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EVALUATING THE 65 MPH SPEED LIMIT: RESEARCH DESIGN AND BASELINE DATA

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16. Abstract

This interim report on the effect of Michigan's increase in speed limit to 65 mph on limited access highways summarizes activity during the first year of a two-year project. We: (1) review national and Michigan experience with the 55 mph speed limit, (2) present methods to be used to determine effects of the recent increase to 65 mph, and (3) describe patterns in 1978-1986 crash, speed, and VMT data. In the project's second year we will: (1) update database and time-series files with 1987 and 1988 calendar year data; (2) develop time-series models for each outcome variable; (3) compare observed effects across road segments with varying speed limits; (4) examine speed limit effects by age, sex, number and type of vehicles involved in the crash, vehicle damage severity, injury severity, and whether speed was reported to be a contributing factor to the crash; and (5) provide recommendations regarding speed limits on rural highways in light of project findings.

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1 INTRODUCTION

The central question addressed in this research is: What are the effects on motor vehicle crash involvement and severity of increasing the maximum speed limit on Michigan's rural interstates (and other rural highways built to interstate standards) from 55 to 65 mph? In April, 1987, U.S. Senate Bill HR-2 was passed enabling states to raise the maximum speed limit to 65 mph on rural interstates. Michigan's governor signed Public Act 154 of 1987 on October 29, 1987 increasing speed limits on segments of Michigan's rural interstates from 55 to 65 mph. New speed limit signs were in place and the speed limit was officially increased to 65 mph on Michigan's rural interstate system on November 27, 1987. Furthermore, as a part of the massive budget reconciliation package passed late in December, 1987, the U.S. Congress authorized a four-year demonstration project in which 20 states would be permitted to increase maximum speed limits from 55 to 65 mph on **non**interstate highways built to interstate standards. New 65 mph speed limit signs were in place and the new limit was in force on all affected sections of rural noninterstate highways built to interstate standards by the end of January, 1988.

Adequate data are not yet available to evaluate Michigan's experience with the change from 55 to 65 mph. Because of the inevitable delay in keypunching the hundreds of thousands of police crash reports in the state, this interim report discusses the research design, data collection to date, and crash patterns over the 1978-1986 baseline period. Before we turn to the methods and data of the current research, the experience with the 1974 reduction in U.S. speed limits to 55 mph is reviewed. We also briefly discuss early reports from other states which have increased their speed limits from 55 to 65 mph.

1.1 National Experience with the Maximum 55 mph Speed Limit

Research on the national experience with the 55 mph speed limit policy was summarized by the National Research Council, Transportation Research Board in a report titled "55: A Decade of Experience" (1984). The interdisciplinary committee completing this report included 19 experts from the fields of statistics, highway safety, economics, trucking, insurance, law enforcement, medical services, transportation administration, traffic engineering, law, sociology, motor vehicle design, and public policy. The committee presented findings concerning the effects of the 55 mph speed limit on speed, safety, energy consumption, and related costs.

1.1.1 Effects of 55 Limit on Speed

The 55 mph speed limit caused a decrease in average highway speeds on rural interstates primarily by reducing the percentage of motorists driving at extremely high speeds. The percentage of drivers exceeding 65 mph on rural interstates declined from 50 to 9 percent during the first year the 55 mph speed limit was in effect. The average speed on rural interstates in 1973 (prior to the 55 mph limit) was 65 mph. Average speed declined to 57 mph in 1974 (the first year of the 55 mph limit); average speeds increased to 59.1 mph by 1983.

A number of changes took place in how speeds were sampled, measured, and reported between 1973 and 1983. Prior to 1976 some states did not report speed data to the Federal Highway Administration. Despite changes in sampling, measurement, and reporting of speeds from 1973 to 1983, speed data collected prior to 1976, between 1976 and 1980, and after 1980 are reasonably comparable within these time periods. Thus, the decrease in speed from 65 mph in 1973 to 57 mph in 1974 appears due to the change in the speed limit, and not to differences in speed data collection or reporting.

1.1.2 Effects of 55 Limit on Safety

Many variables influence motor vehicle crash fatality and injury rates. To estimate the effects attributable to the 1974 change in speed limit, factors other than speed were considered by the National Research Council committee, including: improved medical services available to crash victims, efforts to reduce alcohol-impaired driving, physical improvements to highways, introduction of more stringent motor vehicle standards, increased use of smaller cars, increased volume of heavy truck traffic, and fewer teenage and more elderly drivers.

Increases in the speed limit today will probably have less impact on safety than they would have had in 1973, according to the National Research Council. This is because of improvements in factors related to safety other than speed since 1973 that duplicate the protection afforded by the 55 mph limit. Adjusting for increased travel and improved safety, the 55 mph speed limit is estimated to have saved 3,000 to 5,000 lives annually in the early years of the 55 mph speed limit. Adjusting for increased travel, improved safety, and increased vehicle speeds in more recent years, the National Research Council estimated that 2,000 to 4,000 fewer fatalities occurred in 1983 as a result of the 55 mph speed limit.

Similarly, a decrease of 52,000 to 82,000 injuries in 1974 alone was attributable to the 55 mph speed limit. Of these, approximately 3,500 to 5,700 would have been serious, severe, or critical injuries (i.e., AIS 3, 4, or 5). These estimates are based on the assumption that the reduction in injuries caused by the speed limit on high-speed roads is proportional to the reduction in fatalities on those same roads. As already noted, overall highway safety has improved for reasons other than the decrease in the speed limit. With fewer fatalities (because of safety policies other than the speed limit along with demographic changes), the number of lives saved as a result of the 55 mph limit has declined in recent years. This reduced safety effect attributable to the 55 limit can also be applied to estimates of the number of injuries reduced in recent years. These estimates suggest that injury reductions currently may be 20 to 30 percent smaller than in 1974. Based on these discounted estimates, injuries in 1983 were 36,500 to 65,500 fewer than would have been expected if speed limits had remained at pre-1974 levels. Of these prevented injuries, 2,500 to 4,600 would have been serious, severe, or critical injuries.

1.1.3 Effects of 55 Limit on Energy Consumption

The National Research Council estimates current fuel savings from the 55 mph speed limit to be only about 1 percent of total consumption on all roads. This amounts to a market price (as of 1984) of $2 billion annually in fuel cost savings. Fuel savings on highways on which the speed limit was reduced to 55 mph are greater than 1 percent of the fuel consumed traveling on those highways. However, fuel consumption data are not available by highway classification, so fuel savings for travel specifically on 55 mph roads cannot be determined.

1.1.4 Effects of 55 Limit on Costs and Savings

The National Research Council estimates the 55 mph speed limit produces a minimum savings of $184.8 million annually. This figure includes $122 million in savings for medical costs, legal and court costs, and property damage; $52 million in savings for old age, survivors, and disability insurance, and medicaid/medicare payments; $3.5 million in savings to social service programs (e.g., Supplemental Security Income, Aid to Families with Dependent Children, food stamps); $400,000 in sick leave and lost time compensation to public employees; $3.9 million in savings in indirect public costs (e.g., auto insurance for state and federal vehicles, damaged public facilities, litigation and judgments against local and state governments, medical examiner costs, police and fire department costs, and cost of maintaining the highway system); and $3 million in lost tax revenues from individuals killed or who have lost work time due to injuries. Note that these figures do not include $2 billion saved from decreased energy costs, or costs associated with lost productivity.

In addition to cost savings, the 55 mph speed limit also creates costs, including the additional cost of enforcing the reduced speed limit ($118 million annually) and administrative costs for producing required documentation for FHWA regarding compliance with the 55 mph speed limit ($2.9 million annually). The National Research Council estimates that the 55 mph speed limit costs motorists a total of 1 billion extra hours on the road each year. The cost of this lost time has been estimated to be as high as $2.3 billion annually. However, the Insurance Institute for Highway Safety (Committee on Public Works and Transportation, 1987), has pointed out that most of this lost time is in small segments (one or two minutes). Lost time in 1-2 minute segments is not necessarily as valuable as lost time in longer segments; therefore, it may be improper to add together small-unit time losses and place a monetary value on the total identical to time lost in larger segments. Excluding the cost of lost time, the total additional costs of the 55 mph speed limit are estimated at $120.9 million annually. When one subtracts the $120.9 million additional direct costs produced by the 55 mph speed limit from the estimated $184.8 million in savings generated, a net $63.9 million savings is produced annually by the national 55 mph speed limit.

The National Research Council results are based on the assumptions that: (1) all states return to the higher speed limit posted prior to 1974, (2) the expected increase in fatality rates in 1984 is proportional to the decrease in rates experienced in 1973-1974, and (3) the effect of speed on safety has diminished in proportion to the reduced fatality rate between 1974 and 1984. Hoskin (1987) points out that these assumptions are debatable. Hoskin compared estimates of fatality increases that may be expected with the higher limit using assumptions of the National Research Council with similar estimates using assumptions of the National Safety Council. Using National Research Council assumptions, Hoskin estimates that about 300-450 additional deaths would occur annually on rural interstate highways if states return to their old speed limits, depending on the degree to which lower speeds (and not other safety factors) were responsible for the reduction in traffic deaths from 1973 to 1974.

The National Safety Council made the following assumptions regarding the effects of the 55 mph limit: (1) all states raise the speed limit to the same higher level on all segments of the particular road type, and (2) all drivers increase their travel speed by an amount equal to the difference between the new speed limit and 55 mph (i.e., no change in the distribution of speeds about the mean.) Using the National Safety Council assumptions, Hoskin estimated that raising the speed limit to 60 mph on rural interstates would result in 197 more deaths per year when compared to a 55 mph speed limit; a 65 mph speed limit would cause 458 more deaths annually; a 70 mph limit would mean 616 more deaths annually; and a 75 mph speed limit would mean 725 additional fatalities on rural highways. Hoskin notes, however, that the effect of changes in speed variance produced by increasing the speed limit (considered in the National Research Council estimates) are not accounted for in the National Safety Council estimates.

1.2 Michigan's Experience with the 55 mph Speed Limit

Michigan's experience with the speed limit change between 1973 and 1974 was studied by O'Day, Minahan, and Golomb (1975). This study was limited to a comparison of roughly comparable data from the second half of 1973 (before the 55 mph limit) with data from the second half of 1974 (after the 55 mph limit was implemented). Few design or statistical controls were employed; therefore, causal statements based on these data must be made cautiously. They found that fatalities on interstate highways decreased 14 percent, while travel on these roads decreased only seven percent. During this period, travel speed on interstate highways declined by eight mph (based on Michigan Department of Transportation quarterly speed reports). The authors concluded that the eight mph decline in travel speed was responsible for reducing fatalities by seven percent.

1.3 Role of Speed in Crash Involvement

1.3.1 Physical Effects of Speed on Safety

When traveling at a higher speed, cars move a greater distance during the fixed period of time it takes for drivers to react to problems once they are perceived. That is, vehicle speed does not affect reaction time, but at higher speeds a vehicle travels farther during the fixed perception/reaction time. For example, in 2.5 seconds, a car traveling 70 mph will travel 55 feet further than one traveling 55 mph.

Higher speed negatively affects a vehicle's handling and increases braking distances. Vehicle stability decreases disproportionately to the speed at which the vehicle is traveling. That is, the decline in vehicle stability is greater when speed increases from 50 to 70 mph than when speed increases from 30 to 50 mph. Effects of speed on handling involve a number of interacting factors including sensitivities in tire, suspension, and other vehicle design characteristics, plus road characteristics and driver skills. Effects of speed are most noticeable when turning, such as when passing and in avoidance maneuvers, although vehicle stability will decline at high speeds even when traveling straight. As the vehicle becomes less stable, it becomes more difficult to control, thus increasing the likelihood of a crash. The precise effects of speed on vehicle handling are complex (see Segel (1956) for additional detail).

The distance required to stop a vehicle increases disproportionately with speed. The stopping distance equals the square of the velocity the vehicle is traveling when the stop is begun, divided by two times the rate of deceleration. For example, in an emergency braking situation in which a vehicle is decelerating at 15 feet per second per second, a vehicle traveling 70 mph will travel 351 feet. A vehicle traveling 55 mph will travel only 217 feet.

Crash severity increases disproportionately with speed at impact. That is, the probability that a crash will result in injury to vehicle occupants increases faster than increases in vehicle speed. Assuming that a vehicle strikes a fixed, unmoving object (such as a bridge abutment), the kinetic energy of the occupants must be dissipated in a fraction of a second. If vehicle occupants are not wearing safety belts, this energy will be dissipated against the windshield, dashboard, steering column, or against a seat-back. Since the kinetic energy goes up with the square of the speed, increased speed levels will disproportionately increase the probability that occupants will be injured. According to estimates calculated by Giamotty and associates (1980) a crash with an impact speed of 40 mph is **twice** as likely to result in serious injury (overall AIS greater than 2) than a crash with an impact speed of 30 mph.

1.3.2 Speed Variance

Speed variance refers to the distribution of speeds present on a given road in a given area. That is, how many cars are going faster or slower than the average speed? Lave (1985) found that fatality rates on highways are not related to average speed, but rather to speed variance. "When most cars are traveling at about the same speed, whether it is a high speed or a low one, the fatality rate will be low--presumably because the probability of collision will be low. Variance kills, not speed" (p. 1159). Lave found that when cars were entering and leaving highways frequently, or where there was a wide variation in the speed of cars traveling on the same highway for other reasons, crash rates and fatalities increased. These findings indicate that speed limit enforcement, in part because of its effect in decreasing speed variance, is critical in reducing crash and injury rates.

1.3.3 Speed Adaptation

A driver traveling on an expressway at 55 mph will adapt (become accustomed) to the look and feel of the vehicle, the road, and passing objects at 55 mph. When the driver pulls off the highway to a connecting road with a lower speed limit of 30 mph, the driver may believe he is traveling slower than 30 mph because of the perceptual cues received. This sensation of traveling slower than one actually is after driving at higher speeds is speed adaptation.

The effects of speed adaptation have been examined in several studies (e.g., Schmidt and Tiffen, 1969; Matthews, 1978; and Casey and Lund, 1987). Although the magnitude of the speed adaptation effect differed in these studies, all found significant speed adaptation effects (i.e., drivers coming from higher-speed roads to lower-speed roads traveled faster than drivers who did not recently travel on higher-speed roads). Casey and Lund (1987) found that conditions specific to a traffic site such as speed limit, traffic density, and cross-street activity affected the extent of speed adaptation. Specifically, speed adaptation effects were reduced if drivers were restricted in their ability to drive at higher speeds by traffic flow, as one would expect.

Speed adaptation must be distinguished from speed perpetuation. Drivers do not drive faster on connecting roads only because they just continue at higher expressway speeds (speed perpetuation); they drive at higher speeds on connecting roadways even after coming to a complete stop before traveling on the connecting roads (speed adaptation). These findings suggest that increased speeds on rural interstates may result in higher speeds on other, connecting roads as well.

1.4 Preliminary Estimates of the Effect of 65 mph Limit

According to the Insurance Institute for Highway Safety (1988), after the speed limit was increased from 55 to 65 mph on rural interstates in South Carolina in July 1987, the percentage of vehicles traveling over 70 mph doubled from 12 percent in June 1987 to 24 percent in January 1988. In contrast, the proportion of vehicles traveling over 70 mph remained relatively constant in Georgia where the 55 mph limit remained in force during the same time period.

The National Highway Traffic Safety Administration reports that during May through July, 1987, traffic deaths on rural interstate sections in 22 states that raised the speed limit to 65 increased 52 percent, from 296 for that period in 1986 to 450 in 1987. In contrast, deaths on all other highways in those same states declined 10 percent. In seven states that did not increase the speed limit, deaths on rural interstates increased only 10 percent (62 to 68; Insurance Institute for Highway Safety, 1987). These early data suggest that increasing the speed limit to 65 on rural interstates has a negative effect on the safety of those roads. However, it is important to recognize that these are simple frequency comparisons without controls for other factors that affect fatalities, and are based on only the first three months with the new limits.

2 METHODS

2.1 Research Design

The goal of this research is to answer the question: Did the increase in the maximum speed limit from 55 to 65 mph on rural interstates and rural highways built to interstate standards in Michigan **cause** a change in motor vehicle crash involvement and/or severity? It is not sufficient to find that changes in crash involvement and severity are associated with implementation of the law. The research should be designed so that observed changes in crash involvement and severity can be best explained by the increased speed limit. Other possible explanations for observed changes must be controlled as much as possible.

We will control for alternate explanations for observed changes in crash involvement and severity at the time the speed limit was changed in three ways. First, we will use a monthly time-series design to control for multi-year trends, cycles, and other regular patterns. Measurement of a significant change in crash involvement or severity beginning the month speed limits were changed strengthens the argument that changes in crash involvement or severity were due to changes in speed limit.

Second, time-series models will include multiple covariates to control for their effects on crash involvement or severity. Inclusion of covariates in the time-series models will increase our confidence in making causal statements about the effects of changes in speed limit on crash involvement and severity. Covariates will be used to account for changes in dependent variables (crash involvement and severity) that are not attributable to changes in the independent variable (speed limit). If appropriate controls for the effects of these covariates are not included in the models, changes in the dependent variables may be overstated or wrongly attributed to the independent variable.

The use of multiple comparison groups is the third strategy that will be used to increase our confidence that it is changes in the speed limit that are responsible for any observed changes in crash involvement and severity. Comparisons will be made between roads directly affected by the change in speed limit and roads not directly affected. Comparisons will be made between sections of rural interstates where the speed limit was increased to 65 mph, sections of other limited access highways where the speed limit was increased to 65 mph, sections of limited access highways where the speed limit remained at 55 mph, and other roads. We hypothesize that increases in crash involvement and severity will be detected on road segments where the speed limit was increased to 65 mph. There may also be some "spillover" effects of these increases on road segments where the speed limit remained at 55 mph and other roads because of speed perpetuation and speed adaptation. However, any such spillover effects are expected to be small.

2.2 Data Collection

2.2.1 Motor Vehicle Crash Data

Data on motor vehicle crashes were obtained from the Michigan State Police. Records are available for all traffic crashes that occur in Michigan which are reported to state or local police; data from the years 1978 through 1986 were used to derive crash involvement and severity frequencies. Monthly time-series variables were constructed one year at a time by generating multiple bivariate tables stratified by month and stratified by a combination of variables of interest (e.g., fatal crashes on rural interstates where the speed limit was increased to 65 mph). Frequency counts in such tables were extracted to form individual 12-month time-series. These nine 12-month time series were then combined to produce the 108-month time series used in this interim report. Specific variables and code values used to construct the time series are summarized here. Complete descriptions of each variable are available in codebooks prepared and distributed annually by the UMTRI Data Center. Variable numbers and code values corresponding to the 1986 codebook are enclosed in parentheses for reference. For example, "V1:1-2" refers to variable number one, code values one and two as documented in the 1986 codebook.

Cases included in all time-series were first filtered to exclude motor vehicle crashes involving pedestrians and/or pedalcycles (V30:05,09). These global filters were used to limit data analyzed to crashes which involve motor vehicles where effects of the speed limit change would be seen.

Each variable in the data set was stratified by whether the crash occurred on a section of rural interstate with a new 65 mph speed limit, a section of another limited access highway with a new 65 mph speed limit, a section of limited-access highway (including interstates) where the speed limit remained 55 mph, or another class of road. The Michigan Department of Transportation provided a list of speed limits on all of Michigan's limited access roads (see Appendix A). This list provided data on the location and speed limit of each road segment by MDOT control section (an MDOT highway identifier) and the mile location within each control section identifying specific speed limits within each control section by road mile. These mile points do not represent actual mileage from start to end of the highway, but are MDOT mileage marks within each control section.

Crash location and highway speed limit were identified by merging the data provided by MDOT with data available on traffic crashes. First, all roads without a highway number in the Michigan crash data (V16) were classified as "other roads." Remaining roads were classified based on the list of highway speed limits provided by MDOT. The highway type and speed limit for the section of highway on which each crash occurred was identified by matching data on each crash with the MDOT highway speed limit list. Although MDOT control section information is not directly available in crash records, highway control section was derived from the crash data by combining the county code (V12) with the route code through the county (V14). Miles in control section are available for each crash (V15). Using these data, roads were classified as interstates posted 65 mph, noninterstate highways posted 65 mph, and limited-access highways on which the speed limit remained 55 mph. Roads with a highway number that did not fall within one of these three groups were put in the "other road" classification.

