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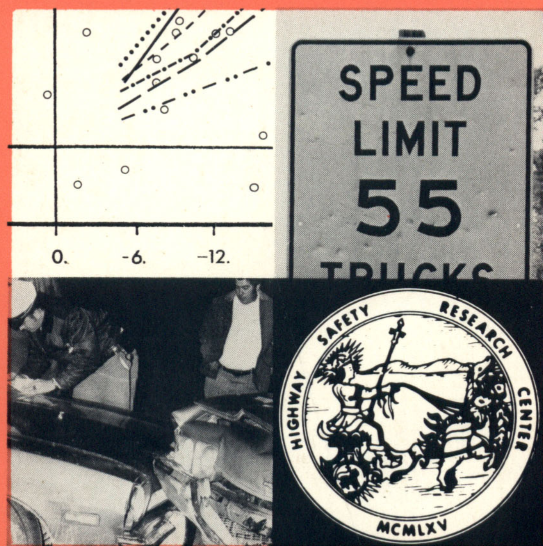

HIGHWAY SAFETY
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University of North Carolina, Chapel Hill, N.C.

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An Examination of the Effects of the 55 MPH Speed Limit on North Carolina Accidents

Forrest M. Council
Linda Pitts
Michael Sadof
Olin K. Dart

University of North Carolina
Highway Safety Research Center
Chapel Hill, North Carolina

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ABSTRACT

Because of the energy crisis of early 1974 and the resulting measures taken to conserve fuel (e.g., reduction of the maximum speed limit to 55 mph, "self-imposed" gas rationing, etc.), there were dramatic changes in the highway transportation system. This paper examines North Carolina data on vehicle speeds, accident frequency and severity, and traffic counts in an attempt to gain insight into the "causes" of the dramatic reduction in highway fatalities and accidents following these system changes. Emphasis is placed on the effects of the 55 mph speed limit. Comparative analyses of 1973 and 1974 data using various parametric and non-parametric statistical tests indicated the following major findings.

1. Changes in vehicle speeds:

   a. Following imposition of the lower limit on certain roadways, all sampled roadways experienced initial decreases in various measures of central tendency of speeds (e.g., means). These initial decreases were fully recovered by November, 1974, except on Interstate highways.

   b. Speed variation, as measured by the percentage of vehicles traveling in the 10 mph pace, decreased for all roadways, and the decrease appeared to become more pronounced through November, 1974.

2. Changes in accidents:

   a. Total 1974 accidents were 3.7 percent lower than 1973 accidents. Fatal accidents decreased 11.2 percent.

   b. The largest proportional decreases in fatalities were noted after the peak of the crisis, with data through October, 1974 indicating decreases of 43 percent on Interstate highways, 29 percent on U.S. highways, 31 percent on N.C. highways, and 19 percent on city streets.

c. While both TAD severity and "estimated speed prior to accident" decreased in 1974 the driver injury distribution did not change significantly on Interstates. In fact, the injury distribution appeared to have shifted slightly upwards in 1974 on all highways combined and for highways where the 1973 limit was 55 mph or greater.

3. Changes in traffic counts:

a. Traffic counts for 1974 were lower than for 1973 for all roadway classes through September. As expected, weekend travel appeared to experience the largest declines in the early months.

b. When proportional changes in accidents are compared to proportional changes in counts and to "predicted" changes based on past research, accidents appear to have decreased significantly more than would be expected on all roadways except rural paved roads, indicating the presence of "causes" other than volume decreases.

These findings, and others, indicate that while any "direct" severity reducing effect of the 55 limit may have disappeared, "indirect" effects on speed variances and possible changes in driver attitude may have continued. Because of this, there is no recommendation that the 55 mph limit be changed on safety groups, but there is a need for continued monitoring of the system since other contributing factors related to the fuel "crisis" have, in all likelihood, continued to change since late 1974.

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I. INTRODUCTION

In late 1973, North Carolina, along with the rest of the U.S., began feeling the effects of the "energy crisis." Because of the anticipated shortage of gasoline, the President of the United States requested that all states move toward a lowered speed limit of 55 mph. North Carolina complied with this request in December, 1973.

From December, 1973 to the present, North Carolina has experienced a dramatic decline in collisions and fatalities. Through September, 1974 there was a 19.8 percent decrease in the number of fatal accidents, a 6.9 percent decrease in the number of injury accidents, a 5.3 percent decrease in the property damage accidents, and an overall decrease of 6.1 percent in the total number of accidents. Because this reduction is unparalled in recent years, many people interested in highway safety have raised questions concerning the real causes behind this reduction. This is, of course, the real factor of reduced exposure due to less driving which would be expected to affect collisions and fatalities. In addition, changes in the highway transportation system (i.e., the shift to small cars, a reduction in "pleasure driving," etc.) have probably been factors in the reduction. However, these factors are not subject to legal or administrative control, and thus the results of these changes can be expected to fluctuate with the variables themselves. Conversely, the posted speed limit is subject to legislative and administrative action. Because of this, there is a need to know what part of the collision and fatality reduction is due to lowered speed limit, i.e., what effect this lowered limit is having on highway safety. Such information is necessary if future decisions on speed limits are to be made logically.

In attempting to gain such information on the speed limit, two main questions arise: (1) What part, if any, of the change in the number and severity of accidents was and is due to the change in the speed limit per se? (2) Can we expect this effect to remain in the future if the limit remains the same? While the answer to the first question is of interest to both researchers and administrators, the extrapolation of this data to the future is of utmost importance to the decision making process which affects our main mode of transportation, our highway system.

II. REVIEW OF THE LITERATURE

By March 3, 1974, the 55 mph speed limit was in effect in all fifty states. The change in the speed limit motivated several states and other organizations to evaluate its effect on such areas as accidents, fatalities, traffic volume, and travel. Some pertinent studies have been reviewed in order to present background and comparison information related to this evaluation.

Pudinski (1974) reported on accident changes under the energy crisis in California. The report, conducted by the California Highway Patrol, (CHP) examined the methods employed to determine the magnitudes of, and reasons for, the atypical accident experience which occurred during the recent fuel shortage. The period of analysis was from January through March 1974.

The findings for the first three months are summarized in the table on page 3. The "Expected" data were based on five years of historical accident information.

The reduction in travel was determined to be the most significant variable in the reduction of total accidents and injury accidents. The 11.4 percent drop in vehicle miles of travel during the analysis period was attributed totally to the fuel shortage condition.

The contribution of the reduction in posted speed limits to the <u>total</u> accident decrease was discounted as minimal. This finding was based upon the fact that the non-CHP reduction was in accordance with the CHP reductions; therefore, the variables responsible for reductions in both categories were applicable statewide; i.e., even on roadways not subjected to a reduction in posted speed limits. However, the non-CHP reductions used for the basis of this finding were fatalities. Thus, the implicit assumption was that reductions in CHP fatal accidents, injury accidents, and property damage only accidents were similar to non-CHP fatality reductions. The results did indicate a strong direct relationship between posted speed limit reduction and the probability of <u>fatal accident</u> occurrence.

The reduction in posted speed limits was also attributed with an indirect effect upon accident experience. This effect resulted from

Summary of findings for first three months of California accident data.

January-February-March	1974 CHP Fatal Accidents	1974 CHP Injury Accidents	1974 CHP PDO Accidents	1974 CHP Fatalities	1974 Non-CHP Fatalities
Expected Total	551	12,559	29,729	626	443
Experienced Total	326	8,795	20,416	395	342
Numerical Decrease	225	3,764	9,313	231	101
Percent Decrease	40.8	30.0	31.3	36.9	22.8
Factors Responsible by Percent of Total Decrease					
Reduced Travel	28	38	36	31	50
55 MPH Speed limit	31	8	-	34	-
New Speed Distribution	11	15	15	12	-
Permanent Daylight Saving	1	-	-	1	4
Unexplained	29	39	49	22	46
Total	100	100	100	100	100

the decrease in speed dispersal on State (CHP) highways produced by the imposition of the 55 mph speed limits. Using plots of involvement rate versus variation from mean speeds, the tighter speed dispersion of 1974 over that of 1972 was credited with a 6.5 percent decrease in total accident involvement rate for all CHP roadways, regardless of previous speed limit. The reduction percentage solely accounted for by the more compact speed dispersions during the three month analysis period on highways with reduced limits was determined to be 5.2 percent. This estimate was based on the fact that 80 percent of previous CHP accidents occurred on highways formerly controlled by speed limits in excess of 55 mph.

In addition to the basic 1974 three-month analysis period, provisional findings were presented for the second quarter of the same year. These findings are illustrated on page 5.

A comparison of the 1974 CHP fatalities for the first and second quarter indicates that there was a 36.9 percent reduction in the first period as compared to only a 25.9 percent reduction in the second period. Reduced travel was attributed with 31 percent and 25 percent of the reduction in CHP fatalities during the first and second quarter, respectively. The tighter speed distribution was attributed with 12 percent of the total reduction in the first quarter as compared to an 18 percent responsibility during the following three months. The reduction in speed was attributed with 34 percent as compared to 45 percent of the CHP fatality reduction during the first and second quarter, respectively. In addition, the unexplained amount of CHP fatality reduction which was unexplained decreased from 22 percent during the first quarter to 12 percent (the sum of "Unexp. Bicycle-Ped." and "Normal Stat Variance") during the second quarter.

The Colorado State Department of Highways (1974) conducted a study on the effects of the 55-mph speed limit in Colorado. From February through August 1974 there was a 12.7 percent decrease in Colorado fatal accidents over the same period of 1973. Areas where the speed limit was lowered accounted for the entire reduction. Rural interstates showed the only statistically significant reduction (43.4 percent). Although not statistically significant, other data indicated an 8.5 percent reduction in urban fatal accidents and a 14.8 percent reduction in rural fatal accidents on all roadways. Traffic volumes for the state decreased 2.5 percent (0.5 percent decrease in rural volumes and 4.5 percent decrease in urban volumes).

The average speed for 55 mph areas which had previously been 60 to 70 mph areas dropped from 64.1 to 56.8 mph. Just as in the California report (1974) the average speed differentials between vehicles decreased.

Provisional April through June CHP fatalities.

	April	May	June	Total
Expected Total	265	249	284	798
Experienced Total	184	195	212	591
Numerical Decrease	81	54	72	207
Percent Decrease	30.6	21.7	25.4	25.9
REDUCTION CATEGORIES				
1. Reduced Travel	17	16	19	52
% Total Decrease	21	30	26	25
2. Unexp. Bicycle-Ped.	6	3	9	18
% Total Decrease	7	6	12	9
3. Daylight Saving	-	-	-	-
% Total Decrease	-	-	-	-
4. Speed Distribution	15	12	10	37
% Total Decrease	19	22	14	18
5. Speed Decrease	29	29	35	93
% Total Decrease	36	54	49	45
6. Normal Stat Variance*	14	- 6	- 1	7
% Total Decrease	17	- 12	- 1	3

*This category includes all unexplained decreases except those involving bicycles and pedestrians.

Alcohol usage, light conditions, driver age, and urban/rural distribution of travel showed no significant changes.

In a study by Lam and Wasielewski (1974), spot speed observations were made on a four-lane suburban freeway in Michigan during the period between November 8, 1973 through November 7, 1974. Speeds were recorded in 15-minute intervals between 1:40 and 3:50 p.m. under light traffic conditions in good weather on 46 days. The study showed that the drivers on the M-59 freeway in Detroit have responded to the lower speed limits. The mean speed was 63.3 mph on November 8-9, 1973 and 60.4 mph on November 29-30, 1973. On March 3, 1974 the 55 mph speed limit was put into effect. From March 5, 1974 to November 7, 1974 the mean speed for cars was 57.6 mph. The speeds of trucks did not change from November, 1973 to November, 1974. The standard deviation of speeds dropped from 6.9 mph to 5.1 mph indicating that speeds are more uniform. Time of day, day of week, traffic flow, and truck composition did not contribute significantly to the variance of the 15 minute mean speeds.

The Highway Users Federation (1974) also studied the decrease in highway fatalities in the U.S. in 1974. The authors concluded that, while there was a significant decrease in fatalities, the 55 mph speed limit did not seem to be the cause of the decrease due to the fact that fatal accidents were also down on city streets and rural roads that were not affected by the lower speed limit. For example, pedestrian fatalities were down 24.7 percent for the first seven months of 1974. This was difficult to explain because most pedestrian deaths occurred in urban areas that were probably not affected by the lower speed limit. The reduction in pedestrian deaths probably accounted for five percent of the total reduction.

The lower speed limit brought about more uniform speeds. The increased number of drivers in the pace was probably important in the reduction in rural fatal accidents involving two or more vehicles. It could be hypothesized that there would be less overtaking and passing under these conditions. The study did indicate that the effects of the lowered speed limit decreased over the year in that at the end of 1974, 70 percent of all motorists were driving between 55 and 65 mph.

The article contained several suggestions for maintaining the low level of fatalities. Weekend speed limits on major rural routes could be reduced. Posted speed limits could be determined by the pace rather than the 85th percentile. Metered lanes and ramps, and sophisticated traffic control systems might be used to adjust speeds to road conditions.

Another study, prepared by an "ad hoc" committee of the American Association of State Highway & Transportation Officials (1974), was also to determine the effects of the 55 mph maximum speed limit and to make recommendations for AASHTO's position on future speed limits.

Each of six committee members was responsible for collecting and analyzing data from a group of 5-12 states. In this manner 48 states were covered. Data was collected on speeds, vehicle miles of travel, and accidents.

Data from the states indicated that speeds were reduced up to 10 mph and seemed to be more uniform as a result of the 55 mph speed limit.

There was a five percent reduction in vehicle-miles of travel from January through June, 1974. The reduction in travel was a result of the fuel shortage, not the 55 mph speed limit. In August, 1974 travel had returned to near 1973 levels, but it was still below what would have been expected.

In the period from January through June of 1973, there were 26,000 fatalities. In the same period of 1974 there were 20,000 fatalities. Approximately half of this reduction was felt to be due to the combination of reduced speeds and more uniform speeds. This conclusion was based on (1) past studies; (2) the fact that fatalities were still down 13 percent even when travel had returned to 1974 levels; and (3) "the fact that fatalities were reduced twice as much on roads where the speed limit was reduced compared to roads where the speed limit was not changed."

The total reduction in fatalities in the first six months of 1974 was 23 percent. Reduced speeds and more uniform speeds accounted for 11 percent of the reduction. Reduced travel accounted for five percent, while other factors accounted for seven percent reduction.

The main recommendation of the study is that the responsibility for maximum speed limits be returned to the states with the recommendation that the maximum speed remain at 55 mph.

The National Safety Council (1974) found a 24 percent fatality reduction in January through April of 1974 versus January through April 1973. Their conclusions concerning causes of this reduction were as follows:

Reduction in speed	-11%
Reduction in gasoline and travel	- 5%
Reduction in average occupancy	- 3%
Change in day-night travel	- 2%
Change in type of road used	- 1%
Increased use of safety belts	- 1%
Other (both known and unknown)	- 2%
Motorcycles, pedalcycles, small cars, age of driver	+ 1%
Four month fatality reduction	-24%

The estimated effect of reduced speed on total fatality reduction was based on "distribution of speeds preceding fatal accidents with speed trend studies, injury-to-death ratios and other supporting evidence." The number of lives that could be saved by reduced speeds was based on the assumption that the chances of being killed or seriously injured double with each ten mile per hour increase over 50 mph. The injury to death ratio increased 13 percent in the first four months of 1974. Most of this reduction was a result of the lowered speeds.

The change in gasoline efficiency, the 7.5 percent cut in gasoline availability, and the 4 percent decline in travel resulted in -1 percent change in urban travel and -8 percent change in rural travel. "Applying these changes to the 1973 urban and rural mileages and multiplying by the corresponding mileage death rates gives a savings of about 3,100 lives." This is a five percent decrease from 1973.

Driver deaths were down 23 percent and passenger deaths were down 33 percent. Using the Personal Transportation Study, it was determined that average occupancy of passenger cars was 1.8 persons per car in early 1974. This was a decline in average occupancy, resulting in a net fatality savings of three percent.

It was assumed that the reduction of night mileage was twice the daytime reduction. Using this information and the day and night mileage death rates and the new mileage totals, a two percent decrease was found.

Because the amount and purposes of driving changed, the type of roads used also changed resulting in a one percent saving in lives.

The use of the interlock system in 1974 model cars resulted in about a one percent saving in lives.

The other factors which accounted for a two percent fatality reduction include engineering and design changes in automobiles, improvements in highway design, and better law enforcement in some areas.

The decline in accident involvement was largest for the middle age groups, and not young drivers as expected. Increased ownership of small cars, motorcycles and pedalcycles accounted for a one-half percent increase in fatalities.

A preliminary analysis of North Carolina data was conducted by Seila and Reinfurt (1975). Using historical trends and information from the first four months of 1973 and 1974, the authors examined the effects of the 55 mph speed limit and the fuel shortage on highway safety.

The analysis indicated that, whereas accidents decreased 9.5 percent and injuries decreased 14.1 percent, fatal accidents dropped 21.0 percent and injury accidents dropped 12.0 percent. The decrease in vehicle miles driven, as estimated from gasoline sales, was 3.2 percent during this four month period. Based on these estimates, the fatality rate per hundred million vehicle miles and the serious injury rate per hundred million vehicle miles dropped 17.7 percent and 19 percent, respectively.

All these changes were attributed to decreased exposure, the reduced maximum speed limit, changes in vehicle size and occupancy, and shifts in times at which trips were made and roads on which they were made. Mean occupancy decreased slightly from 1.587 to 1.573 occupants per car. The accident decreases were found to be more pronounced on the weekend time period. In 1974, a smaller percentage of vehicles were involved in accidents on the Interstate, U.S., N.C., and rural paved roads. There was an increase in vehicles involved in accidents on city streets.

Based on hypothesized shifts in accident speeds and resulting shifts in accident severity, the authors concluded that the 55 mph limit is probably responsible for 5 to 10 percent of the total reduction in fatalities, and that the lowered speed limit and fuel shortage have had a profound effect on highway safety. The authors also noted that planned future research would examine more closely the interactions among these "main" effects, interactions which make interpreting the findings difficult.

In addition to the pure accident-related studies, three papers were reviewed which dealt with the more wide reaching effects of the energy crisis and with public attitudes toward this energy shortage.

Murray, et al., of the National Opinion Research Center (1974) published the results of a survey of the American public's response to the energy shortages during the winter of 1973 and 1974.

This report was based on the results of a weekly national probability sample survey (Continuous National Survey). The survey data showed that the majority of the public believes the energy shortage is a serious problem, but only 25 percent consider it to be the most serious problem facing America today. Most consider the federal government and oil companies to be largely responsible for the energy crisis. Although most people were aware of the energy crisis and made modest attempts at conservation, there was little indication of serious changes in life style.

Attitudes toward the energy crisis were related to expectation of problems in obtaining gasoline and electricity. The percentage of car owners who reported cutting down on driving increased after Christmas. Driving for shopping and recreational purposes dropped. There did not seem to be a shift away from single passenger auto trips to car pools or public transportation. Generally, people who experienced difficulty getting gas and thought the energy shortage was important were now likely to cut down on driving. Between December 6 and March 29, 64 percent of all eligible households reported cutting down on driving to save gas. Fifty-four percent of all eligible households reported driving slower to conserve gas between January 18 and March 29.

"In the area of transportation, conservation came mainly in the form of driving slower and reduced use of the automobile for social, recreational, or driving purposes; there is little incidence of intermodal shifts."

The impact of the energy shortage on travel patterns and attitudes in a suburban area of Columbia, South Carolina was studied by Sacco and Hajj (1974). Some comparisons were made between the Dutch Fork area and the rest of the nation. One purpose of this study was to look at the possibility of attracting suburban residents to mass transit.

The method used to assess the impact of the energy shortage was to compare the patterns and attitudes found in the 1972 Dutch Fork Study and those found in a study conducted in April, 1974. In the 1972 study, data was based on a ten percent sample of the households in the Dutch Fork area. Most of the interviewing was done by telephone. The 1974 survey was broader and more detailed. The survey was administered by personal interview. The main questions to be answered concerned the

extent to which the gasoline shortage changed the amount of automobile travel and increased use of and interest in local mass transit and car pooling.

Basically, the study showed that the energy shortage did not greatly reduce the amount of automobile travel and did not have a strong effect on transit patterns or attitudes in the Dutch Fork area. National patterns indicated similar trends.

Auto travel by residents of the Dutch Fork area was reduced an estimated 10 to 15 percent. The largest decreases in traffic volumes were on weekends. Slower driving and limiting shopping and recreational trips were the most common ways of reducing travel. Most people changed their driving behavior rather than mode of travel.

The gas shortage, rather than the price of gas, had an impact on driving patterns. The only effect the price of gas had was the trend toward the purchase of more economy size cars. At the peak of the gas shortage, traffic volumes decreased and transit ridership increased.

A final report prepared by Braddock, Dunn and McDonald, Inc. (1974) for the National Science Foundation looked at the causes and effects of the 55 mph national speed limit. The report used official and unofficial statistical data and other information to examine the impact of the 55 mph speed limit on economics, safety, and social behavior.

The authors found that travel speeds were reduced in 1974. A weighted average speed, based on a 12 state sample, was computed by weighting the state average speeds for 1973 and 1974 by the total mileage driven on main rural roads from January to June in each state. The average speed dropped from 63.2 mph in 1973 to 55.7 mph in 1974. This decline in average speed would result in a 13.5 percent increase in travel time.

The authors examined studies from California, Colorado, Iowa, and a National Safety Council report to determine the actual portion of the reduction in 1974 traffic fatalities attributable to lower traffic speeds. These studies attributed between 30 percent and 46 percent of the reduction in fatalities to the lower speed.

Gallup, Harris and Opinion Research Center public opinion polls were used to get an indication of public response to the 55 mph speed limit. The 55 mph speed limit was favored by about three-fourths of the respondents. People who considered the energy crisis to be long term and serious were more likely to favor the lower speed limit. In contrast, a mini-survey conducted by Braddock, Dunn, and McDonald showed that more than three-fourths of their respondents favored raising the speed limit to 60 mph or repealing it and letting the states decide.

