# STUDDED TIRES: THEIR EFFECT ON HIGHWAYS AND VEHICLE SAFETY IN MICHIGAN

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Research Laboratory Section
Testing and Research Division
Research Project 65 F-82
Research Report No. R-791

Michigan State Highway Commission
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Lansing, November 1971

## Background

In 1967, a bill was passed by the state legislature, permitting the use of studded tires on Michigan highways. One year later, in the spring of 1968, unusual wear was observed on M 203, a bituminous pavement in Houghton County which had been in service for only one winter. In distressed areas, the matrix was worn from the pavement surface leaving coarse aggregate exposed. That type of wear, which had never been reported before, was evident only in wheelpaths and was especially severe on curves and at acceleration or deceleration areas.

It was also learned that, during the previous winter, studded tires had been extensively used in Houghton County because of the hilly terrain and the heavy snowfall normal in that area. It was concluded at that time that damage was attributable to studded tires and since then, as studs have grown in popularity, stud wear is evident on highways throughout the state.

Other than gathering and reviewing reports of tire stud use published by others, the Department maintained a watch-and-see attitude.

In 1969, the Research Laboratory of the Michigan Department of State Highways published Research Report No. R-721, "Summary of Highway Department Concern In Connection With the Use of Tire Studs." That report summarized all available information describing tire stud wear to pavements as reported by other states. In 1969 the Minnesota Department of Highways began what has probably been the most important study of the effects of tire studs. Michigan, together with seven other states, contributed funds to that study. Results (1) of the Minnesota study have been used to estimate anticipated damage to Michigan Highways if tire studs continue to be used.

## Tire Stud Use in Michigan

The Minnesota Study was designed to provide correlation between wear on different types of pavement surfaces and number of tire stud applications. In order to use the Minnesota results to estimate actual pavement wear, it was necessary that a method be developed for determining the number of studded tires passing over any given area. Therefore, in winter 1969-70, the first Michigan statewide survey of tire stud use was made (2). This survey provided information for estimating numbers of vehicles using studded tires within each county and for the state as a whole.

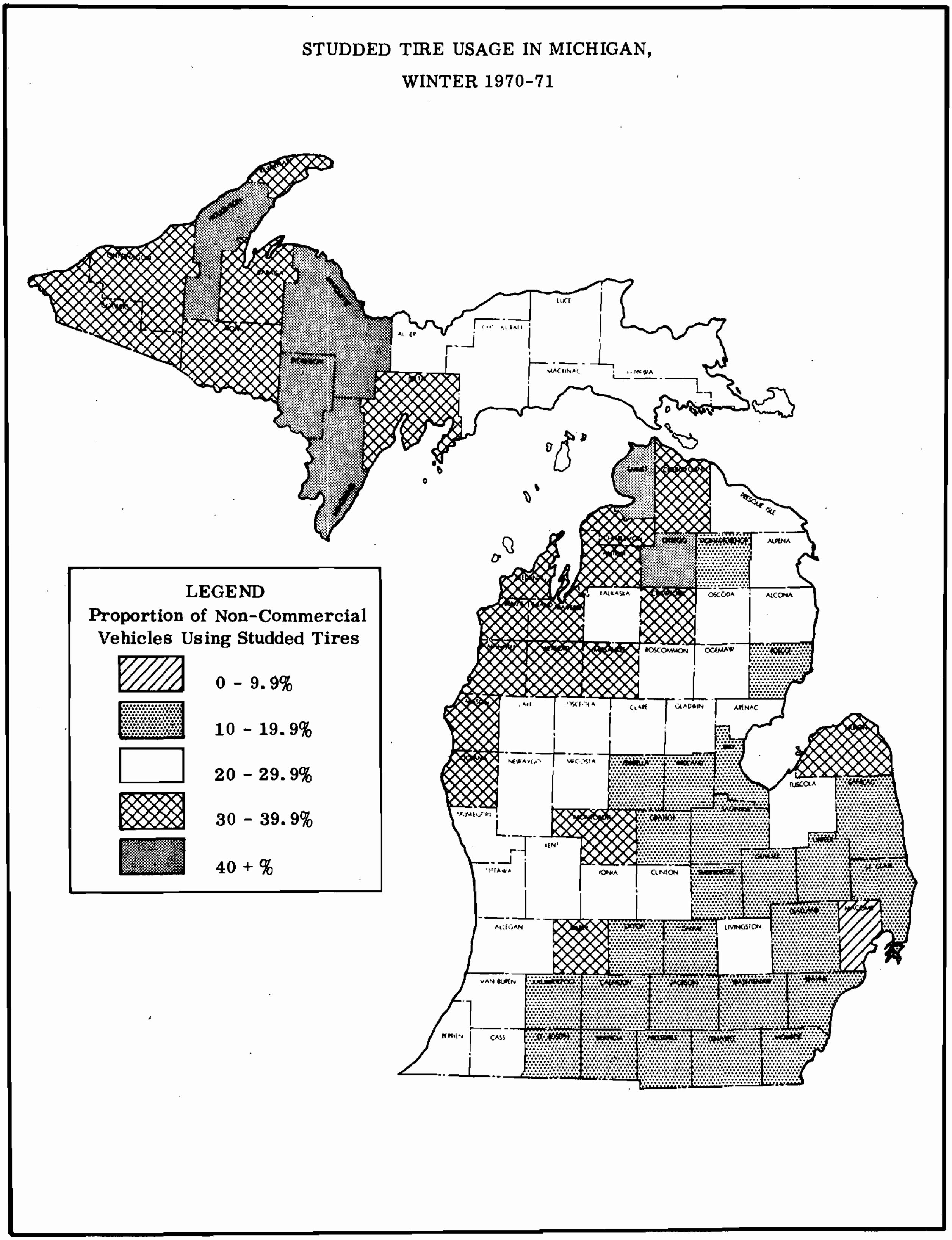



Figure 1. Studded tire usage in Michigan, winter 1970-1971.

Using data from the 1969-70 survey, a more efficient sampling plan was developed and used during winter 1970-71 (3). Statewide, the number of vehicles using studded tires increased over 27 percent from the previous winter. As a proportion of the total traffic stream surveyed, which did not include large trucks or busses, vehicles using studded tires went from 12 percent during 1969-70 to 15.2 percent in 1970-71. Figure 1 shows studded tire use in Michigan counties and Table 1 lists a comparison, by counties, of vehicles with studded tires for each of the two winter surveys.

## Stud Wear Evident on Michigan Pavements

During the past few years, exposed coarse aggregate in wheelpaths of highways has become a common sight throughout the state. The wear is non-uniform, appearing worse in the center of the track and feathering out to zero wear about 18 inches each side of center.

In spring 1971, measurements of pavement wear were made at 45 locations throughout the state. Table 2 lists measured wear and Figure 2 shows where measurements were taken. Troughs up to a depth of 1/2 in. were found during the survey. Figures 3 and 4 are photographs of a few of the locations where measurements were taken. It was estimated that only about one million applications of studded tires caused the almost 1/4 in. wear depth observed on US 10 (John C. Lodge Freeway) at Schaeffer in Detroit.

## Maintenance Costs

A summary of safety hazards which are created by studded tires and which must be countered by highway maintenance are listed below:

1) Premature loss of paint striping to delineate pavement lane lines and center lines
2) Loss of pavement grooving, where provided for skid prevention
3) Loss of texturing on new rigid pavements
4) Reduction in driving visibility due to splash and spray from water accumulating in worn pavement wheel troughs
5) Hydroplaning from accumulated water in wheel troughs
6) Adverse vehicle handling behavior caused by wheel troughs during lane-changing or passing maneuvers
7) Increased noise produced both inside and outside the vehicle from tires riding on roughened pavement
8) Danger from loosened stones.