The following monthly (V2) time-series variables were constructed for each road segment type for the period January, 1978 through December, 1986:[1]

A. Total number of vehicles involved in crashes per month by highway type.

B. Total number of crashes per month by:

(1) single vehicle involved (V39:01)
(2) car-car crash (V39:02)
(3) car-truck crash (V39:03).

C. Total number of vehicles involved in crashes per month by:

(1) speed was a factor in the crash (V125:02-03)
(2) speed was not a factor in the crash (V125:01,04-10).

D. Total number of vehicles involved in crashes per month by:

(1) minor vehicle damage (V118:1-2)
(2) moderate vehicle damage (V118:3-4)
(3) severe vehicle damage (V118:5-8)

E. Total number of vehicles involved in crashes per month by:

(1) male driver (V150:1)

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1. Data for 1987 and 1988 will be added as soon as they are available.

(2) female driver (V150:2)

F. Total number of vehicles involved in crashes per month by:

(1) driver age 15-24 years(V147:15-24)
(2) driver age 25-55 years (V147:25-55)
(3) driver age 56 years and older (V147:56-98)

G. Total number of vehicles involved in crashes per month by:

(1) vehicle sustained property damage only (V139:5)
(2) vehicle occupant sustained injury (no fatality) (V139:2-4)
(3) vehicle occupant was killed (V139:1)

H. Total number of injured occupants per month by:

(1) injury severity = fatal (V210:1)
(2) injury severity = incapacitating (V210:2)
(3) injury severity = nonincapacitating (V210:3)
(4) injury severity = possible (V210:4)

2.2.2 Speed Data

Speed data were collected from two sources. First, annual data from 1978 through 1986 were obtained from the Michigan Department of Transportation. MDOT measures speeds with pneumatic tube speed measuring devices at some locations and permanent magnetic speed loops imbedded in the pavement at other locations. Forty-four sites are sampled annually, approximately one-third of which are measured quarterly. Annual MDOT speed data are stratified by different road segments depending on the year the data were collected, with the exception that interstate speeds were stratified the same way each year. In these data, "urban" interstates do not represent road segments in areas with 50,000+ population as they do in assigning speed limits, but rather are road segments in areas with 5,000+ population. For data collected in 1978, 1979, and 1980, data are stratified into interstates (rural and urban), multi-lane divided, two-lane rural, and multi-lane undivided highways. For 1981 through 1986, roads are stratified into interstates (rural and urban), urban other freeway and expressway, rural other arterials, and rural major collectors. For 1984 through 1986, an additional category was included, urban other arterials. Arterial highways provide direct service between cities and larger towns; collectors serve small towns directly, connecting them to the arterial network, and collect traffic from the lower level system of local roads. See Federal Highway Administration (1974) for detailed descriptions of various types of roads.

To date, we have been unable to obtain raw MDOT speed data. Efforts are continuing to obtain raw quarterly data by site. With these data we would better be able to examine speeds on the specific road segments examined in this study. However, we have been informed that speed data are not currently computerized, and that raw, unadjusted data exist only in original, "hard copy" form. Although we are aware of the sensitive nature of these data due to federal speed compliance regulations, original speed measurements by road segment are important for a full understanding of effects of the new 65 mph speed limit.

We also have speed data from another OHSP-funded project, conducted by Dr. Paul Olson of UMTRI. Speed measurements were conducted at 14 sites on highway segments with current speed limits of both 55 and 65 mph immediately before the speed limit change (i.e., September and October, 1987) and in the spring and early summer of 1988 with the 65 mph limit (i.e., March through July, 1988).

2.3 Statistical Methods

In Section 3, we discuss patterns and trends during the 1978-1986 baseline period for each dependent variable in the research design (charts for each variable are provided in Appendix B). Each time-series plot includes a centered moving average line, which is useful for discerning overall trends. The moving average line was created by summing the six data points preceding and the six data points following each point and dividing this sum by twelve. This procedure is replicated for each of the data points in the series with the exception of the first and last six points. These points are omitted because a full set of twelve data points, six preceding and six following each data point is necessary for calculating the moving average. Monthly crash frequencies and rates often have substantial "noise" or variance around a general trend that masks underlying patterns. Moving average trend lines eliminate much of this "noise," making identification of general trends more straightforward.

The goal of the time-series analyses will be to estimate changes in motor vehicle crash involvement and severity associated with increasing speed limits from 55 to 65 mph on certain rural interstates and other limited access highways built to interstate standards. Box-Jenkins and Box-Tiao (Box and Tiao, 1975; Box and Jenkins, 1976) methods will be employed to control for long-term trends and seasonal cycles and to estimate any changes beginning the first month after the increased speed limit took effect. The Box-Jenkins approach is a versatile time-series modeling strategy that can model a wide variety of trend, seasonal, and other recurring patterns.

At a conceptual level, the analytic strategy involves explaining as much of the variance in each variable as possible on the basis of its past history, before attributing any of the variance to another variable, such as the increased speed limit. The intervention-analysis approach is particularly appropriate for this study, because the objective is to identify significant changes in crash involvement and severity associated with the increased speed limit, independent of observed regularities in the history of each variable. In short, controlling for baseline trends and cycles with time-series models produces more accurate estimates of the effects of the speed limit change.

A number of covariate variables will also be considered for inclusion in the time-series models to account for changes in crash involvement and severity not due to the speed limit. These covariates will include: implementation of child and adult restraint laws, vehicle miles traveled, proportion of the licensed driver population under age 25, alcoholic beverage consumption, employment, and income. These variables are considered important covariates because of hypothesized and empirically established associations with traffic crash involvement. For example, the child and adult restraint laws have been shown to be effective in reducing motor vehicle crash injury rates in Michigan (Wagenaar, Streff, and Liu, 1988). Finally, results from time-series models will be compared across road segments experiencing the recent increase in speed limit and those with unchanged limits. Furthermore, possible effects of the speed limit change will be compared across men and women, number and type of vehicles involved in the crash, age groups, vehicle damage severity, injury severity, and whether speed was reported to be a contributing factor in the crash.

3 RESULTS

3.1 Travel Speeds

Average travel speeds in Michigan have been increasing gradually since 1978, approaching 60 mph in 1986 (Figure 3.1). Slightly higher speeds were recorded on rural interstates than on urban interstates, and on urban freeways and expressways than on urban and rural arterials. Speeds on major collectors were the lowest reported in these data.[2]

Dr. Olson's speed measurements (1988) show that speeds were above 60 mph prior to the speed limit change on all road segments examined (Figure 3.2). Although changes were small, speeds did increase both on roads with 55 and 65 mph limits following the speed limit increase. Interestingly, Dr. Olson's data show higher speeds than one would predict from the trend in MDOT measurements. When interpreting these data, keep in mind the divergent purposes for which they were collected. MDOT data are collected to provide speed compliance data to the U.S. DOT. This may be one reason MDOT highway speeds seem to approach an asymptote as speeds near 60 mph, the highest speed a state could report and remain in compliance with federal speed regulations. Olson's data were collected specifically to study the effects of the speed limit change, and there was no motivation to keep reported speeds below a predetermined ceiling. With respect to effects of speed on crash involvement, remember that extant theory suggests that speed variance may be a more important determinant of crashes than average speed. However, information on speed variance is not available.

Because speeds were relatively high on 55 mph road segments prior to the speed limit change, measuring effects of increasing the speed limit will be more difficult. The difficulty of measuring these effects is compounded by widespread public discussion regarding increased speed limits prior to their formal increase, and varying speed enforcement. That is, drivers may have begun to take advantage of coming changes in the speed limit prior to their official implementation. If this is true, effects on travel speed, as well as on crash involvement and severity, might be noticeable before the official speed limit changed. However, there is no straightforward way to determine exact dates of such publicity and enforcement changes.

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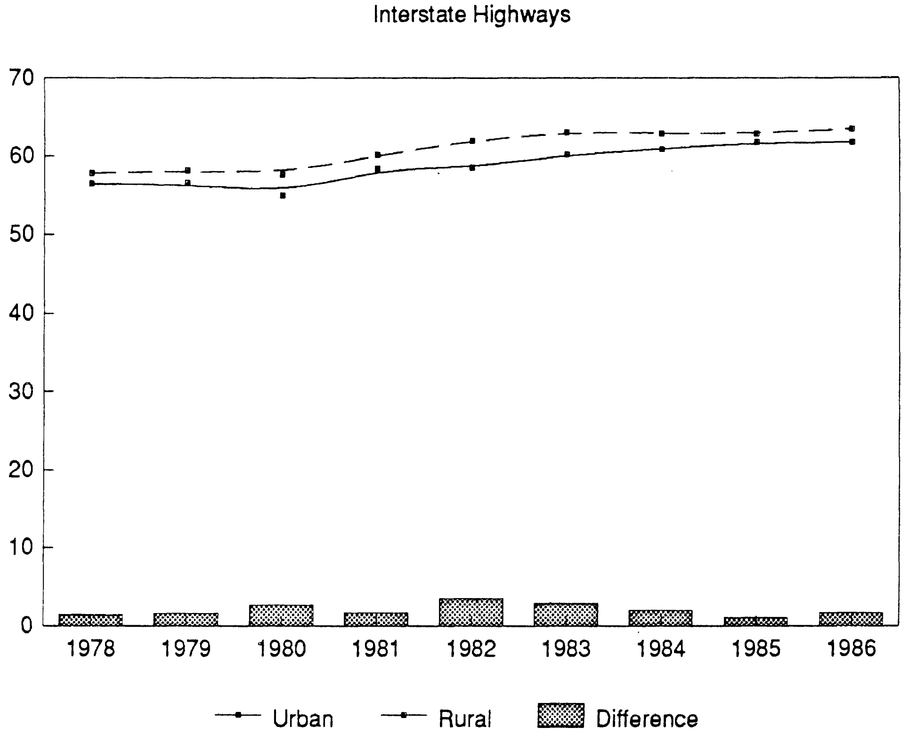
2. To date, we have been unable to obtain average speeds by MDOT measurement location. Therefore, we cannot directly compare travel speeds on road segments that changed to a 65 mph limit with segments that remained at 55.



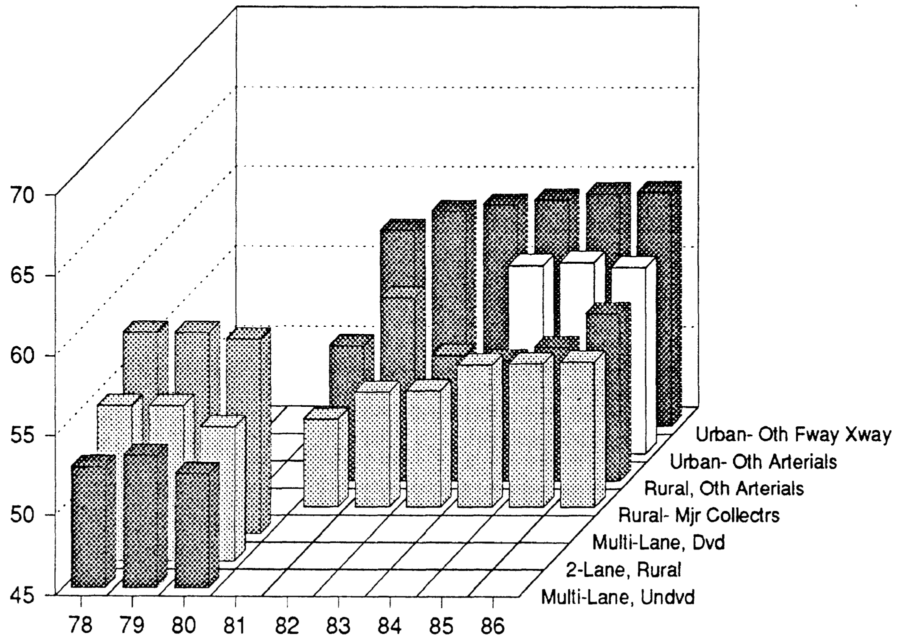


Figure 3.1: Michigan Average Travel Speed by Road Type: 1978-1986

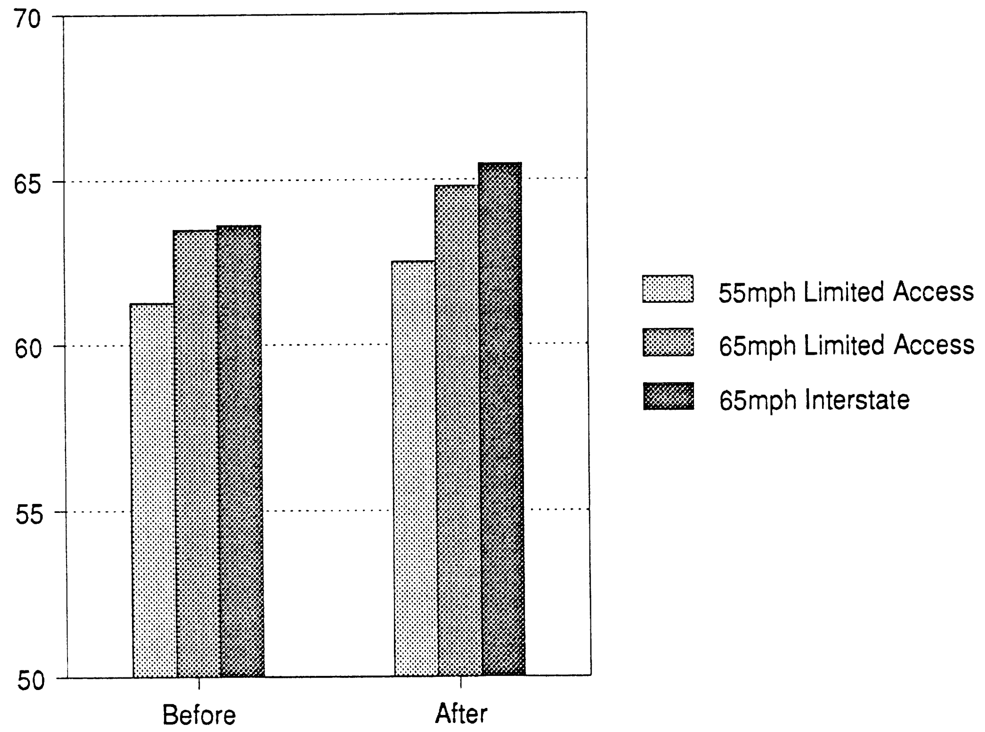


Figure 3.2: Average Observed Speed Before and After Speed Limit Increase

3.2 Crash Involvement and Severity

Crash involvement, crash-related property damage, and injury frequency have been gradually increasing in Michigan since 1983.[3] This gradual increase may make identifying an increase in crash involvement and/or severity caused by the increased speed limit more difficult. If this trend continues through 1987, increases due to the speed limit will have to be of sufficient magnitude that they surpass levels that would be expected due to the upward trend. Interestingly, the increase in crash involvement since 1983 is smaller for older age groups. That is, there is a steeper upward trend for drivers age 15-24 than drivers age 25-55. The upward trend for 25-55-year-olds is steeper than for drivers age 56 and over. These differences are not explained by changes in driving population, since this pattern is also evident in rates per number of licensed drivers (Figures B.10 through B.12).

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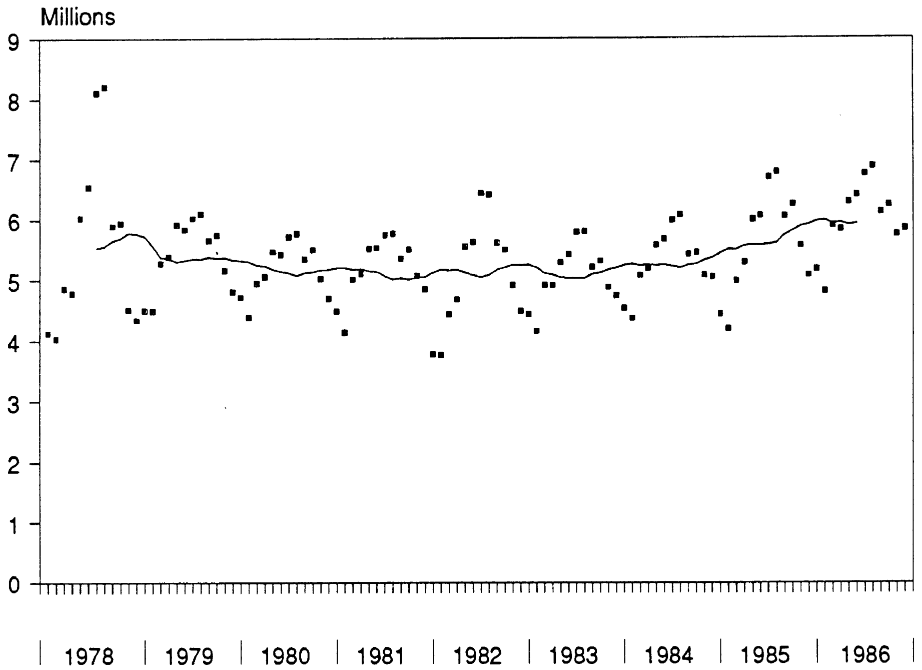
3. See Appendix B for charts of all time-series variables examined.

Strong seasonal patterns are evident in vehicle miles traveled (VMT), crash involvement, and injury severity. However, the seasonal patterns differ across variables. Specifically, VMT and fatal crash involvement are highest in the months of June through August (Figures 3.3 and 3.4). It is not surprising that VMT is highest during these months because of travel due to summer vacations and good summer road conditions. The high number of fatal crash involvements during these months can be explained both by increased travel and high impact speeds that occur when vehicles are traveling on clear, dry roadways. Interestingly, non-65-mph highways also have a higher-than-average number of fatal crash involvements in October and December. This is in contrast to other road segments and VMT, which do not show this pattern. Such differences point out the importance of developing separate time-series models to describe the specific nature of each variable. One model form cannot be straightforwardly applied to all outcome variables of interest.

In contrast to VMT and fatal crash involvement where frequencies are highest in the summer months, nonfatal injury and property damage crashes are most prevalent in October through February (Figures 3.5 and 3.6). Although these months are not the highest in terms of vehicle miles traveled, considerable holiday travel occurs in November, December, and the first few days of January. More importantly, roads become more hazardous with the onset of winter precipitation and cold. Therefore, these seasonal increases in crash involvement may be due to the interaction of slightly increased travel for the holidays and the coming of winter's inclement weather. Many of these crashes are low-speed impacts caused by icy road conditions. Although the highest number of incidents occurs in October through February, early summer months (i.e., May through July) also experience slight increases in involvement. These summer increases are attributable mostly to increased VMT.

Differences in fatal and nonfatal crash outcome rates by month can be explained by driving behavior caused by weather. Summer crashes may have more serious outcomes because of higher crash speeds. Roads are generally warm and dry, resulting in higher driving speed. Higher driving speed at the time of collision results in greater injury. The higher number of crashes in early winter months may be due to the problems drivers have in adjusting their summer driving habits to slick winter road conditions. Even at slower speeds, drivers may be unable to stop in time to avoid a crash on slick roads. Thus, speed at impact is presumably lower during winter than summer months as drivers slow to retain control of their vehicles. Although there are more crashes, crash and injury severity are lower in low-speed winter crashes than in high-speed summer crashes.