Summary of the Review of the Literature

The review of the literature on the effects of the 55 mph speed limit indicates the following findings:

1. After the lowering of the speed limit, the average speed for most vehicles was lower. In the first few months of 1974, the average speed ranged from 55.7 to 57.6 mph.
2. Fatalities and fatal accidents decreased in 1974 as compared to 1973. The reduction was from 12 percent to 40 percent, depending on the study.
3. Traveling speeds seemed to be more uniform in 1974.
4. Traffic volumes on certain types of roads decreased during the energy crisis. The decrease in traffic volumes ranged from 2.5 percent to 4.6 percent.
5. A combination of factors such as reduction in the availability of gasoline, reduction in average occupancy, changes in day-night travel, and increased use of safety belts worked together to cause the lower average speed, the decrease in fatalities and fatal accidents, the uniform speeds, and the decrease in traffic volumes.
6. Although the public perceived the energy crisis as real, little change in overall life style, such as an increased use of mass transit, is noted.
7. There are some indications that vehicle speeds and travel increased in the latter part of 1974.

III. METHODOLOGY

In order to gain insight into the hypothesis in question, three basic types of data were examined. These include (1) speed data collected at 36 "permanent" stations across North Carolina, (2) accident data from the North Carolina Accident File, and (3) Traffic Count data from 59 permanent traffic count stations across the state. For the reader's information, each of these will be discussed briefly here. Details of specific analyses involving these data will be presented in later sections.

The speed data analyzed was extracted from reports provided by the Planning and Research Branch of the North Carolina Division of Highways (N.C. D.O.T., 1973 and 1974). This agency annually collects speed data at 36 stations on rural primary and paved secondary roads, usually during the month of April. The data are collected during daylight hours of weekdays. Radar units concealed in unmarked cars measured speeds of "free-flowing" vehicles, and information on highway class, vehicle type, and speed is recorded. The same team of data collectors covers all stations, and approximately 6000-7000 observations are made.

Because of the energy related change in speed limits, additional samples were collected during December, 1973 and November, 1974 at the same locations as in the annual April studies. Thus the data used in this study were collected in April and December, 1973, and April and November, 1974.

The North Carolina Accident File consists of computer tapes containing information on all accidents reported to the North Carolina Division of Motor Vehicles (DMV). All police agencies in the state use the same report form (see Appendix B), and report on accidents which involve either personal injury or $200 total property damage, as required by law. A recent study by House, et al. (1974) indicated that these North Carolina accident records are fairly complete. When a sample of approximately 1000 crashes which had been reported to insurance companies was examined, it was found that 84.6 percent of those cases which should have appeared on the DMV files were found. The authors note that the recording rates found in this study were considerably higher than those reported in the literature for other states. While this difference may be partly due to the methodology employed, the data indicate that the driver (and accident)file is fairly complete in terms of including reportable crashes.

Detailed accident data were analyzed for accidents occurring between January, 1973 and September, 1974.[1] Basic analyses involved comparisons of accidents in the same three month period in each of the two years, and in comparisons over 1974 for the study of "effect deterioration."

Traffic count data used was also obtained from the Planning and Research Branch of the North Carolina Division of Highways. As part of the agency's ongoing planning program, a series of 59 permanent traffic count stations are operated across the state. Traffic counts are collected 24 hours each day. Most of these stations consist of magnetic loop detectors embedded in the pavement and a recording device which accumulates and records vehicle counts on an hourly basis. The data are then keypunched and placed on computer tape by the Planning and Research Branch. The information recorded on tape includes hourly counts, location and date information, and a series of codes signifying whether or not the data are accurate (the data are coded in 12 hour blocks). Thus, data collected during road construction or equipment malfunction would be coded "bad."

Before the traffic count-related analyses were conducted, the data were "pre-cleaned" to insure comparable sets from each year. Two transformations were carried out. First, the month-date codes on the 1974 data were shifted--one date in time such that the first day of week of the 1973 and 1974 data had the same date. Thus, any given day of week (e.g., the third Tuesday in a given month) would have the same date in both years. In this format, a given month (e.g., March) would have the same number of Saturdays, Sundays, Mondays, etc., facilitating comparisons by month from one year to the next. Following this, the second "pre-cleaning" operation consisted of screening each "date" in the two samples to determine whether data coded as "good" existed. If the data from either sample were bad, both 12 hour blocks were deleted from the final set. This eliminated the possibility that count differences between 1973 and 1974 for a given time period were due to equipment malfunction in the time period for one year but not for the corresponding period in the other. While the resulting data set cannot be thought of as accurate traffic volumes, the counts for any given time period can be accurately compared between years to calculate percentage changes.

The earlier studies reviewed have indicated numerous possible "causes" of the lower accident and death totals. The analyses that follow will concern four major areas--(1) the change in vehicle speeds, (2) the changes

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[1]Less detailed data, not on computer tape, was available for the period through February, 1975.

in the frequency of accidents, (3) the changes in the severity of accidents, and (4) the changes in accidents as related to changes in traffic counts. The various specific hypothesis examined in these four areas will be discussed in the Analysis and Results sections.

In many of the analyses, comparisons of distributions of accidents between the two time periods were made. In cases where the ordering of the rows had no significance (e.g., comparison of January-March total accident frequencies by road type) a Chi-square statistic was used in the statistical testing. In cases where row ordering was relevant (e.g., comparison of January-March accidents by age of driver), the Wilcoxon-Mann-Whitney statistic applicable to grouped data was employed. This nonparametric test of high efficiency is discussed in a recent paper by Flora (1974).

IV. ANALYSES AND RESULTS

As was noted in the Methodology Section, specific hypotheses were tested involving changes in speed and speed dispersion, changes in accident frequency and severity, and differences between changes in accident frequency and traffic counts. Each of these major analysis areas are covered in the following subsections.

In addition to these later analyses, initial work included estimates of the possible effects of the energy crisis. In this work by Council and Waller (1974), 1973 data were used to determine "affectable" accidents, and the resulting estimates were discussed in an article published in Traffic Safety.

One question the authors' dealt with concerned whether or not the rate of accidents per million vehicle miles would be affected by the lowered speed limit. The analysis was based on information from accident reports on 1973 North Carolina accidents which indicated that there were 1190 vehicles in which at least one person was killed in a traffic accident. To estimate the decrease in the number of "fatal" vehicles which might result from a lowered limit, the 1190 fatally involved vehicles were classified according to the posted speed limit where the crash occurred and the estimated speed of the vehicle prior to impact.

Two assumptions were made. First, it was assumed that all vehicles whose speed was greater than 55 mph would drop down into the category of 50-55 mph with its fatality rate. This resulted in an estimate of a 29 percent reduction in total fatalities. A second assumption, a more conservative one, was as follows. For each posted speed and estimated speed, it was assumed that the vehicle would operate at a similar speed relative to the new speed limit. For example, it was assumed that drivers going five mph or less above the "old" posted speed limit would continue to drive 1-5 mph above the "new" posted limit, thus moving into the 56-60 mph range with their fatality rate dropping accordingly. If each group dropped in the predicted manner and experienced the fatality rate of the groups to which they dropped, reduction in fatalities would be approximately three percent. Thus, a rather wide range between a three percent and a 29 percent drop in fatalities was forecasted.

The authors also noted that accident involvements might increase since they are a function of the variability in speeds. This was indcated in a report by Solomon entitled Accidents on Main Rural Highways Related to Speed, Driver, and Vehicle (1964) and a report by the Research Triangle

Institute entitled Speed and Accidents (Vol. 1, 1970). These studies concluded that the increase in the variance of a speed distribution might be expected to result in more crashes per million miles. The authors felt that the lower speed limit might lead to an increase in variance, and thus, to an increase in crashes per million vehicle miles.

The author's final prediction was that lower exposure would cause the frequency of accidents and fatalities to go down, and the accident and fatality rate would be lowered by the new speed limits. However, compliance and variance might complicate these savings.

Thus, estimates of effects were made early in the project. The following analyses will concern the "true" effects of the reduction in the speed limit.

Analysis of Speed Data

Analysis of speed data concerned two hypotheses--(1) there are differences in the average speeds and percentage of vehicles over the speed limit between 1973 and 1974 (before and after the limit changes), and (2) there are differences in speed dispersion between the two time periods.

The average speeds for each of the four sample periods and each class of roadways are shown in Table 1. The first two columns present the old car-truck speed limits and the new reduced limits. Thus, within each vehicle class, the first column presents speed data under the "old" speed limit. The next three columns refer to vehicle speeds under the new reduced limits.

The more dramatic drops are noted on Interstate roadways during the first months of the reduced limit (i.e., decrease from April to December, 1973). However, all roadways (even those without a change in speed limit) appear to experience some light decrease in average speed during this initial period. In general, all roadways experienced an increase in speeds in the later part of 1974. The results of more detailed analyses of these general trends follow.

Table 2 presents data on various speed characteristics when all roadways within a given class are combined. While similar to Table 1, in order to obtain usable sample sizes this data only refers to (1) North Carolina autos and (2) all commercial vehicles. In addition to average speeds, information on median speed, 85th percentile speed, and percent of vehicles over 55 mph and 65 mph is presented. No statistical tests concerning the changes in average speeds were possible since no estimates of the standard

Table 1. Average speeds of various vehicle classes on North Carolina roadways---old and new speed limits.

April 1973 Posted Speed Limit	December 1973 May 1974 November 1974 Posted Speed Limit	Roadway Type	N.C. Passenger Vehicles 1973 April	N.C. Passenger Vehicles 1973 Dec.	N.C. Passenger Vehicles 1974 April	N.C. Passenger Vehicles 1974 Nov.	Total Passenger Vehicles 1973 April	Total Passenger Vehicles 1973 Dec.	Total Passenger Vehicles 1974 April	Total Passenger Vehicles 1974 Nov.	TTST Commercial 1973 April	TTST Commercial 1973 Dec.	TTST Commercial 1974 April	TTST Commercial 1974 Nov.	All Vehicles 1973 April	All Vehicles 1973 Dec.	All Vehicles 1974 April	All Vehicles 1974 Nov.
65-65	55-55	Interstate	65.6	54.4	56.8	59.3	65.4	54.8	57.4	60.0	61.6	55.4	57.4	59.6	64.4	54.7	56.3	59.6
60-50	55-50	Main U.S. (Heavy Traffic) I-Corridors	58.4	58.0	55.2	57.5	59.8	58.1	56.4	59.1	56.1	56.7	51.6	59.4	58.5	57.5	55.1	59.0
55-45	55-45		48.0	51.5	48.6	51.9	48.0	51.5	48.6	52.0	40.1	51.5	41.6	49.1	47.1	50.9	47.6	51.2
55-45	55-45	*Main Former Interstate	52.0	48.7	50.2	53.1	52.1	48.8	50.3	53.1	47.3	44.9	46.0	52.3	51.4	47.7	48.9	52.7
60-50	55-50	Other Main Highways	54.0	51.5	51.9	54.7	54.2	51.6	52.0	54.8	51.2	50.5	50.5	53.7	53.1	51.0	51.2	54.2
55-45	55-45		51.1	48.8	48.8	51.8	51.1	48.8	48.8	51.9	45.3	45.0	45.3	49.7	49.7	48.0	48.0	51.3
55-45	55-45	Secondary Roads	47.3	46.5	46.1	51.6	47.3	46.4	46.1	51.6	46.0	59.0	46.7	49.0	46.6	46.1	45.6	50.4

*"Main Former Interstates" - Main highways which once carried Interstate traffic but no longer do because a parallel Interstate highway has been completed which diverted much of this traffic. These highways would now be assumed to operate similar to the "Other Main Highways."

Table 2. Summary of speed characteristics---North Carolina automobiles and all commercial vehicles.

Highway Type	Speed Characteristics	April 1973 N.C. Autos	April 1973 Comm.	Dec. 1973 N.C. Autos	Dec. 1973 Comm.	April 1974 N.C. Autos	April 1974 Comm.	Nov. 1974 N.C. Autos	Nov. 1974 Comm.
Interstate Highways	Vehicle-Sample	663	463	796	647	762	570	642	591
	Mean	65.6	61.9	54.4	54.6	56.8	54.4	59.3	59.0
	Median	65	62	55	54	56	55	59	59
	85th Percentile	70	69	59	60	61	60	63	63
	Percent > 55	94.7	78.8	33.0	32.9	57.1	35.4	81.3	78.8
	Percent > 65	46.0	25.3	0.9	2.3	2.9	0.5	5.6	4.6
Main Non-Interstate Highways	Vehicle-Sample	2334	1173	2320	1156	2555	1300	2569	1282
	Mean	53.5	50.8	50.8	48.9	51.1	49.0	54.1	52.5
	Median	54	51	51	49	51	50	55	53
	85th Percentile	60	60	57	55	57	55	60	59
	Percent > 55	38.1	26.9	18.6	13.9	20.4	13.8	38.5	30.7
	Percent > 65	4.3	2.5	0.6	0.3	0.5	0	1.4	0.8
Secondary Roadways	Vehicle-Sample	460	155	359	143	433	171	409	197
	Mean	47.3	44.6	46.5	45.4	46.1	44.7	51.6	48.6
	Median	48	45	46	45	46	45	52	50
	85th Percentile	55	55	55	54	53	53	58	57
	Percent > 55	13.0	11.6	13.6	9.8	5.3	7.6	24.7	19.8
	Percent > 65	1.5	0	0.8	0.7	0.2	0	4.9	1.0

deviation of the speeds were available. However, for information purposes, if it is assumed that the speeds at a given location are normally distributed, and that the standard deviation will be less than 20 mph (a very conservative assumption since past speed studies on open highways have shown standard deviations to fall in the 5 to 8 mph range for two lane roads, and the 5 to 10 mph range for Interstates), with a sample size of 500 in each sample, a difference of 2.5 mph in the two means is significant at the $p = .05$ level. (If a standard deviation of 10 mph is assumed, a 1.25 mph difference is significant at the $p = .05$ level). Thus, many of the changes between sampling times shown in Table 2 would probably be considered statistically significant.

Speed on Interstate highways.

Of perhaps greatest interest due to the magnitude of the expected change in speeds, is the Interstate highway category. Here, the data indicate a large decrease of approximately ten mph in the mean, median, and 85th percentile speed between April, 1973 and December, 1973 (the first month under the new limit). Following this initial decrease, vehicle speeds (both passenger cars and trucks) crept back up, until in November of 1974 approximately one-half the initial decrease had been recovered. Also of great importance in terms of accident severity reduction was the reduction in the percent of vehicles traveling at or above 55 mph and 65 mph. In the former category, the percent of vehicles traveling over 55 mph in December of 1973 was only approximately one-third of the level during April of the same year. However, this reduction was almost fully recovered by November, 1974. This was not the case with the percent of vehicles exceeding 65 mph. This group of vehicle speeds was essentially eliminated in December, 1973, and only recovered 12 percent to 18 percent of its original level by November of 1974.

While these results are assumed to be related to the severity of a crash (and thus to the number of fatal crashes), speed per se has not been shown to have a strong relationship with accident involvement rates. However, as noted earlier, speed variance or dispersion is related to involvement: the lower the variance about the mean speed, the lower the accident rate. As noted earlier, because individual speed data was not available, standard deviations could not be calculated. Information on the pace, the 10 mph range containing the greatest frequency of speeds, is known (see Table 3).

Table 3. Information concerning the ten mph pace on Interstate samples.

	April 1973	December 1973	April 1974	November 1974
Pace speed	60-69	50-59	52-61	55-64
Approximate percentage of vehicles in pace	63%	71%	68%	76%

As would be expected from the previous results concerning means, the data indicated that the pace was reduced to a 10 mph lower level in December, 1973 and has recovered approximately 5 mph of this reduction by November, 1974. However, of even greater importance is the indication that the percentage of speeds in this pace has increased significantly ($p < .001$). This result indicates that the lowered limit (along with other changes) may well have lowered speed dispersion, a finding opposite that predicted by the authors in the earlier paper, but in agreement with the works reviewed earlier (Pudinski, 1974; Colorado State Department of Highways, 1974; Lam and Wasielewski, 1974).

The data on Interstates was further broken down into sampling station groups so that difference between the locations could be examined. Analyses of mean speeds (again for North Carolina cars and all trucks) consistently indicated the same general trends as for the group data (with the exception of the station where truck speeds increased in each sample measured). As Figure 1 indicates, the mean speeds of the different stations have become much closer together through the four samples. It appears that, at least in terms of mean speeds, Interstate roadways across the state have tended to more closely resemble each other. Also pointing to this same conclusion were results of analyses of the standard deviations of the mean speeds for the eight locations (not to be confused with the uncalculatable standard deviations of the speed data at each station). The standard deviation for the eight North Carolina automobile mean speeds, $s_{\bar{x}}$, decreased from 4.00 mph in the April, 1973 "before change" sample to 1.02 mph in the November, 1974 sample. The truck data followed a similar pattern.

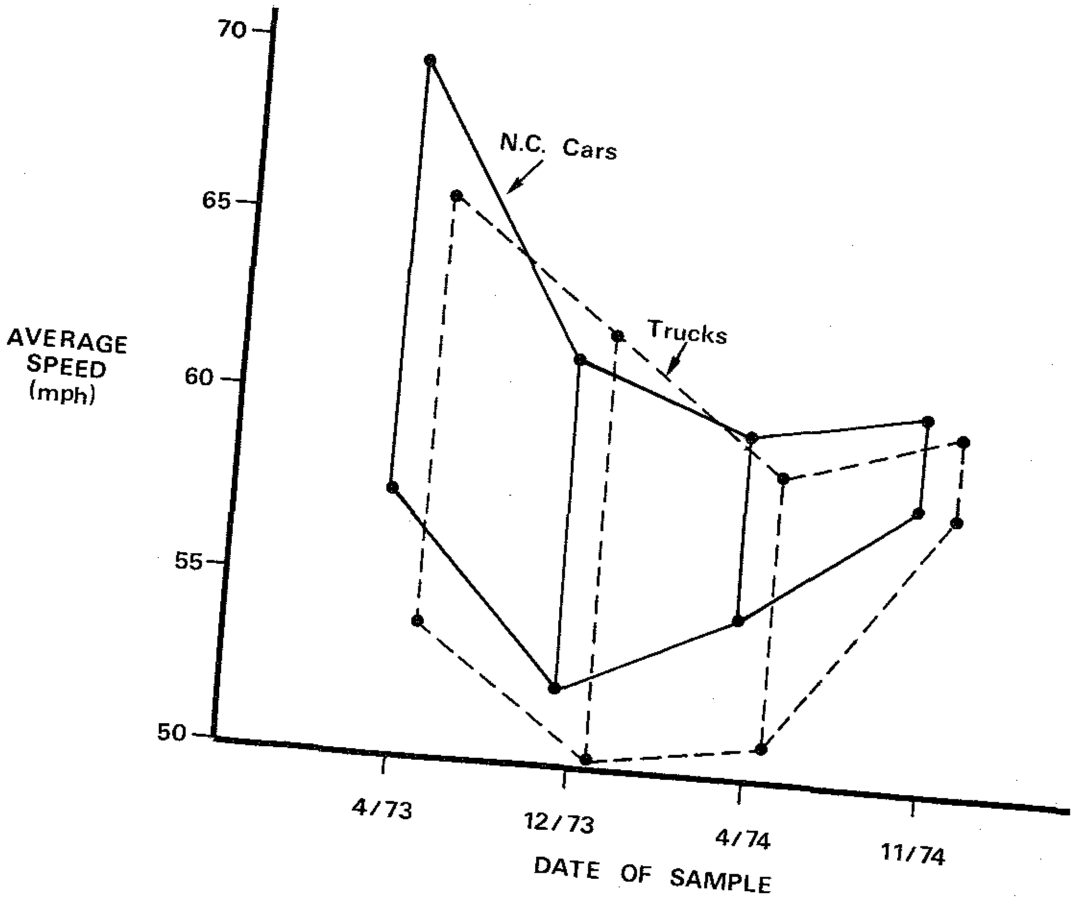

Figure 1. Range of mean speeds for North Carolina cars and all trucks at all Interstate stations.

As noted earlier, slight differences did exist between locations. Analysis of various data groupings indicated that these could reflect true regional differences, or could only be a reflection of differences in sample locations (e.g., high density urban areas versus low density rural locations).

Speed changes on main non-Interstate highways.

Returning again to the data presented in Table 2, the main, non-Interstate highways exhibit trends somewhat different from the Interstates. While there appears to be a (probably significant) decrease in mean, median, and 85th percentile speeds at the initial "after" point (i.e., between April, 1973 and December, 1973), this decrease is much more modest, being approximately 2 to 3 mph. However, by November, 1974, this decrease is fully recovered with mean speeds being slightly above those of April, 1973.

Similar trends are noted in the percent of vehicles exceeding 55 mph. This percentage was reduced by approximately 50 percent in the initial period, but had increased to its original level by November, 1974. While the percent exceeding 65 mph was originally very low (4.3 percent for cars), it was virtually eliminated in December, 1973 and by November, 1974 had increased to only one-third of its original level.

Again there appears to be accident involvement related changes in the variance of the speed distribution. As noted in Table 4 the 10 mph pace followed the trend of the mean speeds: its level originally decreased 3 to 4 mph, and then returned to its original level. However, the percentage of vehicles within this range continued to increase, and a significant difference exists between the initial and final samples ($p < .001$).

Table 4. Information concerning the ten mph pace on main highways.

	April 1973	December 1973	April 1974	November 1974
Pace	50-59	46-55	47-56	50-59
Approximate percentage of vehicles in pace	48%	58%	57%	61%

These data on main highways were further subdivided into two classes for more detailed analysis on average speeds. The first group contained the ten stations where the "old" speed limit had been 60 mph for cars and 50 mph for trucks. The second group of ten stations had "old" speed limits of 55/45 mph and thus were not changed in December, 1973.

For the first group, where an effect might be expected, the mean speeds did indeed decrease between the first two sampling points (see Table 5).

Table 5. Means and standard deviations of mean speeds for main highways experiencing a change in limit.

	April 1973		December 1974		April 1974		November 1974	
	N.C. Autos	All Trucks	N.C. Auto	All Trucks	N.C. Auto	All Trucks	N.C. Auto	All Trucks
$\bar{x}$	54.0	51.0	51.5	49.8	51.9	49.8	54.7	53.0
$s_{\bar{x}}$	3.20	3.28	3.99	3.78	2.58	2.32	2.18	2.46

However, by the final sampling period the means had returned to their pre-change levels. As was noted in the earlier discussion of Interstate routes, the standard deviation of the means is less at the end of the sampling period than in the pre-change data. The group of highways appear to be acting more like each other after the limit change.