TABLE 1
COMPARISON OF 1969-1970 AND 1970-1971 SURVEYS

| County | Registered Vehicles | 1969-1970 Vehicles With Studded Tires | 1969-1970 Studded Tire Proportion | 1970-1971 Vehicles With Studded Tires | 1970-1971 Studded Tire Proportion |
|---|---|---|---|---|---|
| Alcona | 3886 | 427.46 | 0.11 | 1088.08 | 0.28 |
| Alger | 3270 | 981.00 | 0.30 | 863.28 | 0.26 |
| Allegan | 27901 | 4812.92 | 0.17 | 7533.27 | 0.27 |
| Alpena | 13432 | 1007.40 | 0.08 | 3223.68 | 0.24 |
| Antrim | 5168 | 1292.00 | 0.25 | 1653.76 | 0.32 |
| Arenac | 4467 | 625.38 | 0.14 | 1206.09 | 0.27 |
| Baraga | 3231 | 969.30 | 0.30 | 1001.61 | 0.31 |
| Barry | 14301 | 3289.23 | 0.23 | 5219.87 | 0.37 |
| Bay | 50619 | 4120.39 | 0.08 | 8250.90 | 0.16 |
| Benzie | 3830 | 880.90 | 0.23 | 1455.40 | 0.38 |
| Berrien | 78346 | 9793.25 | 0.13 | 16766.04 | 0.21 |
| Branch | 15912 | 1352.52 | 0.09 | 1909.44 | 0.12 |
| Calhoun | 65290 | 6692.23 | 0.10 | 7998.03 | 0.12 |
| Cass | 19065 | 2478.45 | 0.13 | 4575.60 | 0.24 |
| Charlevoix | 6974 | 1255.32 | 0.18 | 2161.94 | 0.31 |
| Cheboygan | 6931 | 1594.13 | 0.23 | 2495.16 | 0.36 |
| Chippewa | 11691 | 1870.56 | 0.16 | 3331.94 | 0.29 |
| Clare | 6722 | 1344.40 | 0.20 | 1411.62 | 0.21 |
| Clinton | 16667 | 1583.37 | 0.10 | 3666.74 | 0.22 |
| Crawford | 2911 | 727.75 | 0.25 | 1018.85 | 0.35 |
| Delta | 14653 | 3003.87 | 0.21 | 4688.96 | 0.32 |
| Dickinson | 10815 | 2595.60 | 0.24 | 5299.35 | 0.49 |
| Eaton | 27415 | 2193.20 | 0.08 | 2823.75 | 0.10 |
| Emmet | 8261 | 2726.13 | 0.33 | 3304.40 | 0.40 |
| Genesee | 195742 | 17244.87 | 0.09 | 33520.82 | 0.17 |
| Gladwin | 5249 | 577.39 | 0.11 | 1417.23 | 0.27 |
| Gogebic | 8575 | 1457.75 | 0.17 | 3001.25 | 0.35 |
| Grand Traverse | 19371 | 4261.62 | 0.22 | 6683.00 | 0.35 |
| Gratiot | 16784 | 2601.52 | 0.16 | 2517.60 | 0.15 |
| Hillsdale | 16209 | 1458.81 | 0.09 | 2755.53 | 0.17 |
| Houghton | 12659 | 5316.78 | 0.42 | 5759.85 | 0.46 |
| Huron | 15225 | 2816.63 | 0.19 | 4872.00 | 0.32 |
| Ingham | 115471 | 14780.29 | 0.13 | 15357.64 | 0.13 |
| Ionia | 18462 | 3323.16 | 0.18 | 3877.02 | 0.21 |
| Iosco | 9432 | 660.24 | 0.07 | 1792.08 | 0.19 |
| Iron | 6118 | 734.16 | 0.12 | 1957.76 | 0.32 |
| Isabella | 13974 | 2165.97 | 0.16 | 2375.58 | 0.17 |
| Jackson | 62310 | 4050.15 | 0.07 | 12337.38 | 0.20 |
| Kalamazoo | 86705 | 15684.93 | 0.18 | 12919.04 | 0.15 |
| Kalkaska | 2411 | 530.42 | 0.22 | 650.97 | 0.27 |
| Kent | 185857 | 33212.65 | 0.18 | 39215.83 | 0.21 |
| Keweenaw | 837 | 292.95 | 0.35 | 309.69 | 0.37 |
| Lake | 2254 | 225.40 | 0.10 | 450.80 | 0.20 |
| Lapeer | 19530 | 1269.45 | 0.07 | 2538.90 | 0.13 |
| Leelanau | 4460 | 758.20 | 0.17 | 1694.80 | 0.38 |

TABLE 1 (Cont.)
COMPARISON OF 1969-1970 AND 1970-1971 SURVEYS

| County | Registered Vehicles | 1969-1970 Vehicles With Studded Tires | 1969-1970 Studded Tire Proportion | 1970-1971 Vehicles With Studded Tires | 1970-1971 Studded Tire Proportion |
|---|---|---|---|---|---|
| Lenawee | 36526 | 1826.30 | 0.05 | 5186.69 | 0.14 |
| Livingston | 22829 | 3349.01 | 0.15 | 4725.60 | 0.21 |
| Luce | 2374 | 688.46 | 0.29 | 640.98 | 0.27 |
| Mackinac | 3525 | 634.50 | 0.18 | 951.75 | 0.27 |
| Macomb | 282989 | 25469.01 | 0.09 | 21790.15 | 0.08 |
| Manistee | 8950 | 2148.00 | 0.24 | 3132.50 | 0.35 |
| Marquette | 24144 | 9730.03 | 0.40 | 10060.08 | 0.42 |
| Mason | 9652 | 1833.88 | 0.19 | 3185.16 | 0.33 |
| Mecosta | 9995 | 1599.20 | 0.16 | 2498.75 | 0.25 |
| Menominee | 10607 | 954.63 | 0.09 | 4348.87 | 0.41 |
| Midland | 29150 | 4372.50 | 0.15 | 6340.13 | 0.22 |
| Missaukee | 2795 | 698.75 | 0.25 | 978.25 | 0.35 |
| Monroe | 50784 | 3133.37 | 0.06 | 7262.11 | 0.14 |
| Montcalm | 17672 | 2120.64 | 0.12 | 5566.68 | 0.32 |
| Montmorency | 2418 | 241.80 | 0.10 | 386.88 | 0.16 |
| Muskegon | 68258 | 12511.69 | 0.18 | 17337.53 | 0.25 |
| Newaygo | 12423 | 3167.87 | 0.26 | 3229.98 | 0.26 |
| Oakland | 432637 | 47979.44 | 0.11 | 52349.08 | 0.12 |
| Oceana | 6638 | 1659.50 | 0.25 | 2389.68 | 0.36 |
| Ogemaw | 5116 | 869.72 | 0.17 | 1227.84 | 0.24 |
| Ontonagon | 4174 | 500.88 | 0.12 | 1460.90 | 0.35 |
| Osceola | 6262 | 1252.40 | 0.20 | 1565.50 | 0.25 |
| Oscoda | 2030 | 263.90 | 0.13 | 507.50 | 0.25 |
| Otsego | 4562 | 821.16 | 0.18 | 2007.28 | 0.44 |
| Ottawa | 55505 | 10623.66 | 0.19 | 13654.23 | 0.25 |
| Presque Isle | 5149 | 463.41 | 0.09 | 1390.23 | 0.27 |
| Roscommon | 5298 | 1006.62 | 0.19 | 1112.58 | 0.21 |
| Saginaw | 92725 | 8039.26 | 0.09 | 13074.22 | 0.14 |
| Sanilac | 14304 | 2002.56 | 0.14 | 1573.44 | 0.11 |
| Schoolcraft | 3619 | 1085.70 | 0.30 | 940.94 | 0.26 |
| Shiawassee | 26421 | 3521.92 | 0.13 | 3778.20 | 0.14 |
| St. Clair | 50958 | 4076.64 | 0.08 | 5299.63 | 0.10 |
| St. Joseph | 22152 | 2215.20 | 0.10 | 3034.82 | 0.14 |
| Tuscola | 19292 | 4147.78 | 0.22 | 4340.70 | 0.23 |
| Van Buren | 24204 | 3872.64 | 0.16 | 5978.39 | 0.25 |
| Washtenaw | 97229 | 10131.26 | 0.10 | 11424.41 | 0.12 |
| Wayne | 1178938 | 114239.10 | 0.10 | 117893.80 | 0.10 |
| Wexford | 9101 | 2184.24 | 0.24 | 3094.34 | 0.34 |

Weighted 1969-70 Statewide Tire Stud Proportion = 0.1195849
Weighted 1970-71 Statewide Tire Stud Proportion = 0.1524489

Increase in percent of cars having studded tires since 1969-70 = 3.2864 %.