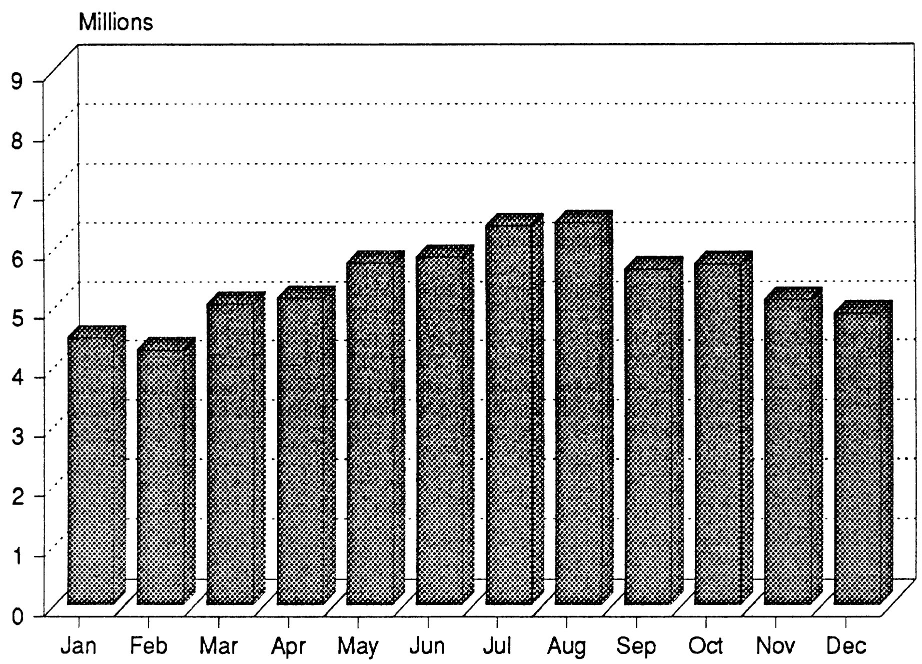
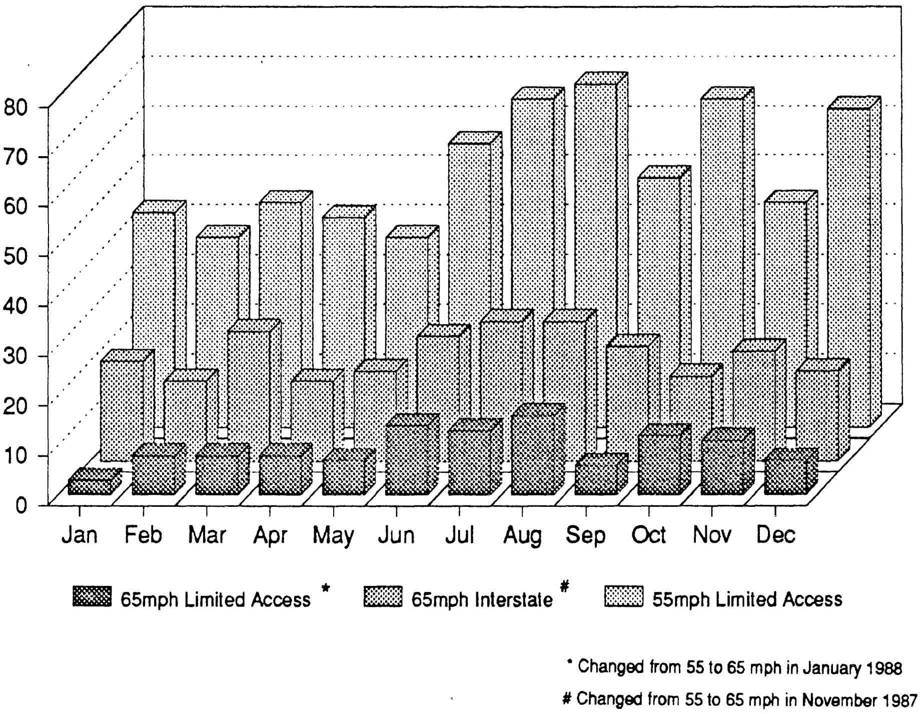


Figure 3.3: Total Vehicle Miles Traveled, and Average Vehicle Miles Traveled by Month: 1978-1986



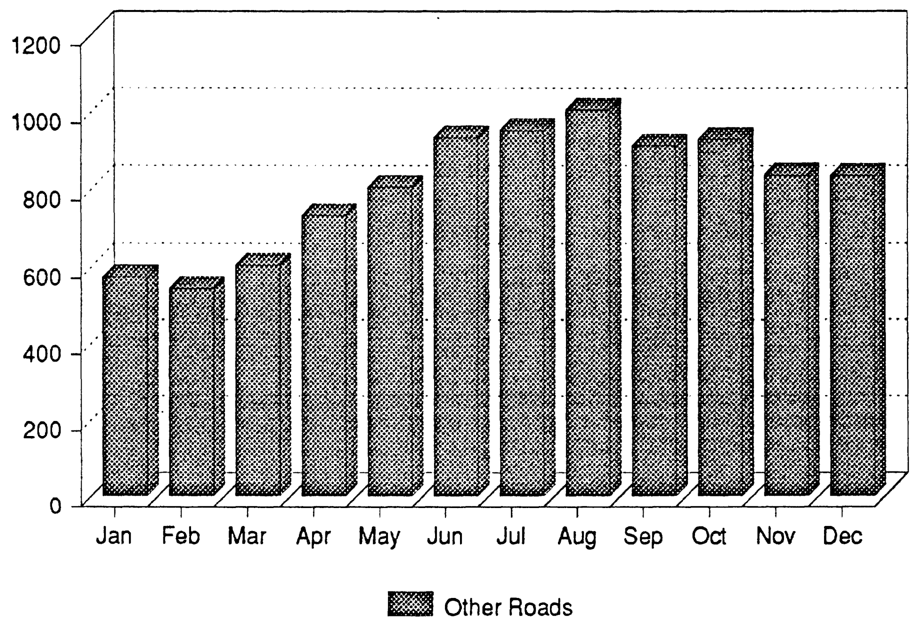
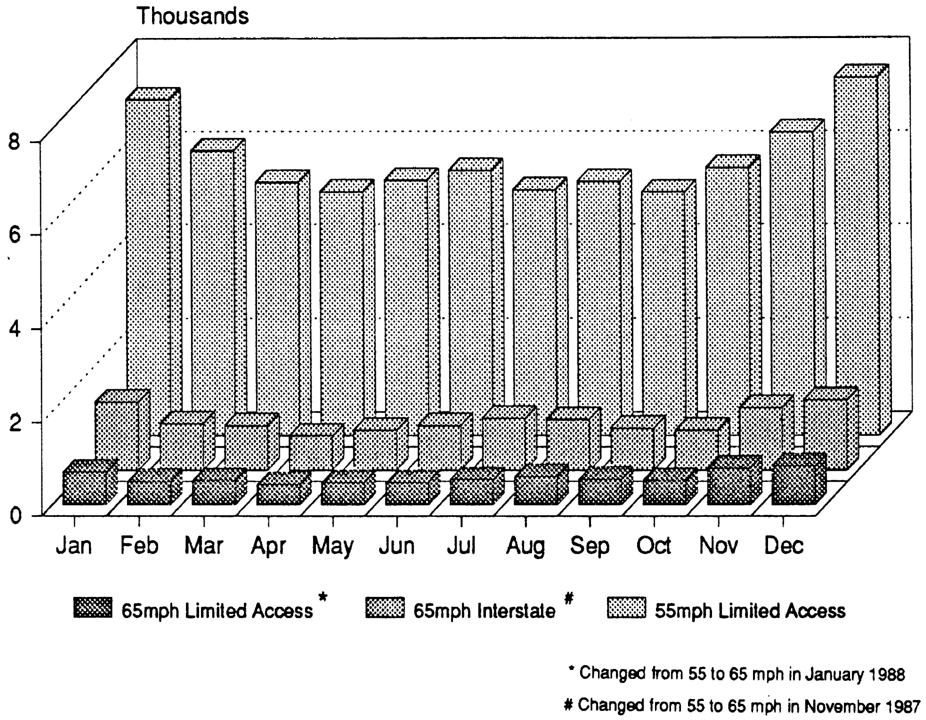


Figure 3.4: Average Number of Crashes with Fatality as the Most Severe Outcome, by Month and Road Type: 1978-1986



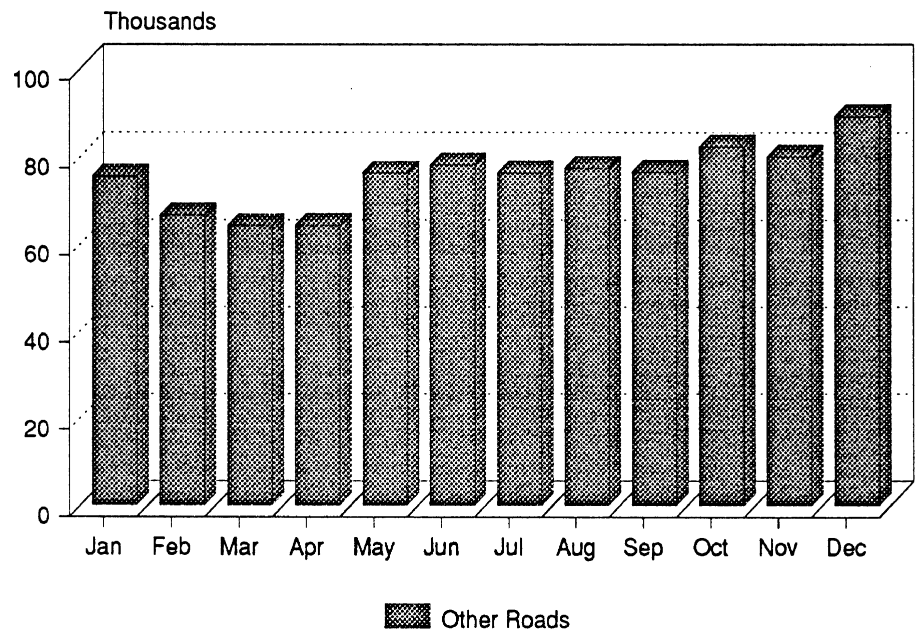
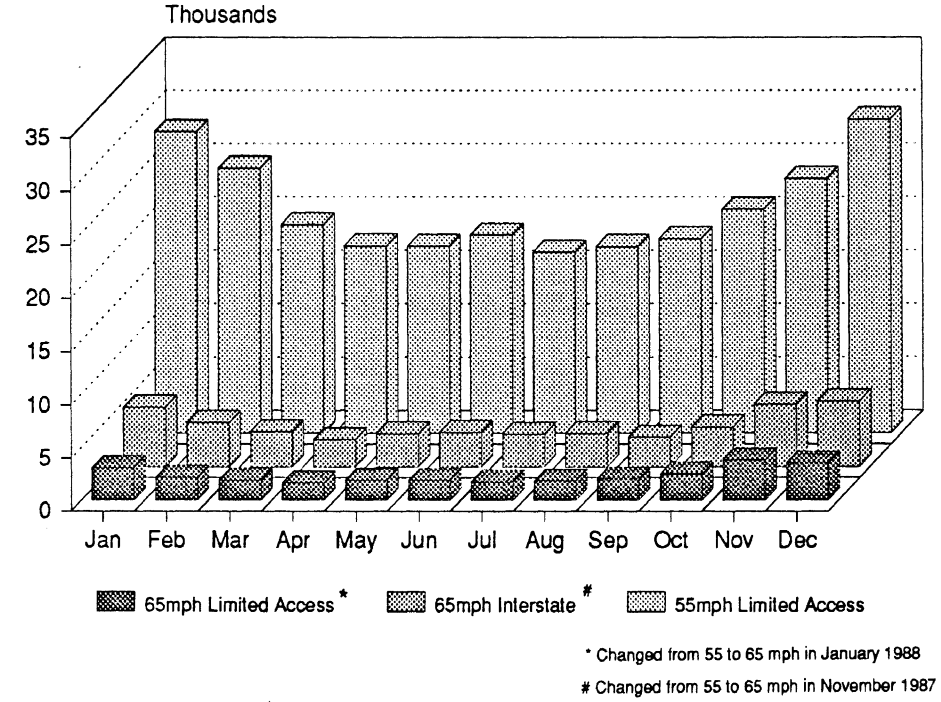


Figure 3.5: Average Number of Crashes with Injury as the Most Severe Outcome, by Month and Road Type: 1978-1986



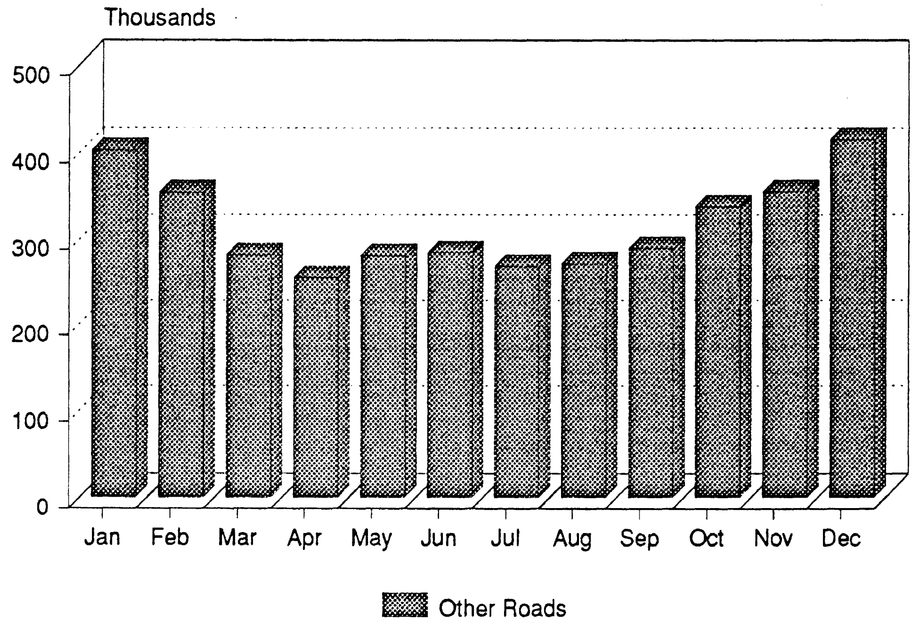
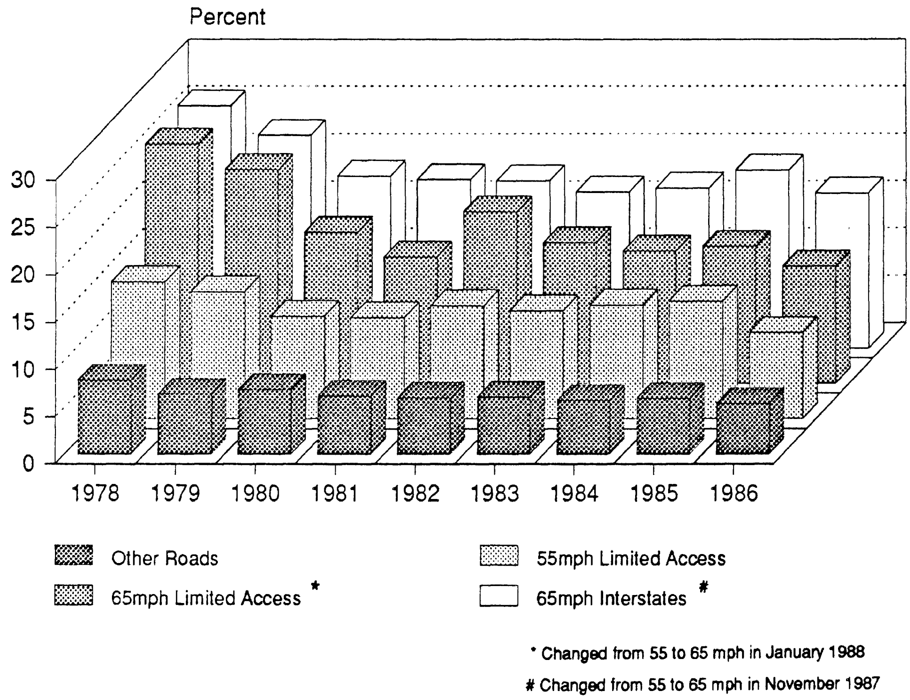


Figure 3.6: Average Number of Crashes with Property Damage as the Most Severe Outcome, by Month and Road Type: 1978-1986

We also examined the number of crashes in which the reporting officer recorded that speed was a contributing factor to the crash. Note that this is the officer's opinion regarding contributions to the crash, and does not necessarily indicate that the posted speed limit was exceeded. In general, there has been a decreasing trend in the proportion of crashes in which speed was reported to be a factor since 1978. This trend is most obvious on highways with the new 65 mph limit (both interstate and other limited access), although it appears to be present on other road types as well (Figure 3.7). Speed is reported as a factor in a higher proportion of crashes in the months of November through April. This is probably because of the slick road conditions that are present during these months. If a driver is unable to stop in time or turn to avoid a crash, one might attribute this to poor road conditions. However, if that driver had been traveling at a slower speed to compensate for poor road conditions, the driver might retain control of the car, avoiding a crash. As a result, officers may consider excessive speed a contributing factor to crashes occurring on slippery roads. Speed may not be recorded as often as a contributing factor during summer months because drivers are able to control their vehicles, even at higher speeds, because of better road conditions.

These examples of differential trends and seasonal patterns across traffic crash categories illustrate the importance of multi-year longitudinal data in evaluating potential effects of policy changes such as the raised speed limit. It is difficult to make accurate inferences about effects of such a law based on the experience during the first few months after it is implemented. Our next report will include 13 months of post-law experience on which to base inferences on whether or not the 65 mph speed limit had an effect on crash involvement and severity.



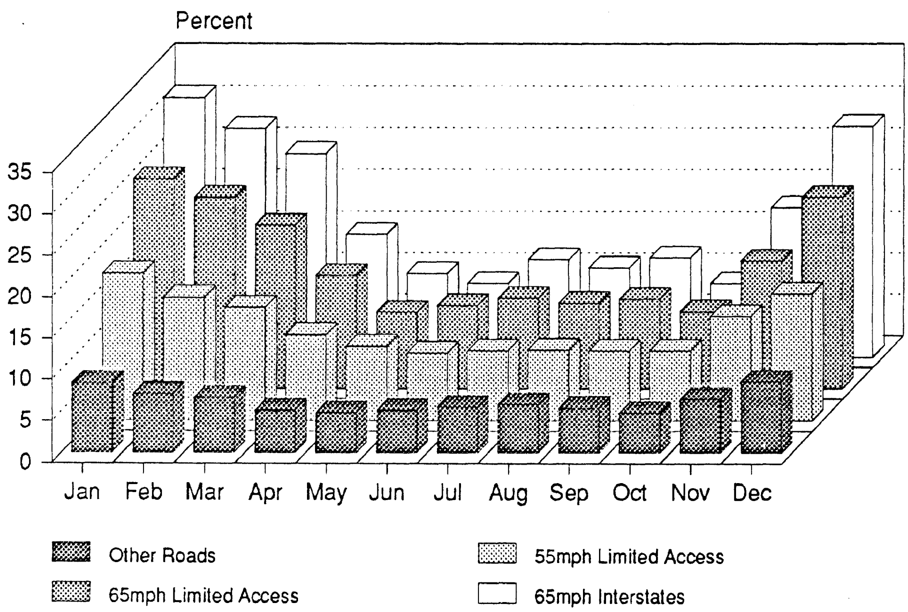


Figure 3.7: Proportion of Crashes Where Speed Was Reported to be a Factor by Year, Month, and Road Type: 1978-1986

4 SUMMARY

This interim report on Michigan's speed limit change summarizes our activity during the first year of a two-year project. We have:

- Reviewed national and Michigan experience with the 55 mph speed limit;
- Collected baseline data on a census of traffic crashes in Michigan from 1978 through 1986;
- Constructed detailed time-series files of multiple outcome indicators;
- Developed a computerized method to identify road segments with a 65 mph speed limit, highways with speed limits other than 65, and other roads; and
- Developed a study design that, within constraints of available resources and data, will provide information on whether traffic safety was affected by the speed limit increase, and provide information on how those effects (if any) differ by age, sex, number and type of vehicles involved in the crash, vehicle damage severity, injury severity, and whether speed was reported to be a contributing factor in the crash.

Objectives for the second project year include:

- Update the database and time-series files with data for calendar years 1987 and 1988;
- Develop time-series models for each outcome variable, including analysis of appropriate covariates;
- Compare observed effects across road segments stratified by posted speed limit, to assess whether observed changes can be plausibly attributed to the new 65 mph limit;
- Compare the magnitude of observed effects by age, sex, number and type of vehicles involved in the crash, vehicle damage severity, injury severity, and whether speed was reported to be a contributing factor in the crash; and
- Provide recommendations regarding rural highways, in light of project findings.