The second class of main highways were those where no change in speed limit was made--those where the old limit was 55 mph for automobiles. Data on the mean speeds of these stations is presented on the following page.

Table 6. Means and standard deviations of mean speeds for main highways experiencing no change in limit.

	April 1973		December 1973		April 1974		November 1974	
	N.C. Autos	All Trucks	N.C. Autos	All Trucks	N.C. Autos	All Trucks	N.C. Autos	All Trucks
$\bar{x}$	50.5*	48.1	49.3	47.0	49.3	47.4	52.3	50.2
$s_{\bar{x}}$	4.89	5.02	3.67	3.24	1.93	2.28	2.03	2.47

*Note: Because of limitations in the basic data, these mean speeds are not weighted by sample sizes as in previous tables, but represent the mean of the 12 different means.

As is noted, there was very little change in mean speeds over the first three sample periods. However, there does appear to be a slight increase in average speeds in the final sampling. That is, for both North Carolina automobiles and all trucks, the average speeds for November, 1974 are slightly higher than they were in April of 1973.

This trend is not particularly surprising in view of historical trends toward higher speeds. The decrease in the standard deviations of these means again is an indication that the highways in this class are acting similarly at least in terms of one statistic--mean speed.

The highways in both these classes were also categorized by region of the state, and indeed some slight differences were noted in the earliest sample. In the 60 mph limit group, the roads in the east were characterized by lower average speeds than in the other two regions. Conversely, in the group with no limit change, the western roadways were characterized by lower speeds. While these differences may indeed be regional, there is some evidence that the differences may simply reflect differences in the geometrics, etc., of the roadways sampled.

<u>Speed changes on secondary roadways</u>.

The final class of roadways examined included seven secondary roadways across the state. Again, the overall data is presented in Table 2, page 19. All roadways in this class had an "old" limit of 55 mph and, thus, experienced no change in December of 1973. The overall data on mean, median, and 85th percentile speeds indicates essentially no changes across the first three sampling periods.

However, just as in the second class of main highways (those experiencing no limit change), when the November, 1974, data are compared to the April, 1973, data, there appears to be some slight increases in these statistics. The same trend holds true in the next two rows of the table, where the percentage of vehicles exceeding 55 mph and 65 mph appears to decrease over the first three samples, but then increase to higher levels in the November, 1974 period.

These increases over the entire period are also of interest in terms of comparison between the final speeds on secondary roads and the main highways whose speed limits were not changed (i.e., those whose average speeds are summarized in Table 6). Average speeds for these two classes of highways extracted from the previous tables, are shown in Table 7.

Table 7. Average speeds for main highways and secondary roads where the speed limit was not changed.

	April 1973		December 1973		April 1974		November 1974	
	N.C. Autos	All Trucks	N.C. Autos	All Trucks	N.C. Autos	All Trucks	N.C. Autos	All Trucks
Main Hgwys.	50.5	48.1	49.3	47.0	49.3	47.4	52.3	50.2
Secon. Roads	47.3	44.6	46.5	48.4	46.1	44.7	51.6	48.6

It is noted that while there was a three mph difference in average speeds for the two classes in the April, 1973 sample which continued through April, 1974, this difference had virtually disappeared by November, 1974. Thus, while geometric and volume differences continue to exist between the three roadway classes, the roadways are now operating in a very similar manner, at least in terms of average speeds.

Just as with the other classes, there also appeared to be a change in speed variation in the secondary roads, even though no change in speed limit was made. As shown in Table 8, the level of the ten mph pace increased between the first and fourth sample, as would be expected from previously derived increases in the mean, median, etc.

Table 8. Information concerning the ten mph pace on secondary roadways.

	April 1973	December 1973	April 1974	November 1974
Pace	45-54	45-54	45-54	48-57
Approximate percentage of vehicles in pace	42%	38%	45%	49%

However, there is an accompanying significant increase in the percentage of vehicles within this pace ($p < .05$), an indication that the speed dispersion on secondary roadways has decreased slightly. Again, this change could affect accident involvement rates on these roads.

Summary of speed changes.

In summary, the energy crisis and the lowering of the speed limit appear to have resulted in initial decreases in average speeds, median speeds, 85th percentile speeds, and the percent of speeds over 55 mph and 65 mph for all classes of highways, factors which could affect accident severity. As expected, the major decrease was on the Interstate roadways. By November of 1974, approximately half this decrease was recovered on Interstates and almost all on other main highways. Historical trends toward higher speeds may be evidenced by slight increases in final speeds for main highways experiencing no limit change and for secondary roads, and, at least in terms of average speeds, the sampled roadways within each class (and between classes) are operating in a more similar manner in November, 1974, than in April, 1973.

Of importance to accident involvement rates were findings indicating that speed variations may have decreased during the period of study in all sampled road classes.

Table 9. North Carolina total* and fatal accidents by month for 1973 and 1974.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Total Accidents													
1973	9911	8380	10560	9581	10692	11078	10586	11259	10676	11536	10912	10526	125697
1974	8872	8083	8778	8952	10067	10105	9910	11504	10823	11120	11163	11572	120949
% change	-10.48%	-3.54%	-16.88%	-6.57%	-5.85%	-8.78%	-6.39%	+2.18%	+1.38%	-3.61%	+2.30%	+9.94%	-3.78%
Fatal Accidents													
1973	117	98	136	130	131	134	143	149	147	170	119	121	1459
1974	109	72	102	97	96	116	121	123	112	125	110	113	1296
% change	-6.84%	-26.53%	-25.00%	-25.38%	-26.72%	-13.43%	-15.38%	-17.45%	-23.81%	-26.47%	-7.56%	-6.61%	-11.17%

*These monthly figures may differ slightly from those in subsequent tables because of exclusion of all reported PDO accidents with less than $200 total damage in this table.

The ten mph paces for each class contained a higher proportion of vehicle speeds in November, 1974, than in April, 1973. This finding is particularly interesting in the roadway classes which experienced no change in speed limits.

Analysis of Accident Data

Just as in the studies reviewed earlier, the accident configuration for North Carolina changed drastically in early 1974 during the energy crisis. This change was noted both in terms of accident frequency and accident severity. As is indicated in Table 9 below, total accidents were lower in eight months of 1974 than in the corresponding months of 1973, and fatal accidents[1] were lower in all months. The largest decreases were noted in the early months during the perceived height of the crisis, but the decreases in fatal accidents continued throughout the year. Total accidents for the entire year were down 3.78 percent, and fatal accidents decreased 11.2 percent.

As was noted in earlier papers, these changes could have resulted from a combination of many "causes," including reduced travel, changes in travel location, changes in driver age, the reduced speed limit, etc. Even though the goal of this current analysis is aimed at detecting the effect of the lowered speed limit, it is obvious that many of these other factors interact with speed changes, making the parceling out of a specific limit effect very difficult if not impossible. Attempts were made at examining at least some of the additional "causative" variables. As indicated in the Introduction section, one of these factors, travel reductions and related shifts, is studied in detail in the final section of this paper.

In this section involving accident analyses, four basic groups of hypotheses come under study. These include (1) analysis of urban versus rural shifts in accident involvement, (2) analysis of changes in fatalities by roadway class, (3) analysis of accident severity, and (4) analysis of changes in the age of accident involved drivers. This fourth area was studied in an attempt to identify another possible cause of the reduction in total accidents--a differential reduction in the mileage of the younger driver.

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[1]Note that these figures refer to fatal accidents and not fatalities. A fatal accident is defined as an accident in which one or more fatalities occurred.

Analysis of urban-rural accident patterns.

As indicated, the above described changes in accidents concern all roadways. While the lowering of the speed limit only affected certain roadways, predominately rural in nature, other possible "causes," such as shifts in the location of travel, would be expected to differentially affect urban and rural accidents. Because of this, the accident data were categorized into urban and rural accidents as shown in Table 10.

As can be seen, the changes in monthly urban accidents alternate in sign. For the total twelve month periods, the 1974 urban accidents are significantly higher than for 1973 although the difference is small. This is some indication that travel in the urban areas may have increased between the two years.

Rural accidents, on the other hand, were down in each month except December, and the twelve month total was down 8.63 percent, again indicating possible changes in travel characteristics and speed variations. Thus, it appears that while there may have been a decrease in vehicular miles driven throughout the state, the majority of the decrease may have been in rural mileage, an hypothesis further explored in the later sections.

Bicycle and pedestrian accidents, which are predominatly urban in nature, also experienced an increase in 1974. As shown in Table 11, the yearly total for 1974 was up by 4.26 percent. While this increase may be a result of increased urban travel and increased pedestrian and bicycle traffic, the fact that the major increases are in the summer months and in December, 1974, long after the apparent crisis period was over, may also simply reflect increased bicycle usage experienced nationwide.

Analysis of changes in fatalities by class of roadway.

Because much of the interest in the energy crisis related changes has been in decreases in fatalities per se (as opposed to fatal accidents or total accidents), and because the lowered speed limit should differentially influence accident involvement and severity on the various classes of roadways, it is important to ascertain where and when these fatality savings are occurring. In the following series of tables, 1973 and 1974 fatalities are categorized by month (January through October) and roadway class, and then data for three month intervals are combined for comparison with later analyses on severity.

Table 10. Monthly accidents from 1973 and 1974 categorized by urban-rural location.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Urban Accidents													
1973	4606	3914	4934	4327	4945	5165	4683	5079	4855	5165	4909	5366	57948
1974	4487	4320	4375	4384	4798	4756	4674	5464	5296	5149	5446	5710	58859
% change	-2.58%	+10.37%	-11.33%	+1.32%	-2.97%	-7.92%	-0.19%	+7.58%	+9.08%	-0.31%	+10.94%	+6.41%	+1.57%
Rural Accidents													
1973	5305	4465	5661	5254	5747	5914	5810	6180	5820	6173	5820	5318	67467
1974	4385	3763	4403	4568	5270	5349	5238	6042	5527	5811	5564	5725	61645
% change	-17.34%	-15.72%	-22.22%	-13.06%	-8.30%	-9.55%	-9.85%	-2.23%	-5.03%	-5.86%	-4.40%	+7.65%	-8.63%

Table 11. Bicycle and pedestrian accidents for 1973 and 1974.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1973	240	185	263	266	305	271	293	331	332	347	265	190	3288
1974	233	199	258	311	305	339	318	335	310	309	275	236	3428
% change	-2.92%	+7.57%	-1.90%	+16.92%	0.00%	+25.09%	+8.53%	+1.21%	-6.63%	-10.95%	+3.77%	+24.21%	+4.26%

It must be noted that all subsequent tables will refer to data from January through September or October, and not for the full year.

For Interstate roadways, where the lowered limit had the greatest effect on speeds, the data shown in Table 12 indicate that while there appear to be fatality reductions between 1973 and 1974, the difference between the monthly distributions for the two years is not significant at the $p = .05$ level, perhaps because of sample sizes. However, when the total numbers for the ten month periods are tested against the hypothesis of no change, the 42.5 percent decrease is shown significant at the $p < .01$ level.

When the data are summed over three-month intervals, the decreases are still obvious (and more consistent) with the greatest decrease in the latter time period being the only one significant at the .05 level.

Data for the United States highways, where some effect would be expected are presented in Table 13. Here, while the two ten-month distributions are not significantly different, the consistent decrease in fatalities (except for January) results in a highly significant overall reduction of 28.73 percent ($p < .001$). The grouped data indicate significant decreases in the latter two three-month periods with the decrease in the first three months being diluted by the increase in January, the first month of the perceived crisis period.

Highways designated as N.C. routes, which are similar in many respects to the U.S. routes, are also similar in changes in fatalities (see Table 14). Again there is a consistent decrease in accidents over the ten month period which results in a highly significant 30.99 percent reduction over the total period ($p < .001$). Again the larger sample sizes in the three month groups indicate more consistent decreases, the latter two of which are statistically significant.

As might be expected, Rural Paved Road produced data of a different nature. On these roadways,which experienced no change in speed limit, the data shown in Table 15 indicate no significant differences in either the two distributions or in the ten month totals. When the data is grouped into three month intervals, increases are noted in the first two periods, but these are not statistically significant. The final period, July through September, experiences a 20.81 percent decrease which is significant at the .05 level.

The accident data for the final roadway class, city streets, are presented in Table 16. Of most interest here is the fact that, when bicycles and pedestrian fatalities are deleted, automobile fatalities

Table 12. 1973 and 1974 fatalities on Interstate highways.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1973	8	11	10	6	12	4	10	5	8	13	87
1974	6	4	11	5	6	4	3	5	3	3	50
% change	-25.00%	-63.64%	+10.00%	-16.67%	-50.00%	0%	-70.00%	0%	-62.50%	-76.92%	-42.53%

	Jan.-March	April-June	July-Sept.
1973	29	22	23
1974	21	15	11
% change	-27.59%	-31.22%	-52.17%
p	N.S.	N.S.	p < .05

Table 13. 1973 and 1974 fatalities for U.S. highways.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1973	34	46	31	45	46	57	47	57	50	50	463
1974	38	35	18	27	21	38	41	51	26	35	330
% change	+11.76%	-23.91%	-41.94%	-40.00%	-54.35%	-33.33%	-12.77%	-10.53%	-48.00%	-30.00%	-28.73%

	Jan.-March	April-June	July-Sept.
1973	111	148	154
1974	91	86	118
% change	-18.02%	-41.89%	-23.38%
p	N.S.	p < .01	p < .05

Table 14. 1973 and 1974 fatalities for N.C. routes.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1973	27	16	35	42	42	37	37	30	45	31	342
1974	23	8	29	29	16	27	21	30	33	20	236
% change	-14.81%	-50.00%	-17.14%	-30.95%	-61.90%	-27.03%	-43.24%	0%	-26.67%	-35.48%	-30.99%

	Jan.-March	April-June	July-Sept.
1973	78	121	112
1974	60	72	84
% change	-23.08%	-40.50%	-25.00%
p	N.S.	p < .01	p < .05

Table 15. 1973 and 1974 fatalities on rural paved roadways.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1973	37	28	43	37	33	46	56	59	58	62	459
1974	39	26	52	39	46	50	43	45	49	65	454
% change	+5.41%	-7.14%	+20.93%	+5.41%	+39.39%	+8.70%	-23.21%	-23.73%	-15.52%	+4.84%	-1.09%

	Jan.-March	April-June	July-Sept.
1973	108	116	173
1974	117	135	137
% change	+8.33%	+16.38%	-20.81%
p	N.S.	N.S.	p < .05

Table 16. 1973 and 1974 fatalities on city streets (with bicycle and pedestrian fatalities deleted).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1973	16	14	28	23	22	17	14	23	18	26	201
1974	12	12	12	12	15	18	23	19	20	18	161
% change	-25.00%	-14.29%	-57.14%	-47.83%	-31.82%	+5.88%	+64.29%	-17.39%	+11.11%	-30.77%	-19.90%

	Jan.-March	April-June	July-Sept.
1973	58	62	55
1974	36	45	62
% change	-37.93%	-27.42%	+12.73%
p	p < .05	N.S.	N.S.

on city streets where no speed limit effect should be noted also experience significant decreases in total fatalities ($p < .05$) and in the first three month period ($p < .05$). This finding is in conflict with the earlier total accident related finding which indicated an increase in total accidents, and an hypothesized increase in travel, on these facilities.

Thus, in summary, statistically significant decreases in fatalities for the total ten month period were noted in all roadway classes except rural paved roads (see Table 17).

Table 17. 1973 and 1974 fatalities for all roadway classes (January through October).

	1973	1974	% Change	p
Interstates	87	50	-42.53%	<.01
U.S.	463	330	-28.73%	<.001
N.C.	342	236	-30.99%	<.001
Rural Paved Roads	459	454	- 1.09%	N.S.
City Streets	201	161	-19.90%	<.05

While the greatest percentage decrease was noted on Interstate highways, all of which experienced speed limit reductions, large decreases were also noted on U.S., N.C., and even city streets, where little (or less) speed limit related reduction might be expected. Also of interest is the fact that, except on city streets, the largest and most significant decreases are noted in the latter two three-month periods (April through September) after the peak of the perceived crisis had passed. Possible reasons for these decreases are further analyzed in the following section concerning accident severity.

Analysis of changes in accident severity.

Previous accident research has indicated a strong relationship between speed and accident severity. The results of the current speed study indicated that there have been changes in the vehicular speeds on North Carolina roadways. To determine whether these speed reductions are reflected in reductions in accident severities, three indicators of severity were compared for January through September of 1973 and 1974. These indicators included driver injury, speed prior to impact, and vehicle damage as measured by TAD damage rating scale. (Data for the last three months of 1974 were not available at the time of analysis.)

Driver injury, rather than accident severity as defined by most serious occupant injury, was chosen as an indicator of crash severity because it is not sensitive to changes in vehicle occupancy. That is, if the number of occupants per vehicle increased in 1974, the probability of <u>any</u> occupant sustaining a given class of injury would also increase in a given crash, thus, forcing severity of accident to increase. While driver injury might be hypothesized to increase with more occupants (i.e., the driver sustains injury by striking or being struck by the other occupants), the presence of and injury to the driver should essentially be a constant over the two years.

The driver injury data for 1973 and 1974 were compared for three month intervals from January to September. This resulted in one period during the crisis immediately following the change in speed limits and two periods later in the year when the effect of speed reductions might have lessened. The injury classes included (1) no injury (property damage of greater than $200); (2) class C injury (no visible sign of injury, but complaint of pain); (3) class B (nonincapacitating injury); (4) class A injury (incapacitating injury); and (5) (fatal) injury. Driver injury was analyzed for all speed limits and for roadways with speed limits of 55 mph and greater before the change. This latter analysis was an attempt to parcel out those rural roadways where the effect would be expected. The basic statistical analysis utilized in the analysis, the Mann-Whitney statistic as applied to ordered grouped data, examined the <u>proportion</u> of drivers falling into each injury class.

Driver injury for all speed limits in 1973 and 1974 appeared to be very similar, as can be seen in Table 18. Class B injury is slightly higher in 1974 in each three-month group. However, analysis revealed the difference in 1973 and 1974 in January through March to be statistically significant at the .001 level. This suggests an increase in driver injury (i.e., a shift toward more serious injury) in January through March, 1974 as compared to January through March, 1973, a finding opposite to what might be expected. Thus, while fewer drivers are involved in accidents during this time period, the 1974 injury distribution appears to be more severe for those who are. No significant differences for April through June, or July through September were noted.

Table 18. Driver injury for all speed limits.

Injury	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
K	201 (0.35%)	169 (0.36%)	239 (0.41%)	173 (0.33%)	254 (0.43%)	199 (0.35%)
A	1679 (2.94%)	1318 (2.83%)	1935 (3.32%)	1648 (3.18%)	1977 (3.38%)	1693 (2.96%)
B	3311 (5.80%)	3122 (6.70%)	4241 (7.28%)	3966 (7.66%)	4292 (7.34%)	4310 (7.54%)
C	3800 (6.66%)	3398 (7.29%)	4251 (7.30%)	3714 (7.18%)	4101 (7.02%)	4183 (7.31%)
No	48078 (84.25%)	38613 (82.82%)	47595 (81.69%)	42252 (81.64%)	47835 (81.83%)	46801 (81.84%)
Total	57069	46620	58261	51753	58459	57186

Because the North Carolina data used does not allow for identification of the 1974 crashes which occurred on specific roadways where the limit had been changed, all 1973 and 1974 accidents on roadways with a limit of 55 mph were compared. While this comparison also includes some accidents on roadways with limits of 55 mph both before and after the change, the data might be expected to give a better indication of effects resulting from the change than the previous analysis would.

As indicated in Table 19, the results were very similar to the previous ones. The main difference was that the proportion in each injury class was higher for both years than in the previous table which included both urban and rural accidents.

The analysis again indicated that the difference between 1973 and 1974 was statistically significant for January through March ($p < .05$). Again, contrary to what might be expected from the earlier speed analyses, it appears that there was an increase in driver injury in 1974.

Because these findings are rather inconsistent with the earlier speed analysis, the data for Interstate roadways, where speed limit changes always occurred, were extracted. Table 20 presents these data grouped into the same three month periods. Of interest here are the lack of shifts in the injury distributions. When the data within each three month period was tested using the Mann-Whitney analysis, none of the difference between 1973 and 1974 approaches significance. While the total numbers of drivers involved in accidents (and thus accidents) decreased in 1974, there appear to be no differences in the severity distributions for those who are involved. Again, this finding is not consistent with what would be expected from the previous finding related to speed changes.

The second indicator of crash severity chosen for analysis was vehicle damage as rated with the TAD scale. TAD is a vehicle damage scale designed to aid investigators in assessing damage sustained by motor vehicles in traffic accidents. Each of the most common types of damage are included in a seven point pictorial scale. The scale is now being used by the North Carolina State Highway Patrol in their investigation of all rural accidents and by certain city police departments for urban accidents. Thus, statewide data is somewhat biased toward rural accidents.

Changes in the TAD damage severity rating were analyzed to determine the effects of the lowered speed limit. TAD ratings for 1973 were compared with TAD ratings for 1974 by again examining three

Table 19. Driver injury for speed limits ≥ 55 mph.

Injury	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
K	148 (0.77%)	130 (0.94%)	188 (0.92%)	127 (0.73%)	194 (0.91%)	148 (0.75%)
A	962 (5.04%)	742 (5.35%)	1147 (5.64%)	1009 (5.79%)	1238 (5.79%)	1066 (5.44%)
B	1596 (8.36%)	1307 (9.42%)	1989 (9.78%)	1869 (10.72%)	2026 (9.48%)	1963 (10.01%)
C	1337 (7.00%)	1069 (7.70%)	1562 (7.68%)	1364 (7.82%)	1548 (7.24%)	1446 (7.37%)
No	15056 (78.83%)	10632 (76.60%)	15461 (75.99%)	13064 (74.94%)	16375 (76.59%)	14984 (76.42%)
Total	19099	13880	20347	17433	21381	19607

Table 20. Driver injury on Interstate roadways.

