lincoln Highway

2002 Accidents

No.	Date of Accident	Principal Location
110	10/25/02	East Lincoln Highway
111	10/27/02	East Lincoln Highway
112	10/30/02	East Lincoln Highway
113	11/5/02	East Lincoln Highway
114	11/9/02	Woodbourne Road
115	11/16/02	South Woodbourne Road
116	11/16/02	East Lincoln Highway
117	11/19/02	South Woodbourne Road
118	11/29/02	East Lincoln Highway
119	12/1/02	East Lincoln Highway
120	12/6/02	East Lincoln Highway
121	12/6/02	East Lincoln Highway
122	12/7/02	East Lincoln Highway
123	12/10/02	East Lincoln Highway
124	12/11/02	North Woodbourne Road
125	12/12/02	East Lincoln Highway
126	12/14/02	South Woodbourne Road
127	12/18/02	East Lincoln Highway
128	12/28/02	East Lincoln Highway

Figure A4-1 (continued). 2001 and 2002 Compiled Accident Data from *PennDOT* Police Accident Reports at the Lincoln Highway and Woodbourne Road Intersection

USSC **FOUNDATION**

538 North Street
Doylestown PA 18901
215-785-1922
www.usscfoundation.org