TABLE 2

MEASUREMENT OF STUD WEAR ON MICHIGAN PAVEMENTS

SPRING 1971

| Map Reference No. | Location | Surface Type | Depth of Wear |
|---|---|---|---|
| 1 | US 131 S of Big Rapids | Bit. over Conc. | 3/16 - 1/4 |
| 2 | US 131 S of Cedar Spring | Bit. over Conc. | 3/8 |
| 3 | Old US 131 at Rockford | Bit. over Conc. | 1/8 |
| 4 | US 31 at Muskegon | Concrete | 0 |
| 5 | US 10 & US 31 W of Scottville | Bit. over Conc. | 1/4 |
| 6 | US 31 S of Manistee | Concrete | 1/16 - 3/32 |
| 7 | US 31 N of Manistee | Bit. over Conc. | 1/8 |
| 8 | M 37 & US 31 S of Traverse City | Concrete | 1/32 |
| 9 | US 31 & M 72 in Traverse City | Concrete | 1/16 |
| 10 | I 96 E of Portland | Concrete | 1/8 |
| 11 | I 96 W of Portland | Concrete | 1/16 |
| 12 | I 94 S of Bridgeman | Bituminous | 1/16 |
| 13 | I 94 at St. Joseph | Concrete | 1/32 |
| 14 | I 94 at Kalamazoo | Concrete | 3/32 |
| 15 | US 27 S of St. Johns | Concrete | 3/32 |
| 16 | US 27 N of St. Johns | Concrete | 1/16 |
| 17 | US 27 at Ithaca | Concrete | 1/16 |
| 18 | US 27 at Mt. Pleasant | Concrete | 1/16 |
| 19 | US 27 at Alma | Concrete | 1/16 |
| 20 | I 75 N of Flint | Concrete | 1/8 |
| 21 | I 75 at Holly | Concrete | 1/16 |
| 22 | I 296 & US 131 in Grand Rapids | Concrete | 3/32 - 1/4 |
| 23 | US 10 at Wyoming | Concrete | 7/32 |
| 23 | US 10 at Schaefer | Concrete | 7/32 |
| 24 | US 10 at 8 Mile Rd | Concrete | 1/8 |
| 25 | M 39 at Ford Rd | Concrete | 3/16 |
| 26 | M 39 at Schoolcraft | Concrete | 5/32 |
| 27 | I 94 W of US 23 | Concrete | 1/16 |
| 28 | US 23 N of Ann Arbor | Concrete | 1/8 |
| 29 | US 27 N of Grayling | Bituminous | 1/8 - 1/4 |
| 30 | US 27 N of Vanderbilt | Bituminous | 1/8 - 3/16 |
| 31 | US 2 W of St. Ignace | Bit. over Conc. | 1/8 - 3/16 |
| 32 | US 2 at Manistique | Bit. over Conc. | 1/8 |
| 33 | US 2 at Escanaba | Concrete | 1/8 |
| 34 | US 2 E of Iron Mountain | Bit. over Conc. | 1/8 |
| 35 | US 2 at Iron River | Concrete | 1/16 |
| 36 | US 2 at Bessemer | Concrete | 1/16 |
| 37 | M 26 at Hubble | Bit. over Conc. | 3/16 |
| 38 | US 41 & M 26 at Mohawk | Bit. over Conc. | 3/8 - 1/2 |
| 39 | US 41 at Chassel | Bit. over Conc. | 1/4 |
| 40 | US 41 S of L'Anse | Concrete | 1/16 |
| 41 | US 41 at Negaunee | Concrete | 1/8 |
| 42 | M 28 E of Munising | Bituminous | 1/8 |
| 43 | M 123 S of Newberry | Bituminous | 1/4 |
| 44 | US 31 N of Petoskey | Bit. over Conc. | 1/8 |
| 45 | I 75 S of Vanderbilt | Bituminous | 3/16 |

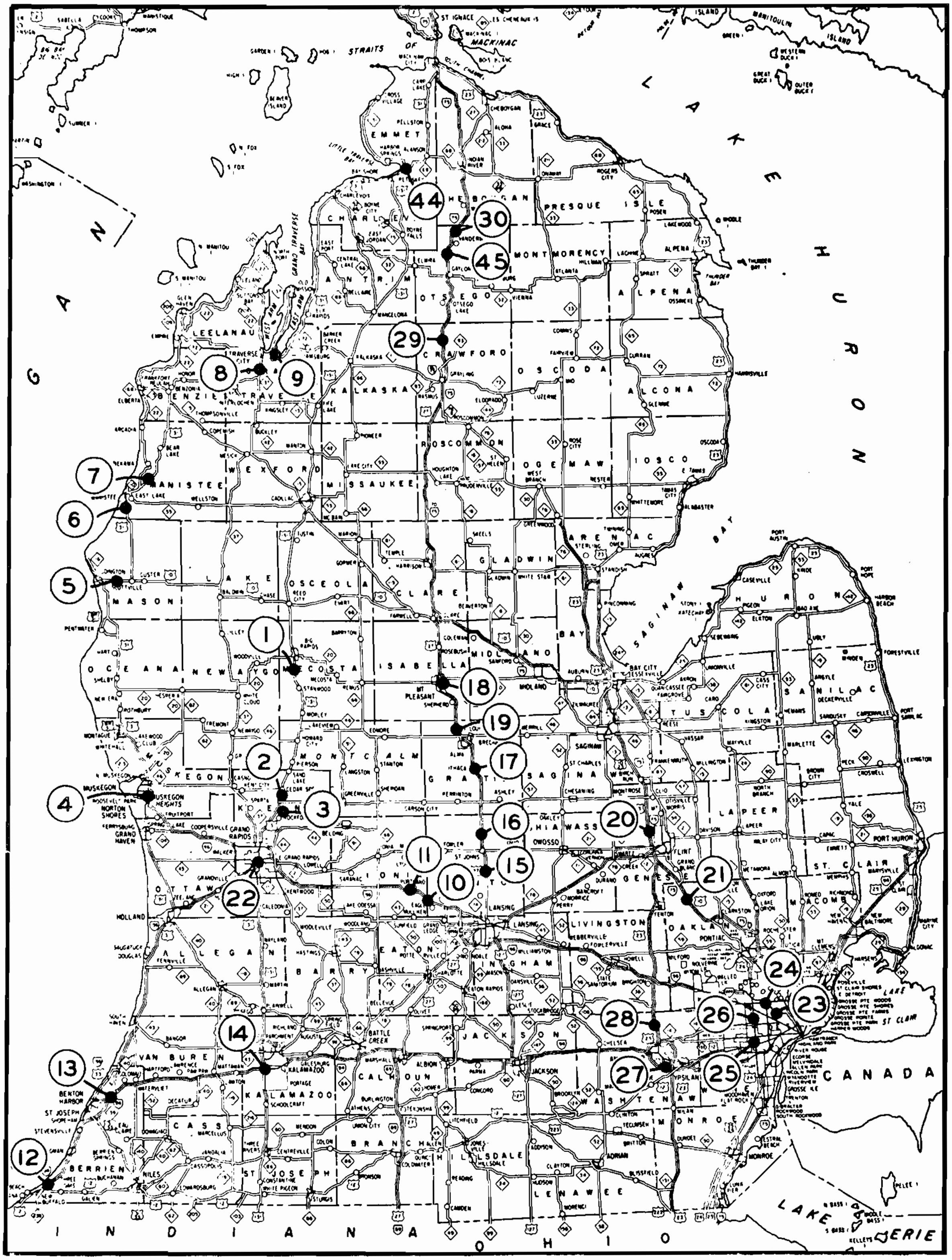


Figure 2. Location of measurements of tire stud wear on Michigan pavements - Spring 1971.