Injury	January-March		April-June		July-September	
	1973	1974	1973	1974	1973	1974
K	14 (0.88%)	15 (1.76%)	11 (0.67%)	11 (1.14%)	10 (0.57%)	5 (0.45%)
A	83 (5.19%)	29 (3.40%)	73 (4.43%)	37 (3.82%)	77 (4.42%)	47 (4.26%)
B	107 (6.69%)	64 (7.51%)	140 (8.51%)	85 (8.77%)	164 (9.41%)	97 (8.79%)
C	110 (6.88%)	73 (8.57%)	142 (8.63%)	78 (8.05%)	135 (7.75%)	83 (7.52%)
No	1286 (80.38%)	671 (78.76%)	1280 (77.76%)	758 (78.22%)	1356 (77.84%)	871 (78.97%)
Total	1600	852	1646	969	1742	1103

month intervals from January through September of both years. This process included an analysis of TAD severity for all speed limits and TAD severity for speed limits of 55 mph and greater. It is important to note that only the numerical "severity" portion of the rating was used. No analysis of "area of damage" was conducted.

As Table 21 shows there was an increase in the percentage of accidents where the TAD severity rating was low in 1974 as compared to 1973. This was true for each of the three-month periods. While the difference in 1973 and 1974 for all other damage ratings was subtle, analysis indicated that the shift in each of these periods was significant ($p < .001$).

The same trend was evident for TAD severity for speed limits of 55 mph and greater, where the effect would be expected to be greater (see Table 22). Again, there is a subtle shift toward the lower TAD ratings, with the percent in the lowest rating (1) being higher for 1974 in all three periods. The results of the Mann-Whitney analyses again indicate these shifts to be highly significant ($p < .001$ in all these cases).

To further examine this indicator, data for Interstate roadways were again extracted. Table 23 presents figures comparable to the previous two tables. Just as in the previous two tables, the data indicate a slight shift toward the less severe accidents in 1974. Of interest is the fact that the shift is more pronounced in the latter two time periods. While the differences in January through March are not significant at the .10 level, the mean severity is comparatively lower and more significant in the latter two periods ($p < .001$ and $p < .01$, respectively). Again, these findings are somewhat in line with what would be expected from the speed-related findings, but were not noted in the analysis of driver injury.

The third and final indicator of crash severity studied was the estimated speed prior to accident. This information, provided by the investigating officer, is his estimate of a vehicle's speed prior to the initiation of an accident sequence, that is, prior to whatever event (e.g., tires leaving roadway, perceiving of other vehicle in lane) began the sequence. While this is not a measure of the speed of impact, the judgment is most assuredly affected by vehicle damage and driver injury along with driver and witness statements. Table 24 presents these data for each month of 1973 and 1974. Comparisons of these monthly data were made under the assumptions of a standard normal distribution. Because the speed limit change could only affect certain roadways and moving vehicles, the data shown concern only those accidents occurring on roadways with limits of 55 mph or greater and only those vehicles which were moving. Thus, all vehicles with estimated speeds of zero were deleted from the analyses.

Table 21. TAD severity for all speed limits.

TAD	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
1	6106 (26.49%)	5007 (29.20%)	5850 (26.09%)	6667 (29.15%)	7224 (27.52%)	7344 (29.86%)
2	5689 (24.68%)	4358 (25.41%)	5330 (23.77%)	5692 (24.89%)	6451 (24.57%)	6201 (25.21%)
3	4334 (18.81%)	3081 (17.97%)	4252 (18.96%)	4165 (18.21%)	4706 (17.93%)	4409 (17.92%)
4	3280 (14.23%)	2352 (13.72%)	3343 (14.91%)	3116 (13.63%)	3762 (14.33%)	3294 (13.39%)
5	1674 (7.26%)	1105 (6.44%)	1625 (7.25%)	1570 (6.87%)	1922 (7.32%)	1577 (6.41%)
6	1226 (5.32%)	816 (4.76%)	1288 (5.74%)	1037 (4.53%)	1357 (5.17%)	1084 (4.41%)
7	738 (3.20%)	429 (2.50%)	735 (3.28%)	623 (2.72%)	831 (3.17%)	689 (2.80%)
Total	23047	17148	22423	22870	26253	24958

Table 22. TAD severity for speed limits ≥ 55 mph.

TAD	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
1	3483 (23.47%)	1957 (25.71%)	3082 (22.40%)	2731 (24.86%)	3385 (23.09%)	3056 (26.01%)
2	3521 (23.72%)	1845 (24.24%)	3111 (22.61%)	2547 (23.18%)	3461 (23.61%)	2810 (23.91%)
3	2931 (19.75%)	1488 (19.55%)	2763 (20.08%)	2150 (19.57%)	2904 (19.81%)	2288 (19.47%)
4	2200 (14.82%)	1103 (14.49%)	2202 (16.00%)	1658 (15.09%)	2241 (15.29%)	1695 (14.43%)
5	1225 (8.25%)	560 (7.36%)	1153 (8.38%)	905 (8.24%)	1257 (8.58%)	876 (7.46%)
6	936 (6.31%)	417 (5.48%)	916 (6.66%)	573 (5.22%)	854 (5.83%)	593 (5.05%)
7	547 (3.69%)	242 (3.18%)	535 (3.89%)	422 (3.84%)	555 (3.79%)	432 (3.68%)
Total	14843	7612	13762	10986	14657	11750

Table 23. TAD severity in accidents occurring on Interstate roadways.

TAD	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
1	171 (23.78%)	97 (28.53%)	145 (21.35%)	142 (30.34%)	218 (26.30%)	158 (32.99%)
2	153 (21.28%)	76 (22.35%)	143 (21.06%)	102 (21.79%)	191 (23.04%)	105 (21.92%)
3	141 (19.61%)	51 (15.00%)	119 (17.53%)	84 (17.95%)	135 (16.28%)	81 (16.91%)
4	114 (15.86%)	50 (14.71%)	128 (18.85%)	49 (10.47%)	114 (13.75%)	63 (13.15%)
5	57 (7.93%)	29 (8.53%)	59 (8.69%)	34 (7.26%)	63 (7.60%)	26 (5.43%)
6	54 (7.51%)	24 (7.06%)	53 (7.81%)	26 (5.56%)	58 (7.00%)	24 (5.01%)
7	29 (4.03%)	13 (3.82%)	32 (4.71%)	31 (6.62%)	50 (6.03%)	22 (4.59%)
Total	719	340	679	468	829	479

Table 24. Estimated speed prior to accident for speed limits $\geq$ 55 mph.

	1973 $\bar{x}$	1973 s^2	1973 N	1974 $\bar{x}$	1974 s^2	1974 N	p
January	37.458	337.543	5965	39.173	337.636	4537	$\leq$.001
February	39.529	353.138	5098	38.425	358.210	3872	<.01
March	40.951	356.374	6430	40.480	355.688	4483	<N.S.
April	41.347	368.466	6016	40.128	375.137	4829	<.001
May	41.123	370.306	6292	39.440	359.661	5723	<.001
June	41.347	355.751	6453	40.420	365.972	5808	<.01
July	41.189	372.44	6636	40.254	363.109	5830	<.01
August	40.502	363.287	6793	39.878	343.313	6675	<.10
September	40.979	365.186	6372	39.656	352.241	5981	<.001

The analysis involving comparisons of these monthly means indicates significant differences in all months except March. The mean estimated speed prior to accident is higher in January, 1974 than in January, 1973, a finding in contrast with what might be hypothesized from the earlier noted reduction in January population at risk speed data in this month. It is noted that the January, 1973 speed is lower than all other 1973 speeds. However, all other months indicate significant decreases in 1974.

This measure of severity is assumed to be less reliable than the previous two indicators since it is more susceptible to estimator bias. That is, the knowledge that lower speed limits were in effect and that vehicle speeds were lower might have easily led the investigating officer to either consciously or subconsciously lower his estimate of speed prior to accident. Interestingly, however, the results here are fairly similar to those obtained from the TAD analyses.

Analysis of age of accident-involved driver.

As noted in the Introduction section, various "causes" for the reduction in fatalities and total accidents can be hypothesized, including shifts in driver age. That is, given that the younger driver has more accidents than the older driver per mile driven, a decrease in the mileage driven by younger drivers could result in a disproportionate decrease in total accidents, and thus fatalities. Because fuel was in short supply during, at least, the initial months of the crisis, it might well have been that in families where only one, or even two cars existed, the limited mileage which could be driven was restricted to those thought most necessary -- shopping trips, work trips, etc., with the mileage driven by the teen-age son or daughter being restricted disproportionately.

Unfortunately, no good exposure data exist for the population at risk. In order to examine these hypothesized age effects, the ages of those drivers who were involved in accidents were compared for 1973 and 1974. The null hypothesis here is that, even though total accidents are lower in 1974, the proportion of driving done, as reflected by the proportion of accidents involved in, did not change over the two years for the various age groups.

Data concerning these hypotheses are found in the following two tables. As in other cases, the data are categorized into three month intervals, and into urban and rural accidents. The latter grouping is in an attempt to examine differential shifts between the two areas. The analysis involving comparison of the two distributions employed the Kolmogorov-Smirnoff test for differences in two independent samples. This nonparametric test, as noted by Siegel (1956), detects differences

in both the central tendencies and dispersion of distribution through comparison of the cumulative distribution.

Tables 25 and 26 present the age information for urban and rural accidents. As is noted, any shifts from one year to the next are very subtle in nature. However, due to the sample sizes involved, certain of these small differences are statistically significant. For urban accidents, the difference in the distributions for January through March are significant at the .01 level, while differences for July through September are significant at the .05 level. The maximum difference in the cumulative distributions for January through March was noted in the fifth interval and the difference was positive. That is, the cumulative proportion of accident-involved drivers less than 25 years old was lower in 1974 than 1973, consistent with what might be hypothesized. However, for the July through September time period, the opposite held. Here, the maximum difference was noted for drivers 34 and less and the proportions for the 1974 accident were higher than for 1973. Findings similar to this latter one were noted in rural accidents where the 1973 and 1974 distributions for January through March and July through September were significantly different at the $p < .05$ level. In the January through March distributions, the proportion of accident-involved drivers 17 years old and less was greater in 1974 than in 1973. In the final time period, July through September, the maximum difference was found in the cumulative proportions below age 25, with the 1974 data again indicating a higher proportion of young drivers. It must be noted that due to the subtlety of these changes, these statistically significant shifts are difficult to express in terms of practical significance.

Because of this, and because the hypothesis under question is primarily concerned with the shifts in accidents involving younger drivers, the data were collapsed into two groups -- those accidents involving drivers under the age of 20 (i.e., 15-19), and those involving drivers 20 or over. The results of this grouping are shown in Tables 27 and 28.

Analyses of these data, utilizing a Chi-square statistic, indicate significant differences only in the July through September urban accidents ($p < .05$) and in the January through March ($p < .001$) and the July through September ($p < .05$) rural accidents. However, these significant differences are in the opposite direction from what might be hypothesized. That is, the proportion of accidents involving younger drivers is slightly greater in 1974 than in 1973 in all cases. Again even though statistically significant, the changes are small, but the trend indicated is not in the hypothesized direction.

Table 25. Age distributions of drivers involved in urban accidents.

Age	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
0-15	60 (0.19%)	62 (0.23%)	91 (0.29%)	72 (0.25%)	99 (0.33%)	98 (0.31%)
16	1242 (4.01%)	1044 (3.83%)	1260 (4.06%)	1260 (4.44%)	1302 (4.30%)	1466 (4.66%)
17	1297 (4.18%)	1143 (4.19%)	1456 (4.69%)	1378 (4.85%)	1396 (4.61%)	1494 (4.75%)
18-19	2875 (9.27%)	2392 (8.77%)	3071 (9.90%)	2765 (9.73%)	2921 (9.64%)	3079 (9.80%)
20-24	6094 (19.65%)	5132 (18.81%)	6122 (19.73%)	5562 (19.58%)	5952 (19.64%)	6106 (19.43%)
25-34	7263 (23.42%)	6660 (24.41%)	7084 (22.83%)	6558 (23.08%)	6875 (22.69%)	7384 (23.49%)
35-44	4385 (14.14%)	3679 (13.48%)	4277 (13.78%)	3740 (13.16%)	4058 (13.39%)	4051 (12.89%)
45-54	3707 (11.95%)	3412 (12.50%)	3612 (11.64%)	3293 (11.59%)	3626 (11.97%)	3614 (11.50%)
55-64	2582 (8.33%)	2304 (8.44%)	2470 (7.96%)	2335 (8.22%)	2467 (8.14%)	2485 (7.91%)
65-74	1132 (3.65%)	1101 (4.03%)	1225 (3.95%)	1094 (3.85%)	1220 (4.03%)	1245 (3.96%)
75+	371 (1.20%)	358 (1.31%)	365 (1.18%)	352 (1.24%)	388 (1.28%)	409 (1.30%)
Total	31008	27287	31033	28409	30304	31431

Table 26. Age distributions of drivers involved in rural accidents.

Age	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
15	70 (0.27%)	72 (0.37%)	116 (0.43%)	122 (0.52%)	148 (0.52%)	148 (0.57%)
16	1111 (4.21%)	952 (4.89%)	1390 (5.10%)	1201 (5.12%)	1480 (5.23%)	1390 (5.37%)
17	1301 (4.93%)	1079 (5.55%)	1446 (5.30%)	1281 (5.46%)	1471 (5.20%)	1496 (5.78%)
18-19	2826 (10.71%)	2056 (10.57%)	3202 (11.74%)	2826 (12.05%)	3268 (11.56%)	3007 (11.62%)
20-24	5411 (20.51%)	3890 (19.99%)	5638 (20.68%)	4924 (21.00%)	5835 (20.63%)	5458 (21.09%)
25-34	6203 (23.52%)	4573 (23.50%)	6238 (22.88%)	5304 (22.62%)	6269 (22.17%)	5705 (22.04%)
35-44	3662 (13.88%)	2671 (13.73%)	3471 (12.73%)	3004 (12.81%)	3732 (13.20%)	3260 (12.60%)
45-54	2924 (11.09%)	2045 (10.51%)	2811 (10.31%)	2299 (9.80%)	3019 (10.68%)	2641 (10.20%)
55-64	1789 (6.78%)	1326 (6.82%)	1830 (6.71%)	1528 (6.52%)	1944 (6.87%)	1758 (6.79%)
65-74	857 (3.25%)	584 (3.00%)	846 (3.10%)	734 (3.13%)	871 (3.08%)	781 (3.02%)
75+	223 (0.85%)	208 (1.07%)	279 (1.02%)	229 (0.98%)	244 (0.86%)	238 (0.92%)
Total	26377	19456	27267	23452	28281	25882

Table 27. Grouped driver age for urban accidents.

Age	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
15-19	5474 (17.65%)	4641 (17.00%)	5878 (18.94%)	5475 (19.27%)	5718 (18.87%)	6137 (19.53%)
20+	25534 (82.35%)	22646 (82.99%)	25155 (81.06%)	22934 (80.73%)	24586 (81.13%)	25294 (80.47%)

Table 28. Grouped driver age for rural accidents.

Age	January-March 1973	January-March 1974	April-June 1973	April-June 1974	July-September 1973	July-September 1974
15-19	5308 (20.12%)	4159 (21.38%)	6154 (22.57%)	5430 (23.15%)	6367 (22.51%)	6041 (23.34%)
20+	21069 (79.88%)	15297 (78.62%)	21113 (77.43%)	18022 (76.85%)	21914 (77.49%)	19841 (76.66%)

Analysis of the Relationship Between Changes in Accidents and Changes in Volumes

As indicated in the Methodology section, the final area of study concerns changes in traffic counts during the energy crisis period. There is, of course, strong evidence that the amount of travel decreased, at least during January through March of 1974, as compared to identical periods in non-crisis years. Gas tax revenues in North Carolina and other states decreased dramatically during this period. Such a decrease in total miles traveled would be expected to be a major influence in the decrease in total accidents, and may indeed be hypothesized to be the cause of the entire decrease. Because of this, it is necessary to analyze such volume changes in any attempt to "parcel out" speed related reductions.

As indicated earlier, the only North Carolina data available for analysis are traffic count data collected at permanent count stations. Thus, the implied assumption in all the analyses which follow is that samples collected at these count stations are representative of the volumes on all other roadways of a given class in the state. As was also indicated in the earlier Methodology section, the data available were "raw" vehicle counts which had not been adjusted into Average Daily Traffic information. The necessary "pre-cleaning" operation noted causes problems in comparing data from one time with that of the next period within the same year. Because of these reasons, and because subsequent analyses involve proportional changes in counts and accidents, a second assumption is necessary. The authors assume that the proportional changes in the count data between compared time periods in 1973 and 1974 are representative of proportional changes in true traffic volumes between the two years. That is, even though "bad" data were deleted in a given time period (say a month) for both years, the proportional changes in the remaining data between the two years is representative of the proportional changes in these volumes. For this reason, the terms "counts" and "volumes" will be used interchangeably in the remaining parts of this paper.

The approach used to "parcel out" speed related changes in accidents from volume related changes could, of course, differ greatly depending on the character of available data. For example, if traffic volumes had decreased during the early months of 1974 (following the limited change) and had then increased to levels which were equal to or greater than corresponding 1973 levels in later months, it might be possible to gain some insight into speed related decreases by analyzing accident changes longitudinally in 1974. That is, if volume changes no longer exist, then continued accident reduction might indicate a speed related effect (among other possible causes). However, this was not the case in the available count data for the first nine months of 1974. Volumes, or at least counts, continued to be lower in the later months of 1974.

Table 29 below presents monthly changes for the various roadway classes (with a negative change meaning that the 1974 volumes were lower than the corresponding 1973 volumes).

Table 29. Percent changes in monthly traffic counts by highway class.

Month	Interstate	U.S.	N.C.	Rural Paved Roads	City Streets
January	+12.7%	-12.1%	-10.1%	- 8.6%	- 4.2%
February	-13.5%	-17.5%	-10.4%	-10.9%	- 3.2%
March	+ 5.4%	-15.9%	- 6.0%	-35.0%	+ 0.6% n.s.
April	- 8.2%	- 0.9% n.s.	- 4.6%	-45.6%	- 6.9%
May	+ 2.8%	- 9.6%	- 4.7%	-11.7%	-10.6%
June	+ 3.6%	-14.3%	-11.4%	-14.3%	+31.2%
July	+34.3%	-11.7%	-12.0%	-18.5%	-14.8%
August	-21.5%	- 9.3%	-16.4%	-15.8%	- 7.3%
September	-30.0%	+ 1.1% n.s.	- 5.2%	- 1.9% n.s.	- 6.4%

Note: n.s. means changes not significant at the $p = .05$ level

As is noted, most of the changes are significant and indicate decreases in 1974 counts. Interstate highways have the least consistent pattern showing both increases and decreases during the nine month period. All other road classes are almost entirely characterized by the continued lower counts in 1974, a trend very much in opposition to historical trends toward 5 to 6 percent increases in volumes.

These monthly traffic count data were further broken down into individual counts for each day of week to further examine differences. Tables A-1 through A-5 containing this information, are found in Appendix A. (These tables also contain accident data to be discussed in the next section.) As expected, "gasless Sundays" were characterized by the greatest decreases in traffic counts in most months on most roadway classes. For the first three months of the year, there is a fairly consistent trend toward the "weekend" days (Saturday and Sunday) having greater decreases than week days on all roadway classes. This "trend" is less evident throughout the remaining six months, but there still seems to be a fairly strong indication that weekend travel, including that on Saturday, experiences the most dramatic decreases. This is important in terms of potential fatality reductions since weekend travel in North Carolina has historically generated the highest number of fatalities.

As noted earlier, these "volume" reductions would be hypothesized to be related to reductions in accidents. The question to be answered, of course, concerns what part of the previously noted accident reductions can be "attributed to" volume changes and what part is due to the many other factors operating during this energy crisis period, including the reduction in the speed limit.

Three different analyses were carried out in attempting to study the relationship between changes in volume and changes in accidents -- (1) a comparison of the proportional changes in traffic counts and accidents, (2) a comparison of the changes with predicted changes based on historical information from other studies, and (3) a slightly more detailed examination of Interstate accident data where either increases or no significant decreases in counts is noted.

The initial analysis involved a comparison of the proportional changes in traffic counts versus the proportional changes in accidents. The data for a given time interval and highway class (e.g., January data for Interstate roadways) were categorized into a two by two table, and a Chi-square statistic with one degree of freedom was used to test whether the change in accidents was significantly different from the change in volumes. The results of this testing are presented in tables in Appendix A. For example, in Table A-1 concerning Interstates, the 16th row concerns all February accidents. The percent changes in traffic counts and accidents are presented in the fifth and sixth columns, and the level of the significant test is given in the final column. Thus, for this row, the data indicate a 13.5 percent decrease in volumes and a 28.7 percent decrease in accidents. Although accidents decreased more than counts, the differences in the changes is not significant at the .05 level.

The results of the analysis for the Interstate highways reveal relatively small increases and decreases in volumes coupled with larger decreases in accidents for most months. Deviations from this pattern exist in February, where although accidents decrease more than counts, the difference is not significant at the .05 level, and in September where the decrease in counts is significantly larger than the decrease in accidents. When individual day of week data is examined, the same general trend again holds. With only eight exceptions, the accident decreases are larger than the corresponding decreases in volumes, although all the differences are not statistically significant. Of interest is the observation that five of the eight "exceptions" are found in September, the final month with available data, where traffic counts are down by 25 to 37 percent while accidents either increase slightly or decrease by a maximum value of 19 percent. Unlike the earlier discussed changes in traffic counts, there does not appear to be any one day of the week which consistently has the largest decrease in accidents.

Table A-2 presents similar data for U.S. highways some of which experienced changes in speed limit. When monthly totals are analyzed, the data indicate that accident decreases are greater than count decreases in all months except August. However, the differences are significant in only five of the nine months. Here, the trend toward greater decreases in accidents appears to disappear during the summer months of June, July, and August, but to then return to lower levels in September. (Of course, this latter indication can not be considered a trend since only one observation point is available). When individual days of the week are analyzed, it is noted that accident decreases are consistently larger through April, with only 5 of the 28 observations being exceptions. It must be noted that not all of these differences are significant. In the later months, the largest differences in day of week categories almost alternate between counts and accidents. When accident decreases are compared between days of the week for the total nine month period, no consistent trends surface, although for the first four months during the height of the crisis, Sundays appear to have the largest decrease in accidents.