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Appendix A

Speed Limits on Michigan's Limited Access Highways[4]

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4. Source: Michigan Department of Transportation

NON-INTERSTATE SPEEDS - URBAN-55MPH/RURAL-65MPH/RURAL-55MPH

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
US-10 - I-75(BAY CO) TO M-115(CLARE CO)								
	I-75 TO 4 MI RD (BAY CO)	09101	XX			10.40	11.60	01.20
	4 MI RD (BAY CO) TO	09101		XX		00.00	10.40	10.40
	M-115 (CLARE CO)	56044		XX		00.00	19.40	19.40
		56045		XX		00.00	06.80	06.80
		37032		XX		00.00	07.20	07.20
		18023		XX		00.00	01.30	01.30
		18024		XX		00.00	07.90	07.90
US-23 - STATE LINE (MONROE CO) TO I-75 (GENESEE CO)								
	STATE LINE (MONROE CO) TO	58034		XX		00.00	16.70	16.70
	1.5 MI S OF TEXTILE RD	58033		XX		00.00	08.10	08.10
	(WASHTENAW CO)	81076		XX		00.00	08.00	08.00
	TEXTILE RD TO WARREN RD	81076	XX			08.00	09.90	01.90
	(WASHTENAW CO)	81074	XX			00.00	07.40	07.40
		81103	XX			00.00	02.90	02.90
		81075	XX			01.60	02.10	00.50
	WARREN RD (WASHTENAW CO)	81075		XX		02.10	09.10	07.00
	TO GRAND BLANC RD	47013		XX		00.00	07.00	07.00
	(GENESEE CO)	47014		XX		00.00	18.30	18.30
		25031		XX		00.00	09.70	09.70
	GRAND BLANC RD TO I-75	25031	XX			09.70	12.40	02.70
	(GENESEE CO)							
US-27	BAGLEY RD [OLD US-27]	29011		XX		10.60	22.30	11.70
	(GRATIOT CO) TO I-75	29014		XX		00.00	04.40	04.40
	(CRAWFORD CO)	37013		XX		00.00	11.70	11.70
		37014		XX		00.00	14.70	14.70
		18033		XX		00.00	12.90	12.90
		18034		XX		00.00	12.20	12.20
		72013		XX		00.00	12.20	12.20
		72014		XX		00.00	12.30	12.30
		20016		XX		00.00	06.30	06.30
US-31 - STATE LINE (BERRIEN CO) TO FREEWAY END (MASON CO)								
	STATE LINE TO WALTON RD	11056			XX	00.00	03.00	03.00
	(BERRIEN CO)	11057				NOT YET BUILT		
	I-196 TO WASHINGTON	03032			XX	00.00	02.30	02.30
	(ALLEGAN CO)							
	M-104 (OTTAWA CO) TO	70016			XX	00.00	02.90	02.90
	WILSON RD (OTTAWA CO/							

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	MUSKEGON CO LINE)							
	WILSON RD (OTTAWA CO/	61074	XX			00.00	03.80	03.80
	MUSKEGON CO LINE) TO	61072	XX			00.00	04.40	04.40
	M-120 (MUSKEGON CO)	61075	XX			00.00	04.10	04.10
	M-120 (MUSKEGON CO) TO	61075		XX		04.10	18.80	14.70
	FREEWY END (MASON CO)	64014		XX		00.00	07.60	07.60
		64015		XX		00.00	18.30	18.30
		53031		XX		00.00	09.80	09.80
US-127 - M-50 S. JCT (JACKSON CO) TO I-69 E. JCT								
	M-50 TO 1.5 MI NORTH OF	38111	XX			09.10	14.40	05.30
	PARNALL RD (JACKSON CO)	38131	XX			00.00	02.90	02.90
	1.5 MI N OF PARNALL RD	38131		XX		02.90	10.50	07.60
	(JACKSON CO) TO COLLEGE	33031		XX		00.00	09.70	09.70
	RD (INGHAM CO)	33035		XX		00.00	05.80	05.80
	COLLEGE RD (INGHAM CO) TO	33035	XX			05.80	06.50	00.70
	I-69 E JCT (CLINTON CO)	33045	XX			02.10	05.50	03.40
		33171	XX			00.00	01.50	01.50
		33172	XX			00.00	01.90	01.90
		19081	XX			00.00	03.10	03.10
US-131 FROM "U" AVE (KALAMAZOO CO) TO FREEWAY END (WEXFORD CO)								
	"U" AVE N 1.0 MI (KALAMAZOO CO)	39013			XX	00.00	01.00	01.00
	1.0 MI N OF "U" AVE TO	39013	XX			01.00	06.60	05.60
	"H" AVE (KALAMAZOO CO)	39014	XX			00.00	05.80	05.80
	"H" AVE (KALAMAZOO CO)	39014		XX		05.80	13.00	07.20
	TO 0.5 MI S OF 84TH ST	03111		XX		00.00	08.10	08.10
	(KENT CO)	03112		XX		00.00	16.20	16.20
		41131		XX		00.00	02.50	02.50
	0.5 MI S OF 84TH ST N	41131	XX			02.50	17.90	15.40
	TO 7 MI RD (KENT CO)	41132	XX			00.00	04.80	04.80
	7 MI RD (KENT CO) N TO	41132		XX		04.80	13.10	08.30
	FREEWAY END S OF CADILLAC	41133		XX		00.00	08.70	08.70
	(WEXFORD CO)	59012		XX		00.00	13.10	13.10
		54013		XX		00.00	08.40	08.40
		54014		XX		00.00	16.10	16.10
		67016		XX		00.00	05.60	05.60
		67017		XX		00.00	07.60	07.60
		67015		XX		00.00	12.10	12.10
		83031		XX		00.00	04.30	04.30
US-131BR - US-131 TO FREEWAY END AT WESTNEDGE AVE (KALAMAZOO CO)								
	US-131 TO 12TH ST (KALAMAZOO CO)	39051			XX	05.00	05.90	00.90

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	12TH ST TO FREEWAY END AT WESTNEDGE (KALAMAZOO CO)	39051	XX			00.00	05.00	05.00
M-10	US-24 TO I-75 WAYNE AND OAKLAND CONTIES	63081	XX			00.00	05.20	05.20
		82112	XX			00.00	09.90	09.90
		82111	XX			00.00	01.40	01.40
M-14	US-23 [E JCT] (WASHTENAW CO) TO I-275 (WAYNE CO)							
	US-23 (E JCT) TO DIXBORO RD (WASHTENAW CO)	81103	XX			02.90	04.40	01.50
	DIXBORO RD (WASHTENAW CO) TO N TERRITORIAL RD (WAYNE CO)	81103		XX		04.40	11.10	06.70
		82102		XX		00.00	00.90	00.90
	N TERRITORIAL RD TO I-275 (WAYNE CO)	82102	XX			00.90	06.60	06.00
M-39	ENTIRE ROUTE THROUGH WAYNE CO AND OAKLAND CO	82192	XX			00.00	11.10	11.10
		82193	XX			00.00	04.00	04.00
		63171	XX			00.00	01.30	01.30
M-47	US-10 (BAY CO) TO FREE-WAY END (SAGINAW CO)	09091			XX	00.00	02.10	01.20
		73075			XX	00.00	02.10	02.10
M-20/US-10BR	US-10 E JCT TO FREEWAY END 0.25 MI E OF WASHINGTON (MIDLAND CO)	56023			XX	02.30	04.30	02.00
M-53	VAN DYKE TO WASHINGTON SQUARE (MACOMB CO)	50011	XX			09.90	12.60	02.70
		50013	XX			00.00	08.10	08.10
M-60	I-94 TO SPRING ARBOR RD (JACKSON CO)	38061	XX			13.00	16.00	03.00
M-13 CONN	US-23 TO M-13 (BAY CO)	09111	XX			00.00	02.50	02.50
M-25/BS-75	I-75 E TO 0.5 E OF M-13 (BAY CO)	09042	XX			00.00	03.50	03.50
M-59	ENTIRE ROUTE THROUGH OAKLAND CO AND MACOMB CO	63043	XX			00.00	10.70	10.70
		50023	XX			00.00	02.00	02.00
		50022	XX			00.00	09.40	09.40
M-102	ENTIRE ROUTE THROUGH OAKLAND CO	63021	XX			00.00	04.10	04.10

STATEWIDE TOTALS BY ROUTE

RTE NO.	URBAN 55MPH	RURAL 65MPH	RURAL 55MPH	TOTAL MILES
US-10	01.20	53.00	00.00	54.20
US-23	15.40	74.80	00.00	90.20
US-27	00.00	98.40	00.00	98.40
US-31	12.30	50.40	08.20	70.90
US-127	18.80	23.10	00.00	41.90
US-131	31.60	118.20	01.00	150.80
US-131BR	05.00	00.00	00.90	05.90
M-10	16.50	00.00	00.00	16.50
M-14	07.50	07.60	00.00	15.10
M-39	16.40	00.00	00.00	16.40
M-47	00.00	00.00	03.30	03.30
M-20/US-10BR	00.00	00.00	02.00	02.00
M-53	10.80	00.00	00.00	10.80
M-60	03.00	00.00	00.00	03.00
M-13 CONN	02.50	00.00	00.00	02.50
M-25/BS-75	03.50	00.00	00.00	03.50
M-59	22.10	00.00	00.00	22.10
M-102	04.10	00.00	00.00	04.10
STWD	170.70	425.50	15.40	611.60

INTERSTATE SPEEDS - URBAN-55MPH/RURAL-65MPH/RURAL-55MPH

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
I-69 (STATE LINE TO PORT HURON)								
	STATE LINE TO BL-69	12033		XX		00.00	12.60	12.60
	(CHARLOTTE)	12034		XX		00.00	09.47	09.47
		13073		XX		00.00	16.13	16.13
		13074		XX		00.00	09.04	09.04
		23061		XX		00.00	09.53	09.53
	BL-69 TO I-96 (S JCT)	NON-FWY						
	I-96 (S JCT) TO I-96	23152	XX			00.00	06.75	06.75
	(N JCT)	19022	XX			07.71	10.16	02.45
	GRAND RIVER AVENUE TO PEACOCK ROAD							
	GR RIVER TO DAGGETT RD	19043		XX		00.00	05.25	05.25
	DAGGETT RD TO US-127	19043	XX			05.25	09.38	04.13
	US-127 TO TEMP I-69	19042		XX		00.00	08.26	08.26
	TEMP I-69 TO PEACOCK RD	NON-FWY						
	PEACOCK RD TO 1.2 MILE E OF M-52 (PERRY)	NON-FWY						
	1.2 MILE E OF M-52 TO	76023		XX		01.20	17.62	16.42
	2.0 MILES W OF MORRISH	25042		XX		00.00	02.97	02.97
	RD (SWARTZ CREEK)							
	2.0 MILES W OF MORRISH	25042	XX			02.97	10.23	07.26
	RD TO OAK RD (DAVISON)	25085	XX			00.00	02.95	02.95
		25084	XX			00.00	09.70	09.70
	OAK RD TO WADHAMS RD	25084		XX		09.70	11.71	02.01
	(PORT HURON)	44043		XX		00.00	07.25	07.25
		44044		XX		00.00	17.57	17.57
		77024		XX		00.00	11.55	11.55
		77023		XX		00.00	12.42	12.42
	WADHAMS RD TO I-94	77023	XX			12.42	15.80	03.38
	(FREEWAY ENDING)							
I-75 (STATE LINE TO SAULT STE MARIE/PORT OF ENTRY/INTERNATIONAL BRIDGE)								
	STATE LINE (TOLEDO) TO	58151		XX		00.00	15.26	15.26
	SO. ROCKWOOD SVL (600 FT	58152		XX		00.00	09.96	09.96
	S OF READY RD)	58152	XX			09.96	11.55	01.59
	SO. ROCKWOOD SVL TO 1.0	82191	XX			00.00	13.96	13.96
	MILE W OF DIXIE HWY	82194	XX			00.00	08.51	08.51
	(OAKLAND CO)	82195	XX			00.00	02.28	02.28
		82251	XX			00.00	02.31	02.31

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	SO. ROCKWOOD SVL TO 1.0	82252	XX			00.00	05.83	05.83
	MILE W OF DIXIE HWY	63174	XX			00.00	18.49	18.49
	(continued)	63172	XX			00.00	13.50	13.50
		63173	XX			00.00	02.83	02.83
	1.0 MILE W OF DIXIE HWY	63173		XX		02.83	14.56	11.73
	TO BALDWIN RD (S OF	25131		XX		00.00	01.60	01.60
	GRAND BLANC)							
	BALDWIN RD TO 0.5 MILE	25131	XX			01.60	08.80	07.20
	N OF STANLEY RD	25031	XX			12.17	15.12	02.08
		25032	XX			00.00	08.81	08.81
	0.5 MILE N OF STANLEY RD	25032		XX		08.81	16.43	07.62
	TO DIXIE HWY	73171		XX		00.00	10.50	10.50
	DIXIE HWY TO WILDER RD	73111	XX			00.00	09.33	09.33
		73112	XX			00.00	01.70	01.70
		73112		XX		01.70	03.78	02.08
		09034		XX		00.00	02.62	02.62
		09034	XX			02.62	05.12	02.50
		09035	XX			00.00	02.07	02.07
	WILDER RD TO SAULT STE	09035		XX		02.07	23.16	21.09
	MARIE/PORT OF ENTRY	06111		XX		00.00	19.46	19.46
	(EXCEPT MACKINAC BRIDGE)	65041		XX		00.00	15.29	15.29
		72061		XX		00.00	23.65	23.65
		20052		XX		00.00	05.90	05.90
		20014		XX		00.00	04.98	04.98
		20015		XX		00.00	14.24	14.24
		69013		XX		00.00	12.61	12.61
		69014		XX		00.00	13.11	13.11
		16093		XX		00.00	15.09	15.09
		16091		XX		00.00	12.37	12.37
		24071		XX		00.00	01.69	01.69
	(MACKINAC BRIDGE)	86000						04.37
		49025		XX		00.00	25.00	25.00
		17033		XX		00.00	17.58	17.58
		17034		XX		00.00	09.24	09.24
I-94	(STATE LINE TO PORT HURON/BLUE WATER BRIDGE)							
	STATE LINE TO STEVENS-	11014		XX		00.00	03.53	03.53
	VILLE SCL (1300 FT S OF	11015		XX		00.00	17.71	17.71
	JOHN BEERS RD)							
	STEVENSVILLE SCL TO	11015	XX			17.71	23.43	05.72
	TERRITORIAL RD	11016	XX			00.00	04.15	04.15
		11016			XX	04.15	05.35	01.20
		11016	XX			05.35	06.11	00.76
	TERRITORIAL RD TO 8TH ST	11016		XX		06.11	07.22	01.11
	(0.5 MILE W OF 9TH ST)	11017		XX		00.00	06.60	06.60
		11018		XX		00.00	02.04	02.04
		80023		XX		00.00	13.47	13.47
		80024		XX		00.00	10.55	10.55
		39024		XX		00.00	04.26	04.26

RTE	LOCATION DESCRIPTION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	8TH ST (0.5 MILE W OF	39024	XX			04.26	09.29	05.03
	9TH ST) TO 31ST ST (2.0	39022	XX			00.00	07.01	07.01
	MILES W OF 35TH ST)							
	31ST ST TO KALAMAZOO	39022		XX		07.01	11.50	04.49
	CO LINE	39025		XX		00.00	04.36	04.36
	KALAMAZOO CO LINE	13081	XX			00.00	06.30	06.30
	TO BEADLE LAKE RD	13082	XX			00.00	01.45	01.45
	BEADLE LAKE RD TO	13082		XX		01.45	11.60	10.15
	BLACKMAN RD	13083		XX		00.00	13.51	13.51
		38102		XX		00.00	05.04	05.04
		38101		XX		00.00	07.32	07.32
	BLACKMAN RD TO 0.25	38101	XX			07.32	15.76	08.44
	MILE E OF SARGENT RD	38103	XX			00.00	00.75	00.75
	0.25 MILE E OF SARGENT	38103		XX		00.75	09.87	09.12
	RD TO BAKER RD	81104		XX		00.00	13.18	13.18
	BAKER RD TO 24 MILE RD	81104	XX			13.18	18.29	05.11
	(MACOMB CO)	81062	XX			00.00	09.13	09.13
		81063	XX			00.00	03.50	03.50
		81041	XX			00.00	02.30	02.30
		82021	XX			00.00	06.13	06.13
		82022	XX			00.00	16.60	16.60
		82023	XX			00.00	04.94	04.94
		82024	XX			00.00	04.02	04.02
		82025	XX			00.00	06.69	06.69
		50111	XX			00.00	17.77	17.77
		50112	XX			00.00	01.50	01.50
	24 MILE RD TO 1.0 MILE	50112		XX		01.50	06.16	04.66
	S OF M-25 (GRATIOT BLVD)	77111		XX		00.00	15.70	15.70
	1.0 MILE S OF M-25	77111	XX			15.70	25.82	10.12
	(GRATIOT BLVD) TO BLUE							
	WATER BRIDGE							
I-96	(MUSKEGON TO DETROIT)							
	US-31 TO ELLIS RD	61152	XX			00.00	01.00	01.00
	ELLIS RD TO M-11	61152		XX		01.00	05.45	04.45
	(REMEMBRANCE RD)	70064		XX		00.00	03.87	03.87
		70063		XX		00.00	14.25	14.25
	M-11 (REMEMBRANCE RD)	70063	XX			14.25	15.64	01.38
	TO WHITNEYVILLE RD	41026	XX			00.00	06.43	06.43
		41025	XX			00.00	11.54	11.54
		41024	XX			00.00	04.70	04.70
	WHITNEYVILLE RD TO BL-96	41024		XX		04.70	12.43	07.73
	(GRAND RIVER)	34043		XX		00.00	12.02	12.03
		34044		XX		00.00	13.54	13.54
		19022		XX		00.00	09.09	09.09

RTE	LOCATION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
	BL-96 (GRAND RIVER) TO	19022	XX			09.09	10.16	01.07
	COLLEGE RD	23152	XX			00.00	06.75	06.75
		23151	XX			00.00	02.86	02.86
		33083	XX			00.00	03.69	03.69
		33084	XX			00.00	02.73	02.73
	COLLEGE RD TO 1.0 MILE	33084		XX		02.73	17.58	14.85
	W OF WIXOM	33085		XX		00.00	02.68	02.68
		47066		XX		00.00	08.76	08.76
		47065		XX		00.00	14.33	14.33
		47064		XX		00.00	04.48	04.48
		63022		XX		00.00	06.18	06.18
	1.0 MILE W OF WIXOM RD	63022	XX			06.18	19.24	13.06
	TO END (I-75)	82125	XX			00.00	03.21	03.21
		82122	XX			00.00	11.67	11.67
		82123	XX			00.00	07.83	07.83
		82124	XX			00.00	01.97	01.97
I-194	BATTLE CREEK AREA	13033	XX			00.00	03.37	03.37
I-196	(FROM I-94 THRU GRAND RAPIDS TO I-96)							
	I-94 TO 40TH AVE.	11111		XX		00.00	07.93	07.93
		80012		XX		00.00	09.66	09.66
		80013		XX		00.00	03.88	03.88
		03033		XX		00.00	12.46	12.46
		03034		XX		00.00	10.45	10.45
		03035		XX		00.00	06.71	06.71
		70024		XX		00.00	10.10	10.10
	40TH AVE (1.0 MILE W	70024	XX			10.10	12.20	02.10
	OF 32ND) TO I-96	70024			XX	12.20	15.68	03.48
		41029	XX			00.00	09.69	09.69
		41027	XX			00.00	04.21	04.21
I-275	FROM I-75 TO I-96							
	I-75 TO PENNSYLVANIA RD	58171		XX		00.00	07.88	07.88
		82291		XX		00.00	06.00	06.00
	PENNSYLVANIA RD TO I-96	82291	XX			06.00	10.32	04.32
		82292	XX			00.00	07.46	07.46
		82293	XX			00.00	04.63	04.63
I-296	GRAND RAPIDS AREA	41131	XX			14.61	17.93	03.32
		41132	XX			00.00	00.86	00.86
I-375	DETROIT AREA	82111	XX			03.45	04.00	00.55
I-475	FLINT AREA	25132	XX			00.00	16.89	16.89
I-496	LANSING AREA	23081	XX			00.00	03.37	03.37
		33044	XX			00.00	02.88	02.88
		33045	XX			00.00	05.54	05.54

RTE	LOCATION	C.S.	UR 55	RU 65	RU 55	BEG M.P.	END M.P.	TOTAL LNGTH
I-675	SAGINAW AREA	73101	XX			00.00	07.33	07.33
		73101			XX	07.33	07.80	00.47
I-696	DETROIT AREA	63101	XX			00.00	08.33	08.33
		63102	XX			00.00	01.08	01.08
		63103	XX			00.00	01.95	01.95
		50062	XX			00.00	02.71	02.71

STATEWIDE TOTALS BY ROUTE

RTE NO.	URBAN 55MPH	RURAL 65MPH	RURAL 55MPH	TOTAL MILES
I-69	36.62	139.47	00.00	177.09
I-75	102.99	272.67	00.00	375.66
I-94	127.42	146.80	01.20	275.42
I-96	79.89	116.24	00.00	196.13
I-194	03.37	00.00	00.00	03.37
I-196	16.00	61.19	03.48	80.67
I-275	16.14	13.88	00.00	30.02
I-296	04.18	00.00	00.00	04.18
I-375	00.55	00.00	00.00	00.55
I-475	16.89	00.00	00.00	16.89
I-496	11.79	00.00	00.00	11.79
I-675	07.33	00.00	00.47	07.80
I-696	20.44	00.00	00.00	20.44
STWD	443.61	751.25	05.15	1,200.01

Appendix B

Time-series Charts[5]

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5. The designation "65 mph" on these charts indicates road segments that changed from a 55 to a 65 mph speed limit in November 1987 and January 1988. These segments all had a 55 mph limit over the 1978 through 1986 period.