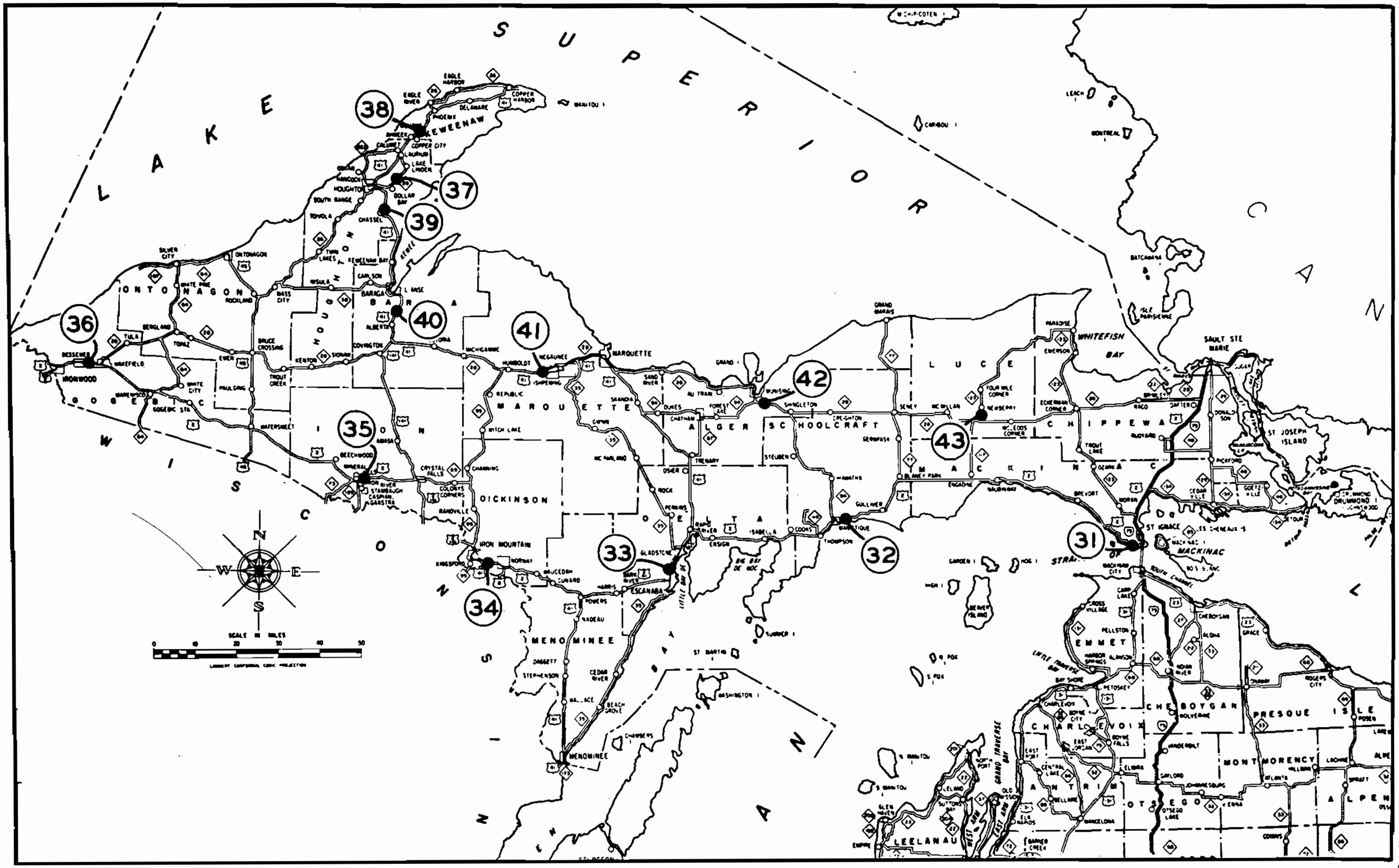



Figure 2 (Cont.). Location of measurements of tire stud wear on Michigan pavements - Spring 1971.

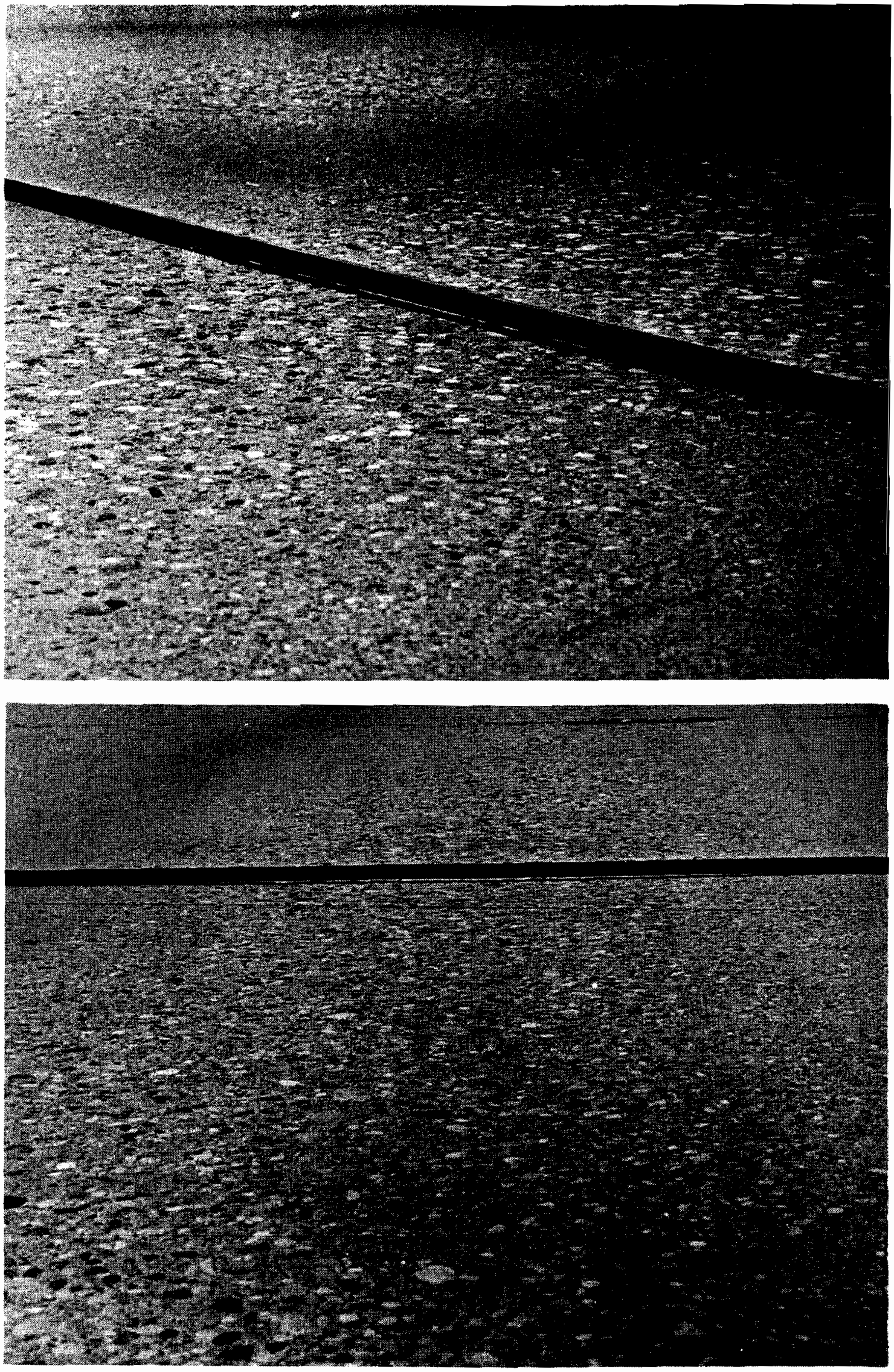


Figure 3. M 39 S of Ford Rd, spring 1971.