Data for highways with N.C. route numbers is found in Table A-3. Total monthly accident decreases are larger than volume decreases through May, with the effect again disappearing during the summer months. When data for individual days of the week are examined, no consistent indications are evident except in March and April when the accident decreases for each day of the week are greater (although not always significantly greater) than traffic count decreases. The only indication of a trend in comparisons between days of the week is in the first four months when the "gasless" Sundays experienced the largest accident decreases (and, of course, usually the largest volume decreases).

The data for rural paved roads indicates findings which differ from those of the earlier discussed classes. (see Table A-4). Here, while traffic counts decrease in every month of 1974 below 1973 levels, the accident decreases are larger <u>only</u> in January and February, and the February difference is not significant at the $p<.05$ level. In all other months, decreases in accidents are either less than count decreases, or accidents <u>increase</u> between the two years ($p<.01$ in all cases except September). Individual days of week indicate similar trends, and while all days do not indicate larger decreases in volumes, every difference which is significant at the $p<.05$ level for March through September is in this direction.

Data for city streets presented in Table A-5 indicate even less consistent trends. Accident decreases are both significantly greater and less than corresponding volume changes. As noted earlier in the discussion of urban accidents, monthly accident totals decreased for every month through June and then experienced increases in July through September. Volume changes fluctuated through the nine month period. As might be expected from this inconsistency, day of week data showed numerous significant differences, but little consistency in direction of difference.

Thus, it appears that, at least for Interstate and U.S. highways, and N.C. highways to a lesser extent, accident decreases are larger than corresponding traffic count decreases in many instances. However, because volume decreases have not historically resulted in a one to one decrease in accidents, it might be possible that even large, significant differences in accidents could be almost totally attributed to a smaller decrease in volume. To further examine this question, a second analysis technique was utilized. Here proportional changes in accidents were compared graphically with changes which would be <u>predicted</u> by volume decrease according to earlier research studies.

Kihlberg and Tharp (1968) analyzed the accident rates for roadway segments in three different states in an attempt to determine and quantify the relationships between accident rates (on a million vehicle mile or a mileage basis) and various roadway geometries including the presence of structure, intersections, gradients over 4 percent, and horizontal curvature greater than 4 percent for various ADT classes. The results of this study were a series of regression equations of the form:

$$\log \bar{A}^* = a + b_1 \log \bar{T} + b_2(\log \bar{T})^2.$$

where

$\bar{A}^*$ = predicted number of accidents (either total, fatal, injury, P.D.O., single vehicle, multi-vehicle) for a given roadway class (categorized by number of lanes, presence of median, and degree of access control).

$\bar{T}$ = Mean Average Daily Traffic (ADT).

a, b_1, b_2 = regression coefficients calculated from the data.

The entire study produced over 1500 of these equations for use in predicting possible reductions in accidents due to higher level design for a given roadway class and ADT level.

In this study,these results were manipulated to produce "expected" reductions in accidents for given reduction in volumes for Interstate, U.S., and N.C. highways. Because the predicted rates are based on accidents/mile, there is an implied assumption that roadway mileage remained constant over the two year period. Using N.C. volume data for Interstate, U.S. and N.C. routes, base line ADT and base line accidents were projected. Then a series of volumes reduced in 5 percent increments were inputed into the model, a series of "expected" accident frequencies were derived, and predicted percent changes in accidents and volumes were calculated for various roadway geometries which were felt to be "average" characteristics for two lane and four lane highways in North Carolina. The resulting "predicted" percent changes were graphed along with the actual percent changes for the various data categories shown in Tables A-1, A-2, and A-3.

Additional information for Interstate highways was extracted from a discussion by Versace in a report by Lundy (1965). In recognition that segment length omission from the predictive equations may distort the relationship between accidents and volume, the author included this

as a third variable. Utilizing three years of data from 659 miles of four-, six-, and eight-lane California freeways, an equation of the following form was fitted:

$$Y = a x_1^{b_1} x_2^{b_2}$$

where

Y = number of accidents per year per segment.

X_1 = segment length (miles)

X_2 = ADT (thousands of veh/day)

a, b_1, b_2 = constants determined from data by method of least squares.

(The equation is of the same form as those discussed earlier). The data was regressed upon three times -- for four-lane, six-lane, and eight-lane roadway segments. The four-lane regression equation which is utilized in the current study, had the following coefficients:

a = -0.544
b_1 = 0.816
b_2 = 1.231

Just as before, this equation was then utilized to predict expected changes in accidents when volume decreased in increments of 5 percent from a base level for N.C. Interstate roadways. Thus, the end product was again a "predicted" regression line for accident and volume reductions.

Figures 2 through 7 present the plotted data for Interstates, U.S., and N.C. roadways, The "predicted" regression lines for the percentage changes are tagged with information concerning the original data source. Again, these plotted curves do not represent regression lines for the current data. They represent "expected" regression lines.

The additional points shown on the graphs represent current data, each representing a different time interval (e.g. January data for Interstate highways.) As indicated in Tables A-1 through A-3, each time interval is identified by two measures, -- a percent change in count and a percent change in accidents. Thus, the inferences drawn are based on the location of the plotted current data in relation to the position of the expected regression lines. In all cases, percent changes in accidents are plotted along the ordinate or y-axis and percent changes in traffic count are plotted along the abscissa or x-axis. Thus, for a given graph, if the points are scattered around the expected lines, there is an indication that the changes in accidents are "totally" predicted by the count changes. If all or most of the points on a graph fall above the predicted line, there is an indication that accident decreases are larger than predicted by volume decreases, and that there appear to be additional "causes" for the reduction in accidents.

Figure 2 and Figure 3 contain data for Interstate highways. Figure 2 contains only the nine points representing monthly totals and Figure 3 contains plotted points for the day of week data within the different months. The same three predicted lines are shown on each figure: (1) the regression line based on "pure" Florida data for four lane divided highways with full access control (i.e., pure highway segments or segments with no grades over 4 percent, no curves greater than 4 degrees, and no structures within the average .3 mile segment) (Kihlberg, 1968); and (2) the regression line for "pure" Ohio data on the same roadways (Kihlberg, 1968); and (3) the regression line deprived from the California data for divided four-lane freeways. Of initial interest, is the fact that the three "expected" lines are so similar in slope and location. In both figures, the overwhelming majority of the plotted points for the current N.C. data fall above the predicted line, indicating that the decreases in accidents are larger than what would be "predicted" by the related volume changes alone.

Figures 4 and 5 present similar data for U.S. routes in North Carolina. Because of possible geometric differences among U.S. roadways, a series of six prediction lines were plotted. These include lines based on Ohio and Connecticut data (Kihlberg & Tharp, 1968) for (1) "pure" segments (i.e., 0.3 miles segments with no structures, gradients larger than 4 percent, curves greater than 4 degrees, or intersections), (2) segments with the sharper curves and intersections present, and (3) segments with curves, intersections and structures present. Just as with Interstate roadways, the majority of the plotted points fall above the set of predicted lines for both the monthly totals and individual day of week data. As might be expected from the previous comparative analysis of proportional changes, neither the deviation from the predicted lines nor the proportion falling above the lines are as large for these highways as for Interstates. However, the general location of the scatter plot again indicates that accident decreases for U.S. roadways appear to be larger than what would be predicted by volume changes alone. One source of error in these plots for this roadway

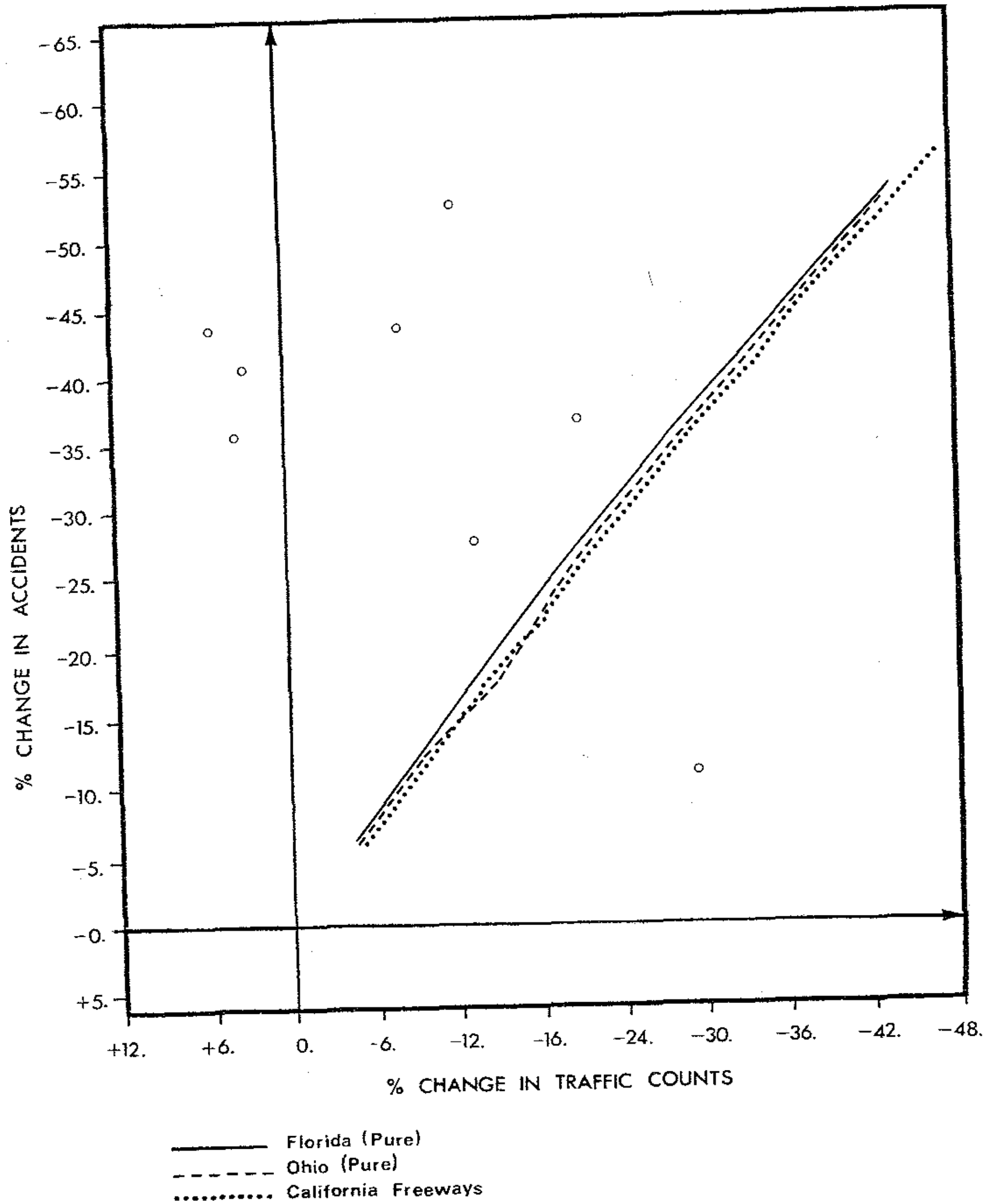

Figure 2. Predicted and actual percentage changes in accidents and traffic counts for Interstate highways (monthly totals).

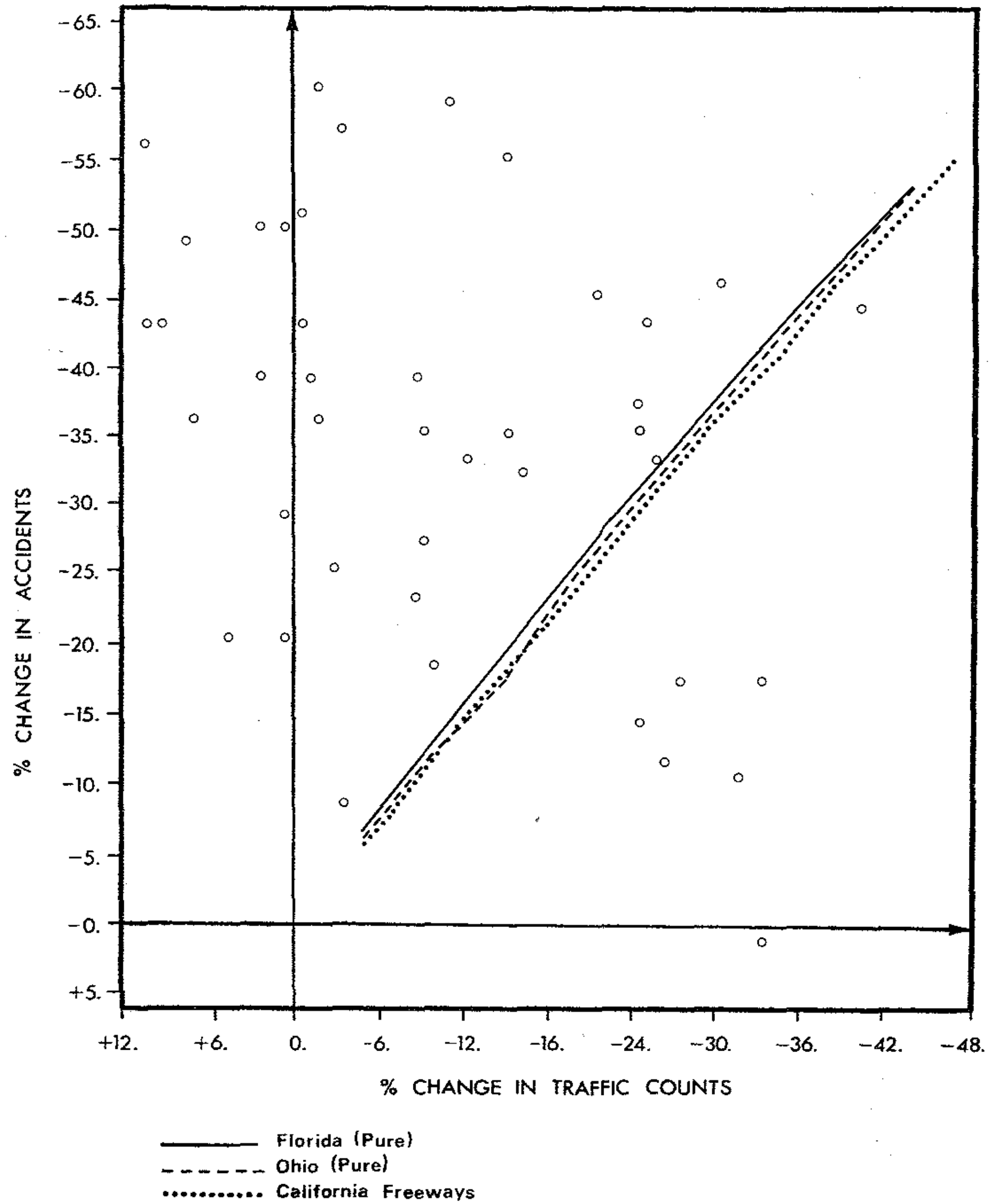

Figure 3. Predicted and actual percentage changes in accidents and traffic counts for Interstate highways (day-of-week data).

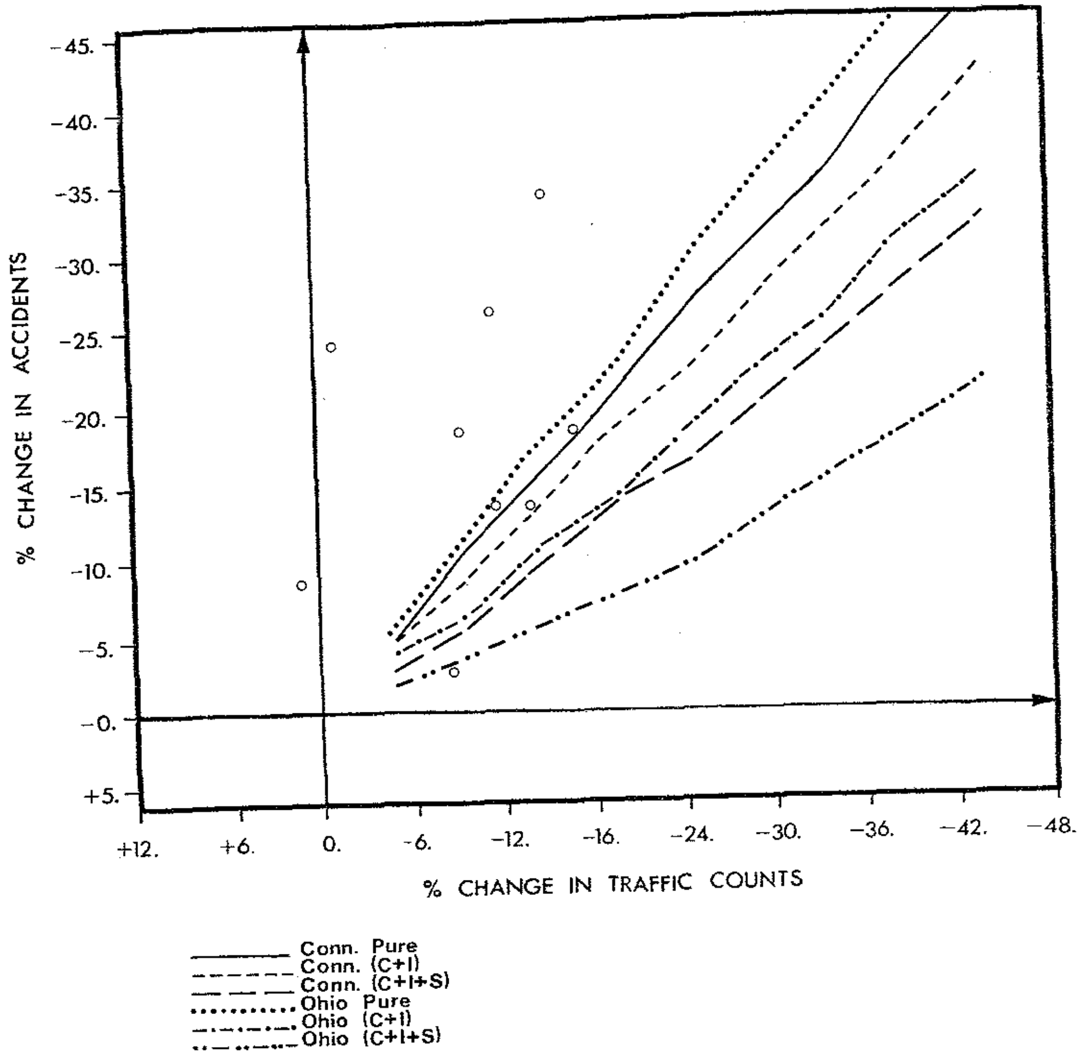

Figure 4. Predicted and actual percentage changes in accidents and traffic counts for U.S. highways (monthly totals).

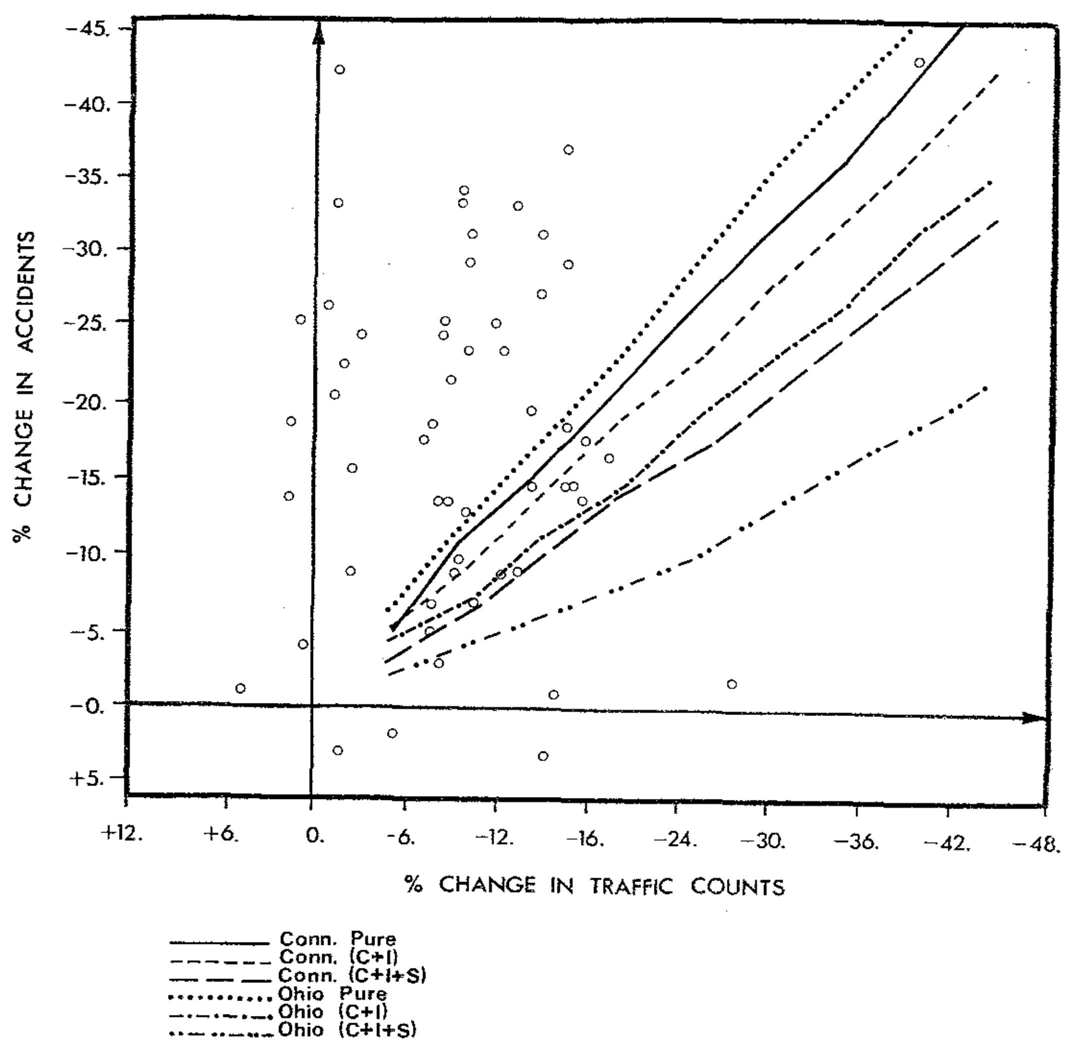

Figure 5. Predicted and actual percentage changes in accidents and traffic counts for U.S. highways (day-of-week data).

class which must be noted concerns the fact that, while all these previously discussed prediction lines refer to two-lane highways, there is some small proportion of the total U.S. mileage which are four-lanes. For this reason, two additional "prediction" lines were similarly calculated based on Connecticut and Ohio data in the previously cited report (Kihlberg and Tharp, 1968). In both cases, the regression coefficients concerning four-lane divided roads chosen for use were the ones which resulted in the most extreme prediction (i.e., highest accident reduction for a given volume reduction). In both cases, the plotted lines fell within the bounds of the series plotted for two lane roadways. For this reason, they would not appear to compromise the above cited finding and are not shown on the final figures.