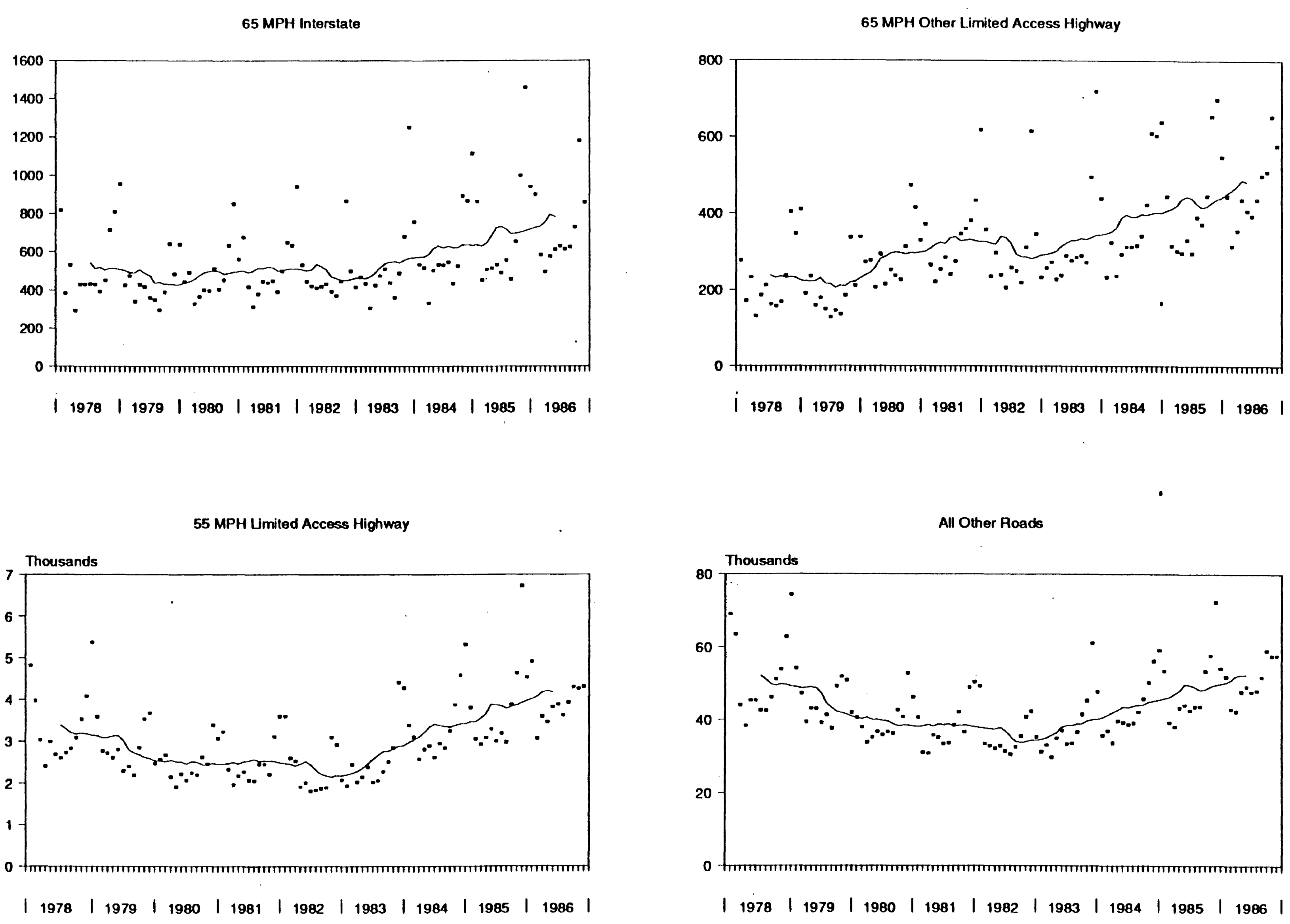

Figure B.1: Total Vehicle Crash Frequency by Highway Type

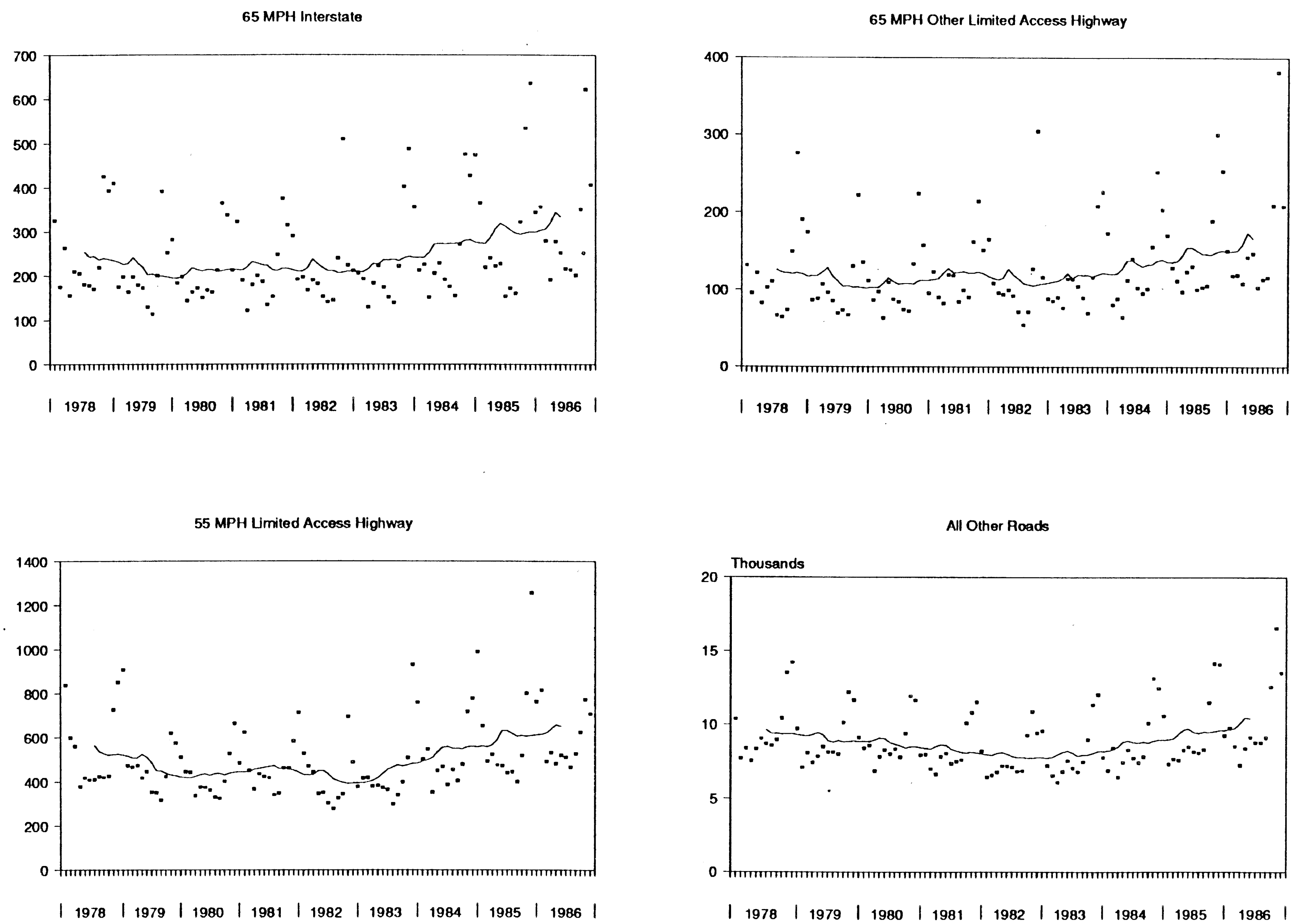

Figure B.2: Single Traffic Unit Crash Frequency by Highway Type

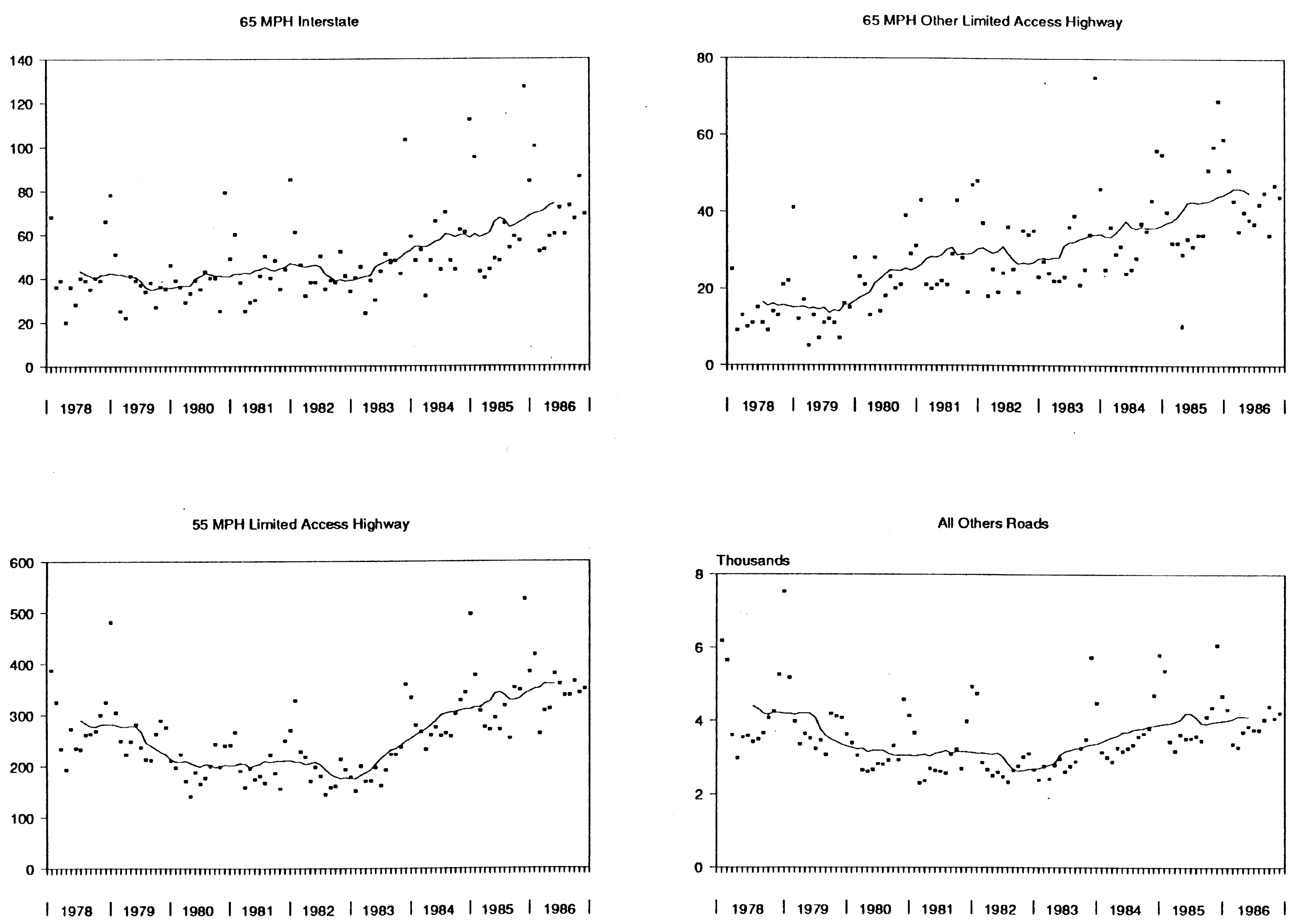

Figure B.3: Car-truck Crash Frequency by Highway Type

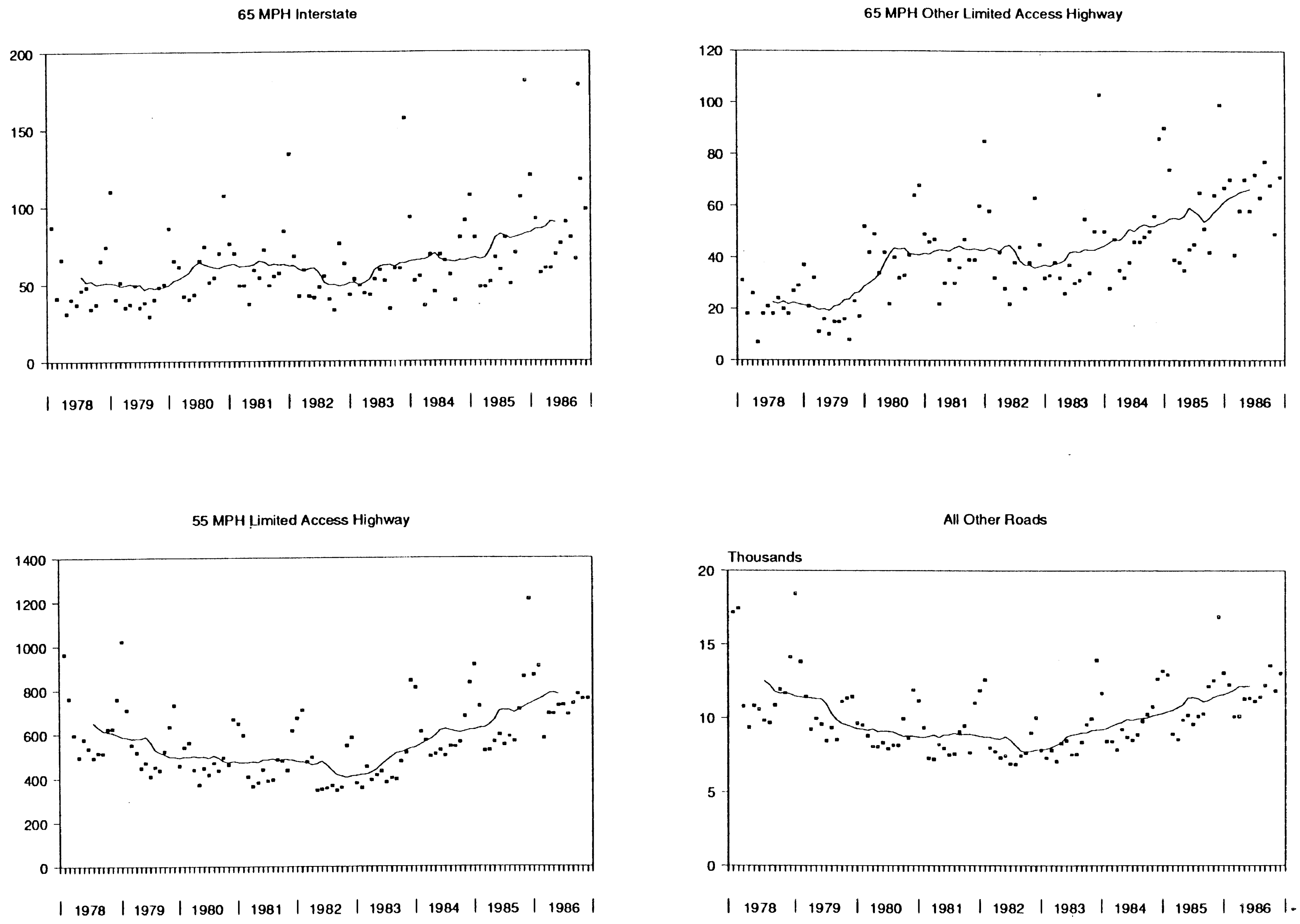

Figure B.4: Car-car Crash Frequency by Highway Type

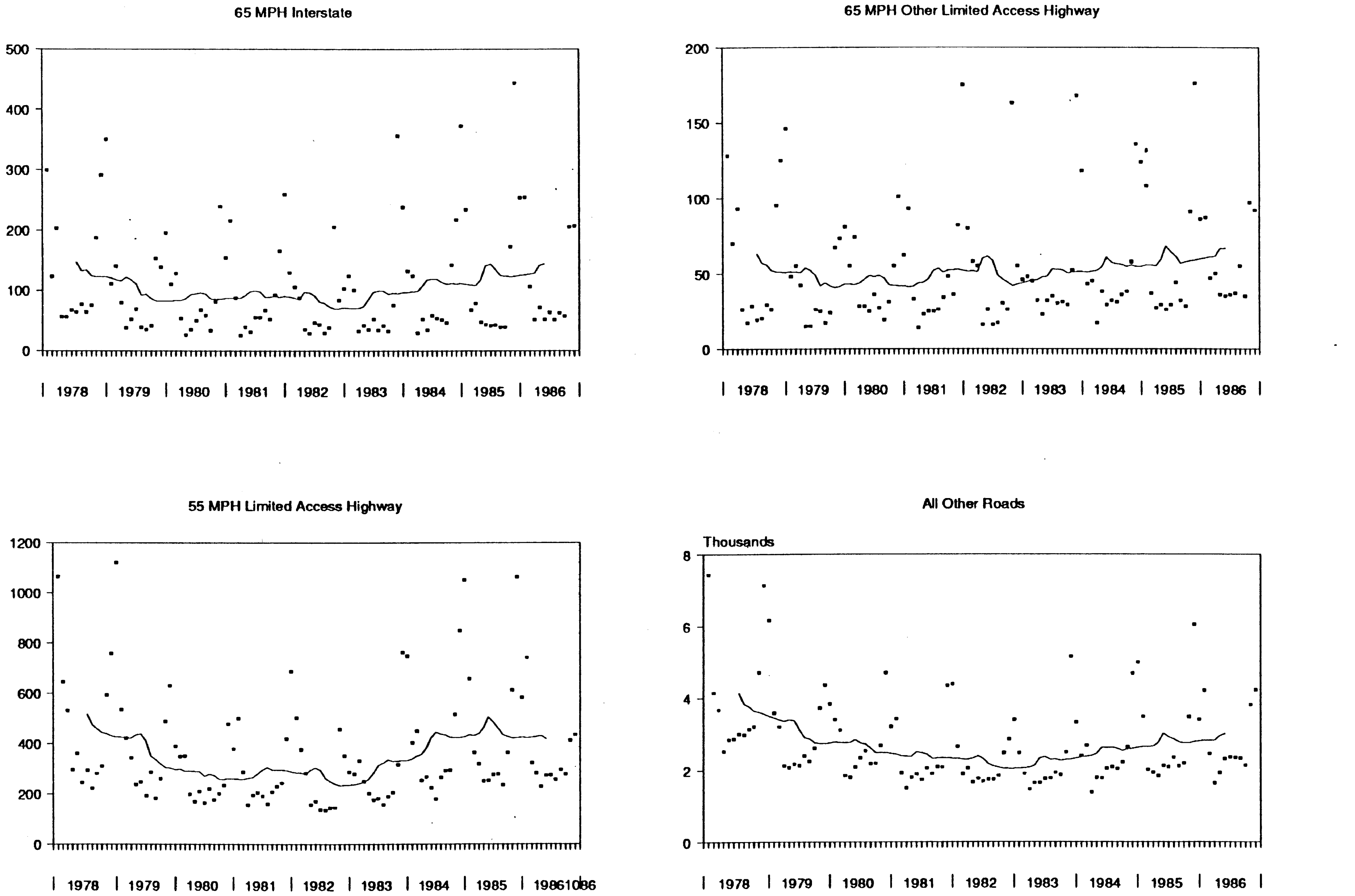

Figure B.5: Frequency of Crashes with Speed as a Contributing Factor by Highway Type

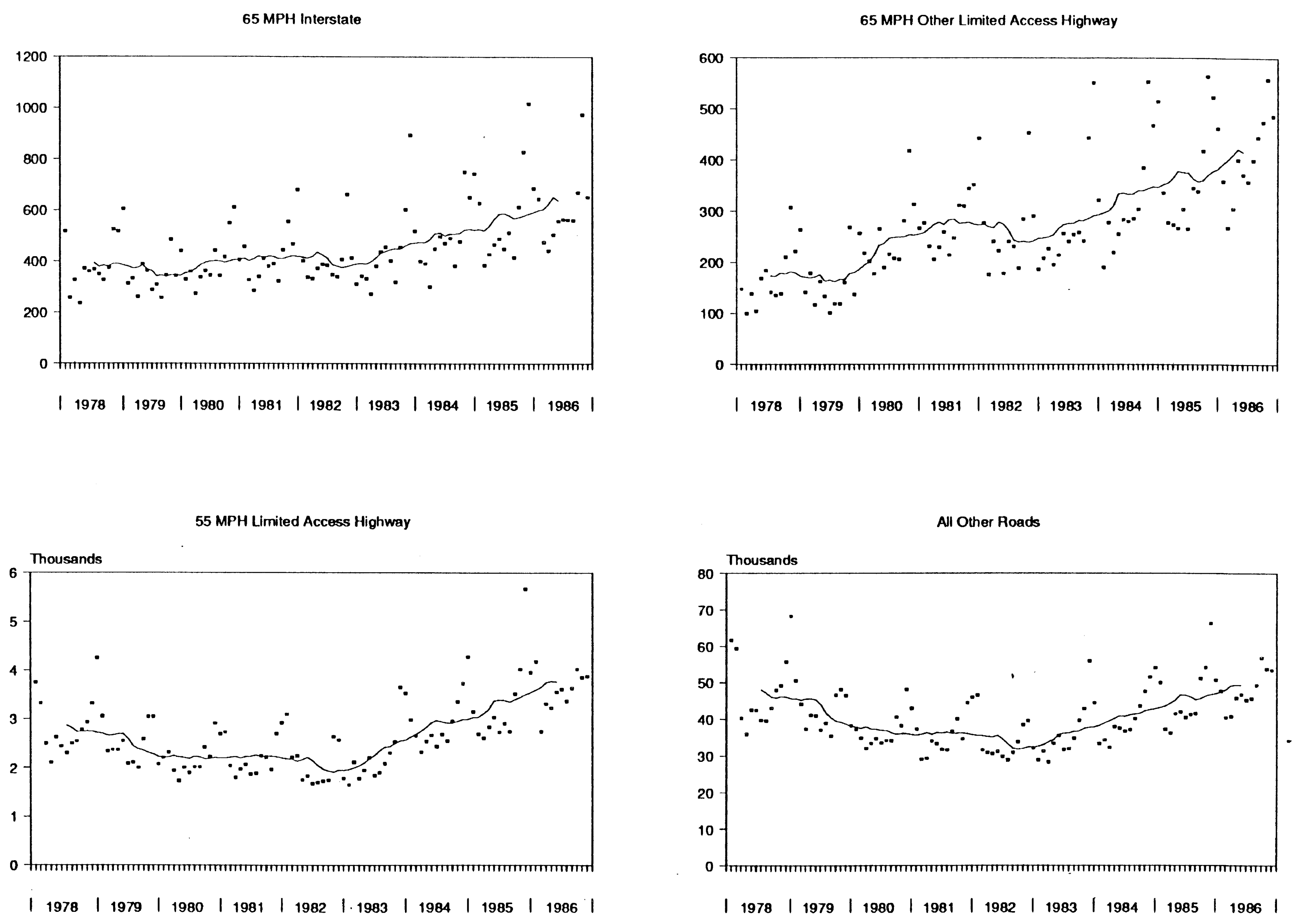

Figure B.6: Frequency of Crashes with Factors Other than Speed as Contributing Factors by Highway Type

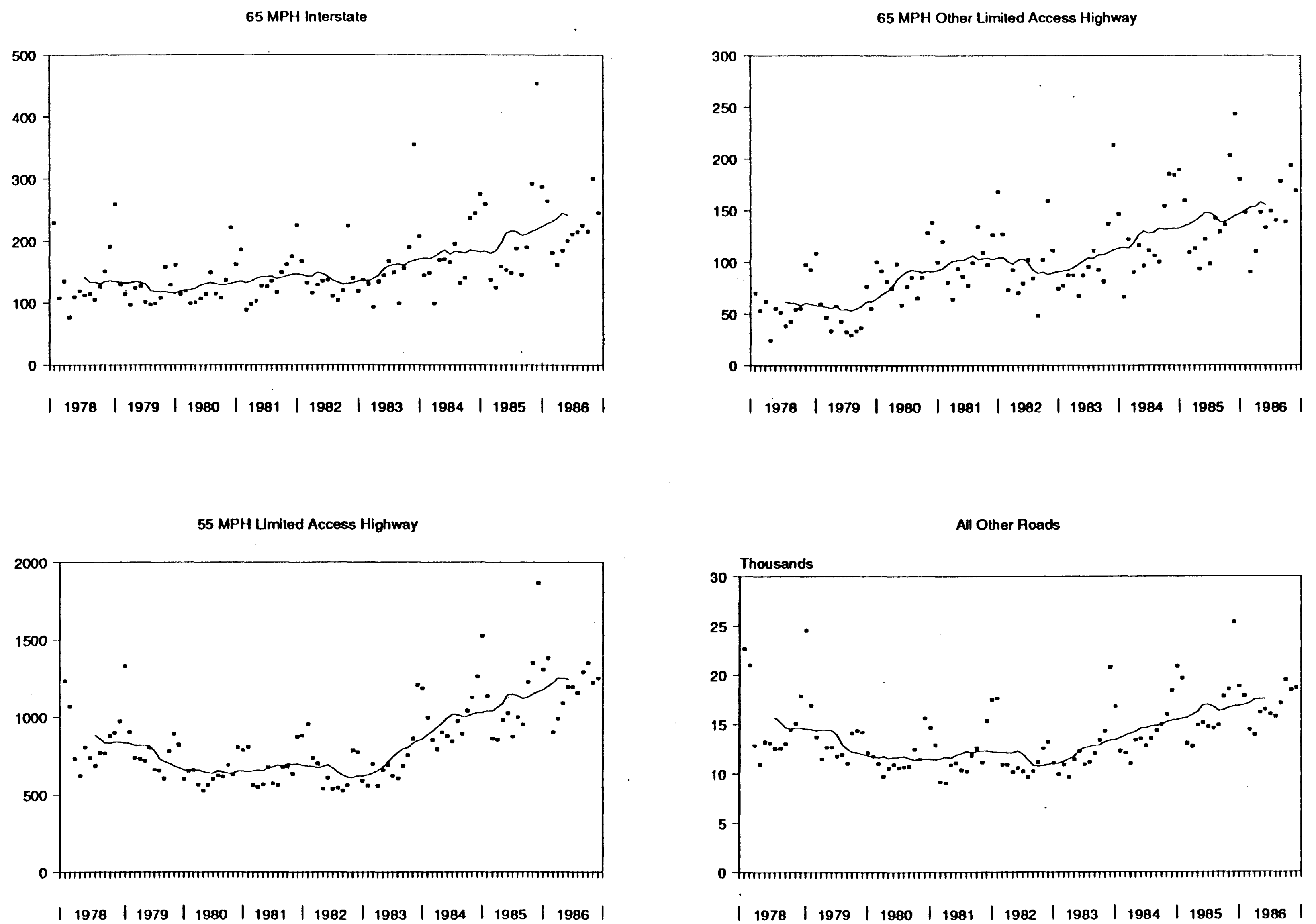

Figure B.7: Vehicle Damage Severity 1-2 Crash Frequency by Highway Type

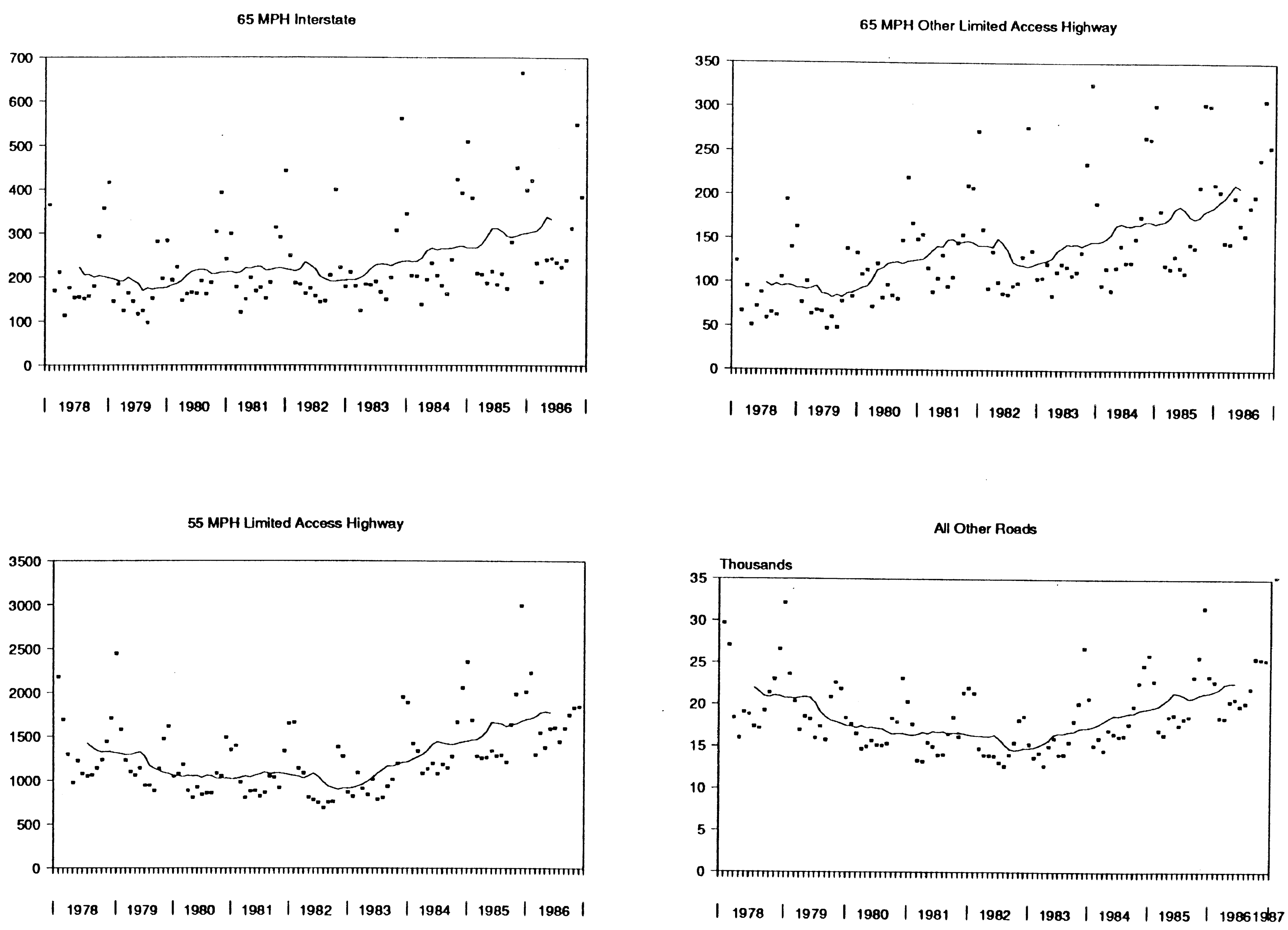

Figure B.8: Vehicle Damage Severity 3-4 Crash Frequency by Highway Type

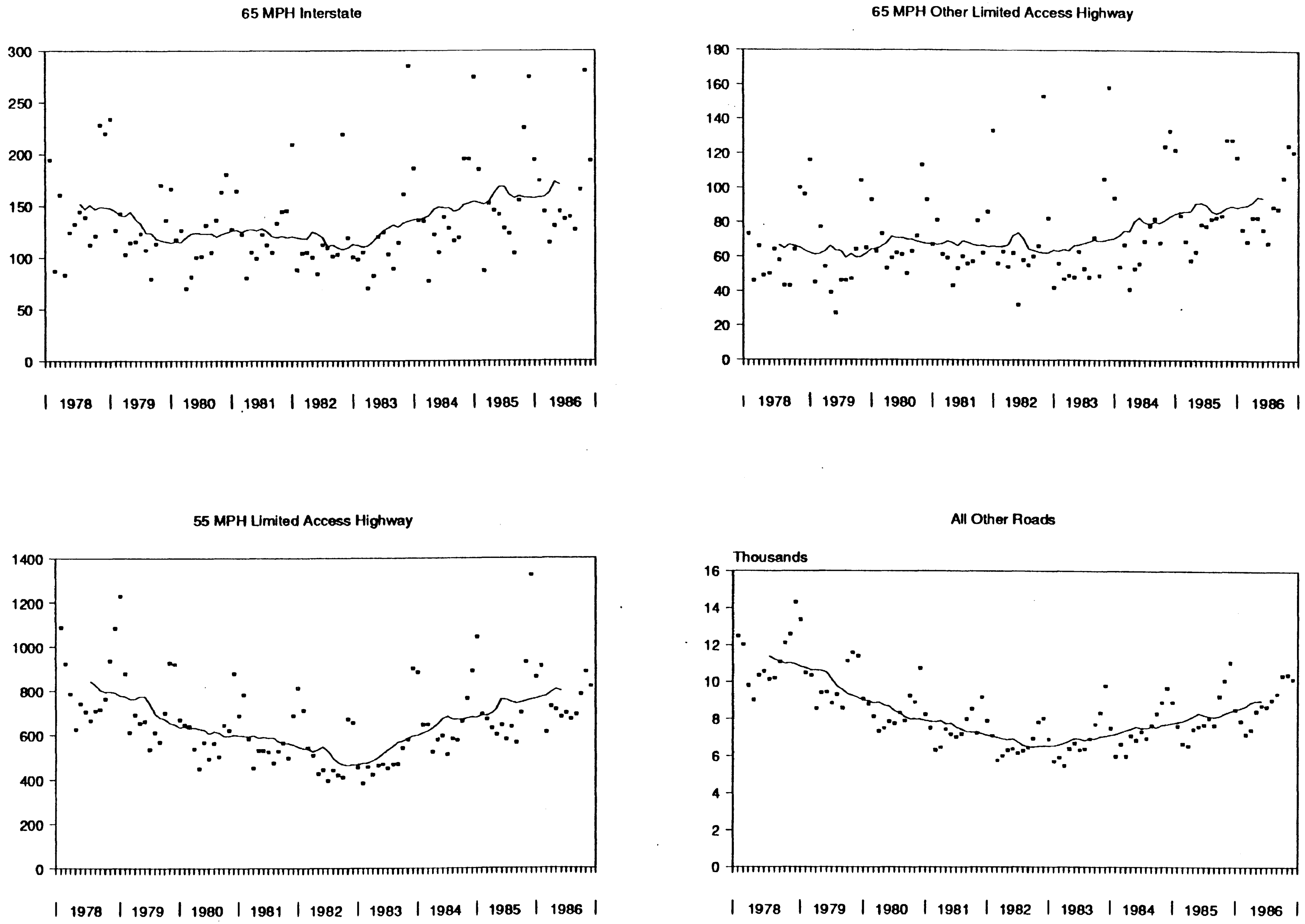

Figure B.9: Vehicle Damage Severity 5-8 Crash Frequency by Highway Type

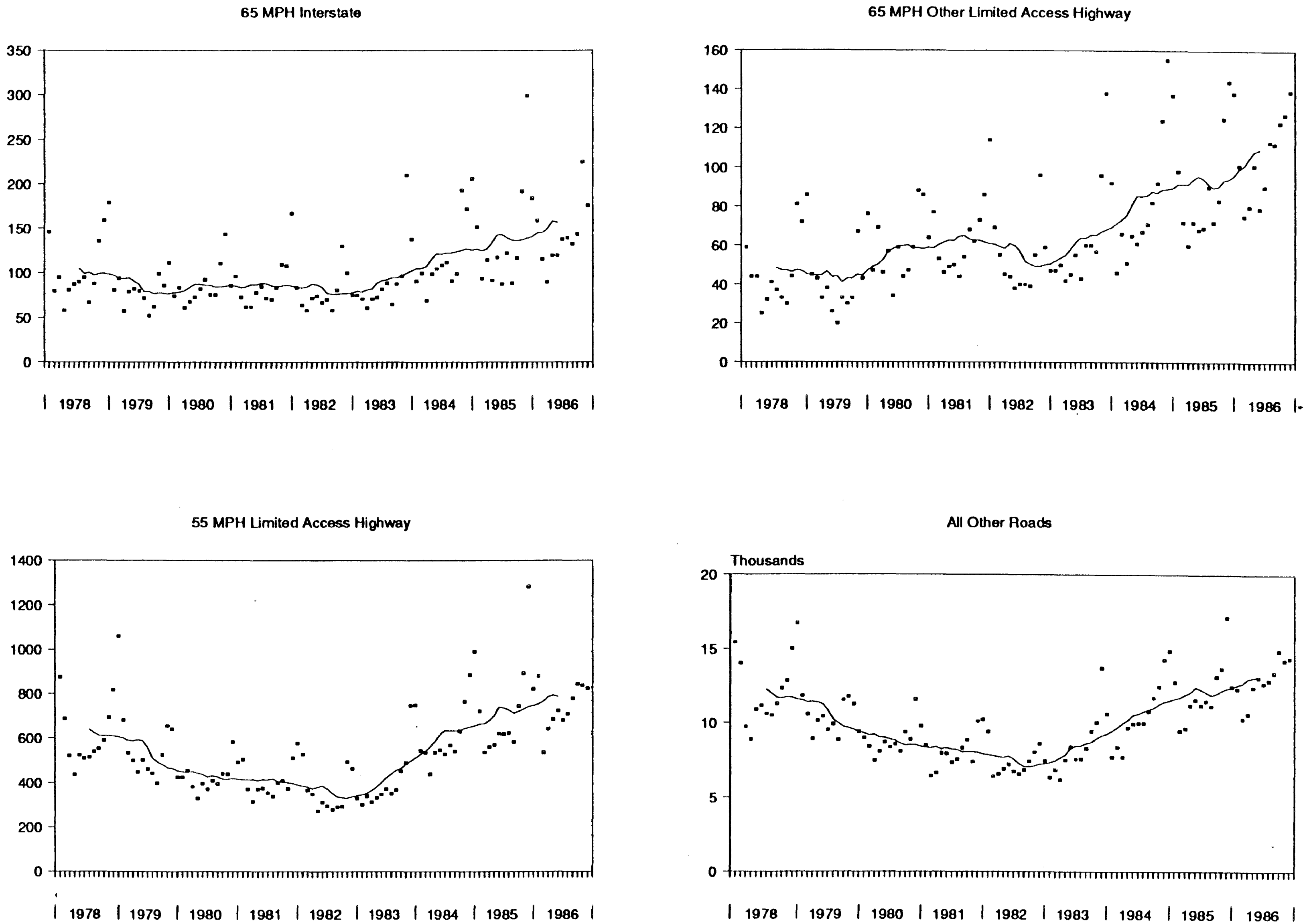

Figure B.10: Crash Rate of Drivers Age 15-24 per Licensed Driver by Highway Type

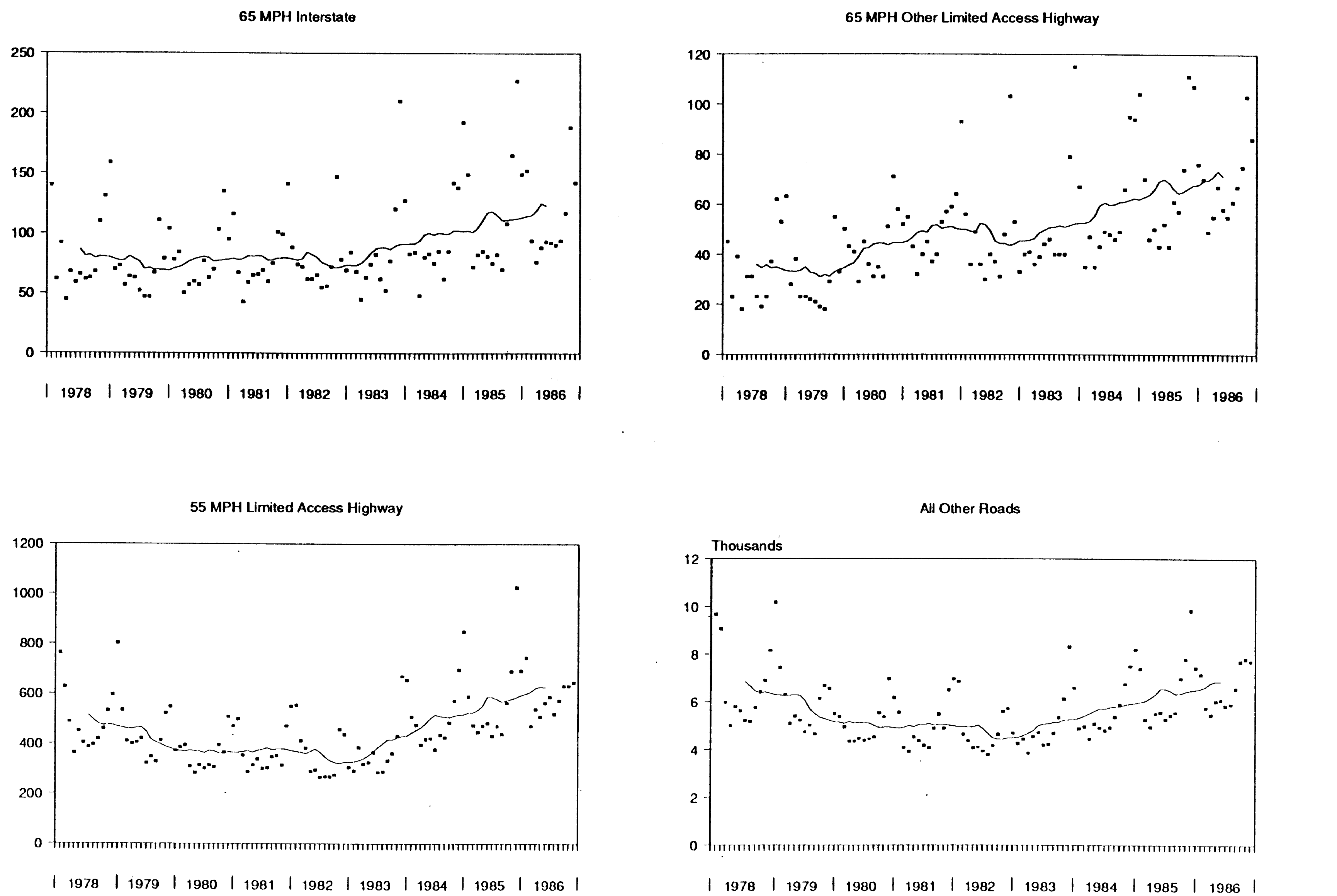

Figure B.11: Crash Rate of Drivers Age 25-55 per Licensed Driver by Highway Type

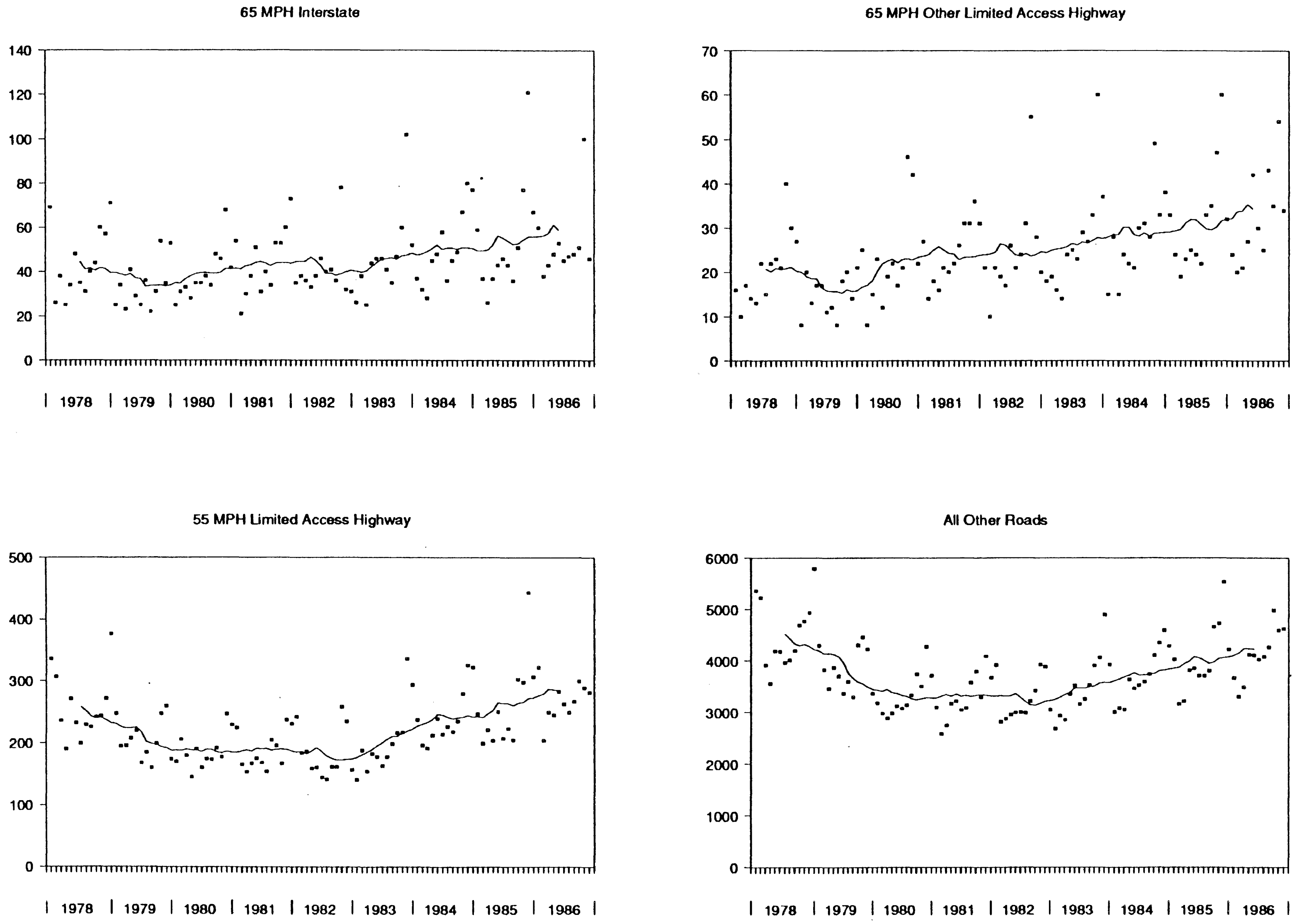

Figure B.12: Crash Rate of Drivers Age 56 and Over per Licensed Driver by Highway Type

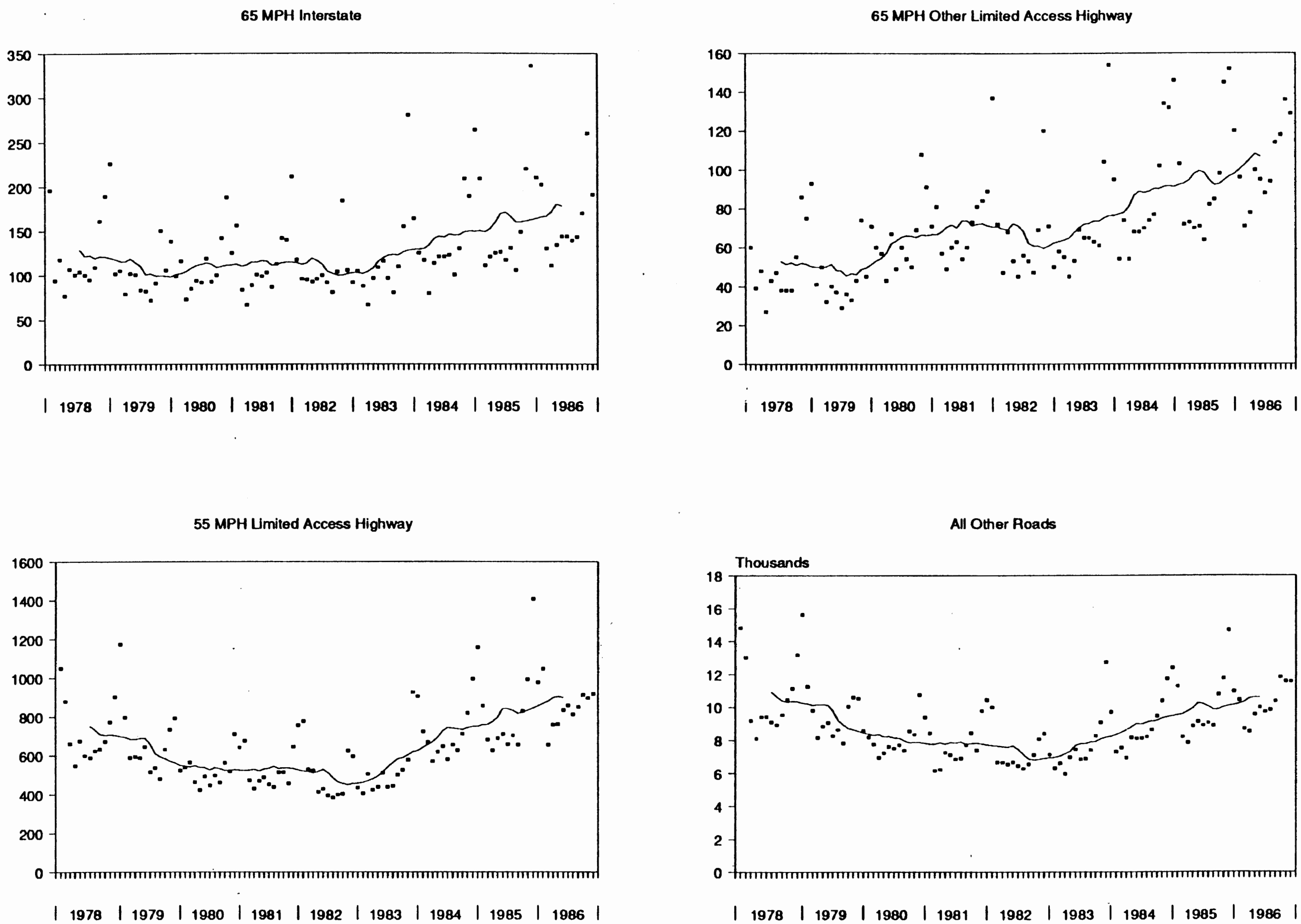

Figure B.13: Crash Rate of Male Drivers per Licensed Driver by Highway Type

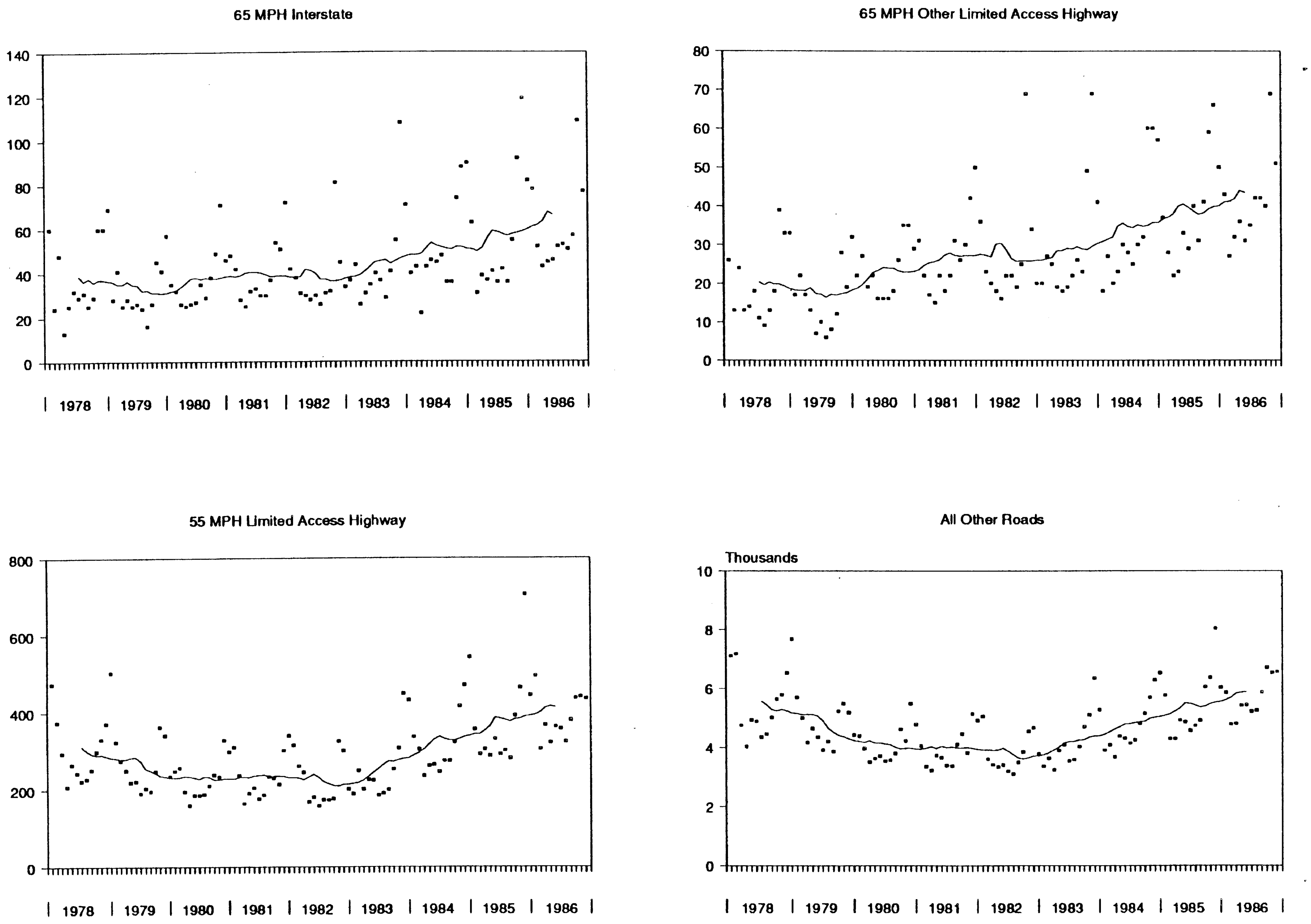

Figure B.14: Crash Rate of Female Drivers per Licensed Driver by Highway Type

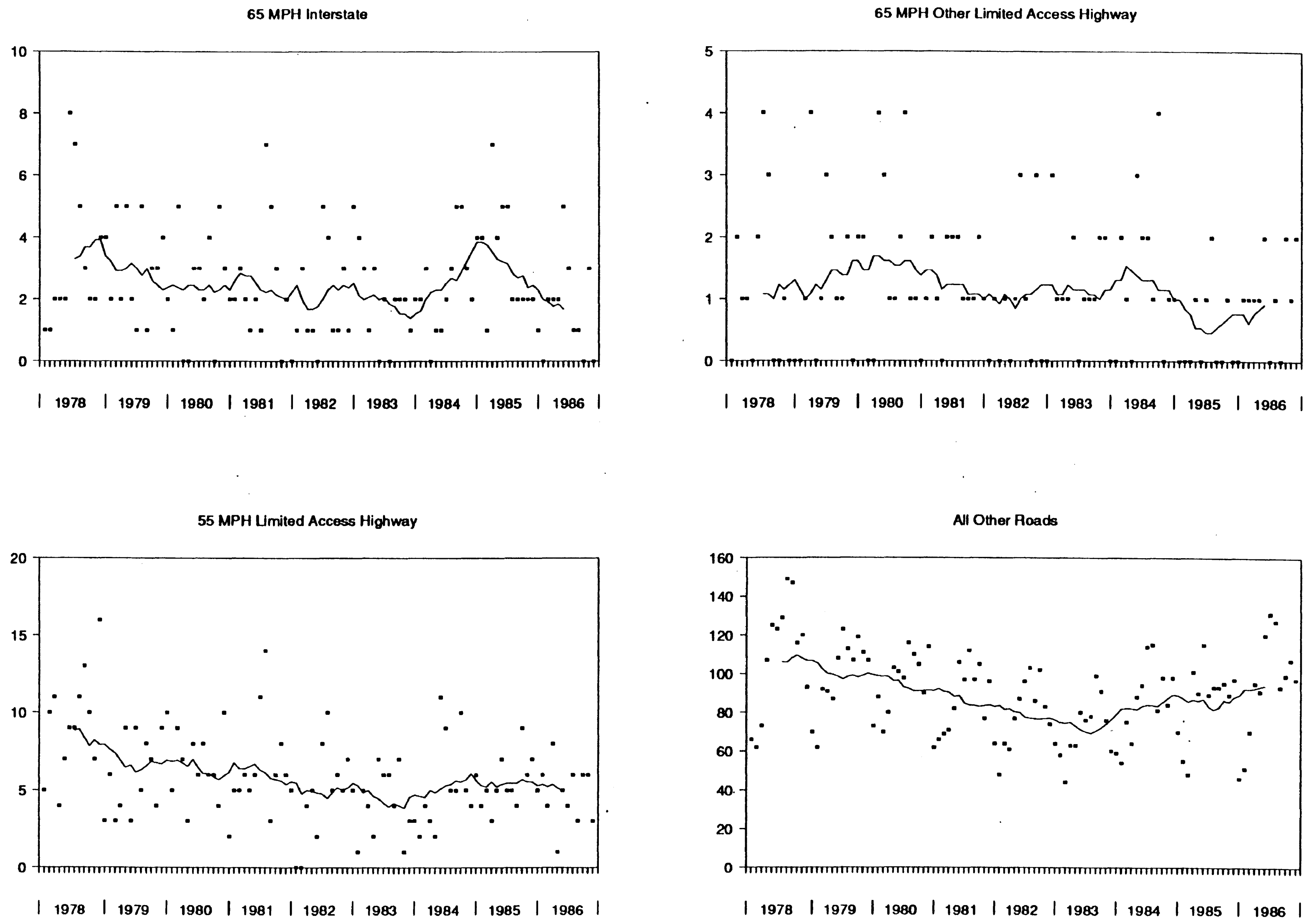

Figure B.15: Fatality as Worst Outcome in Crash, Frequency by Highway Type

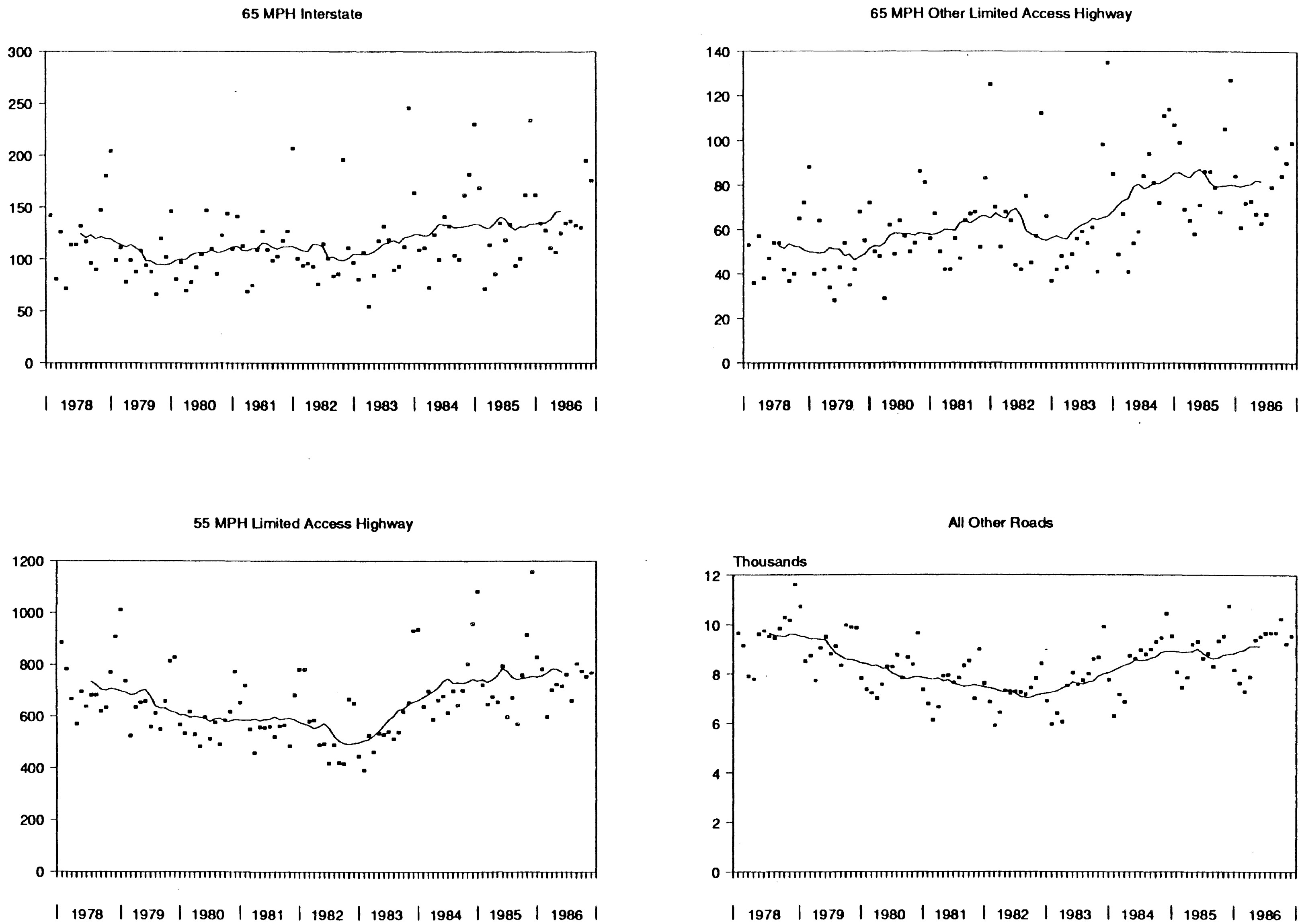

Figure B.16: Injury as Worst Outcome in Crash, Frequency by Highway Type

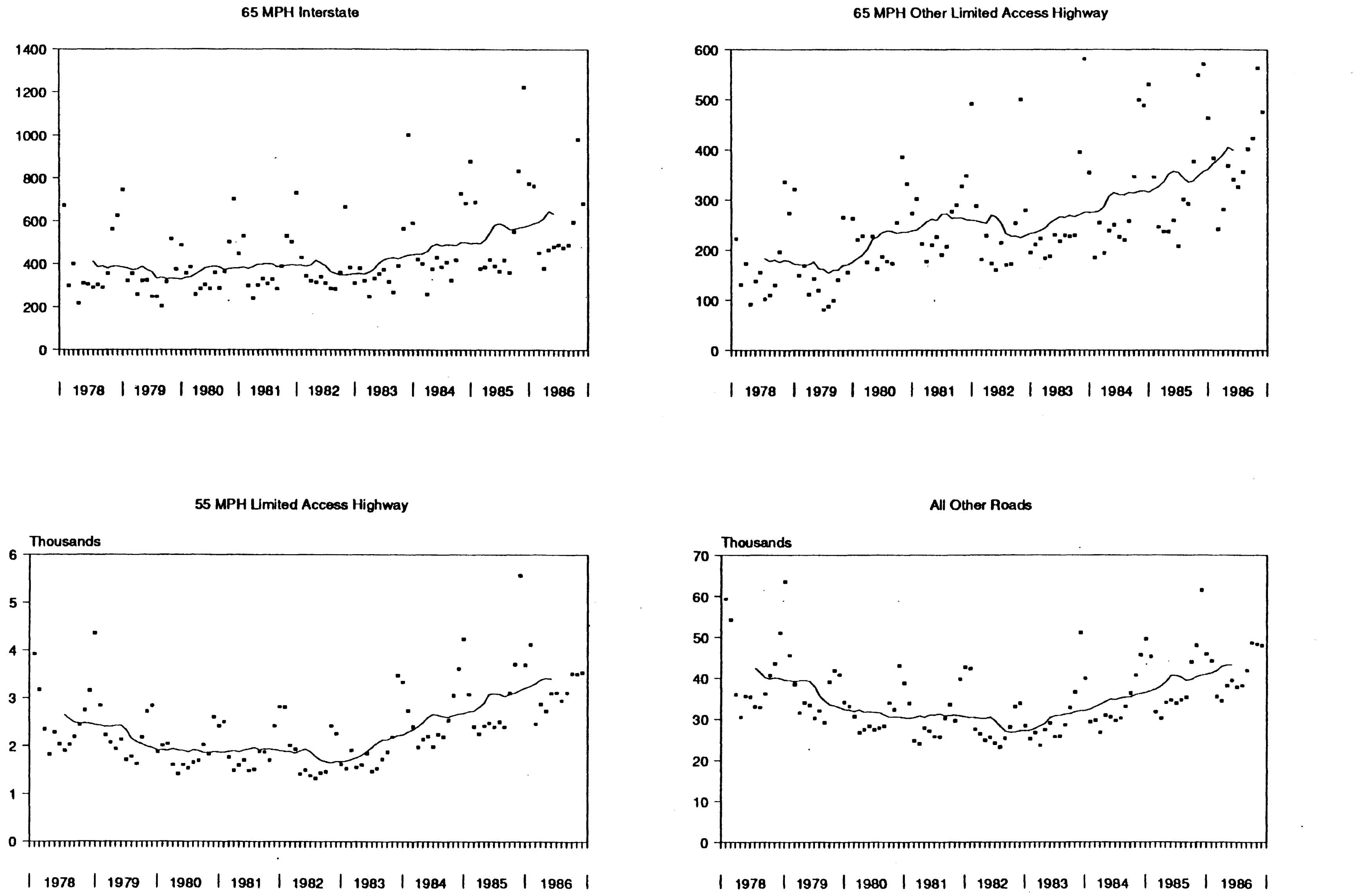

Figure B.17: Property Damage as Worst Outcome in Crash, Frequency by Highway Type

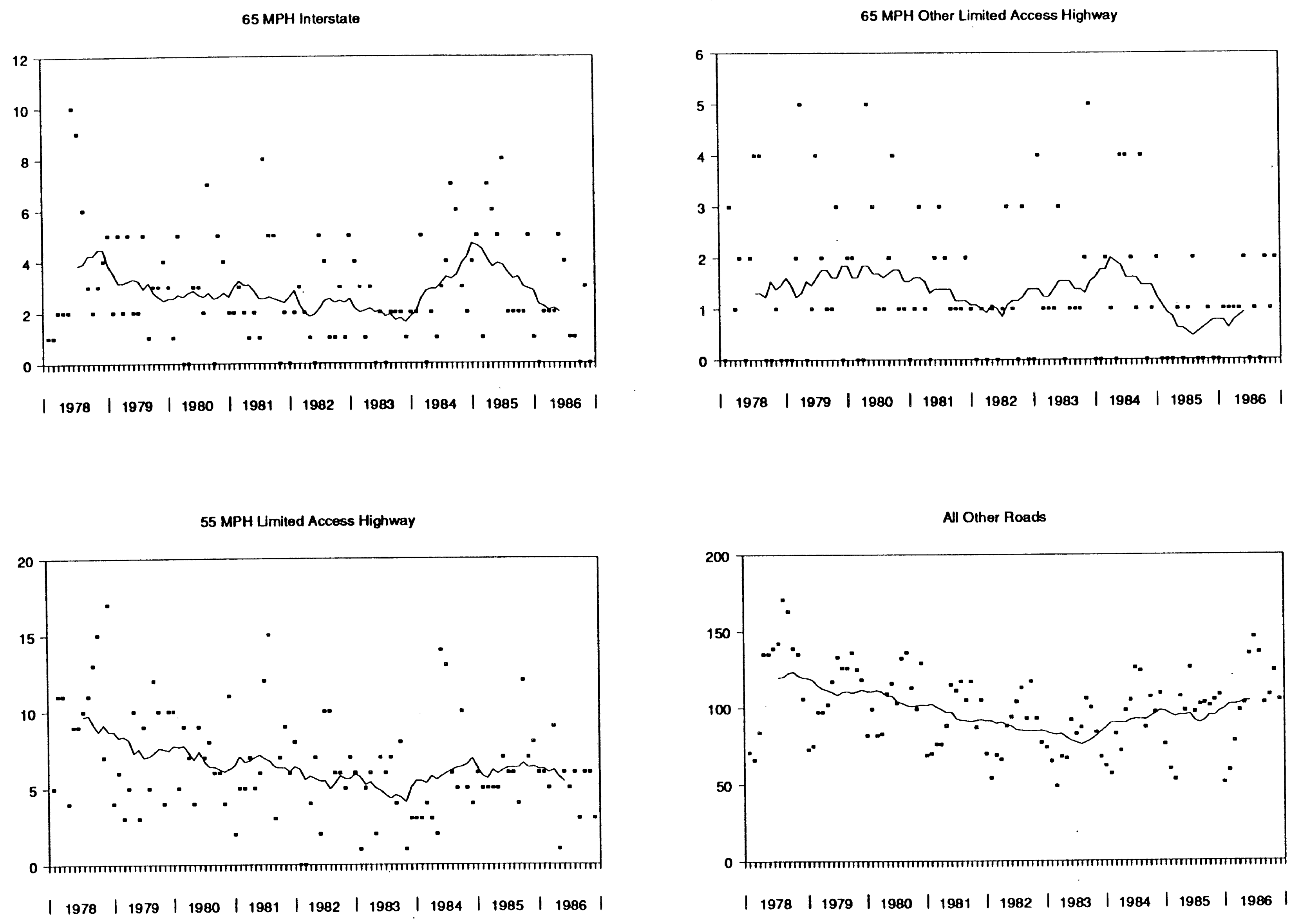

Figure B.18: Fatal Injury Frequency by Highway Type

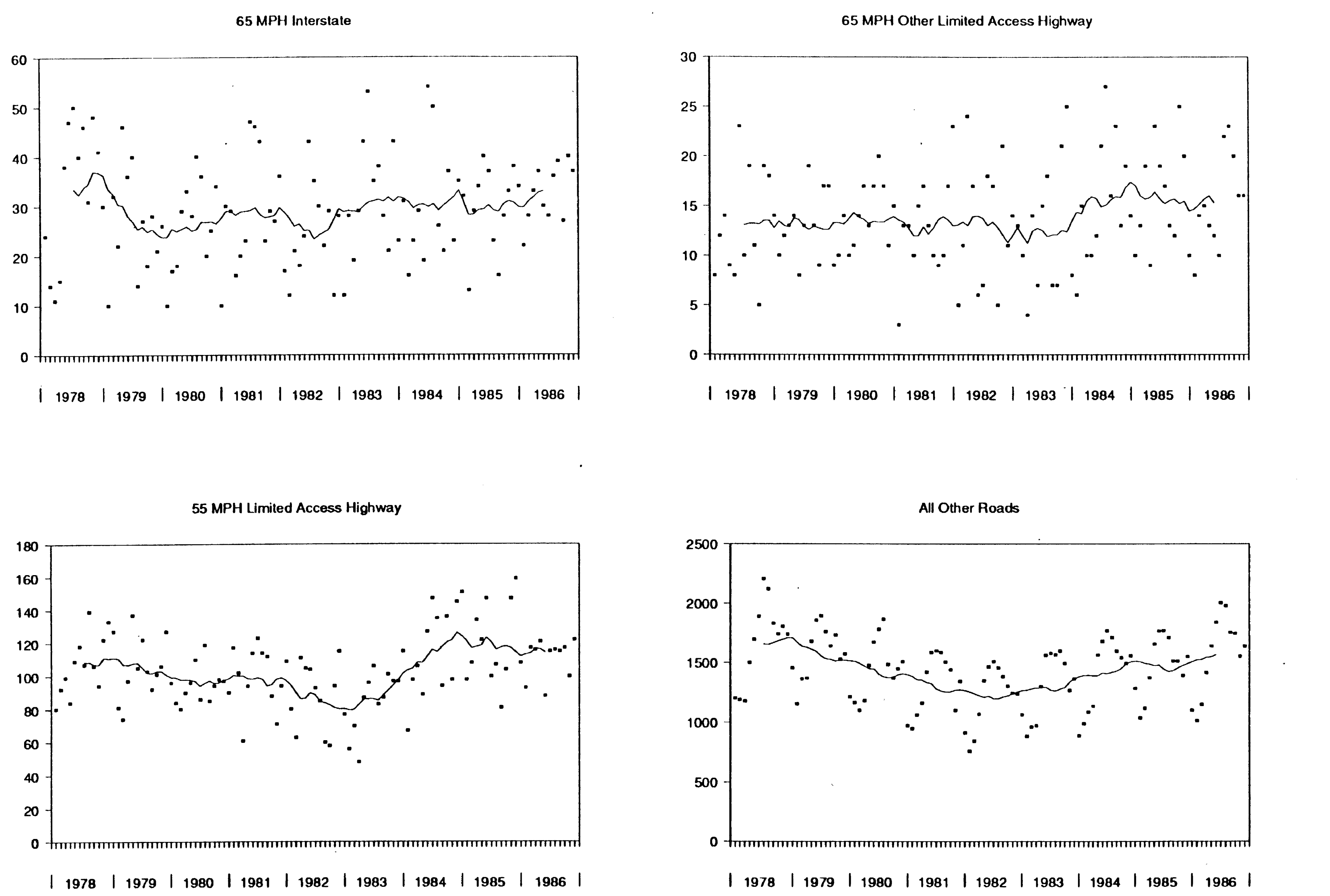

Figure B.19: A Injury Severity Frequency by Highway Type

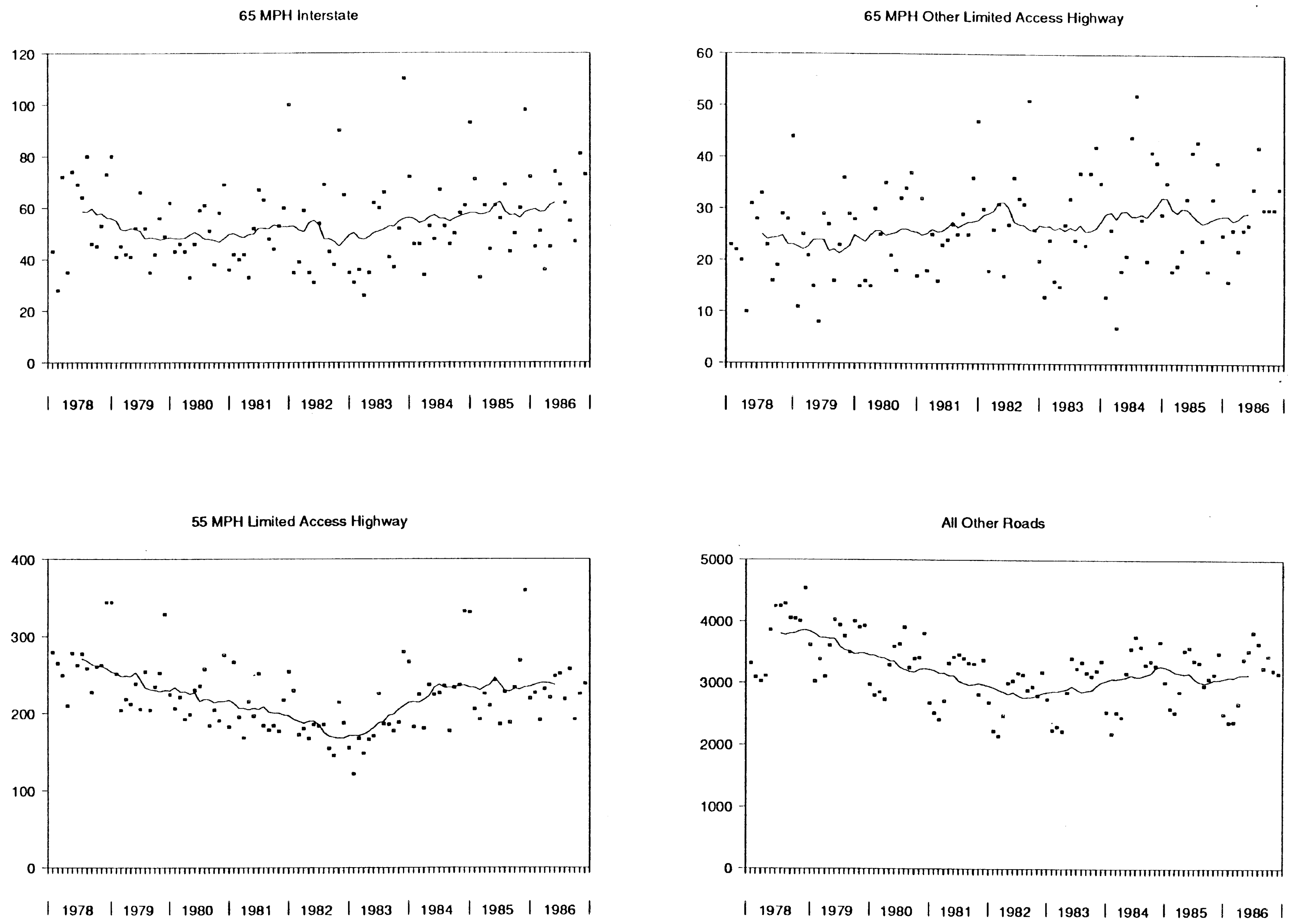

Figure B.20: B Injury Severity Frequency by Highway Type

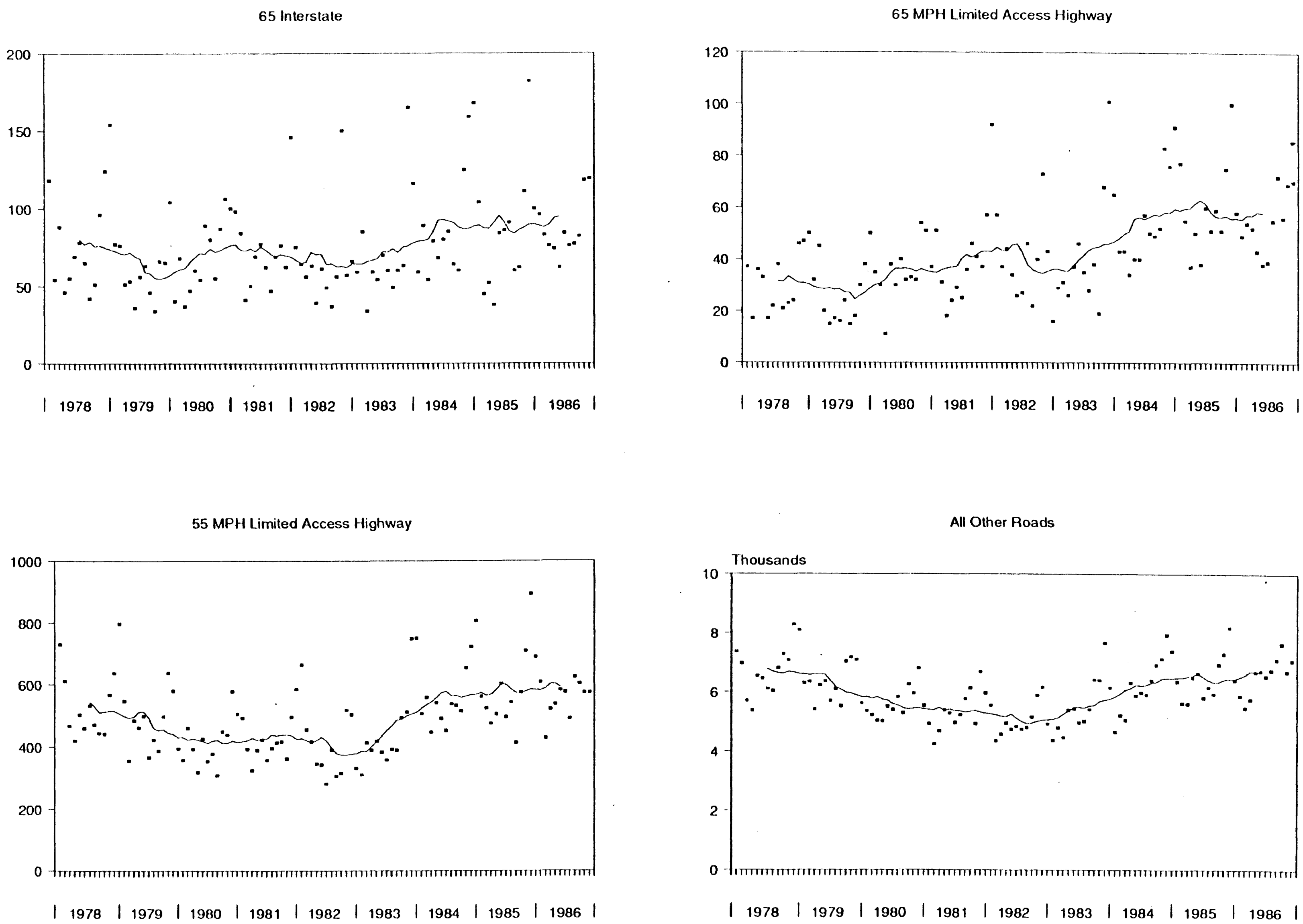

Figure B.21: C Injury Severity Frequency by Highway Type