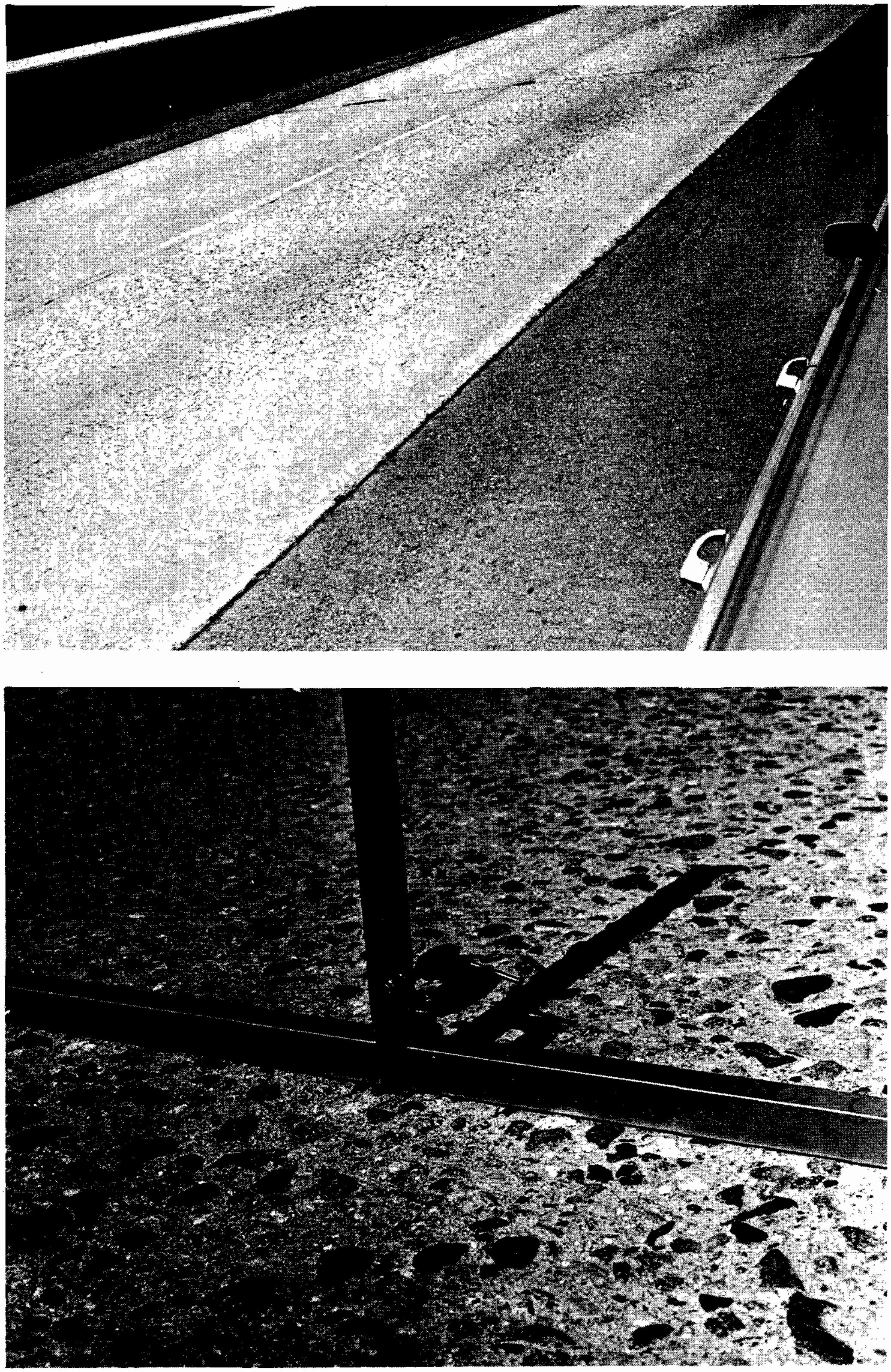


Figure 4. WB I 96 at Portland, spring 1971.

In spring of 1971, an estimate was made of additional maintenance costs that will be required for Michigan trunklines if studded tires continue in use. It was decided that pavements must be resurfaced when troughs 1/2 in. deep are worn in the wheeltracks. Should water 1/2 in. deep or more be impounded in the troughs, dynamic hydroplaning would occur at less than 50 mph even for vehicles with new tires. Dynamic hydroplaning, that is when a moving vehicle's tires ride up on a wedge of water, results in complete loss of driver control and conditions causing this phenomenon cannot be tolerated.

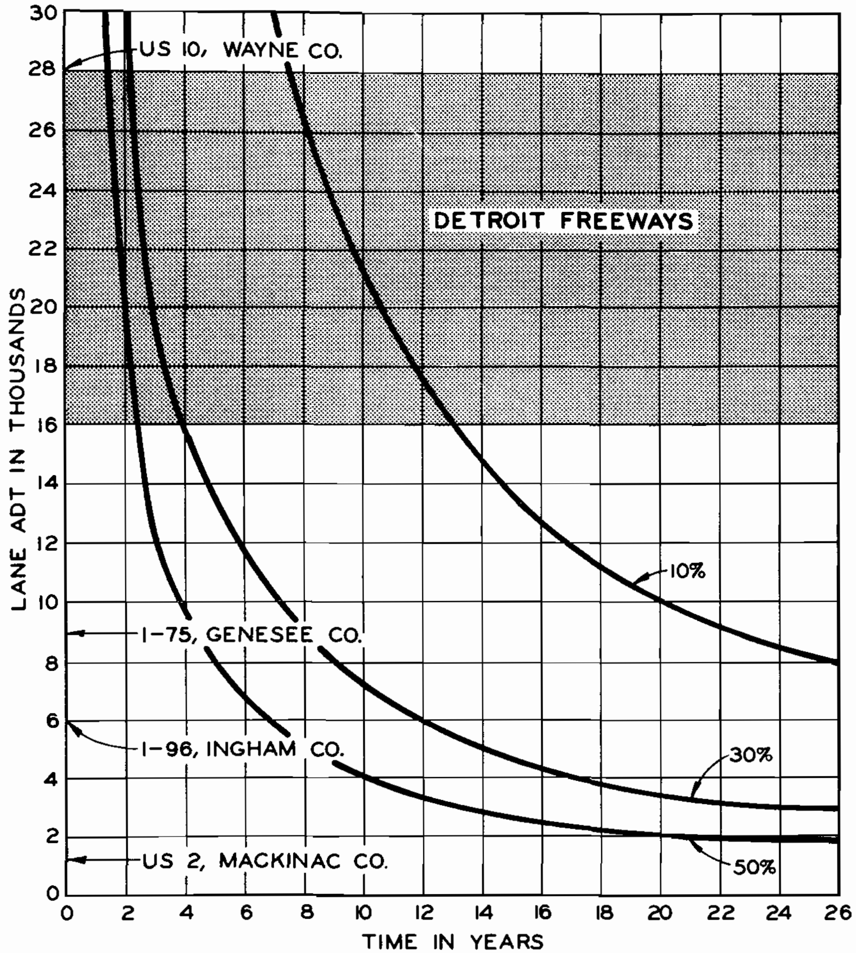
Wear rate was estimated using laboratory data from the Minnesota study (1). However, repeated wear traffic at the Minnesota test was rectangularly distributed over a width of 7.7 in. Michigan field measurements have shown traffic to be distributed over a tire track width of about 36 in. Other studies (4) and theoretical considerations agree that traffic should exhibit a Gaussian (bell shaped) distribution transversely across a wheelpath. Therefore, about one-third of all wheel applications would be in the center 7.7 in. width of a wheeltrack. Thus, for equivalent wear, about three times as much traffic would be required in the field as was observed in the laboratory.

One criticism of the Minnesota study is that studded tires traveled around a circular track only 14 ft in diameter. Thus, there was a large slip angle causing accelerated wear. However, the studded tires in the Minnesota Study were being freely rolled around the track at a constant speed of 35 mph. In Michigan, almost all vehicles using them, have studded tires on their traction wheels. This causes more slip than if the wheels were rolling freely. Slippage also results from traffic accelerating and decelerating from speeds much greater than the 35 mph speed used in the laboratory.

The preceding factors illustrate how the Minnesota test track had conditions which would cause faster wear and others that would cause slower wear than would be observed in the field. Therefore, it was believed that these factors would tend to balance each other to some degree, and the Minnesota laboratory results were corrected only for lateral distribution and then used to estimate actual pavement wear.