The final data set for which predicted changes could be generated were the highways carrying North Carolina route designations. Again, these roadways are essentially all two-lane rural roadways. Plots of these data are presented in Figures 6 and 7. As would be expected from the previous analyses involving comparisons of proportional changes, while more of the data points appear above the "prediction" lines than below them, indicating a tendency toward larger accident reductions, the tendency is not as well pronounced as in the previous cases involving Interstate and U.S. highways. Deviations from predicted values also do not appear to be as large as in previous analyses. Thus, as indicated earlier for highways marked as N.C. routes, the trend toward additional accident reductions above that anticipated from volume changes is not as pronounced as in the cases of Interstate or U.S. roadways.

In the third and final analysis, attention is focused upon Interstate roadway data points where either no significant decrease in monthly traffic counts or a significant increase in these counts are recorded between 1973 and 1974. There are five instances of monthly totals which fulfill the above requirements: (1) January; (2) March; (3) May; (4) June; and (5) July. A bar graph illustrating the absolute changes in accidents observed for these time periods is presented in Figure 8. The data presented in this figure are taken from Table A-1, where the daily accidents have been summed within the relevant monthly periods.

Even though none of the changes in traffic counts exhibit a significant decrease at the 99 percent level, all five monthly periods experienced significant decreases in accidents. The accidents in January, 1974 were 53.2 percent below those of January, 1973. Similarly, accidents in March, 1974 were 44.5 percent below the corresponding 1973 period and the May, June, and July periods experienced accident decreases of 41.2, 36.2 and 40.5 percent, respectively.

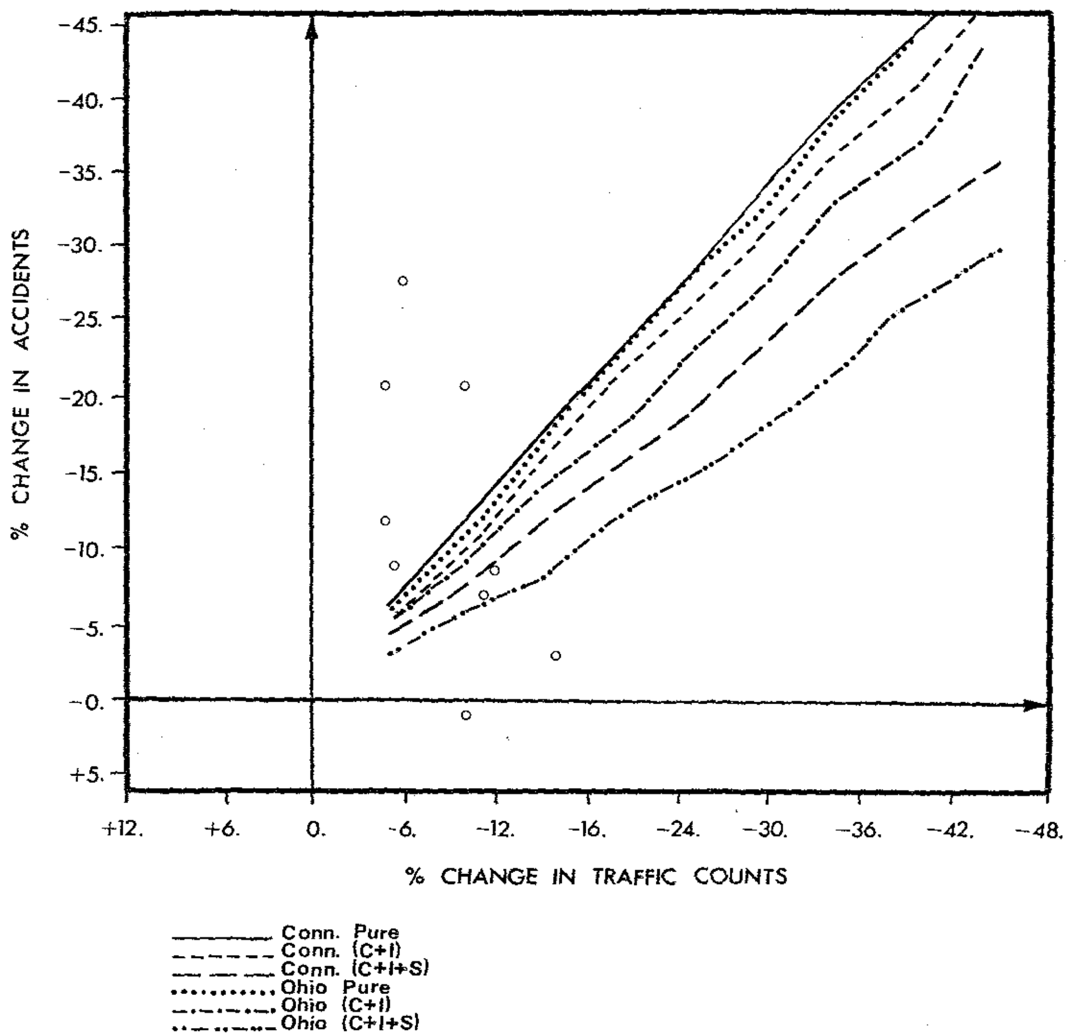

Figure 6. Predicted and actual percentage changes in accidents and traffic counts for N.C. highways (monthly totals).

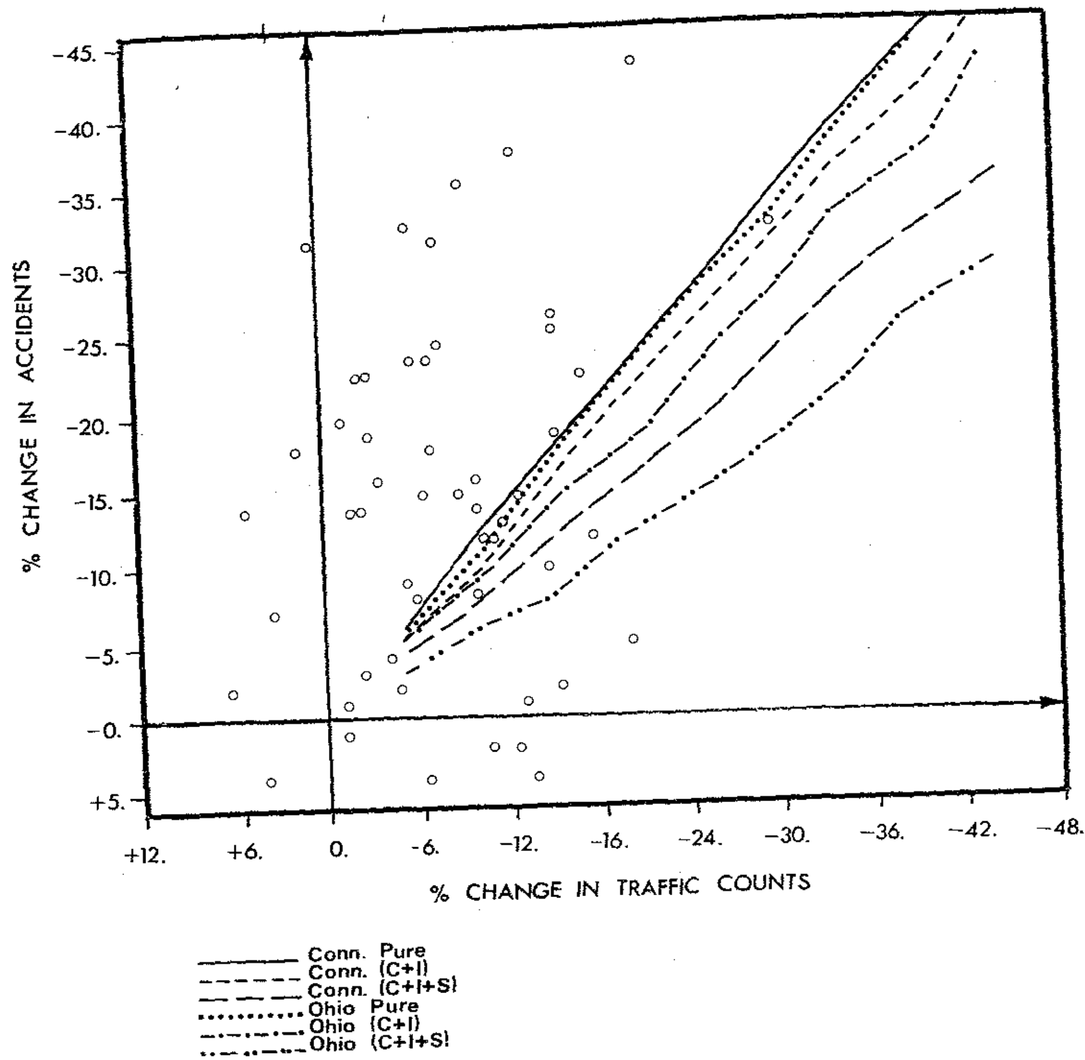

Figure 7. Predicted and actual percentage changes in accidents and traffic counts for N.C. highways (day-of-week data).

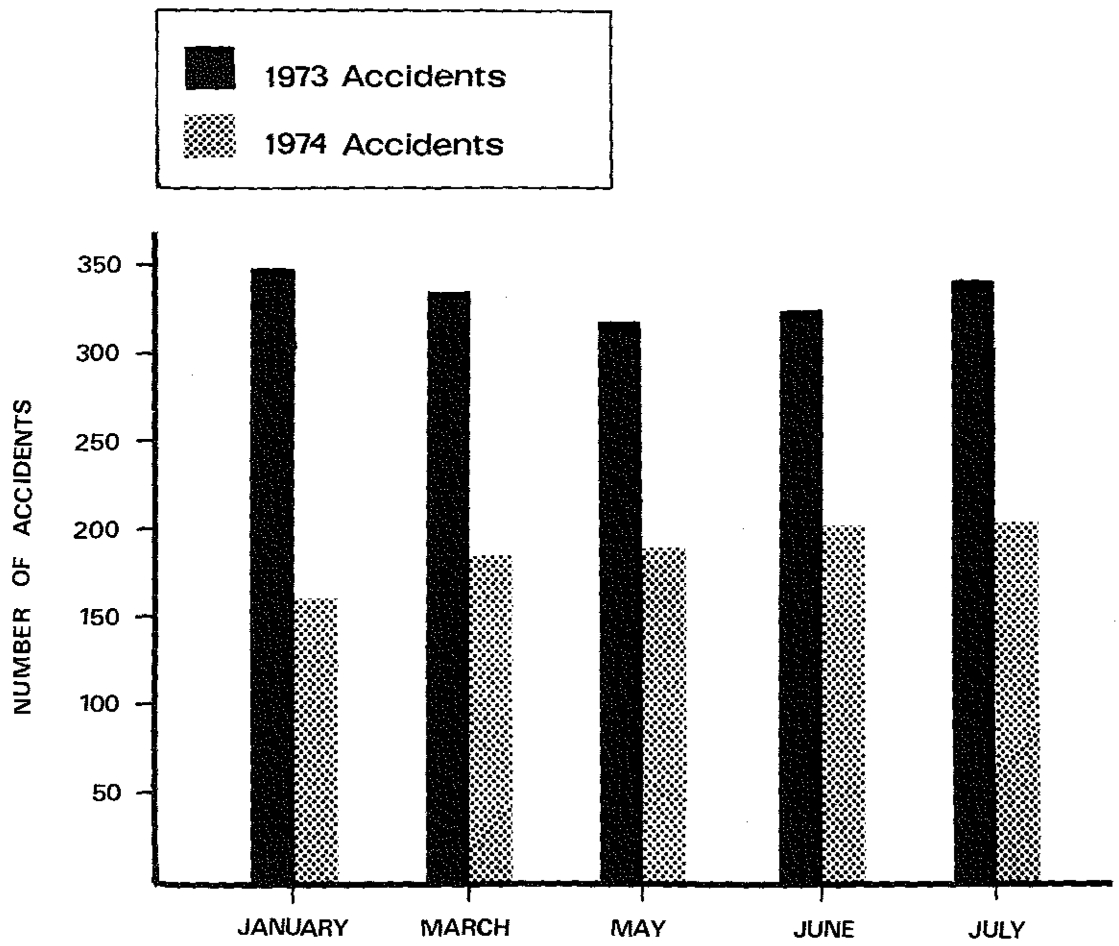

Figure 8. Interstate accidents for non-significant changes or significant increases in monthly volumes from 1973 to 1974.

This analysis again indicates the same trend as that noted in the previous two analyses. Total reductions in accidents do not appear to be totally explainable by corresponding reductions in volumes. Again, it appears that at least on Interstate highways, other "causative" factors including the speed limit reduction appear to have affected accident occurrence.

SUMMARY AND CONCLUSIONS

In this paper, North Carolina data concerning vehicle speeds, accident frequencies, accident severity, and traffic counts have been examined in an attempt to gain insight into the "causes" of the dramatic decline in highway fatalities and accidents following the late-1973 early-1974 energy crisis. Because the speed limit is subject to administrative or legislative control, emphasis was placed on the effects of the lowering of the maximum limit to 55 mph. Because of the multiplicity of possible causes for the reduction, and because of the interactive nature of factors such as speed, traffic volumes, driver characteristics, vehicle type shifts, exposure changes, etc., it is virtually impossible to accurately estimate a specific amount of reduction due to a given cause (such as the lowered limit). However, the analyses conducted have provided some insight into the changes which have taken place. Major findings of these analyses are summarized as follows:

1. Changes in vehicle speeds:

   a. Following imposition of the lower limit, there were initial decreases in average speeds, median speeds, 85th percentile speeds, and in the percentage of vehicles traveling over 55 mph and 65 mph for all roadway classes, regardless of whether the speed limit within these classes was changed or not. As expected, the largest decrease in mean speeds was noted on Interstate highways.

   b. By November, 1974, approximately one-half of the decrease in mean speed had been recovered on the Interstates, and almost all the decrease had been recovered on other main highways. Slight increases in final speeds were noted for highways experiencing no limit change.

   c. Speed variation, as measured by the percentage of vehicles traveling in the 10 mph pace, has decreased for all sampled roadway classes--an important finding in terms of accident involvement. These decreases in variation did not dissipate by November, 1974, but instead appeared to continue to become more pronounced.

2. Changes in accidents and fatalities:

   a. When 1973 and 1974 accidents are compared, the data

indicate total yearly decreases of 3.7 percent in accidents and 11.2 percent in fatal accidents. While urban accidents are 1.6 percent higher, rural accidents are 8.6 percent lower. Bicycle and pedestrian accidents are up 4.3 percent in 1974.

   b. When data for the first ten months of 1973 and 1974 are compared within highway classes, it is noted that the largest and most significant decreases in fatalities is found during the latter two three-month periods (April-September) after the perceived peak of the energy crisis. Fatalities are down by 43 percent on Interstate highways, 29 percent on U.S. highways, and 31 percent on N.C. highways. No differences in fatalities were noted for rural paved roads. Automobile fatalities (excluding bicycle and pedestrian deaths) were down 19 percent on city streets where no limit change would be expected. This latter decrease was in contrast to an increase in total accidents on these streets.

3. Changes in accident severity:

   a. TAD severity for accidents occurring on all highways, highways with speed limits of 55 mph or greater, and Interstate highways was slightly lower in 1974 than in 1973.

   b. For highways where the 1973 speed limit had been 55 mph or greater, estimated speeds prior to the accident were significantly lower in all months of 1974 except January.

   c. In contrast to the above two findings, driver injury appeared to have shifted slightly upward in 1974 on all highways combined and on highways with old limits of 55 mph or greater. No significant differences were observed in accidents on Interstates, a finding contrary to what might have been expected from the decrease in vehicle speeds.

4. Changes in traffic counts:

   a. Traffic counts for 1974 were significantly lower than those for 1973 throughout the January-September period for all roadway classes. Interstate highways showed the least consistent pattern.

b. As expected, "gasless" Sundays experienced the largest decrease in counts on most roadway classes for most months. In the early months (January-March), weekends experienced the largest decreases on all roadways.

c. When proportional changes in accidents are compared to proportional changes in volumes, different roadway classes exhibit different trends. Interstates showed the most dramatic differences with accident decreases being consistently larger than volume decreases for most months in both monthly data and day-of-week data. U.S. and N.C. routes also experienced larger decreases in accidents for the early months, with the effect dissipating during the summer months. Rural paved road data indicated a different trend with consistent decreases in volumes being greater than accident decreases except for January. City streets showed no consistent trends in amount or direction of differences.

d. When Interstate, U.S., and N.C. data concerning changes in accidents are graphically compared to changes "predicted" by historical trends, decreases in accidents appear to be larger than what would be expected from the corresponding decreases in volumes. Again, the most dramatic differences are noted on the Interstate highways. This finding was further evidenced by the presence of significant accident reductions where either non-significant volume reductions or volume increases were found. These findings appear to indicate that "causative" factors other than volume changes were in operation.

5. Changes in driver age distributions:

Where significant differences in the 1973 and 1974 distributions of driver age for accident-involved drivers existed, the proportion of involved young drivers (15-19) was higher in 1974 than 1973. This indicated that a hypothesized decrease in the mileage driven by these young drivers may not have occurred.

These findings indicate a rather involved series of "system" changes which resulted in a decrease in both accidents and fatalities. Speeds, traffic counts, and accident severity appear to have changed in this period. Even here, however, the findings are not all internally consistent, and some discussion may be warranted.

For example, it appears that there were initial significant reductions in vehicle speeds and in what would be considered the related accident severity as measured by the TAD severity shifts and speed prior to accident shifts. However, driver injury appeared not to experience such a decrease even on the Interstate highways where speed reductions were largest. That is, even though there were fewer accidents, and the remaining accidents were less severe in terms of vehicle damage, the drivers who were involved experienced as severe an injury distribution as before the speed limit change. While there is little factual information which might explain this paradox, many hypotheses might be extended. One of these, which has some basis in past research, concerns the relationship between vehicle speed prior to an accident and the probability of fatal or serious injury. While past research has attempted to define such a relationship, the absence of accurate vehicle speed estimates for fatal crashes has hindered progress, and until a currently proposed federal program involving the installation of "crash recorders" in a fleet of vehicles is carried out, little additional progress would be expected. However, it might be hypothesized that because of the interaction between human tolerance levels and vehicle interior designs, such a probability relationship would be similar to that depicted in Figure 9. The curve depicts a situation in which the probability of serious injury increases with speed, but becomes asymptotic at approximately 60 or 70 mph. Past research has indicated that the "true" function is of this shape, since at some speed, essentially all occupants would be fatally injured. The question remaining concerned the speed level at which this curve becomes essentially asymptotic. If the above depicted relationship is "true", instead of, for instance, a relationship in which the curve becomes asymptotic at 90 mph, then 5 to 10 mph reductions in speeds in the range of 50 to 65 mph would have little effect on the probability of a fatality or serious injury. The same reductions where "before" speeds were between 20 and 40 mph would result in much greater "savings."

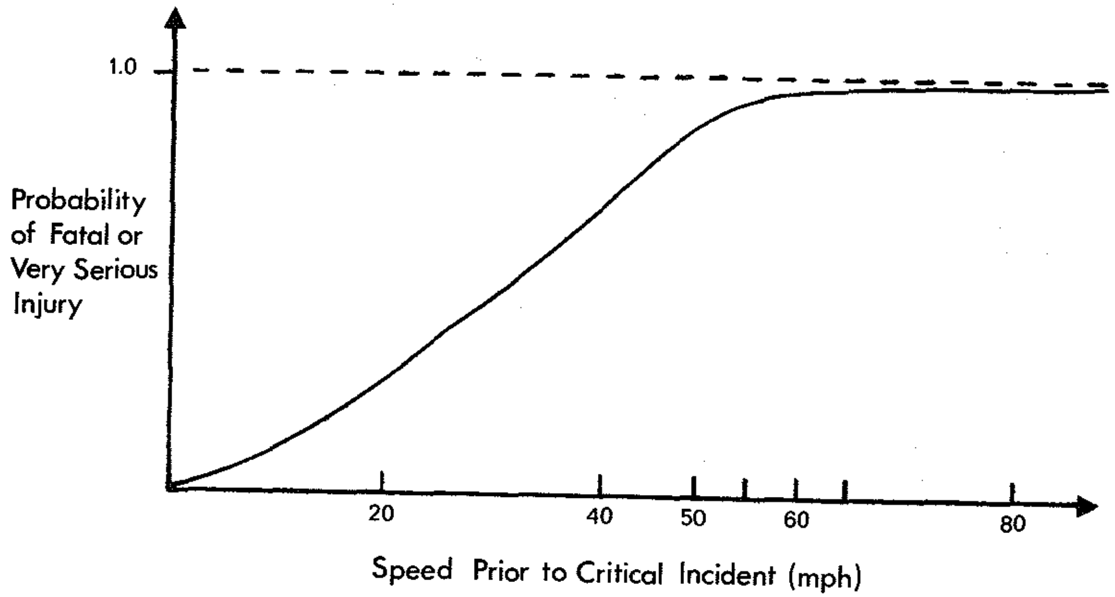

Figure 9. Hypothesized relationship between probability of serious or fatal injury and vehicle speed prior to critical incident.

On the other hand, both the TAD severity and the estimated speed prior to accident could be more sensitive to changes in travelling speeds in the region around 60 mph (see Figure 10).