Maintenance costs were computed using wear rates shown in Figures 5 and 6 and with the following considerations:

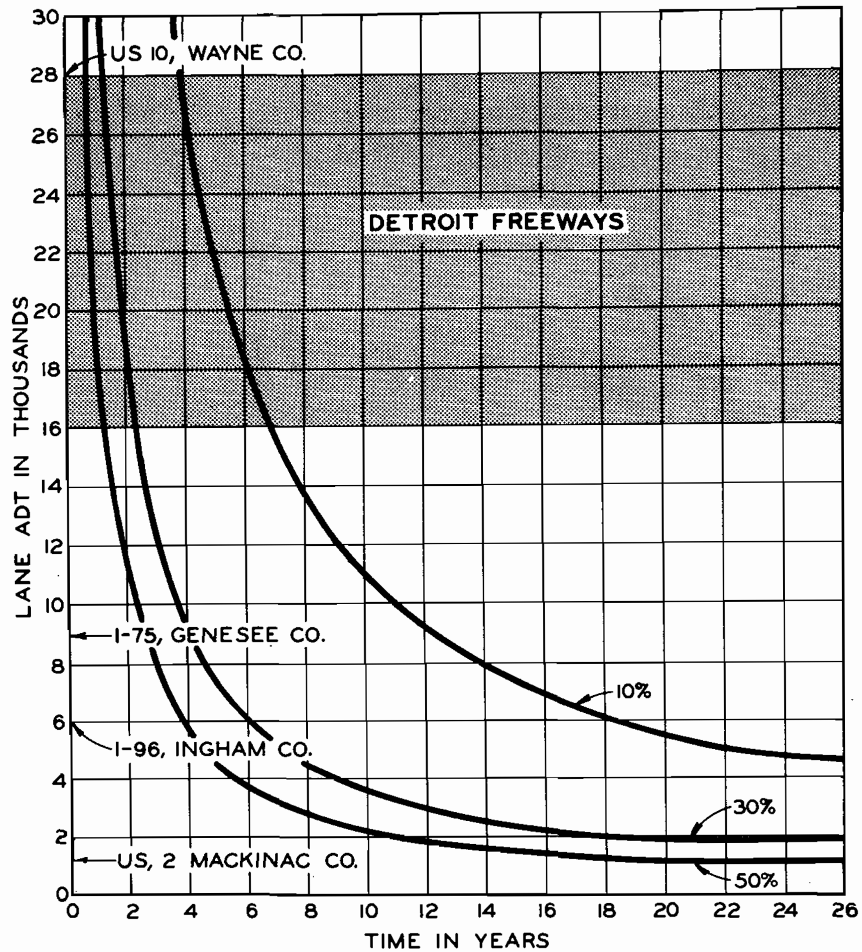
1. Only the lower 36 counties had traffic intensities high enough to warrant inclusion in the preliminary cost estimate. No pavements with




NOTE:

Each curve represents wear estimated for a traffic stream with the indicated percentage of vehicles with studded tires.

Figure 5. Time for tire studs to wear 1/2-in. trough in concrete pavement.




NOTE:

Each curve represents wear estimated for a traffic stream with the indicated percentage of vehicles with studded tires.

Figure 6. Time for tire studs to wear 1/2-in. trough in bituminous pavement.

less than 2,000 ADT were considered. Total mileage of surface types in those 36 counties are:

| Surface Type | Urban | Rural | Totals |
|---|---|---|---|
| Concrete | 390 | 1,640 | 2,080 |
| Bituminous | 549 | 2,343 | 2,892 |
| | | TOTAL | 4,922 miles |

2. A nine-year time horizon was considered, beginning in 1971. Past wear has been neglected.

3. Because vehicle hydroplaning can occur, even with new tires, in less than 1/2 in. of water, pavements are considered to require resurfacing after ruts 1/2 in. deep have been worn. When one lane requires it, the entire width of a roadway will be resurfaced.

4. The proportion of vehicles in the traffic stream will approach, but not exceed, the number of vehicles now using snow tires. Statewide, this upper limit is about 45 percent. If the trend toward increased tire stud use is not interrupted, the upper limit of tire stud use will be closely approached during winter 1974-75.

5. A winter 1970-71 survey shows over 15 percent of Michigan's automobiles, pickup trucks, and panel trucks now use studded tires.

6. The survey showed only a fraction of 1 percent of all vehicles to have studded tires on more than one axle.

7. Annual traffic volume increase will average 5 percent.

8. Cost for resurfacing a two-lane pavement with hot mix bituminous at the rate of about 150 lb per sq yd will average $16,000 per mile. Current average cost per two-lane-mile for the Department is about $25,000 to $27,000, but since this figure includes costs for patching the old pavement, it has been reduced for our estimate.

9. Average daily lane traffic was estimated by dividing average daily traffic for the roadway (1969 traffic volumes) by the number of lanes. The most heavily traveled lane was then considered to have about one-third more traffic than if all lanes were uniform.

10. Bridge decks will be resurfaced with S. M. 100 mortar at a total cost of $30 per sq yd.

Working with the preceding hypotheses, a total cost over the nine-year horizon is estimated to be $248,000,000. Although this value can be said to average about $28,000,000 per year during the nine-year period, actual costs will be small during the first few years but will begin to mushroom during the later years of the period.

A breakdown of average annual costs for the nine-year time horizon is as follows:

| | |
|---|---|
| Paint Marking | 750,000 per year |
| Bridge Resurfacing (excluding Rouge River Bridge) | 6,000,000 per year |
| Rouge River Bridge | 850,000 |
| Pavement Resurfacing | 20,000,000 per year |
| TOTAL | $27,600,000 per year |

The preceding estimated costs are believed to be low for the following reasons:

1. None of the upper part of the State was considered even though some areas already show measurable wear.

2. Wear data are based on Minnesota laboratory tests which were conducted at a constant 35 mph speed. In areas of accelerating or decelerating traffic, wear would be more severe.

3. Average estimated cost of resurfacing is believed low and inflation was not considered.

4. Past wear was neglected, even though measurements made recently show significant pavement wear.

5. No costs for localized patching of intersections and other high wear areas were included.

## Influence on Safety

A major argument by the proponents of tire studs is that studded tires improve vehicular safety. However, police accident data do not show any decrease in accidents, fatal accidents, or injury accidents attributable to tire studs.

For example, Figure 7 shows how the deaths per 100,000,000 miles of vehicle travel in Michigan have been decreasing quite steadily since the early 1930's. Some have pointed to the reduction in accident rate since 1967, when studded tires were introduced in Michigan, as proof of the improved safety of studded tires. However, it is not enough to simply show that vehicle accidental death rate has decreased during the winter months since tire studs became popular, because the rate has been going down for over 30 years, due in large measure to improved highways and better vehicles.

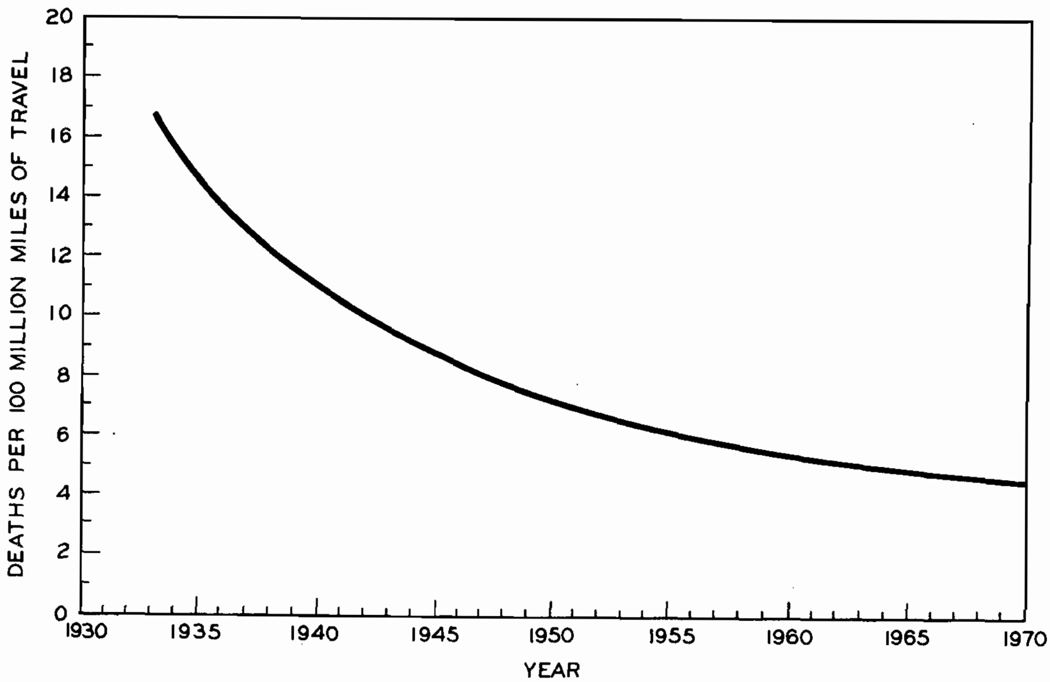



Figure 7. Annual accidental deaths for Michigan motor vehicles.

One way to show the effect of studded tires on accident rates is to look at the total number of accidents that occur during a year and to consider whether that proportion which occurs on snowy or icy roads has decreased. The lower graph on Figure 8 shows how the proportion of cars with studded tires has increased in Michigan. If studded tires were a significant factor in reducing accidents, the proportion of all accidents which occur on snowy or icy pavements would decrease as the proportion of studded tires increases. As shown on the upper portion of Figure 8, neither total accidents, injury accidents, or fatal accidents has shown a proportional reduction on snowy or icy roads.

Another way to examine the problem is to compare accident rates in counties where there is high tire stud use with counties of low stud use.

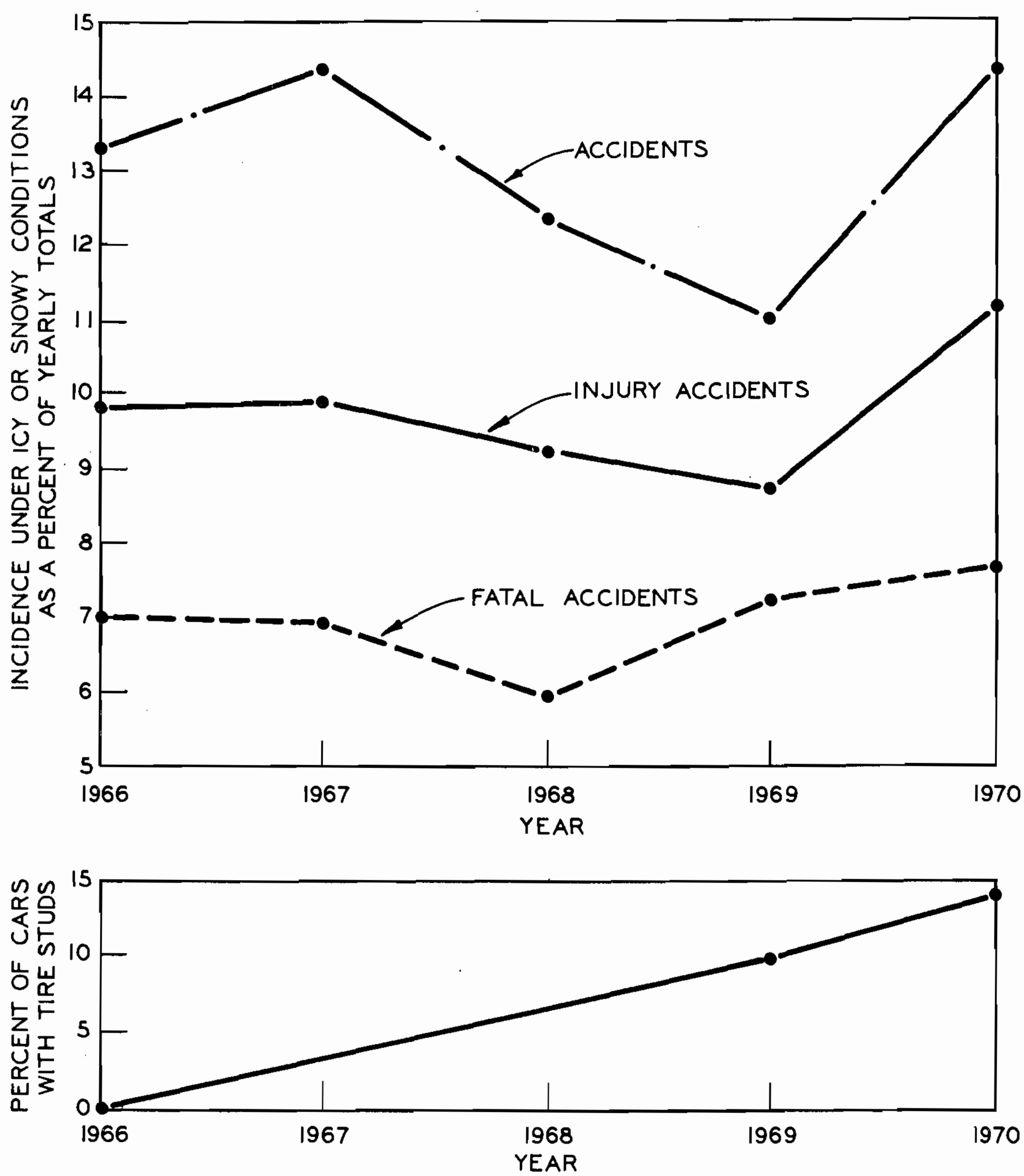



Figure 8. Michigan State Police accident data and proportion of cars with studded tires.

For this study, counties having more than 25 percent of cars with studs were considered high-stud use, those with lower than 25 percent were low-stud use. Figure 9 is a State map showing how counties were classified.

The bottom graph on Figure 10 shows the trends of average stud use in both high and low use counties. The upper three graphs show the ratio of the accident rate in high-stud counties to the accident rate in low-stud use counties. If studs reduced accidents, the rate of accidents in high-stud use counties would decrease faster than low-stud use counties. Thus, the curves would decrease from left to right as tire stud use increased. Obviously, this doesn't happen, thus, the data show no improvements in safe driving attributable to studded tires.

Tests (5, 6) have shown that studded tires are definitely effective in stopping or starting on glare ice. However, even with studs on all wheels it still takes about 350 ft to stop from 35 mph on glare ice as compared to only about 60 ft on dry pavement, so good pavement maintenance is still most important in winter driving safety. The effectiveness of studs are a function of a number of factors including ice temperature, vehicle speed, and whether two or four tires are studded. It is interesting to note that by reducing speed on glare ice by only about 3 mph, the stopping distance for a vehicle without studded tires will be no more than one with studs on the rear wheels only (6). It has also been shown (6) that the stopping distance on a wet concrete pavement of a vehicle with studded tires is greater than for one without studs. Even on dry concrete pavements, vehicles with studded tires take a measurably longer stopping distance than those without studs. A logical question, then, is; how frequently do Michigan driver's travel on glare ice? To provide an answer to that question, U. S. Weather Bureau reports spanning five years, 1966 to 1970, were analyzed. Data from six weather stations located in various parts of the State and reporting weather conditions each 3-hr period of each day were used.

One category of weather which is listed is called "glaze." This category includes periods of freezing rain, sleet, and other conditions causing glaze or icy conditions. From those data, the proportion of 3-hr periods of glaze compared to all annual 3-hr periods was computed. It was assumed that glaze reported during any period existed during the entire three hours.

Next, each county was assigned to a weather station, based upon geographical location and annual snowfall. All vehicles in a county were assumed to travel under conditions described for its respective weather station. Vehicle mileage was assumed proportional to vehicle volume and was assumed equal for all 3-hr periods.