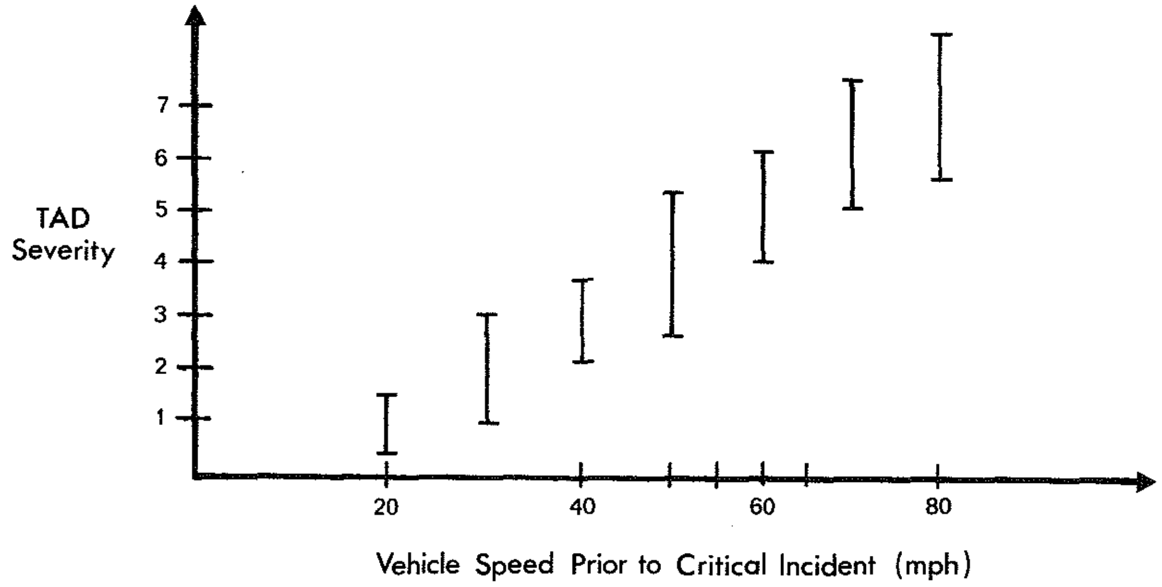

Figure 10. Hypothesized relationship between TAD severity rating and vehicle speed prior to critical incident.

If the above represent 90 percent confidence intervals for TAD severity rating at given speeds, the overall TAD distribution is found by weighting each distribution for a given speed by the accident involvement frequency for that speed and summing. If the accident involvement frequency distribution is shifted downward, i.e., if accidents are occurring at lower speeds, then a significantly different TAD distribution would result. This would lead to the circumstances noted - a significant shift in TAD severity with little or no reduction in driver injury.

Again, these relationships are only based on baseline internal research with TAD severity data and injury data, and are only hypothetical. However, the presence of the seeming contradiction in the current data leads to intriguing possibilities for future research into the relationships.

A second interesting finding related to speed concerns indicated decreases in speed variation on all roadways. Just as in other recent studies (Highway Users Federation, 1974), the data indicate that the initial decreases in average speeds had been almost fully recovered on most roadways by November, 1974. However, the speed variation, as measured by percentage of vehicles traveling in the 10 mph pace, seemed to remain smaller through November, 1974, with no indication of dissipation of this trend. Of even greater interest is the fact that this decrease in speed variation was present on rural roadways where no change in limit had been experienced, perhaps indicating a "carry-over" effect. As noted, such a "tightening" of speeds has been shown to affect accident involvement rates, and could very well be causally related to the lower accident frequencies noted in 1974.

Volume changes, as measured by traffic counts, also were obviously a factor in the reductions in total accidents (and therefore fatal accidents). The current data indicate that decreases in volumes continued to be evident on all roadway classes, at least through September, 1974. It is also noted in Table 29 that volume decreases in September, the last month in the sample, appear to be less for all roadway classes except Interstates, where the maximum monthly decrease occurs in this month. While little confidence can be placed in "trends" based on one or two months, if volumes are indeed increasing on roadways other than Interstates while decreasing on Interstates, one might expect the volume related reductions in accidents to disappear, since such shifts in travel would be "away" from the safest roadways (Interstates) to the less safe two-lane and four-lane rural highways. If such a shift is "caused" by driver frustration with the 55 mph limit on the high design Interstate highways, then continuation of such a situation could lead to an adverse effect on safety.

The current analyses of the relationships between the accident changes and related volume changes, both in terms of differences in the size of proportional changes and in terms of differences between observed accident decreases and "expected" decreases, indicate that while volume changes indeed have resulted in a significant reduction in accidents, there are additional "causes" at work which have resulted in additional savings. One of these additional "causes" may well have been the decreased speed variance due, perhaps, to the change in speed limit. It is also important to note, however, that the current analyses could only

examine changes in overall travel, and could not examine changes in types of travel, and thus, character of exposure. No inferences can be drawn concerning whether or not there was reduced "pleasure" driving or reduced alcohol involved driving, two classes of trips which have been shown to produce a higher relative risk of accident involvement. (Of course, there were fewer Sunday trips.) Nor are inferences drawn concerning shifts in vehicle types, occupancy changes, or other factors which might result in either increased or decreased risk of exposure. While the analysis of driver age did not indicate shifts in age distributions of accident involved drivers, there still remains the possibility of differences in overall driver characteristics and trip characteristics between 1973 and 1974.

Thus, it appears that the series of analyses aimed at determining the effect of the lowered speed limit may have produced more questions than answers. The reduction in the limit appears to have an early "direct" effect on vehicle speeds and, perhaps, accident severity. However, the driver injury distribution for Interstate highways, where speeds decreased most dramatically, did not change from 1973 to 1974. Thus, it appears that any "direct" effect in terms of accident severity has been lost by November, 1974. It is interesting to note that over the nine month period of January through September, while Interstate accidents decreased 39.7 percent, fatalities decreased a comparable 36.5 percent, lending some support to the previously hypothesized speed-injury relationship.

Lending further support to the idea that any "direct" effect of the speed limit reduction is probably not a significant causal factor in the reduction of fatalities is the following data. As indicated in Table 30, below, when accident reductions and fatality reductions are compared on the various roadway classes for the nine month period, fatalities are much lower than what would be predicted by reductions in total accidents on U.S. and N.C. highways and city streets.

Table 30. Percentage changes in total 1973 and 1974 accidents and fatalities for various roadway classes (January - September).

	Percentage Change in Accidents	Percentage Change in Fatalities
Interstate	-39.7%	-36.5%
U.S.	-18.9%	-28.6%
N.C.	-14.4%	-30.5%
R.P.R.	- 8.7%	- 2.0%
City Streets	- 3.0%	-18.3%

As noted earlier, Interstate changes are comparable. Thus, a situation exists where fatalities are reduced approximately the same as accidents on the one roadway system where speed limits are universally reduced and where the maximum speed reductions occurred, while fatalities are reduced much more than total accidents on roadway systems where little or no change in limit or in vehicle speeds is experienced. In addition, Tables 13 and 14 indicate that large reductions in fatalities continue to occur on U.S. and N.C. routes in the later months after all reduction in mean speed has been recovered. It appears that a significant "direct" effect on severity is questionable.

There does, however, appear to be a continuing "indirect" effect which may well be partially due to the lowered limit -- that is, the reduction in speed variation which continued throughout the entire period of study. Of even more interest is the fact that this effect is found on other roadway systems, where no change in limit, or continued change in mean speeds exists. It does appear that there has been a significant change in the behavior of drivers in terms of their speeds relative to other vehicles, and that the change may well have resulted in fewer accidents. Based on this, and on the initial "carry-over" decrease in mean speeds even on roadways not experiencing a limit reduction, it might be hypothesized that there has been a change in, for lack of a more appropriate term, "driver attitude," with individual drivers coping with the energy crisis by driving less, slightly slower, and more nearly at the speeds of surrounding traffic on all types of roadways. If we can assume that this change in "attitude" has resulted in a more "safety conscious" driving public, then perhaps a "cause" for part of the unexplained reduction in fatalities could be cited. While there is no way of proving such a hypothesis or of proving that the reduced speed limit, rather than other energy crisis related factors, was the principal indirect "cause" of the change, it is possible that the reduction in speed limit, a very dramatic and well publicized change in our transportation system, has served as a "reminder" to the driving public that a crisis exists and that changes in driving habits are necessary in order to help insure a comparable level of future mobility. Because accident and fatality reductions have continued through early 1975, it is as yet impossible to anticipate what changes will occur in driving habits if and when "fear" of the energy shortage has disappeared.

If this hypothesized change in attitude exists and is, at least, related to the 55 mph limit, a return to the higher limits could also possibly signal to drivers that the "experts" feel that the crisis is over, and that a return to old driving habits is "allowable". Such a return might also result in a return to old fatality rates.

In conclusion, North Carolina data indicate rather unexpected, and

somewhat confusing, findings. While there appears to be little continuing effect of the reduced speed limit in terms of accident severity, indicated changes in speed variation and hypothesized changes in "driver attitude" may have, at least, partially resulted from the reduction in the limit. It is probably true that 1974 trips were made by a slightly different population of drivers, on different roads, to different places, for different reasons, and in a different manner than was true for 1973 trips. Until more definitive work has indicated that the possible effects of the reduced limit no longer exist, it is difficult to recommend abolishment of the reduced limit as a safety related measure. Because the reduced speeds are probably adding some costs to our transportation system, and because continued relative volume shifts away from Interstate highways might ultimately result in increased accident frequencies and severities, it is very important that studies monitoring these changes continue in the near future.

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APPENDIX A

Traffic Count and Accident Data for Various Roadway Classes

Table A-1. Traffic count and accident data for Interstate roadways.

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
January							
Monday	11706	15526	50	44	-32.6	-12.0	p<.05
Tuesday	17813	20022	48	16	+12.4	-66.7	p<.01
Wednes.	18594	20890	37	22	+12.4	-40.5	p<.05
Thurs.	14358	16646	23	20	+15.9	-13.0	n.s.
Friday	17234	18924	54	30	+ 9.8	-44.4	p<.01
Satur.	13321	14360	34	17	+ 7.8	-50.0	p<.01
Sunday	9833	9558	100	13	- 2.8	-87.0	p<.01
Total	102859	115926	346	162	+12.7	-53.2	p<.01
February							
Monday	21681	19648	28	20	- 9.4	-28.6	n.s.
Tuesday	21809	21630	23	11	- 0.8	-52.2	p<.05
Wednes.	23143	20984	25	19	- 9.3	-24.0	n.s.
Thurs.	23582	22694	36	15	- 3.8	-58.3	p<.01
Friday	30460	26956	61	24	-11.5	-60.7	p<.01
Satur.	17676	13250	52	33	-25.0	-36.5	n.s.
Sunday	19533	11474	31	17	-41.3	-45.2	n.s.
Total	157884	136636	195	139	-13.5	-28.7	n.s.
March							
Monday	19057	21020	33	46	+10.3	+39.4	n.s.
Tuesday	18569	21896	32	17	+17.9	-46.9	p<.01
Wednes.	16083	22269	39	12	+38.5	-69.2	p<.01
Thurs.	23908	29649	61	18	+24.0	-70.5	p<.01
Friday	34848	35684	64	38	+ 2.4	-40.6	p<.01
Satur.	29618	25022	60	38	-15.5	-36.7	n.s.
Sunday	23547	19106	39	13	-18.9	-66.7	p<.01
Total	165630	174646	328	182	+ 5.4	-44.5	p<.01
April							
Monday	31853	31841	45	20	0.0	-55.6	p<.01
Tuesday	24946	24566	41	16	- 1.5	-61.0	p<.01
Wednes.	23969	24525	33	16	+ 2.3	-51.5	p<.05
Thurs.	28353	25839	45	27	- 8.7	-40.0	n.s.
Friday	37531	33728	41	33	-10.1	-19.5	n.s.
Satur.	29863	27042	47	30	- 9.4	-36.2	n.s.
Sunday	38893	30234	43	23	-22.3	-46.5	n.s.
Total	215408	197775	295	165	- 8.2	-44.1	p<.01
May							
Monday	25480	28204	42	18	+10.7	-57.1	p<.01
Tuesday	31113	33898	52	16	+ 9.0	-69.2	p<.01
Wednes.	31629	35140	38	21	+11.1	-44.7	p<.01
Thurs.	35928	35236	54	34	- 1.9	-37.0	p<.05
Friday	35604	35284	45	27	- 0.9	-40.0	p<.05
Satur.	30055	29160	45	33	- 3.0	-26.7	n.s.
Sunday	30762	29762	42	38	- 3.3	- 9.5	n.s.
Total	220571	226684	318	187	+ 2.8	-41.2	p<.01

Table A-1 (cont.)

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
June							
Monday	26365	26547	33	23	+ 0.7	-30.3	n.s.
Tuesday	25022	26226	33	26	+ 4.8	-21.2	n.s.
Wednes.	28885	28727	38	21	- 0.5	-44.7	p<.05
Thurs.	25706	29274	43	30	+13.9	-30.2	p<.05
Friday	42223	42379	84	41	+ 0.4	-51.2	p<.01
Satur.	36762	39442	46	29	+ 7.3	-37.0	p<.05
Sunday	31940	32106	46	36	+ 0.5	-21.7	n.s.
Total	216903	224701	323	206	+ 3.6	-36.2	p<.01
July							
Monday	25090	35354	55	34	+40.9	-38.2	p<.01
Tuesday	27443	33234	64	32	+21.1	-50.0	p<.01
Wednes.	14980	27744	27	30	+85.2	+11.1	n.s.
Thurs.	20968	29915	38	18	+42.7	-52.6	p<.01
Friday	25508	35373	41	31	+38.7	-24.4	p<.01
Satur.	26689	30751	45	34	+15.2	-24.4	n.s.
Sunday	34697	43100	73	25	+24.2	-65.8	p<.01
Total	175375	235471	343	204	+34.3	-40.5	p<.01
August							
Monday	32399	24314	38	32	-25.0	-15.8	n.s.
Tuesday	27344	22844	33	22	-16.5	-33.3	n.s.
Wednes.	34967	29474	55	24	-15.7	-56.4	p<.01
Thurs.	39989	35039	50	33	-12.4	-34.0	n.s.
Friday	54469	40081	98	64	-26.4	-34.7	n.s.
Satur.	40030	29953	52	32	-25.2	-38.5	n.s.
Sunday	41920	31064	50	28	-25.9	-44.0	n.s.
Total	271118	212769	376	235	-21.5	-37.5	p<.01
September							
Monday	33466	24132	32	26	-27.9	-18.8	n.s.
Tuesday	29719	21605	31	37	-27.3	+19.4	p<.05
Wednes.	27258	20413	24	26	-25.1	+ 8.3	n.s.
Thurs.	30655	21096	38	20	-31.2	-47.4	n.s.
Friday	39084	28566	54	47	-26.9	-13.0	n.s.
Satur.	44708	29331	40	40	-34.4	0.0	n.s.
Sunday	46401	30683	33	27	-33.9	-18.2	n.s.
Total	251291	175826	252	223	-30.0	-11.5	p<.05

Table A-2. Traffic count and accident data for U.S. roadways.

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
January							
Monday	44933	43692	289	216	- 2.8	-25.3	p<.01
Tuesday	62027	52582	234	158	-15.2	-32.5	p<.05
Wednes.	64338	58584	241	207	- 9.0	-14.1	n.s.
Thurs.	52555	46837	178	164	-10.9	- 7.9	n.s.
Friday	62372	56782	305	238	- 9.0	-22.0	n.s.
Satur.	55314	46160	240	203	-16.6	-15.4	n.s.
Sunday	36841	27851	324	119	-24.4	-63.3	p<.01
Total	378380	332488	1811	1305	-12.1	-27.9	p<.01
February							
Monday	59562	50917	185	157	-14.5	-15.1	n.s.
Tuesday	62072	53872	196	129	-13.2	-34.2	p<.05
Wednes.	66383	57804	199	180	-12.9	- 9.5	n.s.
Thurs.	67519	61797	193	186	- 8.5	- 3.6	n.s.
Friday	76483	67370	338	249	-11.9	-26.3	p<.05
Satur.	57009	41118	243	238	-27.9	- 2.1	p<.05
Sunday	53534	32057	204	114	-40.1	-44.1	n.s.
Total	442517	364935	1558	1253	-17.5	-19.6	n.s.
March							
Monday	71215	59235	247	198	-16.8	-19.8	n.s.
Tuesday	69568	60735	171	130	-12.7	-24.0	n.s.
Wednes.	69553	57889	198	138	-16.7	-30.3	n.s.
Thurs.	88732	79744	232	190	-10.1	-32.6	p<.01
Friday	108084	91515	424	303	-15.3	-28.5	p<.05
Satur.	90983	75878	483	296	-16.6	-38.7	p<.01
Sunday	67705	50714	311	114	-25.1	-63.3	p<.01
Total	565840	475710	2116	1369	-15.9	-35.3	p<.01
April							
Monday	87808	85873	259	233	- 2.2	-10.0	n.s.
Tuesday	71047	71658	171	164	+ 0.9	- 4.1	n.s.
Wednes.	70637	69682	238	155	- 1.4	-34.9	p<.01
Thurs.	73731	72316	216	165	- 1.9	-23.6	p<.05
Friday	88283	87165	313	248	- 1.3	-21.0	p<.05
Satur.	75593	76580	349	256	+ 1.3	-26.7	p<.01
Sunday	87209	85974	363	205	- 1.4	-43.5	p<.01
Total	554308	549248	1909	1426	- 0.9	-25.3	p<.01
May							
Monday	72670	66466	228	169	- 8.5	-25.9	p<.05
Tuesday	88952	82588	266	217	- 7.2	-18.4	n.s.
Wednes.	91494	82537	268	177	- 9.8	-34.0	p<.01
Thurs.	93771	84401	359	270	-10.0	-24.8	p<.05
Friday	90284	82801	304	224	-8.28	-26.3	p<.05
Satur.	82121	75927	261	246	- 7.5	- 5.8	n.s.
Sunday	81270	67996	306	301	-16.3	- 1.6	p<.05
Total	600562	542716	1992	1604	- 9.6	-19.5	p<.01

Table A-2 (cont.)

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
June							
Monday	77057	69625	204	182	- 9.6	-10.8	n.s.
Tuesday	76626	69802	220	194	- 8.9	-11.8	n.s.
Wednes.	77762	70019	268	186	-10.0	-30.6	p<.01
Thurs.	79319	66871	247	254	-15.7	+ 2.8	p<.05
Friday	117368	96147	475	389	-18.1	-18.1	n.s.
Satur.	109880	91808	390	329	-16.5	-15.6	n.s.
Sunday	86454	70603	270	231	-18.3	-14.4	n.s.
Total	624466	534875	2074	1765	-14.3	-14.9	n.s.
July							
Monday	92529	83055	289	249	-10.2	-13.8	n.s.
Tuesday	93797	84703	305	198	- 9.7	-35.1	p<.01
Wednes.	68800	63340	226	209	- 7.9	- 7.5	n.s.
Thurs.	76956	66061	252	200	-14.2	-20.6	n.s.
Friday	87873	79443	307	279	- 9.6	- 9.1	n.s.
Satur.	80684	73012	322	320	- 9.5	- 0.6	n.s.
Sunday	99385	79958	370	306	-19.6	-17.3	n.s.
Total	600024	529572	2071	1761	-11.7	-15.0	n.s.
August							
Monday	75316	67362	244	217	- 9.9	-11.1	n.s.
Tuesday	72683	62559	209	228	-13.9	+ 9.1	p<.05
Wednes.	91724	84284	262	211	- 8.1	-19.5	n.s.
Thurs.	95835	89112	270	296	- 7.0	+ 9.6	n.s.
Friday	112199	106315	486	492	- 5.2	+ 1.2	n.s.
Satur.	87121	79327	363	310	- 8.9	-14.6	n.s.
Sunday	83104	71029	293	291	-14.5	- 0.7	n.s.
Total	617982	560488	2127	2045	- 9.3	- 3.9	n.s.
September							
Monday	60881	62009	233	188	+ 1.9	-19.3	p<.05
Tuesday	55178	56809	196	206	+ 3.0	+ 5.1	n.s.
Wednes.	55915	54530	201	168	- 2.5	-16.4	n.s.
Thurs.	58799	60022	228	195	+ 2.1	-14.5	n.s.
Friday	70485	69315	385	393	- 1.7	+ 2.1	n.s.
Satur.	82424	86548	368	361	+ 5.0	- 1.9	n.s.
Sunday	77451	76793	347	253	- 0.8	-27.1	p<.01
Total	461133	466026	1958	1764	+ 1.1	- 9.9	p<.01

Table A-3. Traffic count and accident data for North Carolina roadways.

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
January							
Monday	3713	3591	155	166	- 3.3	+ 7.1	n.s.
Tuesday	5076	4580	172	110	- 9.8	-36.1	p<.01
Wednes.	5288	5221	140	138	- 1.3	- 1.4	n.s.
Thurs.	4242	3920	156	106	- 7.6	-32.1	p<.05
Friday	5097	4576	181	166	-10.2	- 8.3	n.s.
Satur.	5103	4212	187	144	-17.5	-23.0	n.s.
Sunday	3374	2647	203	112	-21.5	-44.8	p<.01
Total	31983	28747	1194	942	-10.1	-21.1	p<.01
February							
Monday	4511	4190	135	110	- 7.1	-18.5	n.s.
Tuesday	4678	3939	147	108	-15.8	-26.5	n.s.
Wednes.	4457	4458	149	116	0.0	-22.2	p<.05
Thurs.	4928	4679	145	142	- 5.1	- 2.1	n.s.
Friday	5393	5265	220	168	- 2.4	-23.6	p<.05
Satur.	4408	3740	208	186	-15.2	-10.6	n.s.
Sunday	4274	2968	143	95	-30.6	-33.6	n.s.
Total	32649	29329	1147	925	-10.4	-19.4	p<.01
March							
Monday	4881	4772	141	136	- 2.2	- 3.5	n.s.
Tuesday	5079	4914	109	91	- 3.3	-16.5	n.s.
Wednes.	5066	4401	160	99	-13.1	-38.1	p<.01
Thurs.	6524	6066	158	119	- 7.0	-24.7	n.s.
Friday	7736	7034	238	202	- 9.1	-15.1	n.s.
Satur.	7367	7394	322	217	+ 0.4	-32.6	p<.01
Sunday	5338	4481	213	102	-16.1	-52.1	p<.01
Total	41991	39462	1341	966	- 6.0	-28.0	p<.01
April							
Monday	7553	7808	154	142	+ 3.4	- 7.8	n.s.
Tuesday	6448	5590	123	104	-13.3	-15.5	n.s.
Wednes.	6146	5726	131	111	- 6.8	-15.3	n.s.
Thurs.	6380	6184	141	108	- 3.1	-23.4	n.s.
Friday	8076	7572	198	149	- 6.2	-24.8	p<.05
Satur.	7863	7777	277	221	- 1.1	-20.2	p<.05
Sunday	8898	8364	254	168	- 6.0	-33.9	p<.01
Total	51364	49021	1278	1003	- 4.6	-21.5	p<.01
May							
Monday	5924	5845	126	126	- 1.3	0.0	n.s.
Tuesday	7353	7142	203	163	- 2.9	-19.7	n.s.
Wednes.	7556	7363	166	142	- 2.6	-14.5	n.s.
Thurs.	7849	8013	224	183	+ 2.1	-18.3	p<.05
Friday	7512	6589	190	165	-12.3	-13.2	n.s.
Satur.	7778	7620	205	176	- 2.0	-14.2	n.s.
Sunday	7601	6590	203	200	-13.3	- 1.5	n.s.
Total	51573	49162	1317	1155	- 4.7	-12.3	p<.05

Table A-3 (cont.)