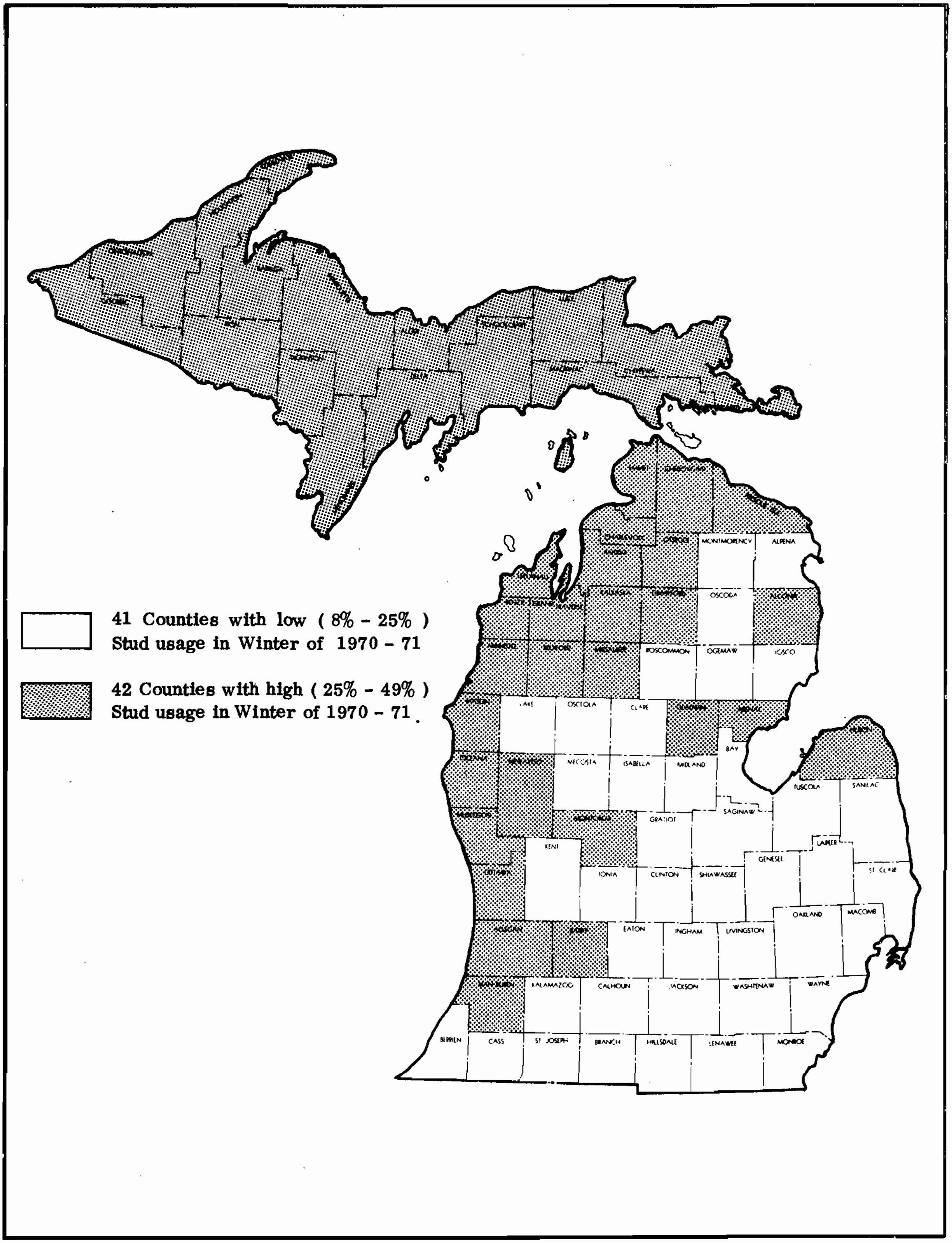



Figure 9. Classification of Counties for high - low stud use.

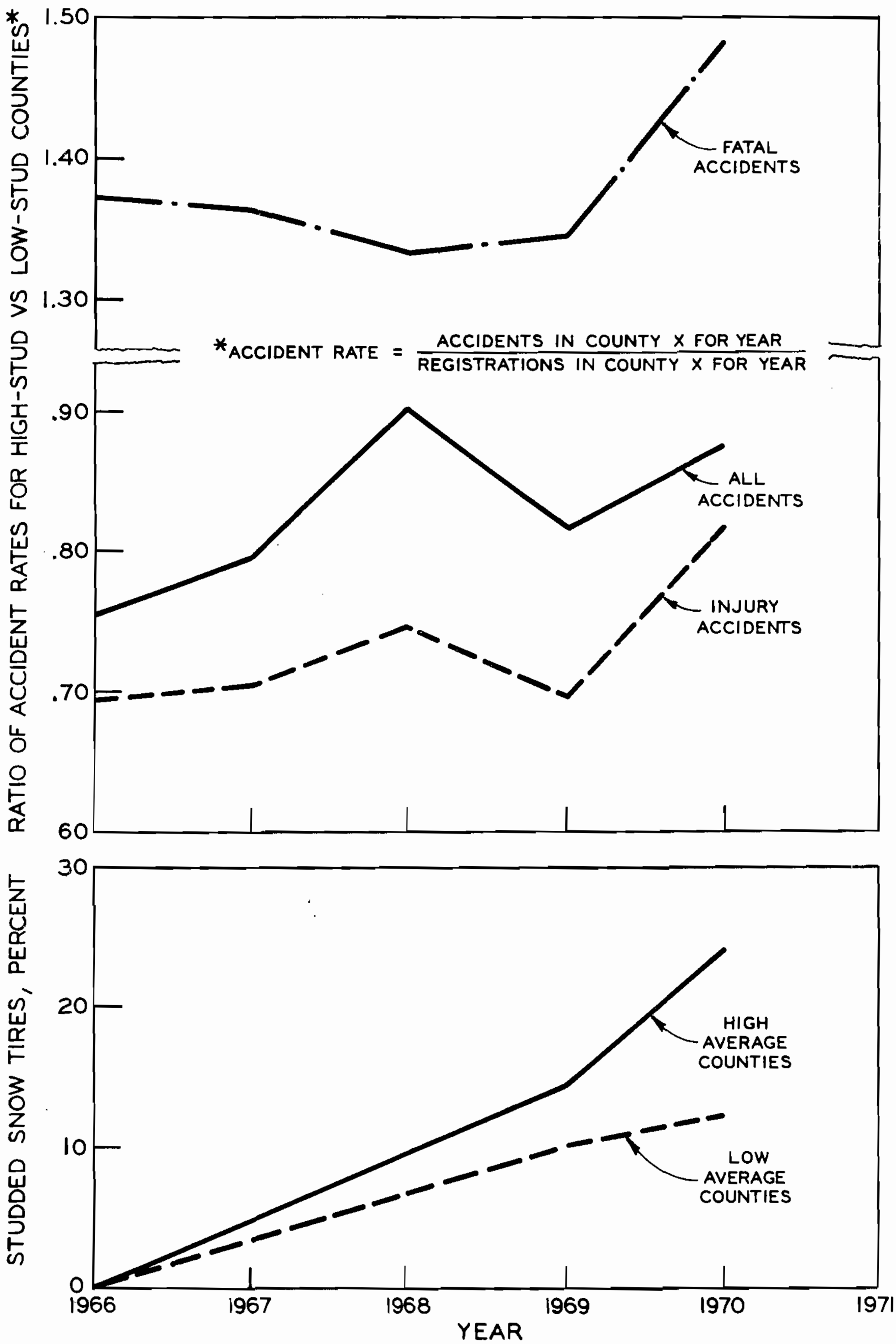



Figure 10. Accident rates for counties with high proportion of studded tire vehicles vs. counties with low proportion of studded tire vehicles.

Proportion of driving mileage on icy pavements was computed by: Multiplying the percent of time when icy conditions exist at a given weather station by the proportion of all state vehicles assigned to that station. Each product was an estimate of the percent of state mileage driven under icy conditions. The products were summed to give the total state mileage driven under icy conditions, which is about one percent. Table 3 summarizes the computations for each weather station.

TABLE 3
COMPUTATION OF PERCENT OF STATE VEHICLE MILEAGE
DRIVEN ON ICY (OR GLAZED) PAVEMENTS

| Location of Weather Station | Percent of Time With Glaze | Vehicles Covered by Station, Percent | Total Mileage Driven on Glaze, Percent |
|---|---|---|---|
| Sault Ste. Marie | 1.71 | 3 | .05 |
| Alpena | 0.86 | 10 | .09 |
| Muskegon | 1.88 | 4 | .08 |
| Grand Rapids | 1.49 | 5 | .07 |
| Flint | 0.91 | 18 | .16 |
| Detroit & Lansing | 1.17 | 60 | .70 |
| | | TOTAL | 1.15 |

The computed percent of vehicle miles driven on icy Michigan highways is believed high for the following reasons.

a) State trunklines are not normally permitted to remain icy for three hours.

b) People often refrain from driving under icy conditions. Thus, although driving mileage was assumed uniform over all 3-hr periods, it would probably be lower during icy weather.

## Conclusions

1) If tire studs continue to be used in Michigan, maintenance costs during the next nine years will be increased by a total of about 248 million dollars.

2) About 1 percent of vehicle mileage on Michigan trunklines is traveled under icy conditions. Therefore, tire studs might be of some benefit for about 1 percent of the vehicle mileage driven.

3) Michigan drivers using studded tires almost all use them only on the drive wheels of vehicles for improved traction rather than on the front or all four wheels for improved stopping on ice. Therefore, it appears that safety is a secondary motive to traction for tire stud users.

4) There is no evidence indicating that studded tires have reduced accidents in number or severity in Michigan.

5) Although studded tires do provide greater traction and stopping ability on ice, the safety hazards which they create, through damage to pavements, appears to outweight their benefits.

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