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
June							
Monday	6645	6389	136	130	- 3.9	- 4.4	n.s.
Tuesday	6619	5887	107	128	-11.1	+19.6	p<.05
Wednes.	6584	5919	168	143	-10.1	-14.9	n.s.
Thurs.	6653	5939	160	169	-10.7	+ 5.6	n.s.
Friday	9948	8923	287	239	-10.3	-16.7	n.s.
Satur.	10396	9210	317	278	-11.4	-12.3	n.s.
Sunday	8233	6545	195	185	-20.5	- 5.1	n.s.
Total	55078	48812	1370	1272	-11.4	- 7.2	n.s.
July							
Monday	7727	6668	196	163	-13.7	-16.8	n.s.
Tuesday	7437	6921	159	165	- 6.9	+ 3.8	n.s.
Wednes.	5895	5420	164	122	- 8.1	-25.6	n.s.
Thurs.	6359	5962	146	134	- 6.2	- 8.2	n.s.
Friday	7502	5235	177	193	-16.9	+ 9.0	p<.01
Satur.	7909	6834	204	212	-13.6	+ 3.9	n.s.
Sunday	9187	7726	261	189	-15.9	-27.6	n.s.
Total	52016	45766	1307	1178	-12.0	- 9.9	n.s.
August							
Monday	5912	4847	171	149	-18.0	-12.9	n.s.
Tuesday	5839	5116	154	156	-12.4	+ 1.3	n.s.
Wednes.	7581	6344	181	145	-16.3	-19.9	n.s.
Thurs.	7956	6879	182	181	-13.5	- 0.6	n.s.
Friday	9156	8717	297	296	- 4.8	- 0.3	n.s.
Satur.	7734	6503	215	210	-15.9	- 2.3	n.s.
Sunday	7348	4690	176	195	-36.2	+10.8	p<.01
Total	51526	43096	1376	1332	-16.4	- 3.2	p<.01
September							
Monday	5577	4991	133	135	-10.5	+ 1.5	n.s.
Tuesday	5111	5393	157	134	+ 5.5	-14.7	n.s.
Wednes.	5124	5450	121	118	+ 6.4	- 2.5	n.s.
Thurs.	5261	5496	148	153	+ 4.5	+ 3.4	n.s.
Friday	6362	6019	257	232	- 5.4	- 9.7	n.s.
Satur.	9048	8100	261	228	-10.5	-12.6	n.s.
Sunday	8001	6726	226	183	-15.9	-19.0	n.s.
Total	44484	42175	1303	1183	- 5.2	- 9.2	n.s.

Table A-4. Traffic count and accident data for RPR roadways.

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
January							
Monday	1538	1483	318	208	- 3.6	-34.6	p<.01
Tuesday	2404	1988	265	209	-17.3	-21.1	n.s.
Wednes.	2579	2507	327	247	- 2.8	-24.5	p<.01
Thurs.	2123	1996	277	211	- 6.0	-23.8	p<.05
Friday	2404	2282	345	261	- 5.1	-24.4	p<.01
Satur.	2145	1810	395	348	-15.6	-11.9	n.s.
Sunday	1211	1100	339	240	- 9.2	-29.2	p<.01
Total	14404	13166	2266	1724	- 8.6	-23.9	p<.01
February							
Monday	2070	2000	217	169	- 3.4	-22.1	p<.05
Tuesday	2267	1846	209	145	-18.6	-30.6	n.s.
Wednes.	2169	2259	209	161	+ 4.1	-23.0	p<.01
Thurs.	2610	2235	208	202	-14.4	- 2.9	n.s.
Friday	2887	2741	324	269	- 5.1	-17.0	n.s.
Satur.	1966	1714	344	337	-12.8	- 2.0	n.s.
Sunday	1893	1341	286	222	-29.2	-22.4	n.s.
Total	15862	14136	1797	1505	-10.9	-16.3	n.s.
March							
Monday	2748	2005	261	227	-27.0	-13.0	n.s.
Tuesday	2782	1834	193	195	-34.1	+ 1.0	p<.01
Wednes.	2724	1873	226	193	-31.2	-14.6	p<.05
Thurs.	3058	2005	298	227	-34.4	-23.8	n.s.
Friday	3809	2422	444	309	-36.4	-30.4	n.s.
Satur.	3412	1940	558	441	-43.1	-21.0	p<.01
Sunday	2438	1545	313	237	-36.6	-24.3	n.s.
Total	20971	13624	2293	1829	-35.0	-20.2	p<.01
April							
Monday	3328	1920	285	302	-42.3	+ 6.0	p<.05
Tuesday	2636	1541	204	190	-41.5	- 6.9	p<.05
Wednes.	2794	1537	228	185	-45.0	-18.9	p<.05
Thurs.	2749	1539	230	224	-44.0	- 2.6	p<.05
Friday	3339	1743	319	299	-47.8	- 6.3	p<.05
Satur.	2964	1565	420	397	-47.2	- 5.5	p<.05
Sunday	3428	1701	369	346	-50.4	- 6.2	p<.05
Total	21238	11524	2055	1943	-45.6	- 5.5	p<.01
May							
Monday	2942	2429	249	215	-17.4	-13.7	n.s.
Tuesday	3665	3012	295	265	-17.8	-10.2	n.s.
Wednes.	3357	3420	282	247	+ 1.9	-12.4	n.s.
Thurs.	3713	3535	365	328	- 4.8	-10.1	n.s.
Friday	3404	2861	300	315	-15.9	+ 5.0	p<.01
Satur.	3034	2286	374	421	-24.7	+12.6	p<.01
Sunday	2554	2469	346	374	- 3.3	+ 8.1	n.s.
Total	22669	20012	2211	2165	-11.7	- 2.1	p<.01

Table A-4 (cont.)

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
June							
Monday	3060	2284	232	206	-25.4	-11.2	n.s.
Tuesday	3019	2789	245	186	- 7.6	-24.1	n.s.
Wednes.	2971	2909	251	222	- 2.1	-11.6	n.s.
Thurs.	3041	2442	255	273	-19.7	+ 7.1	p .01
Friday	3886	3906	401	398	+ 0.5	- 0.8	n.s.
Satur.	3473	2819	483	500	-18.8	+ 3.5	p<.01
Sunday	2701	1845	343	318	-31.7	- 7.3	p<.01
Total	22151	18994	2210	2103	-14.3	- 4.8	p<.01
July							
Monday	2823	2154	318	259	-23.7	-18.6	n.s.
Tuesday	2990	2281	287	279	-23.7	- 2.8	p .01
Wednes.	2155	2337	241	226	+ 8.4	- 6.2	n.s.
Thurs.	2371	1789	250	251	-24.6	+ 0.4	p<.01
Friday	2668	1797	285	366	-32.7	+28.4	p<.01
Satur.	1921	1802	346	384	- 6.2	+11.0	p<.05
Sunday	2424	1985	436	364	-18.1	-16.5	n.s.
Total	17352	14145	2163	2129	-18.5	- 1.6	p<.01
August							
Monday	2514	2375	273	235	- 5.5	-13.9	n.s.
Tuesday	2499	2085	230	245	-16.6	+ 6.5	p<.05
Wednes.	3436	2133	284	222	-37.9	-21.8	p<.05
Thurs.	3430	2928	294	291	-14.6	- 1.0	n.s.
Friday	3896	3269	450	439	-16.1	- 2.4	p<.05
Satur.	2642	2533	397	387	- 4.1	- 2.5	n.s.
Sunday	2388	2200	396	374	- 7.9	- 5.6	n.s.
Total	20805	17523	2324	2193	-15.8	- 5.6	p<.01
September							
Monday	2292	2303	274	261	+ 0.5	- 4.7	n.s.
Tuesday	2316	2206	236	277	- 4.8	+17.4	p<.05
Wednes.	2181	2151	244	221	- 1.4	- 9.4	n.s.
Thurs.	2316	2580	272	255	+11.4	- 6.3	n.s.
Friday	2901	2902	370	402	0.0	+ 8.6	n.s.
Satur.	2992	2650	504	550	-11.4	+ 9.1	p<.01
Sunday	2520	2399	435	396	- 4.8	- 9.0	n.s.
Total	17518	17191	2335	2362	- 1.9	+ 1.2	n.s.

Table A-5. Traffic count and accident data for city streets.

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
January							
Monday	26134	27209	697	627	+ 4.1	-10.0	p<.01
Tuesday	30409	30849	736	512	+ 1.4	-30.4	p<.05
Wednes.	35855	38030	707	618	+ 6.1	-12.6	p<.05
Thurs.	31865	30244	551	523	- 5.1	- 5.1	p<.05
Friday	33313	31946	832	754	- 4.1	- 9.4	n.s.
Satur.	26922	21030	687	612	-21.9	-10.9	p<.05
Sunday	13845	10608	559	320	-23.4	-42.8	p<.01
Total	198343	189916	4769	3966	- 4.2	-16.8	p<.01
February							
Monday	43191	39425	573	560	- 8.7	- 2.3	n.s.
Tuesday	40762	45272	523	504	+11.1	- 3.6	p<.05
Wednes.	40707	44006	506	522	+ 8.1	+ 3.2	n.s.
Thurs.	44241	43736	536	582	- 1.1	+ 8.6	n.s.
Friday	49995	49624	720	807	- 0.7	+12.1	p<.05
Satur.	32916	26378	750	704	-19.9	- 6.1	p<.01
Sunday	24616	19027	420	344	-22.7	-18.1	n.s.
Total	276428	267468	4028	4023	- 3.2	- 0.1	n.s.
March							
Monday	47926	47966	613	526	+ 0.1	-14.2	p<.01
Tuesday	43414	46905	484	432	+ 8.0	-10.7	p<.01
Wednes.	42627	47676	579	453	+11.8	-21.8	p<.01
Thurs.	60618	56529	745	611	- 6.7	-18.0	p<.05
Friday	65829	68990	973	902	+ 4.8	- 7.3	p<.01
Satur.	53293	51234	979	841	- 3.9	-14.1	p<.05
Sunday	32962	29512	480	342	-10.5	-28.8	p<.01
Total	346669	348812	4853	4107	+ 0.6	-15.4	p<.01
April							
Monday	61829	58431	617	637	- 5.5	+ 3.2	n.s.
Tuesday	53159	47495	480	503	-10.7	+ 4.8	p<.05
Wednes.	50786	47989	581	512	- 5.5	-11.9	n.s.
Thurs.	51293	48931	503	587	- 4.6	+16.7	p<.01
Friday	54851	54063	763	674	- 1.4	-11.7	p<.05
Satur.	44781	40778	781	688	- 8.9	-11.9	n.s.
Sunday	44447	38705	577	484	-12.9	-16.1	n.s.
Total	361146	336392	4302	4085	- 6.9	- 5.0	n.s.
May							
Monday	46441	42453	599	524	- 8.6	-12.5	n.s.
Tuesday	58821	52175	693	622	-11.3	-10.3	n.s.
Wednes.	61335	49721	635	551	-18.9	-13.2	n.s.
Thurs.	56713	52178	804	729	- 8.0	- 9.3	n.s.
Friday	59049	55774	733	747	- 5.5	+ 1.9	n.s.
Satur.	44987	41524	653	610	- 7.7	- 6.6	n.s.
Sunday	35175	30170	442	568	-14.2	+28.5	p<.01
Total	362521	323995	4559	4351	-10.6	- 4.6	p<.01

Table A-5 (cont.)

	1973 Vehs.	1974 Vehs.	1973 Accid.	1974 Accid.	% Change Counts	% Change Accid.	Signif.
June							
Monday	28067	34378	572	546	+22.5	- 4.6	p<.01
Tuesday	29689	32628	580	543	+ 9.9	- 6.4	p<.01
Wednes.	29677	34890	577	509	+17.6	-11.8	p<.01
Thurs.	29037	37350	639	643	+28.6	+ 0.6	p<.01
Friday	36465	54715	1066	1016	+50.1	- 4.7	p<.01
Satur.	28211	44271	801	793	+56.9	- 1.0	p<.01
Sunday	17465	22289	437	433	+27.6	- 0.9	p<.01
Total	198611	260525	4672	4483	+31.2	- 4.0	p<.01
July							
Monday	59312	54531	699	684	- 8.1	- 2.1	n.s.
Tuesday	59981	51472	687	632	-14.2	- 8.0	n.s.
Wednes.	44044	41205	485	563	- 6.4	+16.1	p<.01
Thurs.	48270	35574	519	469	-26.3	- 9.6	p<.01
Friday	55084	44834	739	775	-18.6	+ 4.9	p<.01
Satur.	40838	33157	571	658	-18.8	+15.4	p<.01
Sunday	38417	33948	535	543	-11.6	+ 1.5	p<.05
Total	345946	294721	4235	4324	-14.8	+ 2.1	p<.01
August							
Monday	52190	45880	603	609	-12.1	+ 1.0	p<.05
Tuesday	46915	45155	493	579	- 3.8	+16.3	p<.01
Wednes.	54128	55305	644	645	+ 2.2	+ 0.2	n.s.
Thurs.	57923	55969	698	804	- 3.4	+15.2	p<.01
Friday	62595	53291	989	1123	-14.9	+13.6	p<.01
Satur.	41665	37506	642	705	-10.0	+ 9.8	p<.01
Sunday	32556	29602	457	503	- 9.1	+10.1	p<.01
Total	347972	322708	4531	4968	- 7.3	+ 9.6	p<.01
September							
Monday	44347	44157	527	578	- 0.4	+ 9.7	n.s.
Tuesday	46283	46125	509	693	- 0.3	+36.2	p<.01
Wednes.	45707	46559	475	522	+ 1.9	+ 9.9	n.s.
Thurs.	51571	48132	549	576	- 6.7	+ 4.9	n.s.
Friday	59475	52744	896	974	-11.3	+ 8.7	p<.01
Satur.	50796	41124	826	877	-19.0	+ 6.2	p<.01
Sunday	39090	36896	558	570	- 5.6	+ 2.2	n.s.
Total	337269	315737	4340	4790	- 6.4	+10.4	p<.01

APPENDIX B

Standard Accident Report Form

MARKS ADDED BY ______ (Initial)

N. C. Department of Motor Vehicles
DMV-349 (Rev. 1-1-73)

TRAFFIC ACCIDENT REPORT

LOCATION

Date of Accident ______ 19 ___ Day of Week ______ Hour ______ A.M. ☐ P.M. ☐

Do not write in this space

Accident Occurred In ______ County ☐ In ☐ Near City or Town of ______

Outside City or Town ______ Miles ☐ N ☐ E ☐ S ☐ W of ☐ Limits ☐ Center

Patrol Area

On ______ Hwy. No. (I., U.S., N.C., R.P., R.U.) If No., or within corporate limits, identify by name

☐ Miles ☐ Feet ☐ N ☐ E ☐ S ☐ W At or From ______ Hwy. No., or Adjacent County Line ______ Toward ______ Hwy. No., City, or Adjacent County Line

(0 Ft. if Intersec.)

ACCIDENT TYPE

Ran off Road			Non-Collision in Road		Collision of Motor Vehicle in Road With:						
1. Right	2. Left	3. Straight Ahead	4. Overturn	5. Other in Road	6. Pedestrian	7. Parked Vehicle	8. Train	9. Bicycle	10. Animal	11. Fixed Obj.	12. Other Obj.

Collision of M.V. in Road With Another M. V.

13. Read End Slow or Stop	14. Rear End Turn	15. Left Turn Same Roadway	16. Left Turn Cross Traffic	17. Right Turn Same Roadway	18. Right Turn Cross Traffic	19. Head On	20. Sideswipe	21. Angle	22. Backing

VEHICLE NO. 1

No. of Vehicles Involved ☐

Driver: ______ First ______ Middle ______ Last Name

Address: ______

City: ______ State: ______

Is above address same as on Driver's License? Yes ☐ No ☐

Race/Sex: ______ Driver's Lic: ______ State: ______

Date of Birth: ______ Month Day Year Specify Restriction: ______

Member of Armed Forces Yes ☐ No ☐ Veh. Year: ______ Veh. Make: ______ Veh. Type: ______

Lic. Plate No. ______ State: ______ Year: ______

VIN ______ ODOM. ______

Owner: ______

Address: ______

City: ______ State: ______

Parts Damaged (TAD) ______ Amount of Damage $ ______

Drivable: Yes ☐ No ☐ Vehicle Removed to: ______

By: ______ Authority: ______

Other Property Damaged ______ Amt. of Dam. $ ______

VEHICLE NO. 2 or PEDESTRIAN

Driver: ______ First ______ Middle ______ Last Name

Address: ______

City: ______ State: ______

Is above address same as on Driver's License? Yes ☐ No ☐

Race/Sex: ______ Driver's Lic. ______ State: ______

Date of Birth: ______ Month Day Year Specify Restriction: ______

Member of Armed Forces Yes ☐ No ☐ Veh. Year: ______ Veh. Make: ______ Veh. Type: ______

Lic. Plate No. ______ State ______ Year: ______

VIN ______ ODOM. ______

Owner: ______

Address: ______

City: ______ State: ______

Parts Damaged (TAD) ______ Amount of Damage $ ______

Drivable: Yes ☐ No ☐ Vehicle Removed to: ______

By: ______ Authority: ______

Owner and Address ______

INJURY SECTION INSTRUCTIONS

Indicate which seats were occupied at the time of the collision, the degree of injury, the type of restraint used, the race, sex and age of the occupants. If occupant not injured, you do not need name and address. For type of Restraint (Res.) used: N=None, L=Lap Belt, LS=Lap & Shoulder, S=Shoulder Belt only.

K=Killed	A=Incapacitating	B=Nonincapacitating – Injury other than K or A evident at the scene	C=No visible sign of injury but complaint of pain, momentary unconsciousness	O=No injury

SEAT	Inj cl	Res usd	Race sex	Age	INJURED NAMES AND ADDRESSES First Name / Last	SEAT	Inj cl	Res usd	Race sex	Age	INJURED NAMES AND ADDRESSES First Name / Last
Left Front					DRIVER 1	Left Front					DRIVER 2 OR PEDESTRIAN
Center Front						Center Front					
Right Front						Right Front					
Left Rear						Left Rear					
Center Rear						Center Rear					
Right Rear						Right Rear					
Total No. Occupants					Total No. Inj.	Total No. Occupants					Total No. Inj.

Injured taken to: ______

WIT- NESSES Name ______ Address ______ Phone No. ______

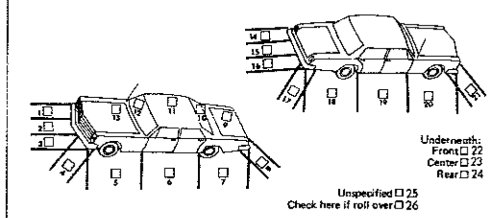
Name ______ Address ______ Phone No. ______

Arrests: Name ______ Charge(s) ______ (Cit. No.) ______

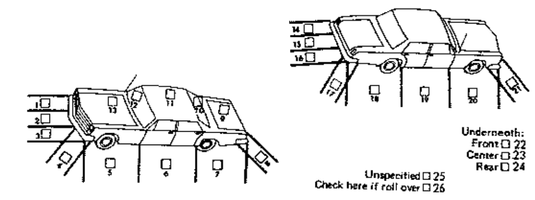
Name ______ Charge(s) ______ (Cit. No.) ______

Sign Here ______ Officer's Rank and Name ______ Number ______ Department ______ Date of Report

VEHICLE 1 POINT OF INITIAL CONTACT



VEHICLE 2 POINT OF INITIAL CONTACT



1. Locality		9. Traffic Control	Not Operating ☐ Not Visible ☐			VEHICLE 1	VEHICLE 2
2. Speed Limit		10. Object Struck			15. Veh. Maneuver		
3. Road Feature			DRIVER 1	DRIVER 2 or PED.	16. Veh. Defects		
4. Road Surface		11. Sobriety			17. Estimated Speed		
5. Road Defects		12. Physical Cond.			18. Tire Impressions(ft)		
6. Road Condition		13. Chem. Test	YES ☐ NO ☐	YES ☐ NO ☐	19. Distance Traveled After Impact (ft.)		
7. Light Condition							
8. Weather		14. Ped. Action					

INDICATE NORTH

Vehicle 1 was Traveling ☐ N ☐ E ☐ S ☐ W on ______ Vehicle 2 was Traveling ☐ N ☐ E ☐ S ☐ W on ______

DESCRIBE WHAT HAPPENED:

Vehicle 1 2 VIOLATION INDICATED

☐ ☐ 1. No. Violation Indicated
☐ ☐ 2. Excessive Speed
☐ ☐ 3. Yield Violation
☐ ☐ 4. Left of Center
☐ ☐ 5. Passing Violation
☐ ☐ 6. Stop S. or Yield S. Vio.
☐ ☐ 7. Traffic Signal Vio.
☐ ☐ 8. Safe Movement Vio.
☐ ☐ 9. Too Close
☐ ☐ 10. Improper Turn
☐ ☐ 11. Improper or No Signal
☐ ☐ 12. Improper Parking Location
☐ ☐ 13. Other Improper Driving
(describe) ______

EMERGENCY ASSISTANCE INFORMATION

INVESTIGATOR NOTIFIED ______ ☐ a.m. ☐ p.m.
BY ______

INVESTIGATOR ARRIVED ______ ☐ a.m. ☐ p.m.

AMBULANCE ARRIVED ______ ☐ a.m. ☐ p.m.

OTHER COMMENTS: ______

RESERVED FOR STATE USE:

20.	21.	22.	23.	24.
25.	26.	27.	28.	29.

RESERVED FOR CITY OR OTHER USE: