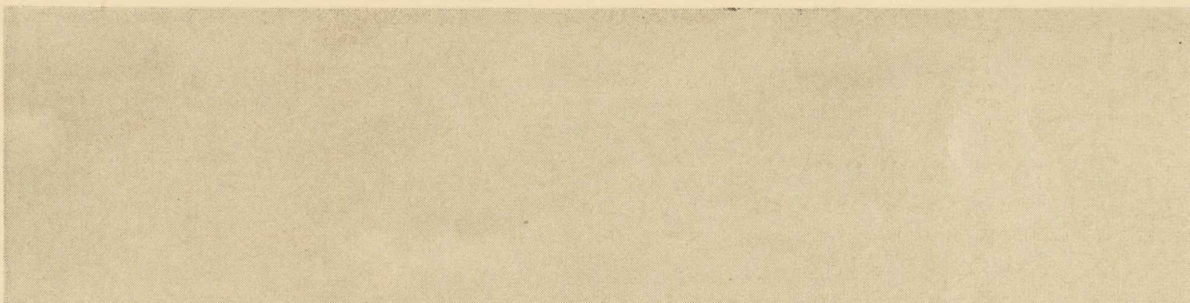
VOL. 27, NO. 11 DECEMBER 1953

Public Roads

A JOURNAL OF HIGHWAY RESEARCH

PUBLISHED BY
THE BUREAU OF
PUBLIC ROADS,
U. S. DEPARTMENT
OF COMMERCE,
WASHINGTON



Intersection of U. S. 40 and U. S. 29 near Ellicott City, Md.

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Vol. 27, No. 11 *December 1953*

Published Bimonthly

Edgar A. Stromberg, *Editor*

IN THIS ISSUE

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The printing of this publication has been approved by the Director of the Bureau of the Budget, January 5, 1952.

Trends in Traffic Volumes, Vehicle Types, and Weights

BY THE HIGHWAY TRANSPORT RESEARCH BRANCH
BUREAU OF PUBLIC ROADS

Reported by
THOMAS B. DIMMICK,
Head, Current Data Analysis Unit

Total travel on all rural roads in 1952 broke all records, exceeding the 1951 previous high by more than 6 percent. On the 361,000 miles of main rural roads in the United States, travel in 1952 was a little more than 203 billion vehicle-miles, of which 77 percent was by passenger cars, 1 percent by buses, and 22 percent by freight-carrying vehicles.

Trucks and combinations hauled 3 percent more ton-mileage of freight on main rural roads in 1952 than in 1951. Single-unit truck travel was 11 percent higher than in 1951 while that of combinations increased only 2 percent. The average carried load for all trucks and combinations in 1952 decreased slightly.

In 1952 over 5 percent of all trucks and combinations exceeded a State legal weight limit, and more than 15 percent of the combinations were illegally overloaded in some particular. In comparison with 1951 the percentage of overweight vehicles for 1952 remained the same in the West South Central States, and increased in all other regions except Middle Atlantic, East North Central, and West North Central States.

RURAL MOTOR VEHICLE TRAVEL broke all previous records in 1952 for the seventh consecutive year. The estimated 1952 traffic on all rural roads was about 6 percent above the 1951 total, 18 percent above 1950, 28 percent above 1949, 40 percent above 1948, 49 percent above 1947, and 63 percent above 1946. Data collected from January through August in 1953 indicate that travel on all rural roads in 1953 will continue the same general trend and will be almost 5 percent higher than in 1952.

The variation in average daily travel on rural roads by months in the three main geographic divisions [1] and in the United States as a whole is illustrated in figure 1 for the years 1951, 1952, and the first 8 months of 1953. Travel in each month of these years in the Central region and in the United States as a whole was well above that of the corresponding month of the earlier year. The Eastern regions showed only a slight gain in September 1952 compared to 1951, but a fairly steady gain in all other months. The Western regions showed only slight gains in travel in January, February, March, October, and November of 1952 compared to that in the same months of the previous year and fairly steady gains in all other months.

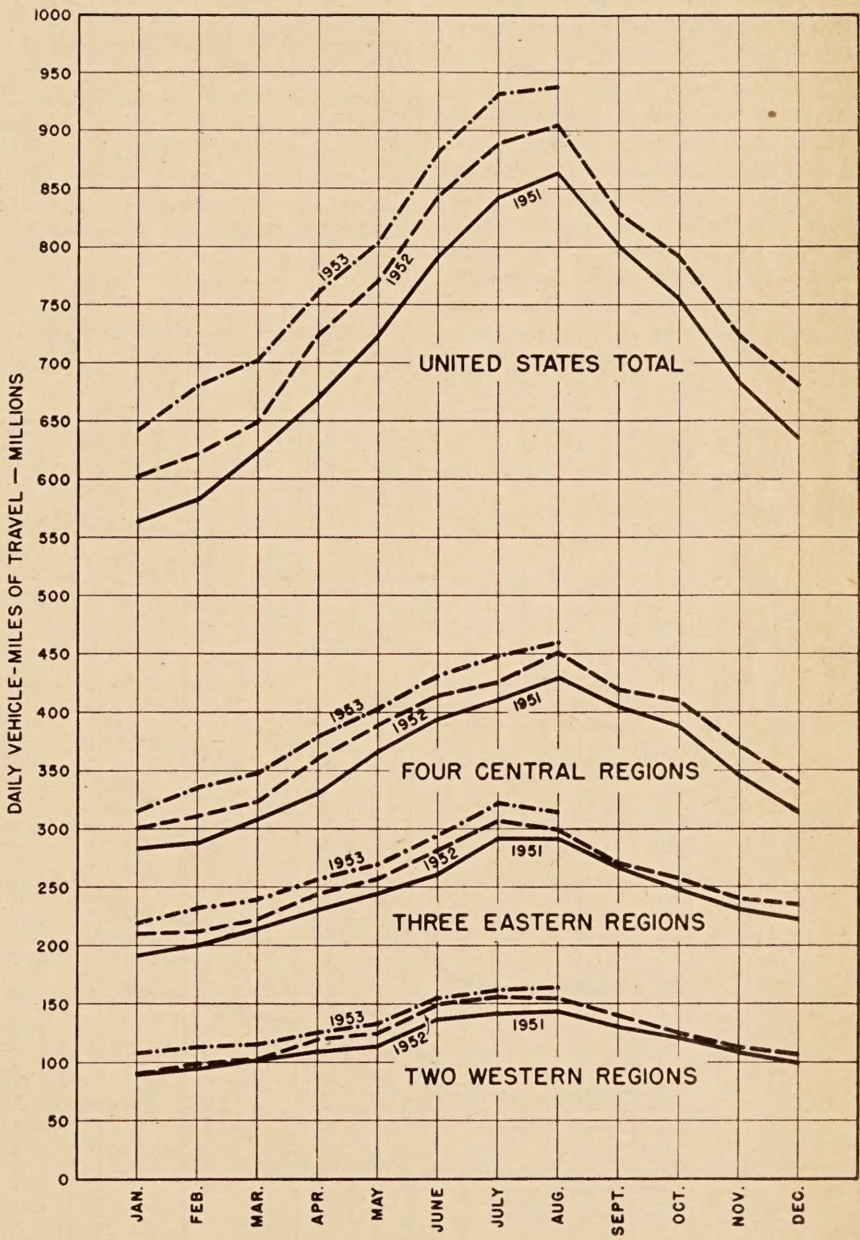


Figure 1.—Travel on all rural roads in 1951, 1952, and in the first 8 months of 1953.

[1] The States comprising each census region and the regions comprising each geographic division are indicated in table 1.

Approximately the same rate of increase in 1953 over 1952 is indicated by data collected in the first portion of the current year. The partial 1953 information indicated an increase of over 5 percent in the Eastern region and slightly less than 5 percent in the Central and Western States. The largest indicated increase over 1952 in any census region was 10 percent in New England and the smallest was 2 percent in the West South Central region.

Summer travel constituted a smaller portion of the annual travel in 1952 than in any recent year. In the last two prewar years (1940 and 1941), the average daily traffic in July and August was 23 percent above the average traffic of the year. Not until 1949 did the summer travel reach the prewar ratio. In 1950 the average daily summer travel was over 24 percent above the annual average daily amount, but this figure slumped to 22 percent in the 1951 summer season and to 21 percent in 1952.

Figure 2, showing travel on all rural roads by 12-month periods ending each month (moving average) and as a percentage of that in the calendar year 1941, gives an accurate picture of the effect of wartime restrictions and the steady traffic growth that has occurred since the end of hostilities in the summer of 1945. The increase in traffic from the end of 1946 to the present has averaged slightly more than 8 percent compounded annually. From these data it is apparent that the general pattern of traffic growth is being maintained but with some slackening in the rate beginning in 1952.

The lower portion of figure 2, showing the relation of travel by 12-month periods in each of the main geographical regions of the United States to that in the calendar year 1941, shows clearly how much travel was shifted westward during the war period, 1942 to 1946. The spread between the curves for the three regions remained fairly constant during 1947 and 1948, was reduced slightly during 1949 and 1950, and was sharply reduced in the first three months of 1952. In the latter portion of 1952, and the portion of 1953 shown, travel in the Western States seems to be resuming its position in relation to that in the Central and Eastern States.

1952 Summer Loadometer Survey

The check survey in the summer of 1952 was conducted in all respects like those of 1942 to 1951, inclusive. The manner of collecting and analyzing the data in conjunction with that obtained in previous years has been completely described previously.[2] The 1952 survey period, number of stations operated, number of vehicles counted, and the number of trucks and truck combinations weighed are shown for each State in table 1.

[2] See previous annual articles on traffic in PUBLIC ROADS: vol. 27, No. 6; vol. 26, Nos. 5 and 11; vol. 25, Nos. 3, 7, and 12; vol. 24, No. 10; and vol. 23, No. 9.

Traffic Continues to Increase

Figure 3 shows in chart form the vehicle-mileage of travel on all rural roads, by vehicle types, for each year from 1936 to 1952 inclusive. It is apparent that the drastic restrictions on travel during the war period, 1942–45, caused but a temporary dip in traffic growth and that the 1952 vehicle-mileage was higher than would have been estimated by any rational projection of the prewar trend. A straight line from the top of the bar for 1936 to the top of the bar for 1952 passes through the top of the bar for 1937 and for 1941, but lies above the tops of the bars for all other years. This line indicates an average (simple) annual increase during the 16 years of more than 7.8 percent of the 1936 traffic. During the period 1946 to 1952, inclusive, the average rate of increase was higher than in the earlier period 1936 to 1941. From 1946 to 1952 total travel increased an average amount of more than 10.4 percent of the 1946 figure. The increase in 1952 over 1951 was below the average for the period, but it is probably too early to speculate whether this smaller rate of increase indicates a leveling-off in the trend.

Travel by trucks and truck combinations and by truck combinations alone increased in a manner very similar to that observed for all vehicles. In both cases the straight line, representing the average rate of increase from 1936 to 1952, generally lies above the tops of the bars

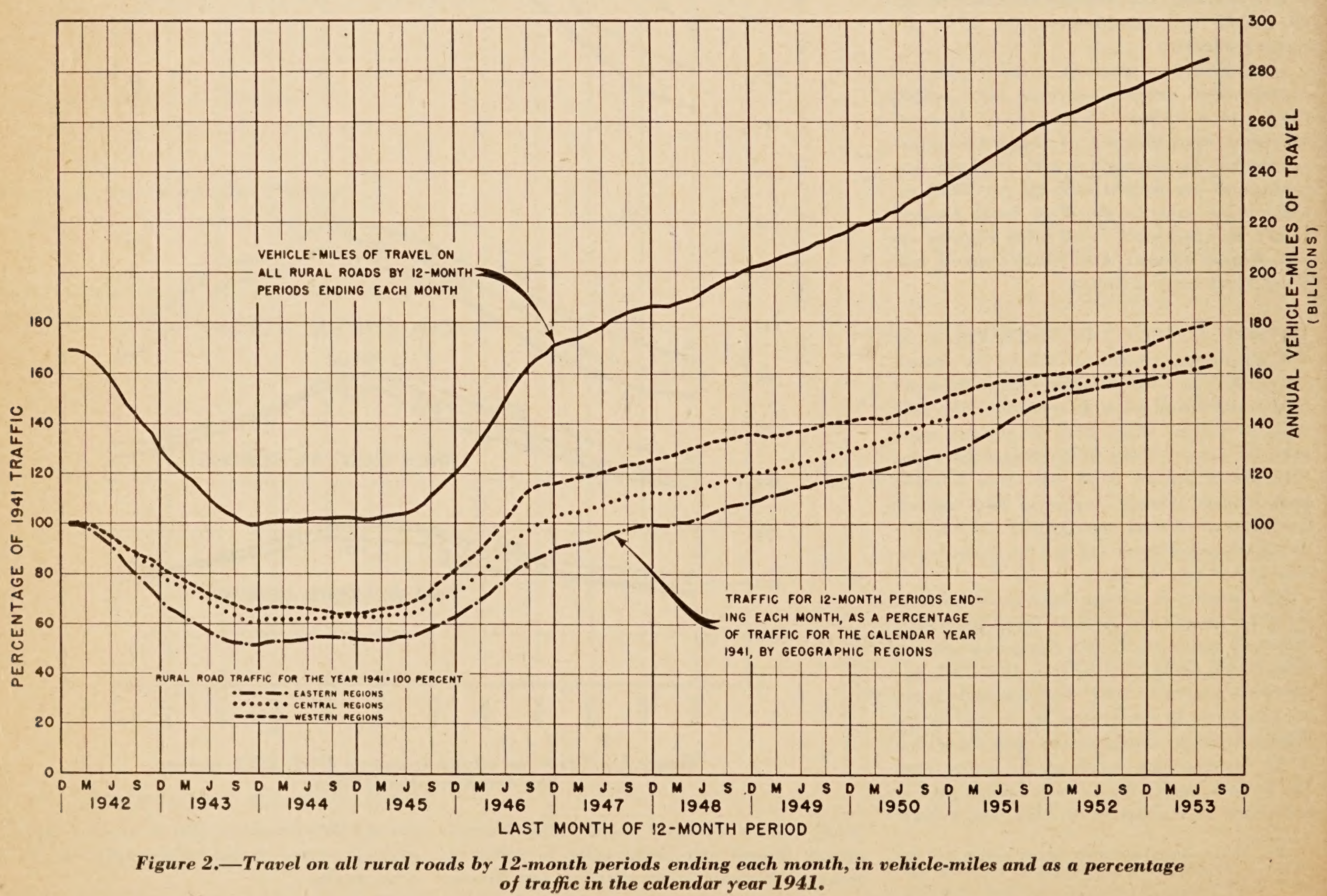


Figure 2.—Travel on all rural roads by 12-month periods ending each month, in vehicle-miles and as a percentage of traffic in the calendar year 1941.

for intervening years, thus showing the accelerated upward trend in travel by these heavier vehicles. This trend is emphasized by data given in other portions of this report.

Travel Increases

The State system of highways in most States is composed of the main rural roads, or those on a connected system carrying the heaviest traffic. In such States as North Carolina, Pennsylvania, and Virginia, where all or a large part of the rural mileage is under State control, only the primary roads are included in this report as a part of the "main" system of highways of the country. These main roads, comprising nearly 361,000 miles, include 12 percent of the total rural mileage but carry 73 percent of the total rural traffic. Because of the greater importance of these highways, from a traffic standpoint, most of the current traffic data were collected at points on them, and the remainder of this report will be concerned only with information concerning this portion of the road mileage.

The data summarized for 1951 and 1952 in this report include, for the first time, the amount of travel on the toll roads of the country. Although the total vehicle-miles of travel on the five major toll roads in these 2 years amounted to less than 1 percent of the total on all main roads, the mileage of toll roads is increasing at such a rate that the omission of their traffic would soon result in an incomplete picture of total traffic.

Although traffic on all rural roads increased over 6 percent, as mentioned before, travel on the main roads alone increased at a slightly higher rate or almost 7 percent. The ratio of traffic volumes on main rural roads in 1952 to corresponding volumes in the previous year is shown in table 2. This table indicates that travel in 1952 on the main highways was higher in every region than in 1951. However, comparison with a similar table comparing 1951 with 1950 shows that the rate of increase for the United States as a whole and for all areas except the Middle Atlantic and the Mountain regions was less than in the previous year. The rate of increase in travel of local passenger cars was considerably less than in 1951, and the rate of foreign (out-of-State) passenger cars and of truck combinations was only slightly higher. Travel by buses on main rural roads was less in 1952 than in the previous year. The rate of increase of all passenger car travel in 1952 was greater than the 1951 rate in the Middle Atlantic and Mountain regions, remained the same in the East North Central and Pacific regions, and was less in all other regions. The rate of increase of all types of truck combinations was less in the Middle Atlantic, the East North Central, the East South Central, the West South Central, and Pacific regions. Foreign travel decreased in volume from 1951 to 1952 in New England, Middle Atlantic, and West South Central and bus travel decreased in New England, Middle Atlantic, East South Central, West North Central, and Mountain regions.

The increase in travel by passenger cars amounted to 6 percent compared to 8 percent for freight-carrying vehicles, and the increase in travel by single-unit trucks in 1952 was 11 percent while that by truck combinations was 2 percent.

The percentage of travel by vehicle types on main rural roads in 1952 is given in table 3. In this table all single-unit trucks are divided into classification types based on the axle and tire arrangements, while the truck combinations are classified according to the total number of axles of the combination. The classification of vehicles into these types has been used in the last 6 annual surveys and has been found to have numerous advantages over the original "light, medium, and

Table 1.—Survey period, number of stations operated, number of vehicles counted, and number weighed in each State in the special weight surveys, summer of 1952

Region and State	Survey period	Number of stations	Total vehicles counted	Trucks and truck combinations	
				Counted	Weighed
New England:					
Connecticut	July 30–Aug. 18	10	36,121	6,455	1,766
Maine	Summer	9	42,428	7,571	3,401
Massachusetts	July 14–Aug. 13	10	111,089	14,085	4,514
New Hampshire	No survey				
Rhode Island	July 16–Aug. 9	4	10,173	2,160	863
Vermont	July 21–July 30	5	8,739	756	756
Subtotal		38	208,550	31,027	11,300
Middle Atlantic:					
New Jersey	July 14–July 29	10	85,783	13,524	1,676
New York	No survey				
Pennsylvania	July 14–Sept. 3	13	82,012	15,923	2,235
Subtotal		23	167,795	29,447	3,911
South Atlantic:					
Delaware	Aug. 7–Aug. 21	8	27,165	5,499	852
Florida	No survey				
Georgia	Aug. 18–Sept. 30	15	37,816	10,077	4,856
Maryland	June 16–July 18	10	118,818	24,361	4,175
North Carolina	Aug. 8–Dec. 8	9	21,059	3,939	3,100
South Carolina	Sept. 8–Sept. 19	10	20,822	5,255	2,088
Virginia	Aug. 5–Aug. 22	5	14,224	3,873	2,383
West Virginia	Aug. 12–Sept. 3	9	14,841	3,479	1,418
Subtotal		66	254,745	56,483	18,872
Eastern regions, subtotal		127	631,090	116,957	34,083
East North Central:					
Illinois	No survey				
Indiana	Aug. 4–Sept. 6	20	56,330	13,204	5,200
Michigan	June 3–July 9	9	31,113	6,529	2,082
Ohio	July 15–July 31	10	29,791	5,166	1,272
Wisconsin	July 1–Sept. 30	20	117,882	18,150	4,132
Subtotal		59	235,116	43,049	12,686
East South Central:					
Alabama	July 15–Aug. 19	10	30,716	6,709	5,965
Kentucky	July 9–Aug. 13	10	36,307	8,746	4,039
Mississippi	June 3–July 18	15	58,430	15,903	7,070
Tennessee	Sept. 3–Sept. 18	8	10,433	3,229	1,740
Subtotal		43	135,886	34,587	18,814
West North Central:					
Iowa	July 21–Aug. 13	10	29,657	5,836	5,789
Kansas	June 6–July 25	10	12,685	2,893	450
Minnesota	June 16–July 3	14	20,787	3,484	1,121
Missouri	July 28–Aug. 27	22	201,680	38,959	13,031
Nebraska	July 17–Aug. 22	20	27,303	5,441	5,365
North Dakota	July 7–Aug. 29	19	36,072	7,407	2,804
South Dakota	June 1–Aug. 31	18	29,263	4,977	4,112
Subtotal		113	357,447	68,997	32,672
West South Central:					
Arkansas	Aug. 1–Aug. 19	10	20,263	6,311	1,450
Louisiana	Aug. 4–Aug. 15	10	13,290	3,922	1,398
Oklahoma	July 9–Aug. 8	10	35,633	7,231	6,008
Texas	June 1–Aug. 31	20	114,525	23,940	6,284
Subtotal		50	183,711	41,404	15,140
Central regions, subtotal		265	912,160	188,037	79,312
Mountain:					
Arizona	July 14–July 25	10	11,775	2,554	1,165
Colorado	July 7–Aug. 29	13	24,813	3,766	805
Idaho	Sept. 8–Oct. 7	13	21,465	4,703	2,249
Montana	July 30–Aug. 31	11	30,003	5,356	2,932
Nevada	Aug. 5–Aug. 28	10	8,470	1,245	986
New Mexico	Aug. 4–Aug. 18	10	16,170	3,625	1,508
Utah	July 21–Aug. 8	10	21,596	3,827	1,165
Wyoming	Aug. 8–Aug. 29	10	14,634	2,812	670
Subtotal		87	148,926	27,888	11,480
Pacific:					
California	June 4–Aug. 13	10	[1] 24,441	4,485	1,959
Oregon	Aug. 6–Aug. 21	7	19,816	4,177	1,468
Washington	June 9–Oct. 6	10	67,270	11,168	6,262
Subtotal		27	111,527	19,830	9,689
Western regions, subtotal		114	260,453	47,718	21,169
United States total		506	1,803,703	352,712	134,564

1 Passenger cars not counted; figure given is an estimate based on data from other reports.

heavy" grouping, particularly in that it provides more homogeneous groupings and more positive identification of the types.

The data in table 3 indicate that truck and truck combination travel in 1952 was more than 20 percent of the total travel in all but the New England, Middle Atlantic, and Pacific regions. It was between 20 and 25 percent in all remaining regions except the East South Central and West South Central regions where it was over 25 percent.

A comparison with the same table in the 1951 report shows that the proportion of trucks was higher in 1952 than in 1951 in the New England, South Atlantic, West South Central, Mountain, and Pacific regions and lower in the other regions, although slightly higher in the United States as a whole.

Table 3 indicates also that the usage of certain types of freight-carrying vehicles varies in different sections. For instance, the truck-tractor and semitrailer with five or more axles and the truck and trailer with six or more axles are used far more frequently in the Pacific region than in any other area. Truck and trailer combinations are used much less in the East South Central region and in the three eastern regions than in other sections. The percentage of combination-type vehicles, nation-wide, was 6.49 percent, a slight decrease from the 1951 figure of 6.71 percent. Similar percentage figures in recent years were 7.21 percent in 1950, 5.95 in 1949, and 5.84 in 1948.

The average weights of loaded and empty trucks and truck combinations are shown in figure 4 for each year from 1942 to 1952, inclusive, and for a prewar year, generally 1936 or 1937. The weights of single-unit trucks, both loaded and empty, increased each year from the 1936–37 period through 1945, then leveled off around 11,000 pounds for loaded vehicles and slightly less than 6,000 pounds for empty vehicles. At the same time weights of truck combinations, both loaded and empty, have increased each year during the period shown. The increase in average weight of loaded combinations from the 1936–37 period to 1952 was over 63 percent compared to only about 14 percent for single-unit trucks.

Table 4 gives the average weight of loaded and of empty trucks and truck combinations separately by types in each region and in the United States as a whole. This table brings out clearly the important differences that exist in the weight characteristics of the vehicles in different groups. It will be noted, for example, that for the United States as a whole, the loaded three-axle, single-unit trucks weighed a little more than twice as much as the two-axle, six-tire trucks. The latter, in turn, weighed a little more than twice as much as the two-axle, four-tire trucks. Similar differences existed throughout the various classifications. On the other hand, the regional differences in average weight for each of the vehicle types that are common throughout the country are surprisingly small. The rather low weights of truck

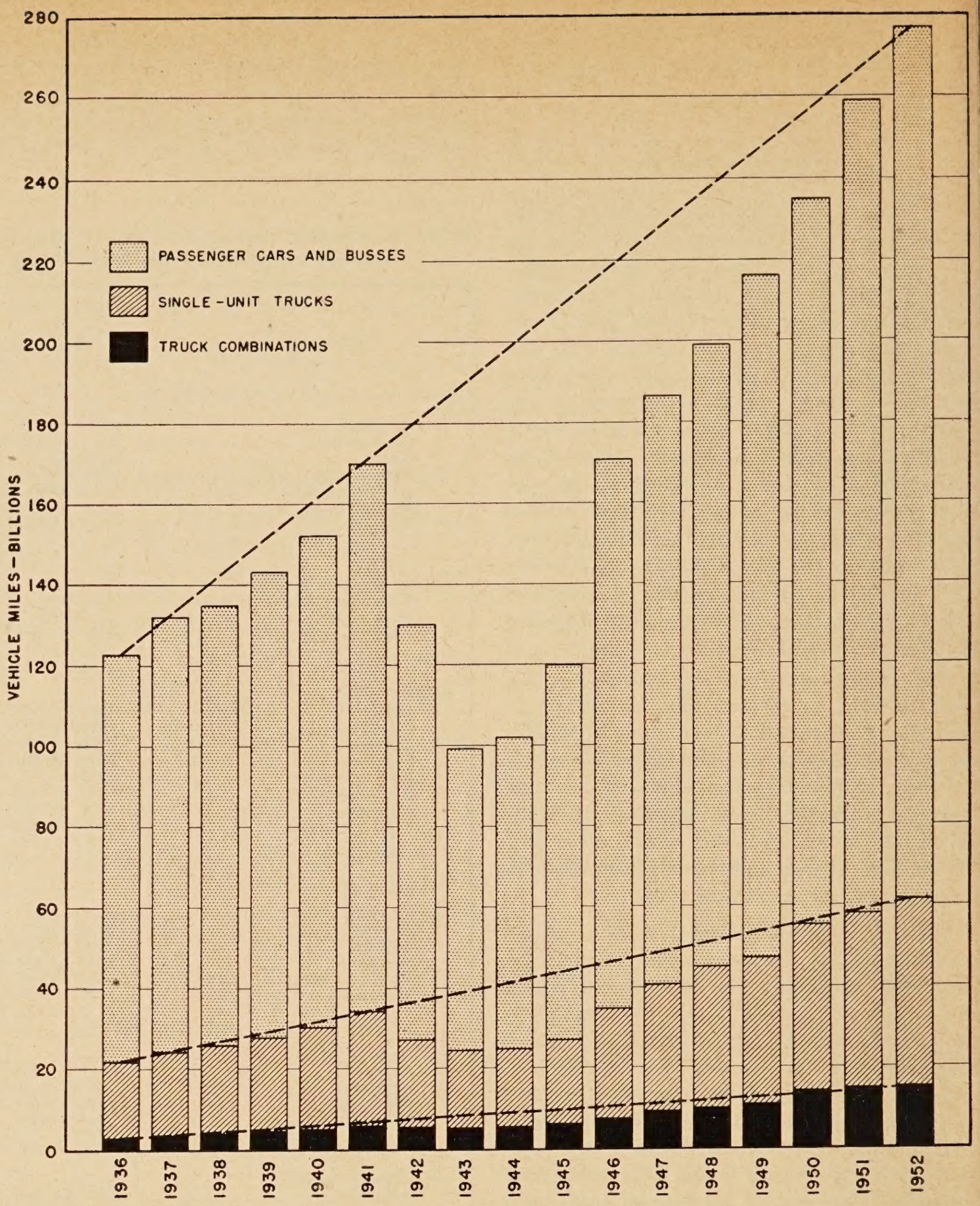


Figure 3.—Travel on all rural roads, 1936–52, by classes of vehicles.

Table 2.—Ratio of 1952 traffic on main rural roads to corresponding traffic in 1951

Vehicle type	Eastern regions [1]				Central regions					Western regions [2]			United States average [1]
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
Passenger cars:													
Local	1.08	1.10	1.01	1.06	1.07	1.18	1.04	1.04	1.07	.98	1.08	1.05	1.06
Foreign	.98	.99	1.14	1.07	1.03	1.01	1.15	.98	1.04	1.27	1.01	1.17	1.07
All passenger cars	1.05	1.08	1.04	1.06	1.06	1.12	1.06	1.03	1.06	1.09	1.07	1.08	1.06
Trucks and truck combinations:													
Single-unit trucks	1.12	1.03	1.20	1.12	1.12	1.02	.95	1.11	1.06	1.33	1.17	1.24	1.11
Truck combinations	1.13	.96	1.12	1.05	.91	1.01	1.19	1.05	1.01	1.28	.94	1.04	1.02
All trucks and combinations	1.12	1.00	1.17	1.10	1.03	1.01	1.01	1.09	1.04	1.32	1.09	1.18	1.08
Buses	.97	.90	1.04	.98	1.00	.95	.95	1.13	1.01	.84	1.01	.95	.99
All Vehicles	1.06	1.06	1.07	1.07	1.05	1.09	1.05	1.04	1.06	1.14	1.07	1.09	1.07

[1] Includes toll road vehicle-mileage for Maine, New Hampshire, New Jersey, and Pennsylvania.
[2] Includes vehicle-mileage for 1952 on the Denver-Boulder toll road, opened Jan. 1952.

Table 3.—Percentage distribution of travel, by vehicle type, on main rural roads in the summer of 1952

Vehicle type	Eastern regions: New England	Eastern regions: Middle Atlantic	Eastern regions: South Atlantic	Eastern regions: Average	Central regions: East North Central	Central regions: East South Central	Central regions: West North Central	Central regions: West South Central	Central regions: Average	Western regions: Mountain	Western regions: Pacific	Western regions: Average	United States average
Passenger cars:													
Local	62.67	66.36	56.38	61.15	56.68	50.06	61.62	60.01	57.67	41.40	69.19	58.64	59.00
Foreign	20.49	13.49	20.47	17.73	22.29	22.21	16.55	13.38	18.72	33.35	10.68	19.29	18.49
All passenger cars	83.16	79.85	76.85	78.88	78.97	72.27	78.17	73.39	76.39	74.75	79.87	77.93	77.49
Single-unit trucks:													
Panel and pickup	4.49	3.74	8.21	5.95	5.73	10.17	6.45	11.09	7.89	10.85	6.12	7.92	7.25
Other 2-axle, 4-tire	.80	1.32	.57	.90	.32	.39	.53	.39	.40	.84	1.25	1.09	.68
Other 2-axle, 6-tire	5.92	7.26	6.31	6.63	6.28	9.62	7.45	7.08	7.25	6.65	4.55	5.35	6.72
3-axle	.36	.47	.76	.59	.42	.48	.24	.15	.32	.73	1.01	.90	.51
All single-unit trucks	11.57	12.79	15.85	14.07	12.75	20.66	14.67	18.71	15.86	19.07	12.93	15.26	15.16
Truck-tractor and semitrailer combinations:													
3-axle	3.63	4.96	3.27	3.99	3.36	4.31	2.71	3.80	3.46	1.34	.78	.99	3.21
4-axle	.49	1.58	2.92	2.07	3.42	1.47	3.12	2.73	2.89	1.12	.88	.97	2.29
5-axle or more	(1)	.02	.03	.02	.21	.03	.50	.09	.22	1.79	2.90	2.48	.54
All truck-tractor and semitrailer combinations	4.12	6.56	6.22	6.08	6.99	5.81	6.33	6.62	6.57	4.25	4.56	4.44	6.04
Truck and trailer combinations:													
4-axle or less	.02	.01	.04	.02	.19	(1)	.18	.33	.19	.31	.27	.29	.15
5-axle	—	.02	—	.01	.34	—	.01	.01	.13	.68	.69	.68	.18
6-axle or more	—	—	—	—	.07	—	—	—	.03	.24	.82	.60	.12
All truck and trailer combinations	.02	.03	.04	.03	.60	(1)	.19	.34	.35	1.23	1.78	1.57	.45
All combinations	4.14	6.59	6.26	6.11	7.59	5.81	6.52	6.96	6.92	5.48	6.34	6.01	6.49
All trucks and truck combinations	15.71	19.38	22.11	20.18	20.34	26.47	21.19	25.67	22.78	24.55	19.27	21.27	21.65
Buses	1.13	.77	1.04	.94	.69	1.26	.64	.94	.83	.70	.86	.80	.86
All Vehicles	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1.00.00	100.00	100.00	100.00

[1] Less than 0.005 percent.

and trailer combinations in the West North Central region indicate a predominance of small home-made trailers of low capacity.

Truck Travel Increases

Figure 5 shows the estimated vehicle-mileage of travel by loaded and empty single-unit trucks and truck combinations on main rural roads for each year, 1936 to 1952, inclusive. This chart demonstrates graphically the steady growth of truck traffic during the prewar years 1936–41, the temporary effect of wartime restrictions in the period 1942–45, and the remarkable increases in truck transportation that have occurred since the end of hostilities in 1945.

Table 5 gives comparisons of the estimated vehicle-mileage of travel by vehicles of different types on all main rural roads in 1936, the earliest year for which comprehensive travel and weight data are available; in 1941, the peak prewar year, 5 years after the beginning of the surveys; in 1946, 10 years after the beginning of the surveys; in 1951, 15 years after the beginning of the sur-

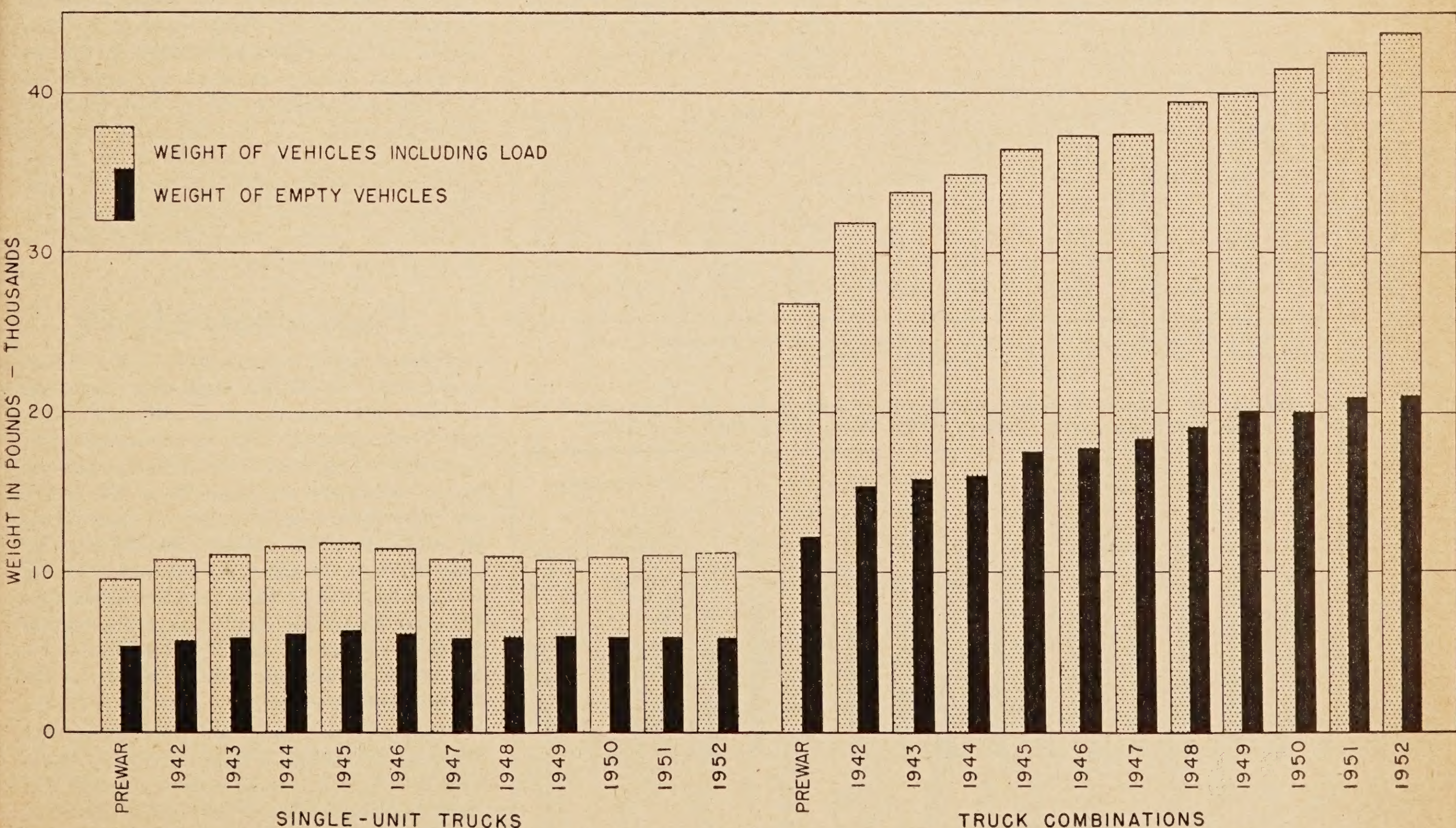


Figure 4.—Average weights of loaded and empty trucks and truck combinations in the summers of 1942–52 and a prewar year.

Table 4.—Average weight (in pounds) of loaded and empty trucks and truck combinations, by vehicle types, in the summer of 1952

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
Average Weights of Loaded Vehicles													
Single-unit trucks:													
Panel and pickup	5,198	5,284	5,270	5,263	5,151	5,292	5,271	6,470	5,615	5,160	4,797	4,979	5,397
Other 2-axle, 4-tire	6,856	6,205	7,154	6,727	6,460	6,755	7,513	7,295	7,006	7,087	6,357	6,560	6,757
Other 2-axle, 6-tire	14,554	16,212	13,911	14,940	13,135	14,947	14,195	13,852	13,864	14,655	13,295	13,868	14,204
3-axle	30,492	38,562	30,188	32,604	28,013	28,303	27,575	31,756	28,493	31,294	29,500	29,916	30,378
Average	11,726	14,064	11,646	12,540	10,316	11,990	10,856	10,129	10,643	10,261	11,083	10,730	11,189
Truck combinations:													
Truck-tractor and semitrailer	40,180	41,425	40,315	40,753	40,412	37,613	41,407	41,129	40,489	47,516	57,269	54,025	42,699
Truck and trailer	(1)	(1)	--------	(1)	62,804	(1)	28,785	32,265	51,017	66,767	63,441	64,223	59,647
Average	40,100	41,475	40,315	40,766	41,851	37,614	41,110	40,727	40,949	50,846	58,824	56,342	43,816
Average, all trucks and combinations	20,583	25,487	22,841	23,583	23,376	19,931	21,212	21,265	21,883	21,982	30,401	27,143	23,409
Average Weights of Empty Vehicles													
Single-unit trucks:													
Panel and pickup	4,309	4,271	3,965	4,066	4,122	3,973	4,213	4,639	4,294	4,015	3,963	3,990	4,172
Other 2-axle, 4-tire	5,280	4,555	5,388	4,793	4,786	4,865	5,358	5,412	5,155	5,182	4,984	5,046	4,941
Other 2-axle, 6-tire	8,813	8,741	7,788	8,335	8,090	7,651	8,225	8,281	8,068	8,065	8,032	8,051	8,160
3-axle	15,307	16,170	13,024	14,194	13,144	11,322	14,477	12,362	12,796	16,541	15,953	16,239	14,189
Average	6,590	6,857	5,473	6,063	6,094	5,522	6,103	5,887	5,889	5,644	5,514	5,582	5,903
Truck combinations:													
Truck-tractor and semitrailer	21,987	20,976	20,228	20,724	20,960	16,123	21,277	20,642	20,162	24,598	24,898	24,741	20,660
Truck and trailer	(1)	(1)	(1)	(1)	26,230	(1)	16,948	16,212	19,742	29,941	29,602	29,752	24,682
Average	21,940	21,001	20,196	20,713	21,551	16,125	21,103	20,399	20,135	26,511	26,948	26,733	20,976
Average, all trucks and combinations	9,693	10,574	8,187	9,217	10,829	7,182	9,946	8,607	9,111	8,587	8,981	8,773	9,101

1 Data omitted because of insufficient sample.

Table 5.—Comparison of estimated vehicle-miles of travel on main rural roads in 1936, 1941, 1946, 1951, and 1952

Year	All vehicles, vehicle-miles	Passenger cars and buses [1]		All trucks and truck combinations		Single-unit trucks		Truck combinations	
		Percentage of all vehicles	Vehicle-miles	Percentage of all vehicles	Vehicle-miles	Percentage of all trucks and truck combinations	Vehicle-miles	Percentage of all trucks and truck combinations	Vehicle-miles
	Millions		*Millions*		*Millions*		*Millions*		*Millions*
1936	88,412	82.6	73,005	17.4	15,407	82.1	12,650	17.9	2,757
1941	122,505	80.3	98,320	19.7	24,185	78.8	19,057	21.2	5,128
1941: 1936 ratio	*1.39*	*.97*	*1.35*	*1.13*	*1.57*	*.96*	*1.51*	*1.18*	*1.86*
1946	124,149	80.4	99,803	19.6	24,346	73.3	17,838	26.7	6,508
1946: 1941 ratio	*1.01*	*1.00*	*1.02*	*.99*	*1.01*	*.93*	*.94*	*1.26*	*1.27*
1946: 1936 ratio	*1.40*	*.97*	*1.37*	*1.13*	*1.58*	*.89*	*1.41*	*1.49*	*2.36*
1951 [2]	190,549	78.6	149,811	21.4	40,738	68.4	27,851	31.6	12,887
1952	203,101	78.4	159,132	21.6	43,969	70.0	30,782	30.0	13,187
1952: 1951 ratio	*1.07*	*1.00*	*1.06*	*1.01*	*1.08*	*1.02*	*1.11*	*.95*	*1.02*
1952: 1941 ratio	*1.66*	*.98*	*1.62*	*1.10*	*1.82*	*.89*	*1.62*	*1.42*	*2.57*
1952: 1936 ratio	*2.30*	*.95*	*2.18*	*1.24*	*2.85*	*.85*	*2.43*	*1.68*	*4.78*

1 Percentages of total 1952 travel by passenger cars and by buses are reported separately in table 3.
2 Includes vehicle-miles of travel on toll roads not previously reported.

Table 6.—Comparison of estimated percentage of trucks loaded, average carried load, and ton-miles carried on main rural roads in 1936, 1941, 1946, 1951, and 1952

Year	All truck and truck combinations			Single-unit trucks			Truck combinations		
	Percentage loaded	Average weight of carried load	Ton-miles carried	Percentage loaded	Average weight of carried load	Ton-miles carried	Percentage loaded	Average weight of carried load	Ton-miles carried
		Tons	*Millions*		*Tons*	*Millions*		*Tons*	*Millions*
1936	62.8	2.90	28,005	60.7	1.86	14,258	72.2	6.90	13,747
1941	66.7	3.64	58,737	65.4	2.29	28,487	71.6	8.23	30,250
1941: 1936 ratio	*1.06*	*1.26*	*2.10*	*1.08*	*1.23*	*2.00*	*.99*	*1.19*	*2.20*
1946	51.7	4.84	60,892	46.4	2.31	19,101	66.2	9.70	41,791
1946: 1941 ratio	*.78*	*1.33*	*1.04*	*.71*	*1.01*	*.67*	*.92*	*1.18*	*1.38*
1946: 1936 ratio	*.82*	*1.67*	*2.17*	*.76*	*1.24*	*1.34*	*.92*	*1.41*	*3.04*
1951 [1]	55.2	5.68	127,605	48.8	2.31	31,440	68.9	10.83	96,165
1952	54.0	5.56	132,009	48.3	2.34	34,735	67.5	10.93	97,274
1952: 1951 ratio	*.98*	*.98*	*1.03*	*.99*	*1.01*	*1.10*	*.98*	*1.01*	*1.01*
1952: 1941 ratio	*.81*	*1.53*	*2.25*	*.74*	*1.02*	*1.22*	*.94*	*1.33*	*3.22*
1952: 1936 ratio	*.86*	*1.92*	*4.71*	*.80*	*1.26*	*2.44*	*.93*	*1.58*	*7.08*

1 Includes ton-miles carried on toll roads not previously reported.

veys; and 1952, the 16th full year of estimates. The ratios of 1952 travel to that of preceding years indicate that increases for trucks and truck combinations were greater than for passenger cars for all years shown, a fact found to be true in most years. The increase of truck-combination travel in 1952 over that in 1951 was less than the increase of single-unit truck travel in the same period, but over the longer periods the increase of travel by truck combinations far exceeds that by single-unit trucks. In the 17 years from 1936 to 1952, passenger car and bus travel combined increased 118 percent, travel by all trucks and combinations increased 185 percent, while travel by truck combinations (considered separately) increased 378 percent, being almost 5 times as great in 1952 as in 1936.

Volume of Highway Freight

Figure 6 gives a comparison of the average load carried by loaded single-unit trucks and truck combinations, separately and combined, in the 17 years that the planning surveys have been operating. The general trend of load weights was upward throughout the period. From 1945 to 1951 the slight decline in the weights of loads carried by single-unit trucks was more than offset by the increased use of combinations and heavier weights of loads carried by vehicles of this type. In 1952, however, the slightly smaller proportion of combinations resulted in a small decline in the average weight of carried load for all trucks and combinations.

Figure 7 shows for each year from 1936 through 1952, the ton-mileage of freight carried by trucks and truck combinations on main rural roads. The chart demonstrates clearly that truck combinations are now transporting a much larger proportion of the total amount of highway freight than in

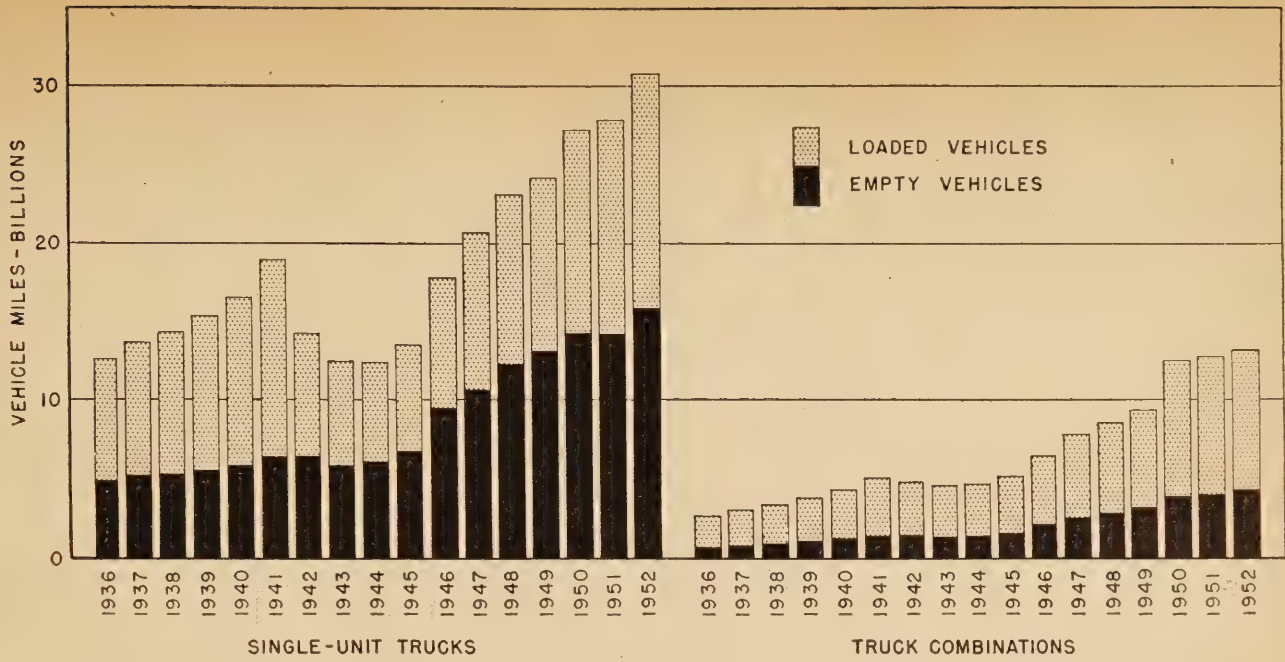


Figure 5.—Travel on main rural roads, 1936–52, by loaded and by empty trucks and truck combinations.

the earlier years. In 1936 the truck combinations hauled slightly less ton-mileage than the single-unit trucks, while in 1952 they hauled almost 3 times the amount transported by the larger number of lighter vehicles. The rapid rate of annual increase in total freight carried, which took place in 1946 and 1947, was reduced somewhat in 1948 and 1949 to a rate more nearly comparable with that of prewar years. In 1950, however, there was a startling increase in freight ton-mileage somewhat similar to the rise that occurred in 1941. In 1951 and 1952, the rate of increase returned to one closely comparable with the prewar trend.

In table 6 are shown comparisons for 1952 with corresponding items for other years as in table 5, of the percentage of vehicles carrying loads, the average carried load, and the ton-mileage carried for single-unit trucks and for truck combinations, separately and combined. The trend from 1936 to 1952 of average weight carried, shown graphically in figure 6, and that of the ton-mileage transported during the same period, shown in figure 7, have already been discussed.

The percentage of truck and truck combinations carrying loads decreased slightly from 1951 to 1952 in the United States as a whole, and in all regions except the New England, East North Central, West North Central, and Mountain regions where slight increases were found. In the country as a whole, the percentage loaded decreased from 55.2 percent in 1951 to 54.0 percent in 1952. Both for single-unit trucks and for truck combinations, the percentage loaded was lower in 1952 than in 1951, but higher than in 1946. The loaded proportion continued to be considerably less for the single-unit vehicles and slightly less for the truck combinations than in the prewar surveys.

Table 7 gives a detailed comparison of the percentage of vehicle-miles of travel, percentage of vehicles loaded, average carried load, and percentage of total ton-miles of freight carried by the various types of trucks and truck combinations traveling on main rural roads in 1951 and 1952. Interesting comparisons can be made from this table showing the relative importance from a freight-carrying standpoint of different portions of the traffic stream. In 1952, for instance, while panel and pickup trucks traveled over 33 percent

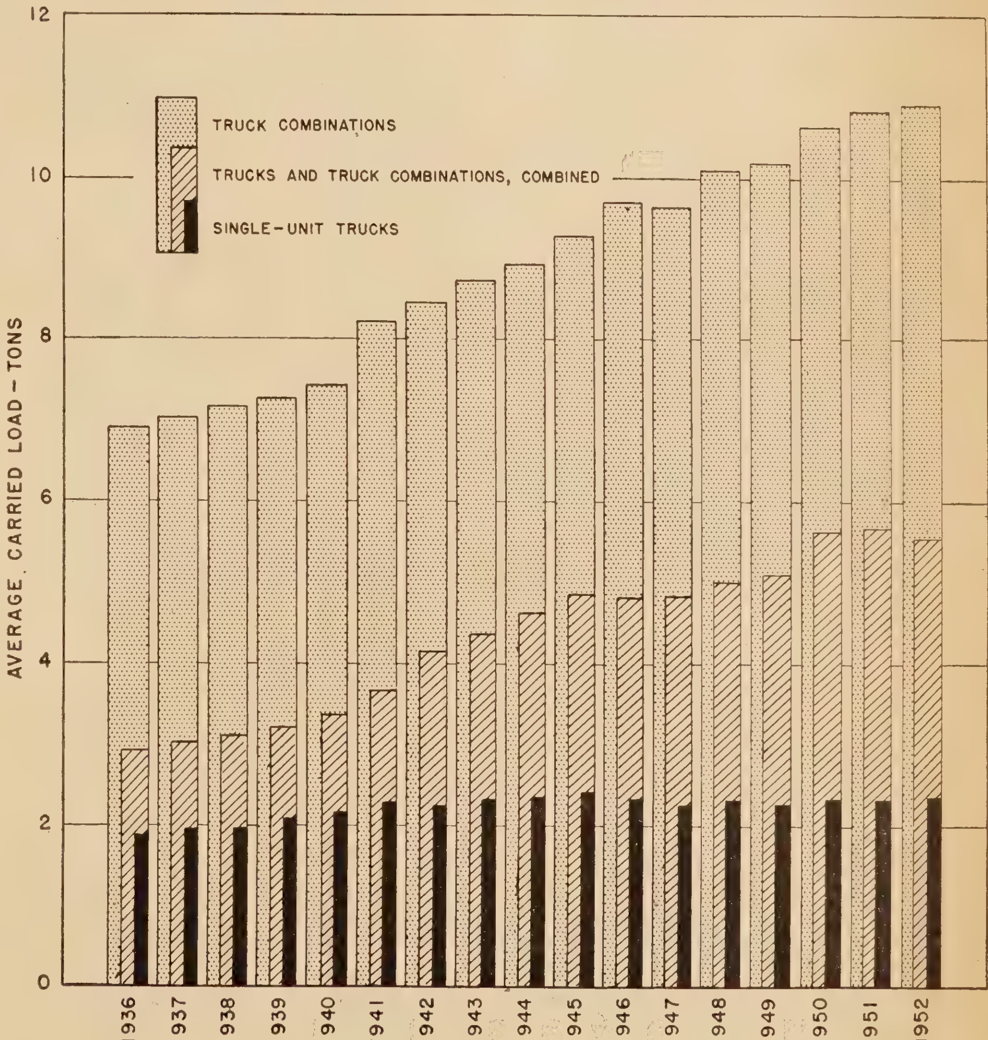


Figure 6.—Average load carried by trucks and truck combinations on main rural roads, 1936–52.

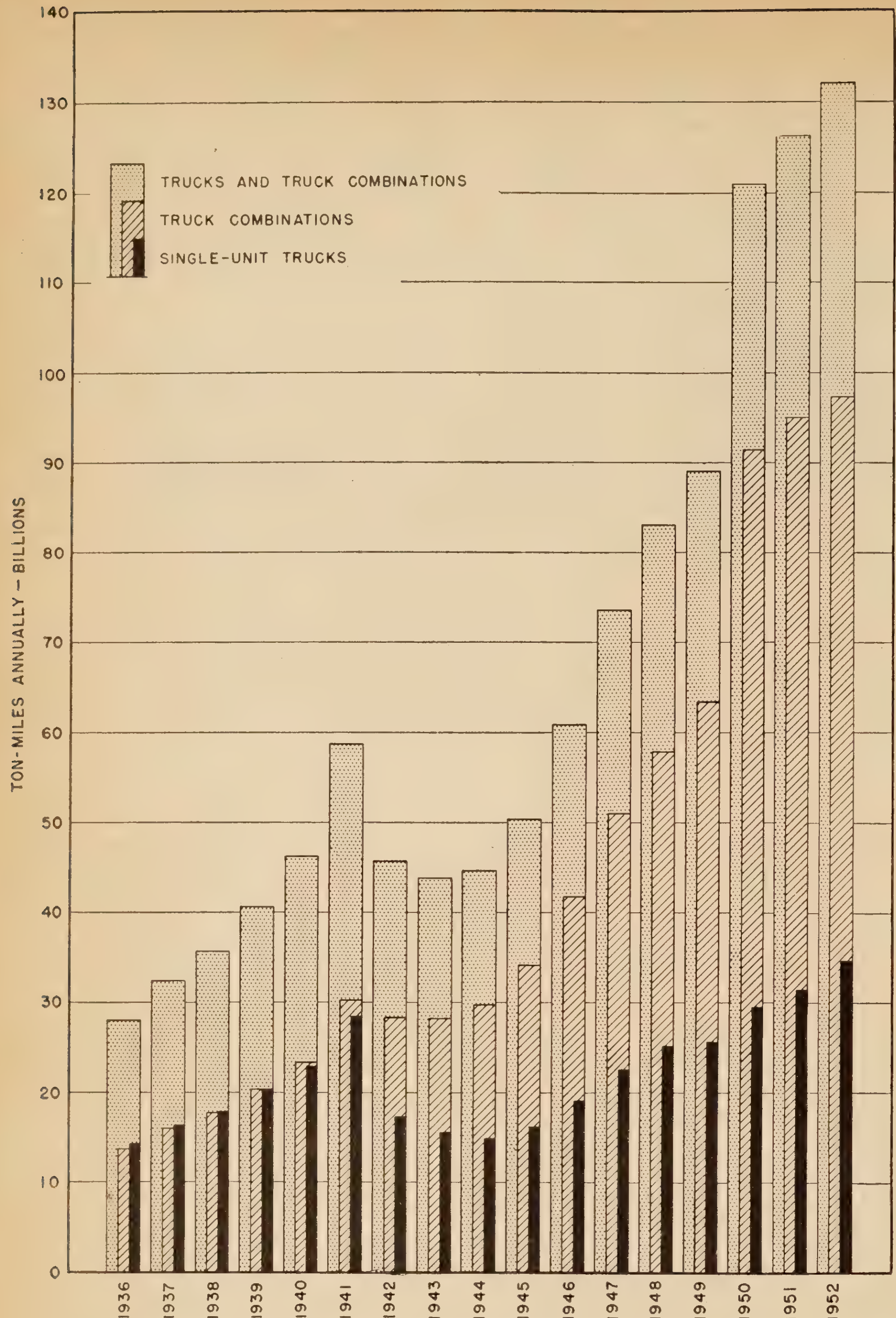


Figure 7.—Ton-miles carried by trucks and truck combinations on main rural roads, 1936–52.

of the vehicle-mileage, they accounted for less than 3 percent of the ton-mileage. The truck-tractors and semitrailers, on the other hand, traveled about 28 percent of the vehicle-mileage but carried almost 67 percent of the ton-mileage.

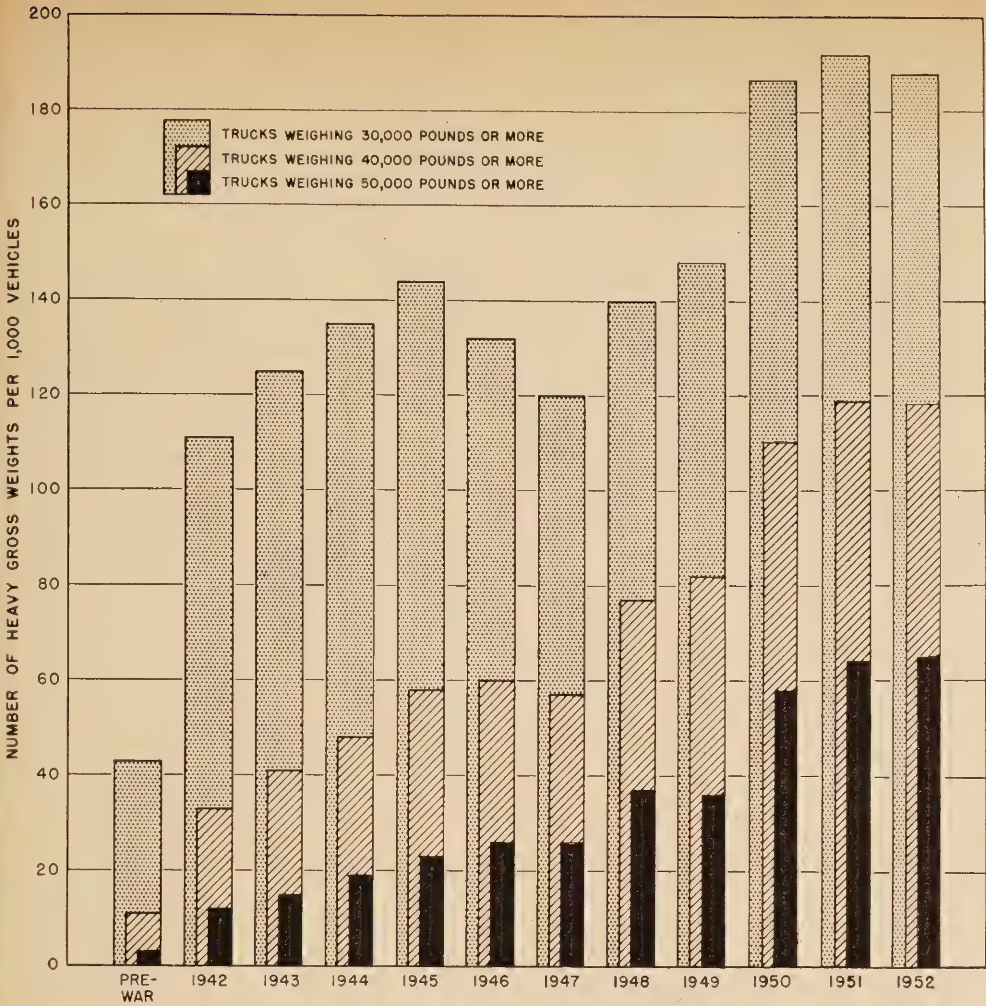
From the column in table 7, showing percentage loaded by types, it can be observed that the percentage of vehicles carrying loads tends to increase directly as the size of the vehicle type, extending from light panel and pickup trucks that are loaded 38 percent of the time to the heavy combinations that are loaded about 67 percent of the time.

Weights Level Off

Figure 8 shows by years, from the prewar years (generally 1936 or 1937) to 1952, for the United States as a whole, the frequency of gross weights of 30,000 pounds or more, of 40,000 pounds or more, and of 50,000 pounds or more. In 1952 it was found that 65 vehicles in each 1,000 loaded and empty trucks and truck combinations weighed 50,000 pounds or more, while in the previous year, 64 vehicles in each 1,000 weighed this amount. On the other hand, it was found in 1952 that 118 vehicles in each 1,000 weighed 40,000 pounds or more, while in 1951, 119 vehicles in each 1,000 weighed that amount. In the 30,000 pound or more class there was a greater reduction. It was found in 1952 that 188 vehicles in each 1,000 weighed 30,000 pounds or more, while in the previous year this frequency was 192 such vehicles. This decline or leveling off of the frequency of heavy gross weights may or may not be significant. It will be seen from the chart that the general upward trend of gross-weight frequencies has been halted or reversed temporarily several times during the period covered, notably in 1946 and 1947. The current frequencies, however, are much larger than those found in 1946, the first postwar year, and an astonishing amount larger than in 1936 or 1937, the first years of the planning surveys. Frequencies of vehicles weighing 30,000 pounds or more in 1952 were 1.4 times as great as in 1946, and over 4 times as great as in the prewar years; those weighing 40,000 pounds or more in 1952 were twice as great as in 1946, and about 11 times as great as in the prewar years; while vehicles weighing 50,000 pounds or more in 1952 were 2.5 times as great as in 1946, and almost 22 times as great as in the prewar years.

The 1952 gross-weight frequency data by vehicle type and region are presented in table 8. No panels, pickups, or other two-axle, four-tire, single-unit trucks were found in the survey weighing as much as 30,000 pounds, so there is no entry for these vehicles in the table though they are included in the total number of vehicles weighed in computing the frequencies for all trucks and combinations. Heavy gross weights are more frequent in the Pacific region than in other parts of the country. In this region 191 of each 1,000 trucks and truck combinations on the main rural highways in 1952, empties included, weighed 50,000 pounds or more, and 280 of each 1,000 weighed 30,000 pounds or more. In the Mountain region 84 of each 1,000 weighed 50,000 pounds or more, while 165 of each 1,000 weighed 30,000 pounds or more. In the East North Central region 78 of each 1,000, a frequency almost as large as that found in the Mountain region, weighed 50,000 pounds or more, while 227 of each 1,000, a frequency almost as large as that found in the Pacific region, weighed 30,000 pounds or more. The lowest frequency of heavy gross loads was found in the East South Central region where only 9 of each 1,000 weighed 50,000 pounds or more, and only 122 of each 1,000 weighed 30,000 pounds or more.

As was pointed out in the discussion of figure 8, the frequencies of heavy gross loads decreased or leveled off in 1952 in the Nation as a whole. This leveling off is not limited to any certain area, but is distributed throughout the entire country. Comparing the frequencies of gross weights in 1952 with those in the previous year, fairly large decreases were found in the frequencies of gross weights of 30,000 pounds or more in the heavily traveled Middle Atlantic and East North Central regions and a slight decrease in the important Pacific region, and with only moderate increases in the other regions. Likewise, decreases were found in the frequencies of gross weights of 50,000 pounds or more in both the Middle Atlantic and East North Central regions and with moderate increases in other regions.



(ABOVE) ***Figure 8.—Number of heavy gross weights per 1,000 trucks and truck combinations (empties included) in the summers of 1942–52 and a prewar year.***

(RIGHT) ***Figure 9.—Number of heavy axle loads per 1,000 trucks and truck combinations (empties included) in the summers of 1942–52 and a prewar year.***

Frequency of Heavy Axle Loads

Figure 9 shows the frequency of axle loads of 18,000 pounds or more, 20,000 pounds or more, and of 22,000 pounds or more for the prewar years (1936–37) and by years from 1942 to 1952, inclusive. The frequency of these heavy loads increased year by year from the prewar period through 1948. Since 1948, however, the trend apparently has been reversed, for with the exception of 1950, the data seem to indicate a definite downward trend. Such a trend is highly encouraging and may indicate the results of better enforcement of legal limits and of attention given, generally, to better load distribution.

Table 9 gives data concerning the number of heavy axle loads per 1,000 loaded and empty trucks and truck combinations of various types on the main rural roads by regions in 1952. Since no panel, pickup or other two-axle, four-tire single-unit truck was found with axles weighing 18,000 pounds or more, there is no entry for these in the table though they are included in figuring the frequencies for all trucks and truck combinations.

Though the greatest frequency of heavy gross weights in 1952 was in the Pacific region, as shown in table 8, this region had a considerably below-average frequency of heavy axle loads. At the same time, by far the greatest frequency of heavy axle loads was in the Middle Atlantic region and the next greatest was in New England where moderately low frequencies of heavy gross loads were found. In these two eastern regions, the relatively high frequency is attributable mainly to the higher legal axle-weight limits in effect in some of the States, and the large number of two-axle truck-tractors pulling one-axle or two-axle semitrailers. The relative infrequency of heavy axles in the Pacific region, in the presence of a large proportion of heavy gross loads, indicates a better general distribution of the loads over a larger number of axles.

Although the frequency of heavy gross loads has increased considerably in all regions since 1949 and has only showed a tendency to level off in some regions in 1952, as stated in connection with the discussion of table 8, the trend in frequency of heavy axle loads is following a different pattern. This is demonstrated by comparing the frequency of heavy axle loads in 1952 with those in 1951 and 1950 and, in general, back to 1948. As shown in table 9 for each region, with the exception of the New England and Pacific regions, the trend in frequency of heavy axle loads is downward, whereas table 8 shows that the frequency of gross loads is increasing somewhat in most regions and leveling off only in a few.

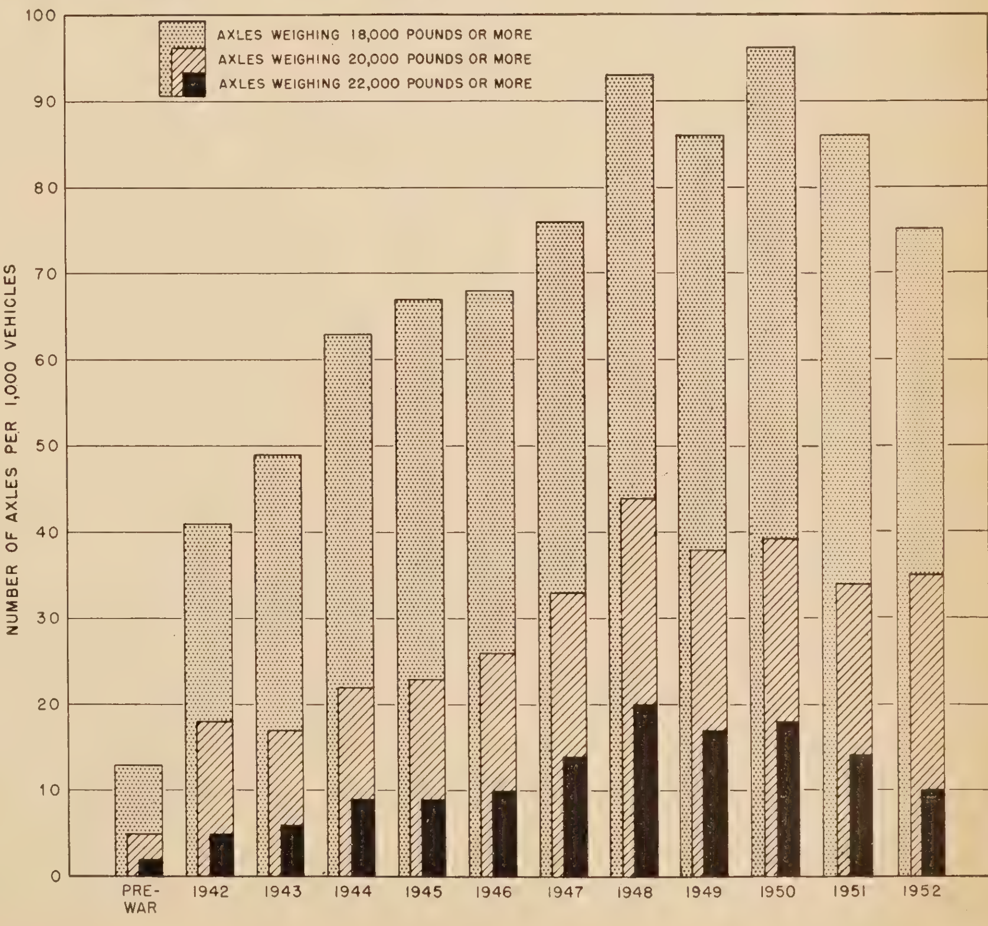


Table 7.—Percentage of vehicle-miles of travel, percentage loaded, average carried load, and percentage of total ton-miles carried by various types of trucks and truck combinations on main rural roads in 1952 compared to that in corresponding months in 1951 [1]

Vehicle type	Percentage of vehicle-miles of travel		Percentage loaded		Average carried load		Percentage of ton-miles carried	
	1952	1951	1952	1951	1952	1951	1952	1951
					Tons	*Tons*		
Single-unit trucks:								
Panel and pickup	33.47	32.66	38.1	39.0	0.68	0.70	2.89	2.83
Other 2-axle, 4-tire	3.16	2.89	50.3	54.6	.90	.91	.48	.46
Other 2-axle, 6-tire	31.01	30.85	58.3	58.0	3.20	3.23	19.26	18.42
3-axle	2.36	2.00	58.2	60.9	8.03	7.53	3.68	2.93
All single-unit trucks	70.00	68.40	48.3	48.8	2.34	2.31	26.31	24.64
Truck combinations:								
Truck-tractor and semitrailer	27.89	29.41	67.8	69.2	10.61	10.48	66.84	68.14
Truck and trailer	2.11	2.19	63.5	65.0	15.42	15.48	6.85	7.22
All truck combinations	30.00	31.60	67.5	68.9	10.93	10.83	73.69	75.36
All trucks and combinations	100.00	100.00	54.0	55.2	5.56	5.68	100.00	100.00

[1] Data for 1951 include estimates for toll roads not previously reported.

Loads Above Legal Limits

Table 10 shows the number of trucks and truck combinations of each type, per 1,000 such vehicles counted, empties included, that exceeded the legal axle, axle-group, or gross-weight limits in effect in the individual States in the summer of 1952, and the number per 1,000 that exceeded these limits by various percentages. Comparative figures are given at the bottom of the table for the Nation as a whole for 1950 and 1951. The table shows that, on the whole, the frequency with which vehicles violated some one of the State weight restrictions was approximately the same as in the previous year, much less than in 1950, and furthermore, that the amount of overload generally was less in 1952 than in the previous years.

Loads in excess of State law in 1952 were most frequent in the Middle Atlantic States, although even in this region, when compared to 1951, a reduction in frequency of overloaded vehicles was found. The frequencies were reduced from 74 trucks and combinations overloaded in 1951 for each 1,000 counted to a frequency of 61 such vehicles in 1952. A slight decrease in the frequencies of overloaded vehicles also was found in the East North Central and in the West North Central regions, and the frequency in the West South Central region remained the same as in 1951. Slight increases in the frequency of overloaded vehicles were found in all other areas. The East South Central region, which had the second lowest frequency of overloaded vehicles in 1951, had the lowest such frequency in 1952 with only 44 trucks and truck combinations overloaded for each 1,000 counted in that area. After the Middle Atlantic region where, of all loaded and empty trucks and truck combinations weighed in 1952, 61 of each 1,000 exceeded one or more of the State weight limits, there followed the East North Central region with the second highest rate of overloads (57), and in descending order of rates of violation were the West South Central (54), the Mountain (54), the Pacific (51), the South Atlantic (49), the West North Central (48), New England (46), and the East South Central (44).

No panel or pickup or other 2-axle, 4-tire truck was weighed that exceeded any of the State weight regulations, and these classifications are

Table 8.—Heavy gross weights per 1,000 loaded and empty trucks and truck combinations on main rural roads, summer of 1952

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
Number per 1,000 Weighing 30,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	16	16	1	9	—	1	—	3	1	2	—	1	4
3-axle	326	367	346	351	239	270	294	478	283	331	373	360	333
Average	18	22	17	19	8	7	5	5	6	13	29	22	13
Truck combinations:													
Truck-tractor and semitrailer	549	566	563	563	589	533	588	550	571	679	786	747	591
Truck and trailer	(1)	(1)	—	(1)	681	400	231	208	511	737	809	788	666
Average	547	565	559	560	596	533	577	534	568	692	793	758	596
Average, all trucks and combinations	158	207	171	183	227	122	181	148	177	165	280	230	188
Comparative average, 1951	153	234	164	191	255	109	158	143	178	164	289	240	192
Comparative average, 1950	137	221	177	189	251	102	142	146	170	160	289	233	187
Number per 1,000 Weighing 40,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	2	2	—	1	—	—	—	—	—	(2)	—	(2)	(2)
3-axle	124	152	58	92	114	25	27	111	79	59	31	40	72
Average	5	7	3	4	4	1	(2)	1	2	2	2	2	2
Truck combinations:													
Truck-tractor and semitrailer	357	341	363	353	353	221	377	353	341	469	664	594	377
Truck and trailer	(1)	(1)	—	(1)	551	200	168	37	379	527	620	592	500
Average	356	341	361	352	369	221	371	338	343	482	652	593	386
Average, all trucks and combinations	97	120	104	110	140	49	115	92	105	110	216	169	118
Comparative average, 1951	95	152	98	120	154	41	98	85	103	103	216	172	119
Comparative average, 1950	78	135	95	109	140	45	82	79	95	106	214	167	110
Number per 1,000 Weighing 50,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	—	—	—	—	—	—	—	—	—	—	—	—	—
3-axle	21	38	1	14	21	12	—	23	16	9	3	5	12
Average	1	1	(2)	1	1	(2)	—	(2)	(2)	(2)	(2)	(2)	(2)
Truck combinations:													
Truck-tractor and semitrailer	141	108	154	128	184	41	209	180	170	344	579	494	197
Truck and trailer	—	(1)	—	(1)	486	—	152	31	334	487	583	555	460
Average	140	109	153	128	208	41	207	173	178	376	580	510	215
Average, all trucks and combinations	38	38	43	39	78	9	64	47	54	84	191	144	65
Comparative average, 1951	31	72	36	50	87	6	54	34	51	78	178	138	64
Comparative average, 1950	24	63	28	41	78	7	44	34	47	76	176	133	58

[1] Data omitted because of insufficient sample. [2] Less than 5 per 10,000.

omitted from tables 10–12 although the number of such vehicles counted is included in the calculations.

Recommended Weight Limits

Uniform regulations concerning maximum allowable gross weights, axle weights, and axle-group weights have been adopted as a policy by the American Association of State Highway Officials and recommended to the State governments for adoption.[3] This policy recommends that no axle shall carry a load in excess of 18,000 pounds, and no group of axles shall carry a load in excess of amounts specified in a table of permissible weights based on the distance between the extremes of any group of axles.

As might be expected, many vehicles were loaded in such a manner that they exceeded more than one recommended weight limit, and some vehicles had more than one axle loaded in excess of the recommended limit. By counting each vehicle only once, regardless of the number of ways in which it exceeded any of the A.A.S.H.O. recommended limits, table 11 was prepared to show the number of vehicles per 1,000 of each type, both loaded and empty, that exceeded the limits by various percentages. Those vehicles which exceeded more than one provision of the recommended restriction were tabulated only in the column showing the highest percentage excess of any item.

In the United States as a whole, the number of vehicles out of every 1,000 that exceeded the recommendations increased slightly, being 73 in 1952 compared to 72 in 1951. A slight reduction in the number exceeding the recommendations was found in the West North Central region. On the other hand, a considerable reduction was found in the important Middle Atlantic and East North Central regions where the number decreased from 127 and 99 in 1951 to 107 and 89 in 1952, respectively. In all other regions, slight increases were found, the largest of which were in the New England and Pacific regions. The large reduction of vehicles exceeding the recommendations in the Middle Atlantic region is particularly gratifying because this is the region of the highest frequency of excessive loads, as measured by the A.A.S.H.O. standards.

Regardless of the reduction in the Middle Atlantic region of the frequency of vehicles out of every 1,000 that exceeded any of the A.A.S.H.O. recommendations in 1952, when compared to 1951, that region led all others in the number of heavy loads. There were 107 vehicles for every 1,000 weighed, including empties, that exceeded one or more of the recommendations. Other regions, ranked in descending order, were New England (103), Pacific (101), East North Central (89), Mountain (69), South Atlantic (65), West South Central (54), West North Central (46), and the East South Central (38).

In the United States as a whole, 73 vehicles out of every 1,000 were overloaded to some degree according to the A.A.S.H.O. standards, and 14 out of every 1,000 exceeded some one of the recommended provisions by 20 percent or more in 1952. Compared to these frequencies, there were in the previous year 72 vehicles out of every 1,000 that were overloaded to some degree, and 16 out of every 1,000 were overloaded by 20 percent or more. Although these data indicate a slight increase in the number of vehicles loaded in excess of the Association's recommendations, there is a gratifying reduction in the number of the more heavily overloaded vehicles.

The frequencies of axle loads of 18,000 pounds or more, 20,000 pounds or more, and 22,000 pounds or more have already been discussed in connection with table 9 and will not be discussed further.

Table 12 shows the number of vehicles of various types per 1,000 vehicles with an axle-group load in excess of the limits recommended by the A.A.S.H.O. and in excess of the limits by various percentages. For the United States as a whole,

[3] *Policy concerning maximum dimensions, weights, and speeds of motor vehicles to be operated over the highways of the United States,* adopted April 1, 1946, by the American Association of State Highway Officials; published by the Association in 1946.

Table 9.—Heavy axle loads per 1,000 loaded and empty trucks and truck combinations on main rural roads, summer of 1952

Vehicle type	Eastern regions: New England	Eastern regions: Middle Atlantic	Eastern regions: South Atlantic	Eastern regions: Average	Central regions: East North Central	Central regions: East South Central	Central regions: West North Central	Central regions: West South Central	Central regions: Average	Western regions: Mountain	Western regions: Pacific	Western regions: Average	United States average
Number per 1,000 Weighing 18,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	45	53	28	41	13	33	11	21	18	39	23	30	27
3-axle	190	158	76	111	34	83	10	118	50	84	19	39	70
Average	30	36	15	24	8	17	6	9	9	17	9	13	14
Truck combinations:													
Truck-tractor and semitrailer	499	395	242	330	176	147	96	207	162	158	135	143	216
Truck and trailer	(1)	------	------	(1)	372	------	42	12	244	227	214	218	223
Average	497	393	240	328	192	147	94	198	167	173	157	163	217
Average, all trucks and combinations	153	157	79	116	76	46	33	60	57	52	58	55	75
Comparative average, 1951	151	207	90	144	88	46	53	60	65	55	44	49	86
Comparative average, 1950	137	208	100	147	98	63	45	67	72	83	69	75	96
Number per 1,000 Weighing 20,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	29	28	8	19	1	13	2	8	5	13	4	9	10
3-axle	77	107	12	47	25	16	------	23	19	21	8	12	27
Average	17	20	4	11	1	6	1	3	3	5	2	4	6
Truck combinations:													
Truck-tractor and semitrailer	305	207	79	254	50	27	15	57	41	33	25	28	111
Truck and trailer	(1)	------	------	(1)	38	------	2	------	24	11	40	31	28
Average	304	206	78	252	49	27	14	54	40	28	29	29	105
Average, all trucks and combinations	93	83	25	84	19	11	5	17	14	11	11	11	35
Comparative average, 1951	97	129	35	79	16	11	12	21	16	17	5	10	34
Comparative average, 1950	82	131	38	80	22	19	12	23	19	35	16	24	39
Number per 1,000 Weighing 22,000 Pounds or More													
Single-unit trucks:													
2-axle, 6-tire	19	16	2	10	------	2	(2)	4	1	7	------	3	5
3-axle	28	49	2	19	13	------	------	18	8	4	(2)	2	10
Average	11	11	1	6	(2)	1	(2)	2	1	3	(2)	1	2
Truck combinations:													
Truck-tractor and semitrailer	157	114	23	74	9	7	2	12	8	8	6	6	30
Truck and trailer	(1)	------	------	(1)	15	------	------	------	10	2	7	5	7
Average	156	113	23	73	9	7	2	11	8	6	6	6	28
Average, all trucks and combinations	49	46	7	26	4	2	1	4	3	3	2	3	10
Comparative average, 1951	46	73	10	39	5	3	3	4	4	5	2	3	14
Comparative average, 1950	39	80	13	42	7	5	3	9	6	16	3	9	18

[1] Data omitted because of insufficient sample. [2] Less than 5 per 10,000.

Table 10.—Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded the permissible axle, axle-group, or gross-weight legal limits in effect in the States by various percentages (maximum) of overload, summer of 1952

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than— 5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
2-axle, 6-tire	16	13	8	4	2	(1)
3-axle	132	106	73	16	12	2
Average, single-unit trucks	12	10	6	3	1	(1)
Truck-tractor and semitrailer	142	101	73	29	10	(1)
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	141	101	73	29	10	(1)
Average, all trucks and combinations	46	34	24	10	3	(1)
Middle Atlantic:						
2-axle, 6-tire	23	18	12	5	2	1
3-axle	116	92	77	54	38	15
Average, single-unit trucks	17	14	10	5	3	1
Truck-tractor and semitrailer	145	90	56	15	6	(1)
Truck and trailer	187	125	62	---	---	---
Average, truck combinations	145	90	56	15	6	(1)
Average, all trucks and combinations	61	40	26	8	4	1
South Atlantic:						
2-axle, 6-tire	15	6	4	1	---	---
3-axle	70	21	14	1	---	---
Average, single-unit trucks	9	3	2	(1)	---	---
Truck-tractor and semitrailer	150	88	52	19	7	1
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	149	87	52	19	7	1
Average, all trucks and combinations	49	27	16	5	2	(1)
East North Central:						
2-axle, 6-tire	5	1	---	---	---	---
3-axle	49	28	27	13	13	---
Average, single-unit trucks	4	1	1	(1)	(1)	---
Truck-tractor and semitrailer	140	79	36	8	1	(1)
Truck and trailer	223	120	58	13	7	---
Average, truck combinations	147	82	38	8	1	(1)
Average, all trucks and combinations	57	31	15	3	(1)	(1)
East South Central:						
2-axle, 6-tire	28	20	14	3	1	---
3-axle	68	48	31	14	---	---
Average, single-unit trucks	15	10	7	2	(1)	---
Truck-tractor and semitrailer	145	84	46	16	3	1
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	145	84	46	16	3	1
Average, all trucks and combinations	44	26	16	5	1	(1)
West North Central:						
2-axle, 6-tire	7	3	1	(1)	---	---
3-axle	55	32	22	11	---	---
Average, single-unit trucks	4	2	1	(1)	---	---
Truck-tractor and semitrailer	148	93	47	12	3	(1)
Truck and trailer	66	37	9	---	---	---
Average, truck combinations	146	91	46	12	3	(1)
Average, all trucks and combinations	48	29	15	4	1	(1)
West South Central:						
2-axle, 6-tire	17	13	7	5	2	1
3-axle	101	88	59	17	---	---
Average, single-unit trucks	7	6	3	2	1	(1)
Truck-tractor and semitrailer	189	126	77	26	9	1
Truck and trailer	4	---	---	---	---	---
Average, truck combinations	180	120	73	25	9	1
Average, all trucks and combinations	54	37	22	8	3	(1)
Mountain:						
2-axle, 6-tire	31	21	11	5	2	---
3-axle	92	87	48	22	13	---
Average, single-unit trucks	14	11	6	3	1	---
Truck-tractor and semitrailer	189	122	74	22	7	1
Truck and trailer	218	157	83	29	18	---
Average, truck combinations	195	130	76	24	9	1
Average, all trucks and combinations	54	38	22	8	3	(1)
Pacific:						
2-axle, 6-tire	6	4	3	---	---	---
3-axle	24	7	4	---	---	---
Average, single-unit trucks	4	2	1	---	---	---
Truck-tractor and semitrailer	125	80	41	16	8	3
Truck and trailer	201	92	44	11	6	4
Average, truck combinations	146	83	42	15	7	3
Average, all trucks and combinations	51	29	14	5	2	1
United States average:						
2-axle, 6-tire	15	10	6	2	1	(1)
3-axle	67	41	30	13	8	2
Average, single-unit trucks	9	6	4	1	1	(1)
Truck-tractor and semitrailer	151	93	52	16	5	1
Truck and trailer	182	98	48	13	7	2
Average, truck combinations	153	93	52	16	5	1
Average, all trucks and combinations	52	32	18	6	2	(1)
Comparative average, 1951	50	32	19	7	3	(1)
Comparative average, 1950	67	44	27	11	5	1

[1] Less than 5 per 10,000.

Table 11.—Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded any of the permissible load limits recommended by the A.A.S.H.O. by various percentages (maximum) of overload in the summer of 1952

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than— 5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
2-axle, 6-tire	47	40	32	23	14	3
3-axle	175	151	126	59	18	---
Average, single-unit trucks	29	25	20	14	8	2
Truck-tractor and semitrailer	312	273	230	143	69	11
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	311	272	229	142	69	11
Average, all trucks and combinations	103	90	75	48	24	4
Middle Atlantic:						
2-axle, 6-tire	45	38	32	18	10	2
3-axle	100	85	77	54	38	23
Average, single-unit trucks	29	25	21	12	7	2
Truck-tractor and semitrailer	257	212	152	88	49	9
Truck and trailer	187	187	125	---	---	---
Average, truck combinations	257	212	152	88	49	9
Average, all trucks and combinations	107	89	66	38	21	4
South Atlantic:						
2-axle, 6-tire	23	13	8	1	(1)	---
3-axle	122	89	44	5	1	---
Average, single-unit trucks	15	9	5	1	(1)	---
Truck-tractor and semitrailer	194	138	89	35	11	2
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	193	137	88	35	11	2
Average, all trucks and combinations	65	45	29	11	3	1
East North Central:						
2-axle, 6-tire	6	1	---	---	---	---
3-axle	41	27	14	13	12	---
Average, single-unit trucks	4	1	(1)	(1)	(1)	---
Truck-tractor and semitrailer	215	132	75	19	7	(1)
Truck and trailer	445	406	323	164	66	12
Average, truck combinations	233	154	95	30	12	1
Average, all trucks and combinations	89	58	35	11	4	(1)
East South Central:						
2-axle, 6-tire	28	20	15	4	(1)	---
3-axle	70	61	35	11	---	---
Average, single-unit trucks	15	11	8	2	(1)	---
Truck-tractor and semitrailer	120	66	34	10	2	(1)
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	120	66	34	10	2	(1)
Average, all trucks and combinations	38	23	14	4	(1)	(1)
West North Central:						
2-axle, 6-tire	8	3	1	(1)	---	---
3-axle	24	21	17	2	---	---
Average, single-unit trucks	4	2	1	(1)	---	---
Truck-tractor and semitrailer	144	82	35	9	2	---
Truck and trailer	56	29	6	---	---	---
Average, truck combinations	141	80	34	9	2	---
Average, all trucks and combinations	46	26	11	3	1	---
West South Central:						
2-axle, 6-tire	17	13	7	5	2	1
3-axle	91	78	54	17	---	---
Average, single-unit trucks	7	6	3	2	1	(1)
Truck-tractor and semitrailer	190	128	79	27	9	1
Truck and trailer	4	4	4	4	---	---
Average, truck combinations	181	122	75	26	9	1
Average, all trucks and combinations	54	37	23	9	3	(1)
Mountain:						
2-axle, 6-tire	31	21	10	5	2	---
3-axle	90	72	43	17	4	---
Average, single-unit trucks	14	10	5	2	1	---
Truck-tractor and semitrailer	251	179	114	34	12	1
Truck and trailer	293	229	132	31	(1)	---
Average, truck combinations	260	190	118	33	9	1
Average, all trucks and combinations	69	50	30	9	3	(1)
Pacific:						
2-axle, 6-tire	6	4	3	---	---	---
3-axle	19	6	4	---	---	---
Average, single-unit trucks	4	2	1	---	---	---
Truck-tractor and semitrailer	261	204	129	40	13	3
Truck and trailer	398	300	190	20	9	4
Average, truck combinations	299	231	146	34	12	3
Average, all trucks and combinations	101	77	49	11	4	1
United States average:						
2-axle, 6-tire	21	15	10	5	2	1
3-axle	74	56	36	15	8	3
Average, single-unit trucks	12	9	6	3	1	1
Truck-tractor and semitrailer	207	146	92	37	16	2
Truck and trailer	330	267	183	54	20	5
Average, truck combinations	216	154	98	38	16	2
Average, all trucks and combinations	73	52	34	14	6	1
Comparative average, 1951	72	52	35	16	7	1
Comparative average, 1950	91	68	46	21	10	3

[1] Less than 5 per 10,000.

the frequency of excessive axle-group loads in 1952 was slightly higher than in 1951, although lower than in 1950. As in table 11, decreases in the frequency of vehicles exceeding the axle-group recommendations were found in the heavily traveled Middle Atlantic and East North Central regions, and small increases were found in all others. As in the previous year, the highest frequency of excessive axle-group loads was found in the Pacific region (91 per 1,000 vehicles), while the regions in descending order of the number of vehicles with excessive axle-group loads were East North Central (61), Mountain (54), West North Central (33), Middle Atlantic (32), South Atlantic (30), New England and West South Central (28 each), and East South Central (6).

It will be noted that a higher proportion of the vehicles have excessive axle-group loads in the

Table 12.—Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded the permissible axle-group loads recommended by the A.A.S.H.O. by various percentages of overload in the summer of 1952

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than— 5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
2-axle, 6-tire	2	1	1	-------	-------	-------
3-axle	131	109	88	47	13	-------
Average, single-unit trucks	5	4	3	1	(1)	-------
Truck-tractor and semitrailer	93	64	43	20	6	1
Truck and trailer	-------	-------	-------	-------	-------	-------
Average, truck combinations	93	64	43	20	6	1
Average, all trucks and combinations	28	20	14	6	2	(1)
Middle Atlantic:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	100	85	77	54	38	15
Average, single-unit trucks	4	3	3	2	1	1
Truck-tractor and semitrailer	83	58	34	16	7	2
Truck and trailer	187	187	125	-------	-------	-------
Average, truck combinations	83	58	34	16	7	2
Average, all trucks and combinations	32	22	14	7	3	1
South Atlantic:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	114	83	35	5	1	-------
Average, single-unit trucks	5	4	2	(1)	(1)	-------
Truck-tractor and semitrailer	96	65	41	14	6	1
Truck and trailer	-------	-------	-------	-------	-------	-------
Average, truck combinations	95	65	41	14	6	1
Average, all trucks and combinations	30	21	13	4	2	(1)
East North Central:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	38	27	14	13	13	-------
Average, single-unit trucks	1	1	(1)	(1)	(1)	-------
Truck-tractor and semitrailer	141	84	44	11	4	(1)
Truck and trailer	404	387	321	160	65	12
Average, truck combinations	162	108	66	23	9	1
Average, all trucks and combinations	61	41	25	9	3	(1)
East South Central:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	54	47	30	11	-------	-------
Average, single-unit trucks	1	1	1	(1)	-------	-------
Truck-tractor and semitrailer	23	10	5	1	(1)	(1)
Truck and trailer	-------	-------	-------	-------	-------	-------
Average, truck combinations	23	10	5	1	(1)	(1)
Average, all trucks and combinations	6	3	2	(1)	(1)	(1)
West North Central:						
2-axle, 6-tire	(1)	(1)	-------	-------	-------	-------
3-axle	22	21	17	2	-------	-------
Average, single-unit trucks	(1)	(1)	(1)	(1)	-------	-------
Truck-tractor and semitrailer	108	62	23	6	1	-------
Truck and trailer	42	2	-------	-------	-------	-------
Average, truck combinations	106	60	22	6	1	-------
Average, all trucks and combinations	33	18	7	2	(1)	-------
West South Central:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	83	70	45	8	-------	-------
Average, single-unit trucks	1	1	(1)	(1)	-------	-------
Truck-tractor and semitrailer	104	73	43	17	5	1
Truck and trailer	4	4	4	4	-------	-------
Average, truck combinations	99	70	41	16	5	1
Average, all trucks and combinations	28	20	11	4	1	(1)
Mountain:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	81	55	43	17	4	-------
Average, single-unit trucks	3	2	2	1	(1)	-------
Truck-tractor and semitrailer	221	159	102	32	9	1
Truck and trailer	262	196	126	31	(1)	-------
Average, truck combinations	230	167	107	32	7	1
Average, all trucks and combinations	54	39	25	8	2	1
Pacific:						
2-axle, 6-tire	-------	-------	-------	-------	-------	-------
3-axle	12	2	-------	-------	-------	-------
Average, single-unit trucks	1	(1)	-------	-------	-------	-------
Truck-tractor and semitrailer	239	186	119	33	9	3
Truck and trailer	369	279	167	17	7	4
Average, truck combinations	275	212	132	29	8	3
Average, all trucks and combinations	91	70	43	10	3	1
United States average:						
2-axle, 6-tire	(1)	(1)	(1)	-------	-------	-------
3-axle	67	50	31	14	8	2
Average, single-unit trucks	2	2	1	(1)	(1)	(1)
Truck-tractor and semitrailer	118	79	45	15	5	1
Truck and trailer	302	247	172	52	19	5
Average, truck combinations	131	91	54	18	6	1
Average, all trucks and combinations	41	29	17	5	2	(1)
Comparative average, 1951	39	26	17	5	2	(1)
Comparative average, 1950	44	33	22	8	3	1

[1] Less than 5 per 10,000.

Pacific, Mountain, and East North Central regions than elsewhere, whereas table 9 shows that these regions are among those having the lowest frequencies of heavy axle loads. The far more frequent use of multiple-axle vehicles in these areas enables vehicle operators to distribute better their heavy loads. This is particularly true in California and other nearby States.

In considering the data concerning the frequencies of vehicles exceeding the State legal limits and the A.A.S.H.O. recommendations, especially the frequencies in the Middle Atlantic and New England regions, the fact should be recognized that higher limits generally are permitted under State laws in these areas than are recommended by the Association. Axles exceeding the recommended limits by as much as 25 percent may be within the legal limits of certain States, particularly in these two regions. Some States have no axle-group limits and one State has no prescribed axle-load limit in their motor-vehicle restrictions, a fact that further complicates direct comparison of excess weights based on law and those based on the recommendations. Comparison of the frequency data for New England and the Middle Atlantic regions shows that only about one-half of the vehicles exceeding one or more of the Association's recommendations actually exceeded a State legal limit. Due to more stringent weight laws in the East South Central and in the West North Central regions, the frequencies of vehicles exceeding the weight limits in the States of these areas are slightly greater than the frequencies of those exceeding the Association's recommendations. In the West South Central region, the frequencies of vehicles exceeding the State weight laws and of those exceeding the Association's recommendations are the same. For the United States as a whole, over two-thirds of the vehicles exceeding one or more of the Association's recommendations also exceeded a State legal limit.

Influence of Population, Sales, and Employment on Parking

BY THE HIGHWAY TRANSPORT RESEARCH BRANCH
BUREAU OF PUBLIC ROADS

Reported by S. T. HITCHCOCK
Assistant Branch Chief

The principal objective of traffic studies of any type is to obtain information needed for planning the improvement of highway facilities. An auxiliary objective of traffic studies is to improve the methods of making the studies, not only with respect to accuracy or completeness of the information, but also with respect to costs and time. A disturbing circumstance in making traffic studies is the length of time it takes to appraise a problem situation, obtain the information for solving the problem, analyze the data, and present the facts and recommendations for programming improvements.

The purpose of this discussion is to point out a few empirical relations which exist between certain basic economic factors such as population, retail sales, employment in urban areas, and the parking of automobiles, one part of the traffic problem which has been studied in the downtown area of many cities. If these relations can be shown to exist, it should be possible to learn how to use them in making parking and traffic studies in a few weeks instead of months and with considerable less expense.

Parking studies are one form of traffic studies, limited in most instances to problem situations in the downtown areas of cities where the economic interests of the community are centered and where traffic and transportation is focused to serve those interests. The increased use of the private automobile has made this problem one of common concern in all cities throughout the nation. The terminal problem in the downtown area is the concern not only of business in the area, but also of several departments of city government charged with the responsibilities of highway or street construction and maintenance, of traffic regulation, and of raising money for the administration of city government.

PRIOR to 1945, parking studies of limited area had been undertaken with expedient methods but without effort of a comprehensive nature or for the entire business district. In 1945, the first comprehensive type studies,[1] which now number 76, were initiated. Of the 76 parking studies, reports are available for analysis from 58 cities (table 1). These studies are centered around the people who drive their cars to the downtown area, and information is obtained about where they parked, how long they stayed, where they went after parking, and for what purpose. The reports from these studies are proving to be extremely useful in the planning and development of local parking improvements. Because of the similarity of methods used in obtaining information in these 58 cities, the reports have much added value in permitting a comparison of conditions and data for groups of these cities having similar characteristics.

Many cities are generally recognized as being of a certain type such as a manufacturing city, a retail market center, a resort town, or a center of governmental activity. Different economic factors have been used from time to time by market analysts and by other economists to express these differences. Several series of statistics that are available for this comparison provide an indication of the economic classification of cities. These are (1) census of population, 1950, (2) census of manufactures, 1947, (3) census of business, retail, wholesale, and service trades, 1948, and (4) economic classification of cities.[2]

For several years the International City Managers' Association has published in the Municipal Yearbook a classification of cities based primarily on retail and manufacturing employment characteristics for cities in different population groupings. These factors and several others generally

[1] Proceedings of the Highway Research Board, vol. 25, 1945, p. 269, and vol. 26, 1946, pp. 430-444.

[2] Municipal Yearbook, 1950, p. 48.

DEFINITIONS

Average parking accumulation.—The number of vehicles parked at a particular time is the accumulation at that time. The average parking accumulation is the average of the volumes parked at each one-half-hour interval from 10 a.m. to 6 p.m.

Employment in manufactures.—Number of all employees (average for the year) for each urban place in each State. *Census of manufactures,* Bureau of the Census, vol. III, table 2, 1947.

Employment per 100 population.—The number of persons who work in a city per 100 inhabitants. It includes employment in manufacturing and retail, wholesale, and service trades.

Employment in retail trade.—Number of paid employees, work week ended nearest November 15, 1948, for each city in each State. *Census of business,* Bureau of the Census, vol. III, table 103, 1948. Retail trade-area statistics.

Employment in service trade.—Number of paid employees, work week ended nearest November 15, 1948, for each city in each State. *Census of business,* Bureau of the Census, vol. VII, tables 103A, B, and C, 1948. Service trade-area statistics. Service trade includes automotive repair, laundry, cleaning, amusements, hotels, and restaurants.

Employment in wholesale trade.—Number of paid employees, work week ended nearest November 15, 1948, for each city in each State. *Census of business,* Bureau of the Census, vol. V, table 103, 1948. Wholesale trade-area statistics.

G.A.F. retail sales.—The dollar volume of annual retail sales of general merchandise (*G*), apparel (*A*), and furniture, appliance, and furnishings (*F*) as reported in table 103 for each State. *Census of business,* Bureau of the Census, vol. III, 1948. Retail trade-area statistics.

Number of parkers.—This is the number of vehicles parked in the central business district at any time between 10 a.m. and 6 p.m. at the curb and offstreet, legal and illegal, and it includes trucks as well as passenger vehicles. All studies used in this analysis were made under comparable methods. In some instances modification was necessary to develop volumes on a 10 a.m. to 6 p.m. 8-hour period.

Rank-size.—A listing of cities ranked in order of size from largest to smallest.

Retail trade-manufacturing employment ratio.—Ratio of employment in retail trade business to employment in manufacturing industry.

Urban population.—Number of inhabitants of urbanized area if 50,000 persons or more; places under 50,000 population is the city population. Tables 18 and 24 P-A1, *Census of population,* Bureau of the Census, 1950.

Vehicle cordon count.—A count of traffic crossing the boundary of the survey area.

Table 1.—Cities in which comprehensive parking studies have been made

City and State	Year of study	1950 population of urbanized area
Albert Lea, Minn.[1]	1947	13,545
Albuquerque, N. Mex.[2]	1949	96,815
Alexandria, La.	1947	34,913
Allentown, Pa.[3]	1948	106,756
Anderson, Ind.	1948	46,820
Anderson, S. C.	1947	19,770
Atlanta, Ga.[1]	1945	507,887
Baltimore, Md.	1946	1,161,852
Bethlehem, Pa.[1,3]	1948	66,340
Biddeford-Saco, Maine[1]	1950	31,160
Boise, Idaho	1948	34,393
Bristol, Va.–Tenn.[1]	1950	32,725
Butler, Pa.[1]	1951	23,482
Charlotte, N. C.	1947	140,930
Chattanooga, Tenn.	1947	167,764
Cleveland, Ohio	1948	1,383,599
Clovis, N. Mex.	1950	17,318
Coatesville, Pa.[1]	1951	13,826
Columbus, Ind.	1948	18,370
Corpus Christi, Tex.	1947	122,956
Dallas, Texas	1950	538,924
Decatur, Ind.	1948	7,271
Easton, Pa.	1948	35,632
Eugene, Oreg.[1]	1952	35,879
Evansville, Ind.	1949	137,573
Fond du Lac, Wis.[1]	1950	29,936
Frankfort, Ind.	1948	15,028
Gary, Ind.[3]	1949	133,911
Harrisburg, Pa.	1946	169,646
Honolulu, T. H.[1,2]	1947	248,034
Huntington, Ind.	1948	15,079
Independence, Mo.[1]	1950	36,963
Jacksonville, Fla.	1947	242,909
Knoxville, Tenn.	1946	148,166
Kokomo, Ind.	1948	38,672
Lake Charles, La.	1947	41,272
Lexington, Ky.[1,2]	1952	55,534
Lincoln, Nebr.	1950	99,509
Louisville, Ky.	1951	472,736
Lynchburg, Va.	1948	47,727
Martinsville, Va.	1949	17,251
Meadville, Pa.	1948	18,972
Memphis, Tenn.	1950	406,034
Miami, Fla.	1951	458,647
Monroe, La.	1947	38,572
Morristown, N. J.[1]	1950	17,124
Nashville, Tenn.[1]	1946	258,887
New Haven, Conn.	1946	244,836
Norristown, Pa.	1949	38,126
Ogden, Utah[1]	1952	57,112
Omaha, Nebr.	1948	310,291
Pawtucket, R. I.[3]	1945	81,436
Portland, Oreg.	1946	512,643
Portsmouth, N. H.	1946	18,830
Pottstown, Pa.	1949	22,589
Providence, R .I.	1945	583,346
Reading, Pa.	1947	154,931
Reno, Nev.	1949	32,497
Richmond, Va.	1948	257,995
Roswell, N. Mex.	1950	25,738
Rushville, Ind.[1]	1950	6,761
St. Louis, Mo.	1950	1,400,058
Seattle, Wash.	1946	621,509
Seymour, Ind.	1948	9,629
Spokane, Wash.	1947	176,004
Steubenville, Ohio[1]	1952	35,872
Stevens Point, Wis.	1947	16,564
Syracuse, N. Y.	1951	265,286
Toledo, Ohio	1947	364,344
Topeka, Kans.	1951	89,104
Uniontown, Pa.	1950	20,471
Wabash, Ind.	1948	10,621
Walla Walla, Wash.	1946	24,102
Waynesboro, Va.[1]	1952	12,357
West Chester, Pa.	1949	15,168
Wichita, Kans.	1947	194,047

[1] Cities not included in this study because their report was not received in time, did not provide sufficient detailed information, or data were not comparable to the 58 cities studied because of unusual conditions in the area.

[2] City population only.

[3] Part of an urbanized area. Population shown is that of named city only.

used were listed in this analysis for each of the 58 cities. As a result of an examination of these factors, it appeared that there were five groupings which could be readily recognized. Parking volumes for cities in each group were then studied in relation to the economic characteristics of the same group.

Several approaches were made to compare parking habits and volumes with economic characteristics of cities, three of which appear to offer useful methods of estimating parking volumes:

1. Rank-size order. Cities in which the parking studies had been made were arranged in order of size with respect to population, retail sales of general merchandise, apparel, and furniture (commonly known as G.A.F. sales), employment in manufacturing, and parking.

2. G.A.F. sales and parking. The number of parkers per million dollars of G.A.F. sales was compared with urban population.[3]

3. Statistical evaluation. The standard error of estimate was determined for 17 different factors in 31 different combinations.

Conclusions

Based on these studies the following conclusions are warranted:

1. Cities of similar economic characteristics may be recognized by types of employment and by population change, and may be grouped according to ratios based on these factors.
2. The amount of parking in the central business district has an empirical relation to the overall economy of the community.
3. Patterns of parking in a rank-size order have a definite relation to rank-size of cities of similar characteristics as grouped above with respect to population, G.A.F. sales, and employment in manufacturing.
4. The volume of parking per one million dollars of G.A.F. sales has a definite relation to population.
5. A statistically reliable relation exists between parking volumes and certain independent variables, and for certain groups of cities an equation can be developed to express this relation.
6. Estimates made by rank-size order, by the relation of parking volumes to G.A.F. sales, and by statistical evaluation when compared with actual observed volumes indicate that the volume of parkers for the central business district, as a whole, can be estimated within reasonable limits of accuracy.
7. Additional studies should be made to demonstrate how these relations can be used in planning parking facility improvements either directly in relation to land use or in combination with other known relations involving available parking spaces, trip purpose, length of time parked, and distance walked.

Economic Classification

The factors which were found to be usable in grouping the cities according to economic conditions were (1) retail trade-manufacturing employment ratio, which is the ratio of the number of persons employed in retail trade to the number employed in manufacturing; (2) employment per 100 population; (3) percent of population increase for the period 1940–50; and (4) percent of employment in service trades, which is the percent of total employment in such establishments as amusements, laundries, dry cleaning places, and hotels. These factors are summarized in table 2.

[3] *Gross retail sales and automobile parking requirements* by Floyd M. Jennings, Highway Research Board, Bulletin No. 19, 1948.

Employment in wholesale trade, motor-vehicle registrations in urban areas, total retail sales, and gasoline filling station sales were among other factors considered. They either duplicated trends apparent in the four factors selected, were not available for some cities, or were too far out of date to be used with assurance.

A considerable range in economic activity is represented in this group of cities. Employment in retail trade and manufacturing together account for more than one-half the total employment in all 58 cities and more than 80 percent in 31 of the 58 cities. The distribution of employment between these two factors, however, varies from five persons employed in retail trade for every person in manufacturing in Clovis, New Mex., to one person in retail trade for every six persons in manufacturing in Anderson, Ind. (table 2).

When cities are arrayed in order of the retail trade-manufacturing employment ratio, a progressive group classification can be made ranging from a group dominant in retail trade with a ratio of 1:0.2 through cities of decreasing retail trade importance to a group dominant in manufacturing with a ratio of 1:4.2 (table 2). Group averages for employment per 100 population arranged in the same group sequence increases from 15 to 36 percent. Employment in service trades tends to increase with dominance of retail trade and, generally speaking, population growth tends to be greatest in the cities showing greatest dominance in retail trade.

The population increase of 13.2 percent in group V cities is apparently inconsistent with the trend evident in the other groups and in relation to employment ratios. One of the cities in this group, Columbus, Ind., is located near Camp Atterbury, and the exceptional population growth of 56.5 percent in the 10-year period 1940–50 may be due to this proximity. Wabash, Seymour, and Decatur, all in Indiana, are also in this group and show population growth contrary to the apparent trend. These cities and Columbus, according to the census of manufactures, show increased industrial activity from 50 to 120 percent in production workers in the 1937–47 period, whereas other cities in this group show increases of less than 25 percent.

Individual cities vary somewhat from these group averages as might be expected, and 8 of the 58 cities do not seem to fit any of the 5 groups. Whether other or additional groupings would be significant if more cities could be included is conjectural.

Group I Cities

Retail trade-manufacturing employment ratio ranges from 1:0.2 to 1:0.4 with an average of 1:0.23 for the eight cities in this group. Employment in manufacturing is less than 20 percent.

Table 2.—Population and employment in 58 cities in which comparable parking studies have been made

City and State	Urbanized area population	City population increase, 1940–50	Employment per 100 population of city	Persons employed in— Manufacturing: Number	Manufacturing: Distribution	Retail trade: Number	Retail trade: Distribution	Wholesale trade: Number	Wholesale trade: Distribution	Service trades: Number	Service trades: Distribution	Total: Number	Total: Distribution	Retail trade-manufacturing employment ratio
Group I Cities														
	Thousands	*Percent*		*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	
Miami, Fla.	458.6	44.8	19.0	7.1	15.0	22.5	47.5	8.4	17.8	9.3	19.7	47.3	100.0	1:0.3
Corpus Christi, Tex.	122.9	89.0	12.2	2.6	17.6	7.2	47.7	2.5	17.0	2.7	17.7	15.0	100.0	1:0.4
Albuquerque, N. Mex.	[1] 96.8	173.1	12.2	1.5	12.4	6.4	53.7	1.9	16.3	2.1	17.6	11.9	100.0	1:0.2
Lake Charles, La.	41.3	94.6	11.5	0.6	13.7	2.5	53.2	0.8	16.5	0.8	16.6	4.7	100.0	1:0.2
Boise, Idaho	34.4	31.6	19.8	0.8	11.8	3.5	50.9	1.4	20.2	1.1	17.1	6.8	100.0	1:0.2
Reno, Nev.	32.5	52.4	24.9	0.7	9.0	3.5	42.9	0.8	9.6	3.1	38.5	8.1	100.0	1:0.2
Roswell, N. Mex.	25.7	90.9	10.8	0.3	12.4	1.7	59.4	0.3	10.4	0.5	17.8	2.8	100.0	1:0.2
Clovis, N. Mex.	17.3	72.1	11.0	0.2	8.8	1.1	55.8	0.3	16.9	0.3	18.5	1.9	100.0	1:0.2
Group II Cities														
Dallas, Tex.	538.9	47.4	25.3	34.2	31.2	37.0	33.7	25.2	22.9	13.5	12.2	109.9	100.0	1:0.9
Jacksonville, Fla.	242.9	18.2	21.1	12.2	28.3	15.0	34.9	9.4	21.8	6.5	15.0	43.1	100.0	1:0.8
Wichita, Kans.	194.0	46.4	17.0	9.6	29.1	12.9	39.1	5.7	17.3	4.8	14.5	33.0	100.0	1:0.7
Spokane, Wash.	176.0	32.6	16.0	6.5	25.2	10.5	40.6	5.4	20.8	3.5	13.4	25.9	100.0	1:0.6
Lincoln, Nebr.	99.5	20.6	19.6	7.3	37.4	8.0	41.3	2.0	10.1	2.2	11.2	19.5	100.0	1:0.9
Topeka, Kans.	89.1	16.2	15.7	4.8	34.0	5.8	41.5	1.7	12.2	1.7	12.3	14.0	100.0	1:0.8
Monroe, La.	38.6	36.3	20.0	1.7	22.8	3.3	42.3	1.4	17.8	1.3	17.1	7.7	100.0	1:0.5
Alexandria, La.	34.9	29.0	17.6	1.6	26.1	2.7	44.7	0.8	12.2	1.0	17.0	6.1	100.0	1:0.6
Walla Walla, Wash.	24.1	33.0	19.0	1.2	25.3	2.1	46.0	0.7	14.5	0.6	14.2	4.6	100.0	1:0.6
Group III Cities														
Baltimore, Md.	1,161.8	10.5	25.0	120.9	51.0	69.3	29.2	26.2	11.0	20.8	8.8	237.2	100.0	1:1.7
Seattle, Wash.	621.5	27.0	24.8	50.2	43.5	34.2	29.5	20.0	17.3	11.3	9.7	115.7	100.0	1:1.5
Portland, Oreg.	512.6	22.3	24.1	33.8	37.5	30.5	33.9	15.8	17.5	10.0	11.1	90.1	100.0	1:1.1
Memphis, Tenn.	406.0	35.2	21.1	33.2	38.7	27.6	32.3	15.1	17.6	9.7	11.4	85.6	100.0	1:1.2
Omaha, Nebr.	310.3	12.2	24.6	25.4	41.2	17.7	28.8	11.7	19.0	6.8	11.0	61.6	100.0	1:1.4
Richmond, Va.	258.0	19.3	29.3	28.0	41.5	22.2	32.8	11.0	16.2	6.4	9.5	67.6	100.0	1:1.3
Knoxville, Tenn.	148.2	11.8	26.4	19.3	49.3	11.4	29.2	4.5	11.5	3.9	10.0	39.1	100.0	1:1.7
Charlotte, N. C.	140.9	32.8	27.0	13.5	37.3	10.6	29.3	8.1	22.4	4.0	11.0	36.2	100.0	1:1.3
Portsmouth, N. H.	18.8	27.0	18.0	[2] 1.4	41.9	1.3	39.5	0.3	8.6	0.4	10.0	3.4	100.0	1:1.1
West Chester, Pa.	15.2	14.1	22.9	1.8	51.1	1.4	39.6	0.1	2.2	0.2	7.1	3.5	100.0	1:1.3
Frankfort, Ind.	15.0	9.6	16.2	1.2	48.7	1.0	41.8	0.1	3.6	0.1	5.9	2.4	100.0	1:1.2
Group IV Cities														
St. Louis, Mo.	1,400.0	5.0	36.2	173.0	55.8	67.6	21.8	45.1	14.6	24.3	7.8	310.0	100.0	1:2.6
Louisville, Ky.	472.7	15.7	28.2	55.6	53.7	24.4	23.6	13.6	13.0	10.0	9.7	103.6	100.0	1:2.3
Toledo, Ohio	364.3	7.5	36.8	59.5	61.6	22.4	23.2	8.2	8.5	6.5	6.7	96.6	100.0	1:2.7
Syracuse, N. Y.	265.3	7.1	30.2	35.3	53.0	18.1	27.3	7.6	11.4	5.5	8.3	66.5	100.0	1:2.0
Chattanooga, Tenn.	167.8	2.2	37.2	30.6	62.6	10.5	21.6	3.7	7.5	4.0	8.3	48.8	100.0	1:2.9
Allentown, Pa.	[1] 106.8	10.2	36.2	24.2	62.5	9.4	24.3	2.9	7.5	2.2	5.7	38.7	100.0	1:2.6
Lynchburg, Va.	47.7	7.2	31.9	8.8	57.8	4.0	26.1	1.1	7.3	1.3	8.8	15.2	100.0	1:2.2
Easton, Pa.	35.6	6.1	35.1	7.3	58.4	3.7	29.5	0.6	5.0	0.9	7.1	12.5	100.0	1:2.0
Huntington, Ind.	15.0	8.5	29.7	3.1	69.0	1.1	24.5	0.2	3.5	0.1	3.0	4.5	100.0	1:2.8
Group V Cities														
Cleveland, Ohio	1,383.6	4.2	38.8	223.6	63.1	68.9	19.5	36.9	10.4	24.9	7.0	354.3	100.0	1:3.2
Providence, R. I.	583.3	−1.9	16.3	61.2	64.4	19.6	20.7	8.1	8.5	6.1	6.4	95.0	100.0	1:3.1
New Haven, Conn.	244.8	2.4	22.7	33.5	60.2	11.1	20.0	6.7	12.0	4.3	7.8	55.6	100.0	1:3.0
Reading, Pa.	154.9	−1.1	26.6	27.1	65.8	9.0	21.8	2.5	6.0	2.6	6.4	41.2	100.0	1:3.0
Gary, Ind.	[1] 133.9	19.9	34.6	35.6	76.8	7.5	16.3	1.1	2.4	2.1	4.5	46.3	100.0	1:4.7
Pawtucket, R. I.	[1] 81.4	7.4	34.1	20.9	75.4	4.9	17.6	0.8	3.1	1.1	3.9	27.7	100.0	1:4.3
Anderson, Ind.	46.8	12.6	27.1	22.9	82.0	3.6	13.1	0.5	1.7	0.9	3.2	27.9	100.0	1:6.4
Kokomo, Ind.	38.7	14.4	38.0	11.1	75.5	2.7	18.2	0.4	2.6	0.5	3.7	14.7	100.0	1:4.1
Pottstown, Pa.	22.6	11.9	50.3	8.9	78.3	1.8	16.1	0.4	3.1	0.3	2.5	11.4	100.0	1:4.9
Columbus, Ind.	18.4	56.5	44.4	6.0	73.2	1.6	19.0	0.4	5.0	0.2	2.8	8.2	100.0	1:3.8
Wabash, Ind.	10.6	10.0	49.9	[3] 4.3	82.2	0.8	14.6	0.1	2.0	0.1	1.2	5.3	100.0	1:5.4
Seymour, Ind.	9.6	11.7	46.7	3.3	73.9	0.9	20.0	0.1	2.8	0.1	3.3	4.4	100.0	1:3.7
Decatur, Ind.	7.3	24.1	44.1	2.5	76.9	0.5	16.8	0.1	4.1	0.1	2.2	3.2	100.0	1:5.0
Cities not Readily Classified by Groups														
Harrisburg, Pa.	169.6	6.7	14.6	8.7	35.1	9.2	37.2	4.1	16.6	2.7	11.1	24.7	100.0	1:0.9
Evansville, Ind.	137.6	32.5	29.1	25.2	63.0	8.8	21.9	3.3	8.2	2.8	6.9	40.1	100.0	1:2.9
Norristown, Pa.	38.1	−0.1	19.8	4.1	54.9	2.5	32.7	0.4	5.3	0.5	7.1	7.5	100.0	1:1.6
Uniontown, Pa.	20.5	0.3	32.5	2.1	31.6	3.3	48.5	0.7	10.8	0.6	9.1	6.7	100.0	1:0.6
Anderson, S. C.	19.8	1.8	27.1	2.4	44.5	2.2	40.6	0.3	5.9	0.5	9.0	5.4	100.0	1:1.1
Meadville, Pa.	19.0	−6.2	20.5	1.4	36.9	1.9	47.9	0.2	4.4	0.4	10.8	3.9	100.0	1:0.7
Martinsville, Va.	17.2	71.1	24.7	2.6	59.5	1.2	28.6	0.1	3.2	0.4	8.7	4.3	100.0	1:2.2
Stevens Point, Wis.	16.6	5.0	20.3	1.7	49.9	1.1	31.4	0.3	9.6	0.3	9.1	3.4	100.0	1:1.5
Summary														
Group I		81.1	15.2	1.7	12.6	6.1	51.4	2.0	15.6	2.5	20.4	12.3	100.0	1:0.2
Group II		31.1	19.0	8.8	28.8	10.8	40.5	5.8	16.6	3.9	14.1	29.3	100.0	1:0.7
Group III		20.2	23.6	29.9	43.8	20.6	33.3	10.3	13.3	6.7	9.6	67.5	100.0	1:1.3
Group IV		7.7	33.5	44.2	59.4	17.9	24.6	9.2	8.7	6.1	7.3	77.4	100.0	1:2.5
Group V		13.2	36.4	35.5	72.9	10.2	18.0	4.5	4.9	3.3	4.2	53.5	100.0	1:4.2

[1] City population only.

[2] Modified to include an estimate for employment in nearby U. S. Navy Yard.

[3] County figure. Urban place employment volume is not available.

Employment per 100 population varies from 10.8 to 24.9 and averages 15.2. This group also includes the fastest growing cities of all the cities studied. Population increase during the 1940–50 period averaged 81.1 percent (table 2).

Economic activity in this group of cities is dominantly in retail trade with a much larger proportion of employment (20.4 percent) in service trades—hotels, service stations, amusements, and laundries, cleaning, and clothes repair establishments—than in the average city which is seldom more than 12 percent. This high percentage is an indication of resort centers and higher than average auto usage which is synonymous with resorts. Six of these eight cities are located in such areas.

Group II Cities

Retail trade is dominant in the economy of the cities in this group but more diversification in employment is evidenced. Employment in retail trade is slightly greater than in manufacturing. Employment in manufacturing exceeds 20 percent. Employment in both retail trade and manufacturing comprises about two-thirds of all employment covered by the censuses. Employment in service trades is 14.1 percent, only a little more than the average of all 58 cities. The retail trade-manufacturing employment ratio ranges from 1:0.5 to 1:0.9. Employment per 100 population varies from 15.7 to 25.3 with an average of 19.0.

Population increase averages 31.1 percent for the 10-year period 1940–50 with the newer cities showing more increase than the cities which were well established before the advent of the automobile.

Group III Cities

Economic activity in this group of cities may be considered to be nearly balanced, at least with respect to employment in retail trade and in manufacturing. Employment in manufacturing is the greater of the two but less than 50 percent of the total. The retail trade-manufacturing employment ratio ranges from 1:1.1 to 1:1.7 with an average of 1:1.3. Employment per 100 population varies from 16.2 to 29.3 and averages 23.6. Employment in service trades is generally 11 percent or less.

Population increase averaged 20.2 percent during the 1940–50 period. Here again may be noted the differences in pattern of cities which have experienced the greater portion of their growth since the advent of the automobile, and those which were fully developed as cities before the automobile became a means of transportation.

Group IV Cities

Economic activity in these cities is dominantly in manufacturing, although employment in retail trade represents nearly one-third of the employment in some instances. The retail trade-manufacturing employment ratio ranges from 1:2.0 to 1:2.9, and averages 1:2.5 for the group as a whole. Employment in retail trade is more than 20 percent. Employment per 100 population varies from 28.2 to 37.2 and averages 33.5. Employment in service trades is low, 7.3 percent of all employment.

Population increase in this group, on the average, is less than that in the first three groups and averages 7.7 percent for the group as a whole. This is somewhat less than the average for all cities in the country. No "new" cities are represented in this group. All were established urban communities before the development of the automobile, although all have shown some growth during this period.

Group V Cities

The economic activity in this group of cities is dominantly industrial in character, as is indicated by the relatively high proportion of employment in manufacturing in comparison with that in retail trade. The retail trade-manufacturing employment ratio ranges from 1:3.0 to 1:6.4 and averages 1:4.2. Employment per 100 population varies from a low of 16.3 to a high of 50.3 and averages 36.4. Employment in service trades is low, averaging 4.2 percent of all employment.

Rank-size Rule

After having established these groupings of cities by recognizing differences in certain economic characteristics, it should be possible to determine whether the relative amount of parking differs for these different groups; and if so, how it differs, and if these differences can be estimated.

The rank-size rule suggests one method for making such a determination. Economists for many years have recognized an empirical relation which exists in the distribution of urban population in large continental areas.[4] It was first recognized in Europe where it appeared that the economy of cities was somehow interconnected in spite of national boundaries. Regardless of change in population over the years, if all cities are arranged in order of population for any census period, the ratio of the population of any one city to the population of the largest city is approximately the same as its rank.

The rank-size rule means that the 10th largest city is about one-tenth the size of the largest city, and the 100th largest city, one-hundredth the size of the largest city. In the United States, for example, the urbanized area of New York has a population of 12.30 million persons. According to this theory the 10th largest city should have a population of about 1.23 million. Actually Cleveland, the 10th largest urbanized area, had a population of 1.38 million persons in 1950. The 100th largest city, the Bristol-New Britain urbanized area in Connecticut, had a population of 123,079, almost exactly one-hundredth the size of New York.

This relation[5] has been stated as $r.P^q = K$ where r = rank of a particular city in population.

P = population of the particular city.

q = constant (in the United States = 1 approximately).

K = constant for largest city population in the group (in the United States this would be New York where $r = 1$).

[4] Christaller, Loesch, Stouffer, Zipf, Isard, among others.

[5] Quarterly Journal of Economics, Harvard University, May 1951.

With the population of an individual city so closely determined by its rank in relation to all cities, it would appear reasonable to assume that the economy of each city might also have some similar relation to that of the other cities, and further that communication and transportation might also reflect some relation to this economic activity in the interchange of goods and persons. Inasmuch as the stores and office buildings where much of this interchange takes place are usually clustered in the downtown area of most cities, it is reasonable to study those factors which are centered there or which are dependent on that area as a center of a much larger trading area.

Factors Used in Ranking

These 58 cities were ranked in four different ways: (1) in order of urban population, (2) in order of volume of retail sales of general merchandise, apparel, and furniture (G.A.F. sales), (3) in order of employment in manufacturing, and (4) in order of number of parkers. These are detailed in table 3. Other factors involving employment in retail trade, motor-vehicle ownership, and gasoline service station sales were also tested, but were discarded since it appeared that they duplicated one of the other rankings or were incomplete for some of the cities.

The purpose of making these rankings is to determine if similar proportional relations might exist with respect to parking volumes as exist with respect to population, or if some patterns in ranked position might be typical of certain economic characteristics.

Information for establishing proportional relations with respect to parking volumes proved to be inadequate because the largest parking volume and the city having the largest parking volume are unknown, and because 58 studies are too few to establish a ranking representative of all cities in the United States. Fifty-eight cities represent but 2.4 percent of all cities of 5,000 population or more.

When the rankings of these factors for each city were compared, five fairly distinct patterns were apparent if the pattern with respect to parking is omitted. Examination of the cities in each of these five patterns revealed the fact that, with but a few exceptions, the cities were the same as those grouped according to similarity of economic factors. Accordingly, a pattern representing the averaged ranked positions for each group was developed as being characteristic of that group. Of the remaining eight cities four have patterns similar to one of the five ranked patterns, but not having economic characteristics classifiable in the five groups, they have been omitted from further comparisons. The remaining four have some eccentricity which does not seem to fit any of the five patterns. After having recognized these general patterns, the ranked characteristics of the factors including parking are discussed for each of the economic groups.

Group I Cities

The characteristic pattern of the rankings of the four factors in the eight cities in group I finds the ranked position of urban population and G.A.F. sales almost the same, employment in

Table 3.—Ranked position with respect to urban population, G.A.F. sales, employment in manufacturing, and parking in 58 cities in which comparable studies have been made

City and State	Ranked position in—			
	Urbanized area population	G.A.F. retail sales	Employment in manufacturing	Number of parkers
St. Louis, Mo.	1	3	2	1
Cleveland, Ohio	2	1	1	2
Baltimore, Md.	3	2	3	8
Seattle, Wash.	4	5	7	6
Providence, R. I.	5	12	4	18
Dallas, Tex.	6	4	10	3
Portland, Oreg.	7	6	11	4
Louisville, Ky.	8	8	6	9
Miami, Fla.	9	11	32	7
Memphis, Tenn.	10	7	13	17
Toledo, Ohio	11	9	5	11
Omaha, Nebr.	12	13	17	14
Syracuse, N. Y.	13	14	9	19
Richmond, Va.	14	10	15	10
New Haven, Conn.	15	16	12	28
Jacksonville, Fla.	16	15	24	12
Wichita, Kans.	17	18	26	5
Spokane, Wash.	18	19	33	16
Harrisburg, Pa.	19	21	29	26
Chattanooga, Tenn.	20	23	14	24
Reading, Pa.	21	24	16	29
Knoxville, Tenn.	22	17	22	37
Charlotte, N. C.	23	22	23	21
Evansville, Ind.	24	26	18	20
Gary, Ind.	25	25	8	32
Corpus Christi, Tex.	26	28	40	27
Allentown, Pa.	27	20	19	30
Lincoln, Nebr.	28	27	30	15
Albuquerque, N. Mex.	29	29	49	22
Topeka, Kans.	30	30	35	13
Pawtucket, R. I.	31	31	21	40
Lynchburg, Va.	32	37	28	31
Anderson, Ind.	33	38	20	49
Lake Charles, La.	34	41	55	44
Kokomo, Ind.	35	42	25	46
Monroe, La.	36	34	45	45
Norristown, Pa.	37	40	37	38
Easton, Pa.	38	32	31	34
Alexandria, La.	39	39	48	47
Boise, Idaho	40	33	54	25
Reno, Nev.	41	36	56	23
Roswell, N. Mex.	42	47	57	33
Walla Walla, Wash.	43	44	52	41
Pottstown, Pa.	44	45	27	39
Uniontown, Pa.	45	35	44	35
Anderson, S. C.	46	43	43	36
Meadville, Pa.	47	46	50	43
Portsmouth, N. H.	48	53	51	56
Columbus, Ind.	49	51	34	48
Clovis, N. Mex.	50	52	58	42
Martinsville, Va.	51	48	41	54
Stevens Point, Wis.	52	50	47	53
West Chester, Pa.	53	49	46	50
Huntington, Ind.	54	54	39	51
Frankfort, Ind.	55	55	53	55
Wabash, Ind.	56	57	36	52
Seymour, Ind.	57	56	38	57
Decatur, Ind.	58	58	42	58

manufacturing considerably lower, and parking in a higher ranking position. For the group as a whole, the average city ranks about 17 places lower in employment in manufacturing than in population, while parking ranks 8 places higher than population (fig. 1). These differentials are not so great in the larger cities probably for the reason that fewer cities are represented in the upper range of values, and hence there is less change in ranked position. The patterns with relation to employment in manufacturing, population, and G.A.F. sales are nearly all similar.

Relatively low income and consequently low motor-vehicle ownership, travel, and hence parking may be the influence which positions parking in Lake Charles in an opposite direction from that of other cities in this group. The ranked position of parking for Corpus Christi is not as high relatively as for the other cities in this group. It is a resort city but the 1:0.4 retail trade-manufacturing ratio is lower than the average for the group (table 3).

Group II Cities

The characteristic pattern of the rankings of the four factors for the nine cities in group II shows a similarity to group I, but with less differentials in rank between employment in manufacturing, parking, population, and G.A.F. sales. The average city in this group ranks about eight places lower in employment in manufacturing than in population, and about the same amount higher in parking (fig. 1). The patterns of the three economic factors other than parking are similar.

The rank of parking in Wichita, Lincoln, and Topeka with respect to population is greater than in other cities in this group—almost as much as for group I cities. These three cities have relatively wide streets and, with angle parking permitted at some curbs, have larger numbers of curb spaces available than in the average city. Lincoln and Topeka are both centers of government employment which is not included in the computation of employment ratios. With many government employees parking in the downtown area twice a day as they do in the cities of this size — going home for lunch — the number of parkers is duplicated to some extent. This could account for the increased rank position of these cities with respect to parking (table 3).

The ranked position of parking in Alexandria and Monroe, La., is lower than for other cities in this group. Low parking with respect to population and G.A.F. sales is characteristic of cities where the economy is dominated by manufacturing, but this is not the case in these two cities. It appears as in the case of Lake Charles that for the city as a whole, they are low income cities which means low purchasing power, low car ownership, and hence, low parking volumes.

Group III Cities

The characteristic pattern of the rankings of the four factors for 11 cities in group III shows the rankings to be approximately the same for all factors. There is a tendency for the differential in ranking to be less in the larger cities as in the other groups. For the group as a whole, there is less than one position variation in rank in any one of the factors with relation to any of the other factors (fig. 1). A spread of five or six positions between high and low rankings for the four factors is not significantly different for individual cities, particularly in the smaller cities where six cities lie between the 50th and 55th positions inclusive for population with a variation between 15,000 and 17,300 persons (table 3).

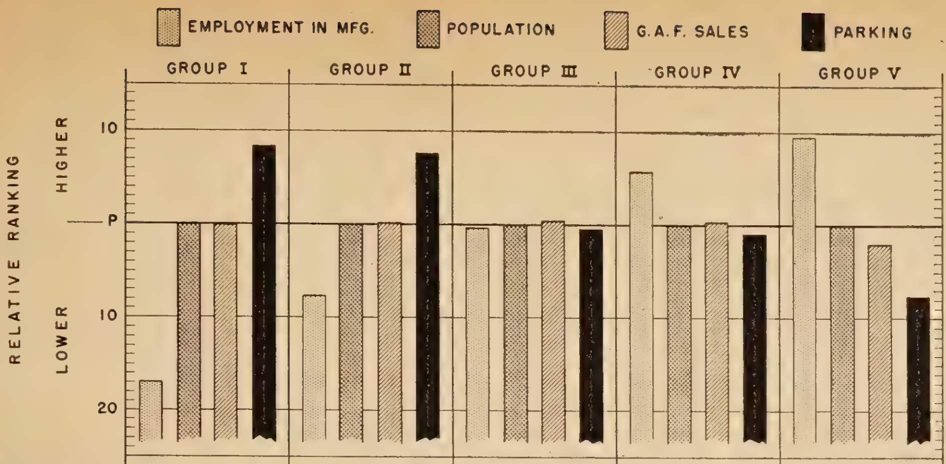
The ranked position of parking in Memphis, Baltimore, and Knoxville is somewhat less than for the group as a whole. In these cities, as in the three Louisiana cities, the proportion of nonwhite population is large, the purchasing power less than average, and hence automobile ownership and parking could be expected to be less, but all of the cities in this group have similar patterns with relation to employment in manufacturing, population, and G.A.F. sales.

Group IV Cities

The characteristic pattern of the rankings of the four factors for the nine cities in this group shows no appreciable difference as far as population, G.A.F. sales, and parking is concerned. Ranking with respect to employment in manufacturing for the group as a whole is about six positions higher than for other factors. The reason for the upswing in ranked positions for parking in Lynchburg is not apparent. It has similar patterns of rank with respect to the other three factors.

Group V Cities

The characteristic pattern of the rankings of the four factors for the 13 cities in this group shows a reversal in position with respect to the cities in group I. Generally speaking, the cities



	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V
NUMBER OF CITIES	8	9	11	9	13
RETAIL TRADE MFG. EMPLOYMENT RATIO	1:0.2	1:0.7	1:1.3	1:2.5	1:4.2
EMPLOYMENT PER 100 POPULATION	15.2	19.0	23.6	33.5	36.4
POPULATION INCREASE 1940-1950	81.1%	31.1%	20.2%	7.7%	13.2%
PERCENT EMPLOYMENT IN SERVICE TRADE	20.4%	14.1%	9.6%	7.3%	4.2%

Figure 1.—Relative rank of parking, employment in manufacturing, and G.A.F. sales with respect to population in five groups of cities in which comparable parking studies have been made.

in this group rank higher by about 12 positions in manufacturing than in population. Ranking in G.A.F. retail sales is about three positions lower than population, and parking is about five positions lower than that (fig. 1). Here again the differential in ranking is less in larger cities.

The patterns of the ranked positions of Pottstown, Pa., and Columbus and Wabash, Ind., show a relative higher ranking for parking than for the group as a whole. The actual differences in rank for these cities represent relatively small volumes of parkers. Pottstown, for example, although ranked 39th in parking with 10,600 parkers, is less than 10 percent greater than the 45th city having 9,600 parkers.

Where a given city in group I has a ranked position with respect to population of P, it will generally have a ranked position with respect to parking of $P - 8.3$ although some judgment should be used when the cities under consideration are at the extreme ends of the rankings (table 4). This is shown graphically in figure 1.

If the groupings which have been established were based only on rank-size patterns, Norristown, Pa., Martinsville, Va., Stevens Point, Wis., and Meadville, Pa., would also be included in one of the groups. Ranked position of the remaining four cities do not seem to fit any of the five patterns, nor are there enough studies involving patterns of their type to suggest more than five patterns of rank-size characteristics. Reasons for their eccentricities are not apparent.

Consideration of these rank-size patterns seems to confirm the groupings of cities made on a basis of economic classification and to indicate that with known ranked positions of population, G.A.F. sales, and employment in manufacturing, a definite relative ranked position in parking can be expected to follow. Further, it appears that with known parking volumes for each rank (fig. 2), the volume of parking can be estimated for cities in which parking studies have not yet been made, but which can be properly grouped by use of the economic factors.

G.A.F. Sales, Population, and Parking

The second approach to this study is the relation of G.A.F. sales, population, and parking.[6] Kenneth C. Welch, vice president of the Grand Rapids Store Equipment Co., has studied the records of the Comptroller's Congress and of other agencies summarizing data relative to retail sales over a period of more than 20 years. As a result of these studies, a relation was developed between parking area requirements and the retail sales dollar. When this subject was presented, hope was expressed that this relation could be given further study under a wider range of conditions and with more data. The completion of reports on parking studies in more than 50 cities provides quantitative information about parking volumes for the central business district. The census of business for 1948 provides information on the volume of retail sales in each city. Some of this volume accrues to stores which are not necessarily part of the downtown area and in many instances are not. Examples are food, lumber, gasoline service stations, and drug stores. Sales of general merchandise, apparel, and furniture, appliances and furnishings (G.A.F. sales) are generally downtown functions.

In this article it has been assumed that they are a measure of the retail sales in the entire downtown area. There are other functions in the downtown area which attract traffic and persons such as recreational facilities, professional services, etc., but from many points of view the downtown area may be considered as one big department store with the many auxiliary services needed to support the economy of the trading area of that big store. The underlying principle of this assumption is that parking requirements of a community are more closely allied to the volume of retail business than they are to any other single factor.

The thought inherent in this basis for estimating parking needs is that retail sales is a source of data that, when analyzed, provides a community with a true picture of parking requirements and not merely a picture of an existing parking pattern. This could be applied to the needs of large individual retail units or a group of units comprising even the entire central business district. In most cities of the size under consideration, retail sales of general merchandise, apparel, and furniture and furnishings (G.A.F. sales) are a central business district function. Other retail sales are generally in "convenience" locations near consumer residences or near railroad stations or sidings for bulky merchandise.

There are some nonretail land and structural uses in most central business districts, but the

[6] See footnote 3, p. 249.

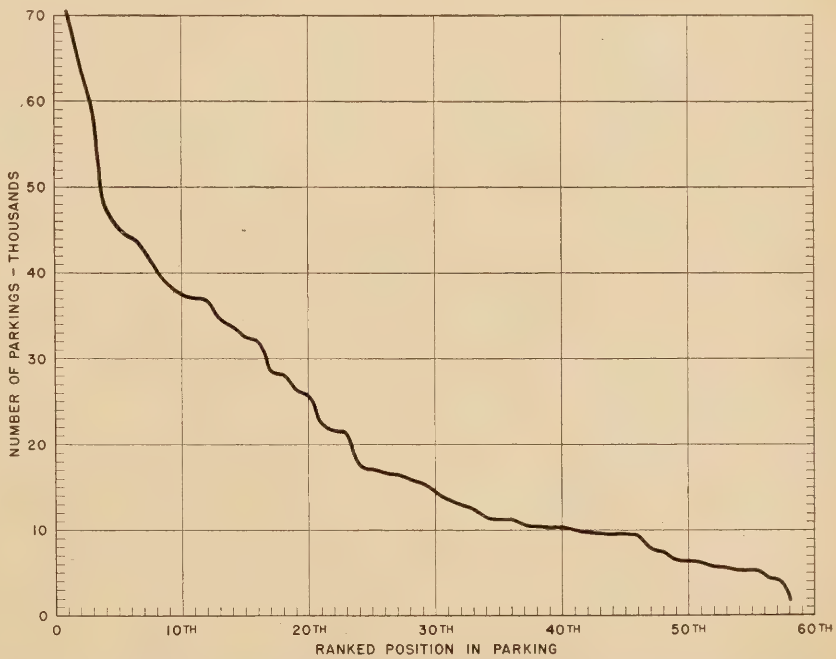


Figure 2.—Number of parkings and ranked position with respect to number of parkings in 58 cities in which comparable parking studies have been made.

Table 4.—Ranked position with respect to urban population, G.A.F. retail sales, employment in manufacturing, and parking in 58 cities in which comparable studies have been made

City and State	Ranked position [1] in—			
	Urbanized area population	G.A.F. retail sales	Employment in manufacturing	Numbers of parkers
Group I				
Miami, Fla.	9	11	32	7
Corpus Christi, Tex.	26	28	40	27
Albuquerque, N. Mex.	29	29	49	22
Lake Charles, La.	(34)	(41)	(55)	(44)
Boise, Idaho	40	33	54	25
Reno, Nev.	41	36	56	23
Roswell, N. Mex.	42	47	57	33
Clovis, N. Mex.	50	52	58	42
Group II				
Dallas, Tex.	6	4	10	3
Jacksonville, Fla.	16	15	24	12
Wichita, Kans.	17	18	26	5
Spokane, Wash.	18	19	33	16
Lincoln, Nebr.	28	27	30	15
Topeka, Kans.	30	30	35	13
Monroe, La.	(36)	(34)	(45)	(45)
Alexandria, La.	(39)	(39)	(48)	(47)
Walla Walla, Wash.	43	44	52	41
Group III				
Baltimore, Md.	3	2	3	8
Seattle, Wash.	4	5	7	6
Portland, Oreg.	7	6	11	4
Memphis, Tenn.	(10)	(7)	(13)	(17)
Omaha, Nebr.	12	13	17	14
Richmond, Va.	14	10	15	10
Knoxville, Tenn.	(22)	(17)	(22)	(37)
Charlotte, N. C.	23	22	23	21
Portsmouth, N. H.	48	53	51	56
West Chester, Pa.	53	49	46	50
Frankfort, Ind.	55	55	53	55
Group IV				
St. Louis, Mo.	1	3	2	1
Louisville, Ky.	8	8	6	9
Toledo, Ohio	11	9	5	11
Syracuse, N. Y.	13	14	9	19
Chattanooga, Tenn.	20	23	14	24
Allentown, Pa.	27	20	19	30
Lynchburg, Va.	(32)	(37)	(28)	(31)
Easton, Pa.	38	32	31	34
Huntington, Ind.	54	54	39	51
Group V				
Cleveland, Ohio	2	1	1	2
Providence, R. I.	5	12	4	18
New Haven, Conn.	15	16	12	28
Reading, Pa.	21	24	16	29
Gary, Ind.	25	25	8	32
Pawtucket, R. I.	31	31	21	40
Anderson, Ind.	33	38	20	49
Kokomo, Ind.	35	42	25	46
Pottstown, Pa.	(44)	(45)	(27)	(39)
Columbus, Ind.	(49)	(51)	(34)	(48)
Wabash, Ind.	(56)	(57)	(36)	(52)
Seymour, Ind.	57	56	38	57
Decatur, Ind.	58	58	42	58
Cities not Readily Classified				
Harrisburg, Pa.	19	21	29	26
Evansville, Ind.	24	26	18	20
Norristown, Pa.[2]	37	40	37	38
Uniontown, Pa.	45	35	44	35
Anderson, S. C.	46	43	43	36
Meadville, Pa.[2]	47	46	50	43
Martinsville, Va.[2]	51	48	41	54
Stevens Point, Wis.[2]	52	50	47	53
Relative Rank with Respect to Population				
Group I	P	P—0.1	P+16.7	P—8.3
Group II	P	P—0.1	P+ 7.6	P—7.6
Group III	P	P—0.4	P+ 0.6	P+0.5
Group IV	P	P+1.1	P— 6.1	P+1.0
Group V	P	P+2.1	P— 9.5	P+7.7

[1] Figures in parentheses were not used in determination of average relative rank.
[2] Classifiable with respect to rank position but not by employment ratios and population increase.

bulk of the total parking space requirements for the central business district are those required for retail sales and professional offices. Remaining uses are not major factors affecting the "total space requirements" for the entire district. Existing land-use patterns demonstrate that as much as 45 percent of the offstreet property is devoted to retail sales purposes, and on an area basis including upper floors an even greater proportion is so used. The use of gross sales to reflect parking requirements is thus suggested as a basis for estimate.

The development of this basis for estimating parking needs recognizes that the extremely large cities, those of a million population or more and even perhaps a few nearing that size, cannot possibly solve the problem at the present time under existing urban land patterns. But in cities ranging up to one-quarter or one-half million people, the size and proportions of the central business district area remain in a functional character in a limited area, and are not too large in relation to the parking problem to be solved. There are in the central business districts of these cities extensive areas of land lying in the submarginal areas commonly called blighted commercial land. These areas present an excellent opportunity for providing parking as well as recovering some lost tax values.

Classification of Retail Trade

The Bureau of the Census in its census of business classifies retail trade in three business groups: convenience goods, shopping goods, and all others.

Convenience goods include foods, drugs, general stores, and gasoline service stations comprising 36.5 percent of all retail sales, but which are bought near home and except in very small cities are not in the central business district.

Shopping goods include general merchandise, apparel, and furniture, the G.A.F. group amounting to 25.3 percent of all retail sales and are predominantly found in the downtown areas.

All other groups include automobile, lumber, fuel, eating and drinking, and other stores amounting to 38.2 percent of all retail sales. Automobile sales, although at one time in downtown areas, are now generally located on "automobile row" where land values are cheaper and where more space is available for display and garage facilities. Lumber and fuel are usually sold from areas near railroad sidings where land values are cheaper than in the downtown area, and where appearance is not a factor in the esthetic value of the neighborhood. Eating and drinking places, even if downtown, do not add much to parking requirements during the business day since patrons are generally downtown for other reasons such as work or shopping. In the evening parking requirements are normally less and adequate space is then available.

By recognizing that certain retail business establishments are usually grouped in the central business district, it is possible to use 1948 census figures on gross sales and make estimates for problem areas to the extent that the statistics are in common for the area.

Other references are made as to uses made of these same census statistics such as those of

Homer Hoyt in his paper presented at the January 1952 meeting of the Highway Research Board. Sears, Roebuck and Co. has used annual retail sales of $10,000 per car space as a criterion for planning their parking space needs. Supermarkets have used $15,000 per car space, a larger figure than Sears, Roebuck and Co. since the time per sales transaction is not so long.

The relation of urbanized area population and the number of parkers per million dollars of G.A.F. sales is shown graphically in figure 3, while supporting data for each of the 58 cities studied are included in table 5. At first glance it appears that there is a wide range of values obtained, and this is true if no further consideration is given to differences in the economy of individual cities. The nature of dominant employment in cities is an indication of the economy of each city, and statistics are available from census sources classifying employment as to manufacturing, retail business, wholesale business, and service trades.

When the averages are used for each of the conventional census population groups, the average curve clearly indicates that a definite relation exists between parking, G.A.F. sales, and population (figure 3). It should be noted that all of the cities in economic groups I and II with but two exceptions, Monroe and Alexandria, La., are on the average curve or above it, and the curve for these retail cities has been drawn to indicate a reasonable upper limit to be expected for cities within the range of those in these studies.

It appears that cities dominant in industry, groups IV and V, are generally below the average curve, and the industrial curve has been drawn as a reasonable lower limit for cities within the range of those in these studies. Group III cities are generally closer to the average.

Here again it would appear that knowing certain economic characteristics of a city such as population, and dominance in industry or retail trade, it should be possible to estimate parking volumes for a given city by determining the group of cities in which the particular city falls, and assuming that the relation between parking and G.A.F. sales also holds.

Statistical Evaluation

The facts with respect to population, employment, sales, and parking in the discussion on economic groupings of cities on rank-size and on G.A.F. sales seem to indicate that parking volumes bear some relation to the basic economy of urban areas. The third approach in this analysis was to make a statistical evaluation of whatever relation these factors might have, so that some assurance might be placed on estimates of the parking volumes as being within reasonable limits.

Before proceeding with the development of an equation, assurance has to be obtained that a definite relation exists between the particular data, in this case parking volumes, and the independent variables and the extent of this relation measured. By using the multiple regression method,[7] it is possible to measure the degree of reliability of an estimate derived from an equation based upon the interrelation of one series of data (parking volumes) and independent variables or factors.

Factors Studied

Seventeen factors were tested in 31 different combinations. The maximum number of factors used in any combination was four and many combinations were not tested. Several of the factors were closely related with each other such as population, G.A.F. sales, gasoline filling station sales, and the number of employees in retail and wholesale trade. The use of any one of these factors in an equation duplicated to a large extent the use of the others in this group. Factors tested in relation to parking volumes are as follows:

1. 1950 urban area population.
2. Percent of employees in manufacturing.
3. Percent of employees in retail trade.
4. Area of central business district.
5. G.A.F. retail sales.
6. Rural population per square mile.
7. 1950 county registration of vehicles.
8. G.A.F. sales per capita.
9. Gasoline service station sales.
10. Number of employees in retail trade.
11. Number of employees in retail and service trades.
12. Number of employees in retail, wholesale, and service trades.
13. Number of parking spaces.
14. Area of urbanized area.
15. Inbound cordon count of vehicles, 10 a.m.–6 p.m.
16. Curb parking spaces.
17. Percent of all parking spaces at the curb.

A considerable range is represented in the 58 cities in which comparable parking studies have been made. Not only are cities ranging in population from 7,300 to 1,400,000 represented, but different areas of the country are included. Some of the tests were limited to groups of the 58 cities in an effort to stabilize the test within specific groups if it were possible to do so. Groups of cities in which tests were made are as follows:

1. All 58 cities.
2. 27 cities under 50,000 inhabitants.
3. 23 cities of 100,000 inhabitants or more.
4. 13 cities in northeastern U. S.
5. 16 cities in north central U. S.
6. 29 cities in northeast and north central U.S.

Reliability of Estimate

The best adjusted standard error obtained indicated unsatisfactory results (—37 to +59 percent) for all 58 cities regardless of factors used (table 6). Only slightly better results were obtained for the group of cities of 100,000 inhabitants and over (—29 to +41 percent). Best results were obtained when only the 27 cities under 50,000 inhabitants were used.

Trial and elimination of factors indicated that this was the best grouping of cities, and that (1) the cordon count of inbound traffic, 10 a.m. to 6 p.m., (2) total number of parking spaces in the central business district, and (3) number of employees in retail and service trades produced the most satisfactory adjusted standard error (—16 to +19 percent). This means that an equation using these three variables will have about two chances out of three of being within the range of —16 to +19 percent of the parking volume determined from actual field observations.

Factors showing the closest relation to parking volume were found to be:

1. Total number of available parking spaces in the central business district.

[7] *Methods of correlation analysis* by Mordecai Ezekiel, John Wiley & Sons, Inc., New York, 1930, chs. 12–13.

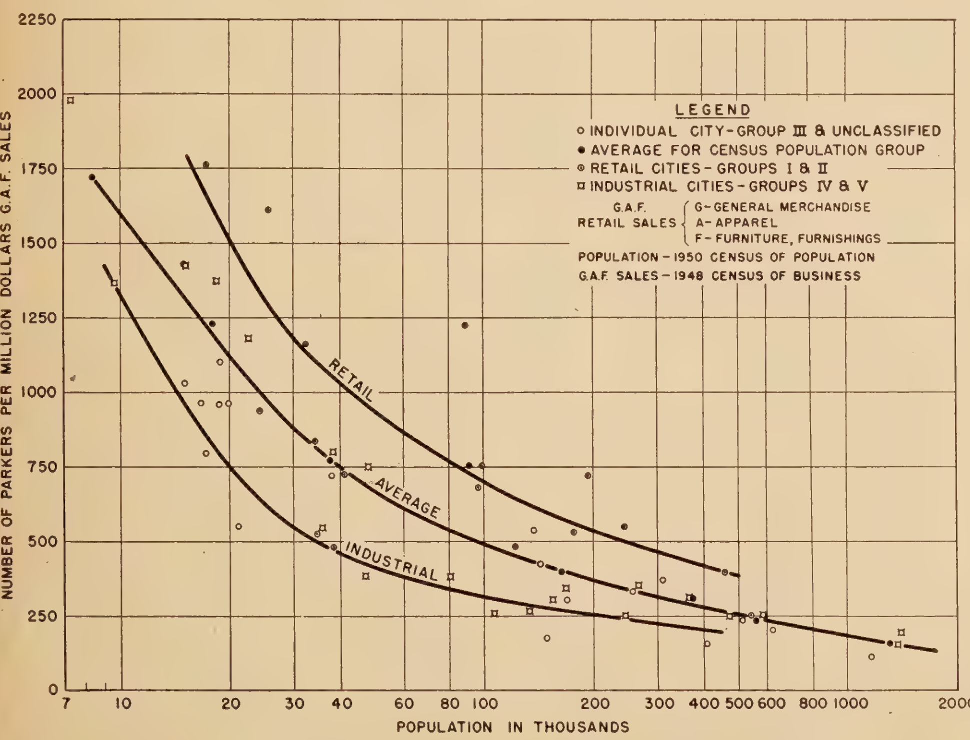


Figure 3.—Relation between urban population and the number of parkers per million dollars of G.A.F. retail sales.

2. Inbound vehicle cordon count 10 a.m. to 6 p.m.
3. Number of employees in retail and service trades.
4. G.A.F. sales.
5. Gasoline service station sales.
6. Urban area population.

Although a significant relation seems to exist between the parking demand and most of the factors tested, as is indicated by the standard error, nevertheless the variation in the original set of data cannot be entirely explained by these factors alone. It is apparent that factors other than those tested also influence parking volumes found in the central business district. Data for these other factors such as use of mass transit facilities to the central business district, proximity to other cities, and volume of parking in neighborhood and suburban shopping centers are not so generally available, cannot be measured in quantitative manner, or cannot be obtained from other sources.

Census information for dollar volume of retail sales and employment are available only for the entire urban area which is not, of course, an exact measurement of activity of the central business district. Then, too, data which have been used do not represent the same time periods. Census years are spread from 1947 for census of manufactures, 1948 for census of business, to 1950 for the census of population, and the parking studies were made between 1945 and 1952. Such disparity in time periods can scarcely be avoided under present conditions, since no other data are available having common base years.

Table 5.—G.A.F. sales and parking volumes in 58 cities in which comparable parking studies have been made

City and State	Urbanized area population	Volume of retail sales			Number of parkers [1]	
		Total	G.A.F.	Percent of total	Total	Per million dollars of G.A.F. sales
	Thousands	*Millions*	*Millions*	*Percent*	*Thousands*	
St. Louis, Mo.	1,400.0	$987.7	$357.5	36.2	70.5	197
Cleveland, Ohio	1,383.6	1,178.2	390.1	33.1	64.7	166
Baltimore, Md.	1,161.8	1,052.9	369.7	35.1	40.7	110
Seattle, Wash.	621.5	613.7	212.2	34.6	44.3	209
Providence, R. I.	583.3	328.4	109.6	33.4	28.2	257
Dallas, Texas	538.9	621.9	234.0	37.6	59.2	253
Portland, Oreg.	512.6	574.8	200.2	34.8	47.4	237
Louisville, Ky.	472.7	411.1	130.0	31.6	38.8	298
Miami, Fla.	458.6	388.3	110.9	28.6	44.1	398
Memphis, Tenn.	406.0	461.8	179.9	39.0	28.6	159
Toledo, Ohio	364.3	393.6	118.1	30.0	37.1	314
Omaha, Nebr.	310.3	308.5	90.8	29.4	33.8	372
Syracuse, N. Y.	265.3	290.2	90.2	31.1	26.4	351
Richmond, Va.	258.0	319.5	112.1	35.1	37.8	337
New Haven, Conn.	244.8	206.0	63.5	30.8	15.9	250
Jacksonville, Fla.	242.9	247.8	67.6	27.3	37.0	547
Wichita, Kans.	194.0	201.6	61.5	30.5	44.5	724
Spokane, Wash.	176.0	198.0	60.0	30.3	32.7	545
Harrisburg, Pa.	169.6	140.8	54.0	38.4	16.9	313
Chattanooga, Tenn.	167.8	167.0	50.9	30.5	17.7	348
Reading, Pa.	154.9	140.0	50.8	36.3	15.8	311
Knoxville, Tenn.	148.2	174.8	61.6	35.2	10.7	174
Charlotte, N. C.	140.9	169.7	53.6	31.6	22.6	422
Evansville, Ind.	137.6	139.3	48.1	34.5	25.9	538
Gary, Ind.	133.9	140.4	48.3	34.4	13.0	269
Corpus Christi, Tex.	122.9	123.2	34.5	28.0	16.6	481
Allentown, Pa.	106.8	142.1	55.6	39.1	14.6	263
Lincoln, Nebr.	99.5	118.0	42.9	36.4	32.7	762
Albuquerque, N. Mex.	96.8	114.9	32.2	28.0	21.8	677
Topeka, Kans.	89.1	92.0	28.4	30.9	34.9	1,229
Pawtucket, R. I.	81.4	89.6	26.9	30.0	10.2	379
Lynchburg, Va.	47.7	60.1	18.0	30.0	13.5	750
Anderson, Ind.	46.8	61.3	17.6	28.7	6.7	381
Lake Charles, La.	41.3	44.6	13.4	30.0	9.7	724
Kokomo, Ind.	38.7	44.5	11.9	26.7	9.5	798
Monroe, La.	38.6	62.7	20.1	32.1	9.6	478
Norristown, Pa.	38.1	43.9	14.8	33.7	10.7	723
Easton, Pa.	35.6	58.2	21.4	36.8	11.7	547
Alexandria, La.	34.9	46.8	15.2	32.5	7.9	520
Boise, Idaho	34.4	65.6	20.6	31.4	17.1	830
Reno, Nev.	32.5	71.9	18.5	25.7	21.5	1,162
Roswell, N. Mex.	25.7	32.0	7.7	24.1	12.4	1,610
Walla Walla, Wash.	24.1	41.4	10.6	25.6	10.0	943
Pottstown, Pa.	22.6	33.7	9.0	26.7	10.6	1,178
Uniontown, Pa.	20.5	54.7	19.1	34.9	11.4	597
Anderson, S. C.	19.8	34.6	11.7	33.8	11.3	966
Meadville, Pa.	19.0	33.4	8.9	26.6	9.8	1,101
Portsmouth, N. H.	18.8	23.2	5.0	21.6	4.8	960
Columbus, Ind.	18.4	23.6	5.6	23.7	7.7	1,375
Clovis, N. Mex.	17.3	24.2	5.6	23.1	9.9	1,768
Martinsville, Va.	17.2	21.4	6.7	31.3	5.3	791
Stevens Point, Wis.	16.6	18.4	5.8	31.5	5.6	966
West Chester, Pa.	15.2	29.0	6.3	21.7	6.5	1,032
Huntington, Ind.	15.0	19.7	4.4	22.3	6.3	1,432
Frankfort, Ind.	15.0	19.8	3.7	18.7	5.3	1,445
Wabash, Ind.	10.6	13.1	2.2	16.8	5.8	2,636
Seymour, Ind.	9.6	15.6	3.0	19.2	4.1	1,367
Decatur, Ind.	7.3	10.1	1.4	13.9	2.9	2,071

[1] Actual observed number for period 10 a.m.–6 p.m. from parking study reports.

Multiple Correlation Analysis

Three factors, inbound cordon count of vehicles, number of parking spaces, and number of employees in retail and service trades for cities under 50,000 population, were used in a formula most satisfactorily for all groups tested to produce an estimate of probable parking volumes. This estimate in terms of average parking accumulation, which is the average number of vehicles parked at any one time in the central business district, can be expanded to daily parking volumes by the known percentage relation existing between average accumulation and daily parking volume. The formula used for estimating the volume of parking in relation to traffic volumes, parking spaces, and employment for cities of less than 50,000 population is as follows:

$X = 2547 + 0.0125\,X_2 + 0.0894\,X_3 + 0.0362\,X_4$

Where:

X = 1000 times the log of the average parking accumulation.[8] (X is a logarithmic number and is converted into the estimated number of parkers by use of the logarithmic tables.)

X_2 = inbound cordon count of vehicles, 10 a.m.–6 p.m.

X_3 = number of parking spaces in the central business district.

X_4 = number of employees in retail and service trades.

The average parking accumulation in percent of the daily number of parkers (10 a.m.–6 p.m.) determined from the analysis of 65 studies, is as follows:

Population group	*Percent*
Under 25,000	12
25,000-50,000	14
50,000-100,000	16
100,000-250,000	18
250,000-500,000	22
500,000-1,000,000	24
1,000,000 and over	30

The equation demonstrates this part of the analysis and the results may be used for comparison with estimates made under the rank-size and G.A.F. sales ratio methods for the smaller cities.

Comparison of Analyses

Each of these three methods appeared to offer possibilities for estimating parking volumes. A comparison of estimates made by each of these three methods was made for 8 cities where comparable parking studies have been made, and where results have been reported since the analysis of the reports from the 58 cities was completed. In 6 of these 8 cities sufficient data have been reported to make an estimate by means of the formula, and in 5 of the 6 cities estimates were within 15 percent of actual observed volumes. An average of the estimates made independently by each of the three methods was within 14 percent of actual observed parking volumes in all of the cities, and in 5 of the 8 cities estimates were

[8] Adjusted to 1948 by using a straight-line relation based on the population change in a particular city from 1940–50.

Table 6.—Summary of adjusted standard error in percent for each of the groups of factors tested

Test symbol	Factors tested [1]	Solving for—	Number of cities	Adjusted standard error
		ALL CITIES		
A	1, 2, 3	Daily number of parkers per million dollars of G.A.F. sales	53	(2)
Q	1, 5, 9	Daily number of parkers, unadjusted	58	—37 to 59
R	1, 5, 9	Average daily parking accumulation, adjusted to 1948	54	—42 to 73
		CITIES UNDER 50,000 INHABITANTS		
B	1, 2, 3, 4	Daily number of parkers per million dollars of G.A.F. sales	27	—27 to 37
C	1, 4	do	27	—26 to 36
D	1	Daily number of parkers, unadjusted	27	—24 to 34
E	1, 5	do	27	—27 to 37
F	1, 5, 6	do	27	—27 to 37
G	1, 5, 7	do	27	—27 to 37
I	8, 9, 10	Daily number of parkers, adjusted to 1948	27	—24 to 32
J	8, 9, 11	Average daily parking accumulation, adjusted to 1948	27	—21 to 26
K	5, 9, 11	do	27	—22 to 28
EE	11, 13, 15	do	27	—16 to 19
		CITIES OF 100,000 INHABITANTS OR MORE		
L	8, 9, 11	Average daily parking accumulation, adjusted to 1948	23	—32 to 47
M	5, 9, 11	do	23	—32 to 46
N	4, 9, 11	do	23	—29 to 41
O	4, 9, 12	do	23	—30 to 42
P	4, 9, 11	Peak parking accumulation, unadjusted	23	—29 to 41
		CITIES IN NORTHEASTERN UNITED STATES		
S	4, 9	Average daily parking accumulation, adjusted to 1948	13	—23 to 30
T	4, 9, 11	do	13	—24 to 31
U	13	do	13	—19 to 24
V	9, 13	do	13	—20 to 25
W	13, 14	do	13	—17 to 21
X	11, 13, 14	do	13	—14 to 16
CC	15, 16	do	13	—22 to 29
		CITIES IN NORTH CENTRAL UNITED STATES		
Y	11, 13, 14	Average daily parking accumulation, adjusted to 1948	16	—34 to 52
Z	13, 15	do	16	—30 to 42
AA	13, 15, 17	do	16	—30 to 43
BB	15, 16	do	16	—21 to 27
		CITIES IN NORTHEAST AND NORTH CENTRAL UNITED STATES		
DD	15, 16	Average daily parking accumulation, adjusted to 1948	29	—22 to 28
		CITIES BELOW THE AVERAGE CURVE [3]		
H	1, 5	Daily number of parkers, unadjusted	17	—35 to 55

[1] For a list of factors tested, refer to items numbered 1-17 on page 255.
[2] Adjusted standard error is 366 parkers per million dollars of G.A.F. sales.
[3] Refer to figure 3, page 255.

Table 7.—Comparison of estimates and actual observed number of parkings

City and State	Year of study	Population	Estimated number of parkers from—				Observed number of parkers	Average estimate in percent of total
			Rank size	G.A.F. sales	Formula	Average		
		Thousands						*Percent*
Ogden, Utah	1952	57.1	18,100	15,800	24,100	19,300	18,548	104
Lexington, Ky.	1952	55.5	18,100	22,100	(1)	20,100	21,641	93
Norristown, Pa.	1949	38.2	10,500	11,100	11,850	11,150	10,660	105
Steubenville, Ohio	1952	35.7	10,500	10,200	(1)	10,350	11,979	87
Bristol, Va.-Tenn.	1950	32.7	9,900	10,500	9,300	9,900	8,864	112
Fond du Lac, Wis.	1950	29.9	9,800	8,960	9,430	9,400	10,893	86
Butler, Pa.	1951	23.5	9,650	11,985	12,417	11,350	11,812	96
Coatesville, Pa.	1951	13.8	5,200	5,650	6,742	5,860	6,246	94

[1] Insufficient data received.

within 7 percent of actual observed volumes (table 7).

The following example is illustrative of the methods used in making estimates using the city of Bristol as an example. The twin city of Bristol is located on the Virginia-Tennessee State line, has essentially one business district, and a combined population of 33,000 persons. It is located on the Norfolk and Western Railroad, and U. S. Highway No. 11 passes through, connecting eastern Tennessee with the northeastern States. It is on the edge of the Great Smoky National Park, an area of increasing recreational importance, and on the edge of eastern Tennessee which has grown industrially with the power developments of the Tennessee Valley Authority. Considerable diversification in manufacturing for a city of this size is reported. The proximity of Kingsport and Johnson City within a 25-mile distance to the south and west tends to reduce the normal trading area in these directions.

Bristol has a retail trade-manufacturing employment ratio of 1:2.0 which is typical of a group IV city (see figure 1 and table 2). Employment per 100 population of 31 percent is also typical of a group IV city, but the percentage increase in population of 38 percent is more nearly typical of a group II city. The percentage of employment in service trades of 7.5 percent is also typical of group IV cities, so it seems reasonable to consider Bristol as being included in this group.

Bristol ranks between 40th and 41st with respect to population, and between 38th and 39th with respect to G.A.F. sales. With 5,644 persons employed in manufacturing, it would rank between 35th and 36th for this factor which is about five places higher than population, a pattern similar to the rank-size patterns of the cities in group IV. This confirms the assumption that Bristol appears to be similar to a group IV city. In this group parking has a ranked position of about one position lower than population, and thus Bristol would be expected to have a rank in parking of 41.5 (40.5+1). This would mean that in figure 2 an estimated 9,900 daily parkers could normally be expected.

For the second type of estimate based on G.A.F. sales data, modest dominance in manufacturing together with proximity to Kingsport and Johnson City suggests lower than average retail sales. If we assume 675 parkers per million dollars of G.A.F. sales (fig. 3) which is about half way between the average city and a dominant industrial city, and knowing that Bristol has an annual G.A.F. sales volume of $15.5 million, it is estimated that there would be 10,500 daily parkers in Bristol.

By formula the estimate is computed to be 9,300 parkers. The actual study showed that 8,864 parkers were observed. The formula estimate was less than 5 percent greater than the observed volume, and the average of all three estimates was within 12 percent of the actual volume. Average estimates for some of the other cities were closer to observed volumes, and formula estimates were not uniformly the closest (table 7).

Summary

The findings of this study have not been presented with the idea that a definite and unqualified basis for making estimates of parking volumes is now available. They are presented rather to indicate that it should be possible to make a relatively quick appraisal of probable parking requirements for the central business district as a whole. If origins and destinations of parkers are needed for the planning of specific highway or parking facility improvements, then more detailed information must be obtained by other means.

The three types of analyses indicate that some basic relations seem to exist between parking volumes and the basic economy of the community, and that the average of the estimates of parking made by the various methods can be used with reasonable assurance of reliability. Before any extensive use can be made of the estimates for specific locations, however, studies should be made to demonstrate how the estimates can be used in relation to parking habits and current land and building usage. A further conclusion may be inferred. If these relations exist between the volume of parking in the central business district and the size of a city, and the amount of retail trade and certain kinds of employment, then similar relations must exist with respect to travel since parking is directly related to travel in that vehicles are parked at the end of each trip. The application of such relations with respect to urban travel appears to be of much greater significance because entire urban areas must be considered which involves the movement of vehicles rather than their parking.

Standard Plans for Highway Bridge Superstructures: a new publication

The Bureau of Public Roads has just published *Standard Plans for Highway Bridge Superstructures,* in which are presented standard plans providing complete details for various types of superstructures for highway bridges. The publication is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $1.00 a copy.

Standard Plans for Highway Bridge Superstructures is intended to serve as a useful guide to State, county, and local highway departments in developing designs for bridges of adequate strength and economical proportions on primary, secondary, and urban highways. The plans should be particularly valuable to the smaller highway departments with limited engineering staffs.

Included in the several series of drawings are detailed plans for I-beams, riveted deck plate girders, welded deck plate girders, reinforced concrete slabs, reinforced concrete T-beams, reinforced concrete box girders, post-tensioned precast reinforced concrete deck girders, and precast reinforced concrete deck girders. One series of I-beam spans involves 3-span continuous units. All other types of spans are simply supported. One series of simply supported I-beam spans is designed for composite action. The design of the reinforced concrete slab spans has been based on participating curbs.

Designs are included for two widths of roadway, 24 feet and 28 feet. The span lengths for the simply supported structures range from a minimum of 20 feet to a maximum of 140 feet. The 3-span continuous units vary from 130 feet to 260 feet in overall length, with the end spans having a length 80 percent of the center span. The ranges in span lengths are based on the economy and suitability of the different types of superstructures. The live load capacity for all types of superstructures is H15-44 for 24-foot roadway widths and H20-S16-44 for 28-foot roadway widths, with the exception of the precast reinforced concrete deck girder spans which are designed for a loading of H15-S12-44.

All of the designs are in accordance with the "Standard Specifications for Highway Bridges," adopted by the American Association of State Highway Officials in 1953.

A list of the more important articles in PUBLIC ROADS may be obtained upon request addressed to Bureau of Public Roads, Washington 25, D. C.

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Work of the Public Roads Administration:

1941, 15 cents. 1948, 20 cents.

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1943; 1944; 1945; 1946; 1947. (*Free from Bureau of Public Roads*)

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1950, 25 cents. 1951, 35 cents. 1952, 25 cents.

HOUSE DOCUMENT NO. 462

Part 1.—Nonuniformity of State Motor-Vehicle Traffic Laws (1938). 15 cents.

Part 2.—Skilled Investigation at the Scene of the Accident Needed to Develop Causes (1938). 10 cents.

Part 3.—Inadequacy of State Motor-Vehicle Accident Reporting (1938). 10 cents.

Part 4.—Official Inspection of Vehicles (1938). 10 cents.

Part 5.—Case Histories of Fatal Highway Accidents (1938). 10 cents.

Part 6.—The Accident-Prone Driver (1938). 10 cents.

UNIFORM VEHICLE CODE

Act I.—Uniform Motor-Vehicle Administration, Registration, Certificate of Title, and Antitheft Act (1945). 15 cents.

Act II.—Uniform Motor-Vehicle Operators' and Chauffeurs' License Act. 15 cents. (revised 1952)

Act III.—Uniform Motor-Vehicle Civil Liability Act (1944). 10 cents.

Act IV.—Uniform Motor-Vehicle Safety Responsibility Act. 15 cents. (revised 1952)

Act V.—Uniform Act Regulating Traffic on Highways. 20 cents. (revised 1952)

Model Traffic Ordinance. 20 cents. (revised 1952)

MAPS

State Transportation Map series (available for 39 States). Uniform sheets 26 by 36 inches, scale 1 inch equals 4 miles. Shows in colors Federal-aid and State highways with surface types, principal connecting roads, railroads, airports, waterways, National and State forests, parks, and other reservations. Prices and number of sheets for each State vary—see Superintendent of Documents price list 53.

United States System of Numbered Highways together with the Federal-Aid Highway System (also shows in color National forests, parks, and other reservations). 5 by 7 feet (in 2 sheets), scale 1 inch equals 37 miles. $1.25.

United States System of Numbered Highways. 28 by 42 inches, scale 1 inch equals 78 miles. 20 cents.

MISCELLANEOUS PUBLICATIONS

Bibliography of Highway Planning Reports (1950). 30 cents.

Construction of Private Driveways, No. 272MP (1937). 10 cents.

Electrical Equipment on Movable Bridges, No. 265T (1931). 40 cents.

Factual Discussion of Motortruck Operation, Regulation, and Taxation (1951). 30 cents.

Federal Legislation and Regulations Relating to Highway Construction (1948). *Out of print.*

Financing of Highways by Counties and Local Rural Governments, 1931–41. 45 cents.

Highway Accidents (1938). 10 cents.

Highway Bond Calculations (1936). 10 cents.

Highway Bridge Location, No. 1486D (1927). 15 cents.

Highway Capacity Manual (1950). 65 cents.

Highway Needs of the National Defense, House Document No. 249 (1949). 75 cents.

Highway Practice in the United States of America (1949). 75 cents.

Highway Statistics (*annual*):
1945, 35 cents. 1948, 65 cents.
1946, 50 cents. 1949, 55 cents.
1947, 45 cents. 1951, 60 cents.

Highway Statistics, Summary to 1945. 40 cents.

Highways in the United States, *nontechnical* (1951). 15 cents.

Highways of History (1939). 25 cents.

Identification of Rock Types (1950). 10 cents.

Interregional Highways, House Document No. 379 (1944). 75 cents.

Legal Aspects of Controlling Highway Access (1945). 15 cents.

Local Rural Road Problem (1950). 20 cents.

Manual on Uniform Traffic Control Devices for Streets and Highways (1948). 75 cents.

Mathematical Theory of Vibration in Suspension Bridges (1950). $1.25.

Principles of Highway Construction as Applied to Airports, Flight Strips, and Other Landing Areas for Aircraft (1943). $2.00.

Public Control of Highway Access and Roadside Development (1947). 35 cents.

Public Land Acquisition for Highway Purposes (1943). 10 cents.

Results of Physical Tests of Road-Building Aggregate (1953). $1.00

Roadside Improvement, No. 191MP (1934). 10 cents.

Selected Bibliography on Highway Finance (1951). 55 cents.

Specifications for Construction of Roads and Bridges in National Forests and National Parks, FP-41 (1948). $1.50.

Taxation of Motor Vehicles in 1932. 35 cents.

Tire Wear and Tire Failures on Various Road Surfaces (1943). 10 cents.

Transition Curves for Highways (1940). $1.50.

Single copies of the following publications are available to highway engineers and administrators for official use, and may be obtained by those so qualified upon request addressed to the Bureau of Public Roads. They are not sold by the Superintendent of Documents.

Bibliography on Automobile Parking in the United States (1946).

Bibliography on Highway Lighting (1937).

Bibliography on Highway Safety (1938).

Bibliography on Land Acquisition for Public Roads (1947).

Bibliography on Roadside Control (1949).

Express Highways in the United States: a Bibliography (1945).

Indexes to PUBLIC ROADS, volumes 17–19 and 23.

Title Sheets for PUBLIC ROADS, volumes 24, 25, and 26.

STATUS OF FEDERAL-AID HIGHWAY PROGRAM

AS OF OCTOBER 31, 1953

(Thousand Dollars)

STATE	UNPROGRAMMED BALANCES	ACTIVE PROGRAM: PROGRAMMED ONLY			PLANS APPROVED, CONSTRUCTION NOT STARTED			CONSTRUCTION UNDER WAY			TOTAL		
		Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles
Alabama	$4,798	$12,162	$5,799	194.4	$13,176	$6,578	147.6	$39,051	$20,041	462.0	$64,389	$32,418	804.0
Arizona	1,112	2,190	1,497	55.9	1,070	758	7.4	7,093	5,029	108.2	10,353	7,284	171.5
Arkansas	1,683	13,085	6,804	372.5	6,219	3,114	149.6	9,488	4,706	223.7	28,792	14,624	745.8
California	1,710	5,550	2,969	40.5	11,892	4,159	43.5	97,843	49,321	269.8	115,285	56,449	353.8
Colorado	2,482	3,991	2,258	101.8	3,244	1,835	47.9	16,809	9,084	184.3	24,044	13,177	334.0
Connecticut	6,804	1,870	1,041	3.6	477	237	.6	9,289	4,558	28.7	11,636	5,836	32.9
Delaware	3,126	605	305	.8				4,260	2.123	20.3	4,865	2,428	21.1
Florida	4,583	14,270	7,286	210.1	7,087	3,826	132.7	17,036	8,598	236.4	38,393	19,710	579.2
Georgia	4,521	16,923	8,656	383.6	7,036	3,510	134.1	34,167	16,083	434.4	58,126	28,249	952.1
Idaho	2,400	7,195	4,497	112.4	2,781	1,767	46.0	11,786	7,442	207.2	21,762	13,706	365.6
Illinois	9,017	26,721	14,543	130.7	13,755	6,927	31.3	65,147	34,324	495.5	105,623	55,794	657.5
Indiana	10,629	33,269	17,900	149.2	6,677	3,351	30.9	23,850	12,150	103.0	63,796	33,401	283.1
Iowa	2,580	13,906	7,486	331.1	4,188	3,115	75.4	18,308	9,202	885.9	36,402	19,803	1,292.4
Kansas	3,513	9,383	4,694	814.1	3,925	1,995	315.7	16,155	7,747	755.1	29,463	14,436	1,884.9
Kentucky	3,012	8,997	4,777	106.6	7,297	3,648	106.8	21,208	11,167	246.9	37,502	19,592	460.3
Louisiana	1,729	20,185	10,122	133.5	3,549	1,772	17.5	26,357	12,745	142.7	50,091	24,639	293.7
Maine	973	5,433	2,851	37.0	2,279	1,119	17.4	13,324	6,508	103.9	21,036	10,478	158.3
Maryland	8,281	5,391	2,869	50.3	4,595	2,232	19.2	7,006	3,892	34.9	16,992	8,993	104.4
Massachusetts	4,124	8,643	4,416	18.5	6,961	3,358	3.9	41,821	19,951	34.9	57,425	27,725	57.3
Michigan	1,818	28,868	14,967	366.1	11,170	5,594	138.9	49,808	21,277	289.5	89,846	41,838	794.5
Minnesota	4,414	9,239	5,083	811.9	2,509	1,283	130.5	17,207	8,953	432.6	28,955	15,319	1,375.0
Mississippi	1,098	12,645	6,438	378.4	4,534	2,146	113.7	20,755	10,590	567.4	37,934	19,174	1,059.5
Missouri	6,937	14,810	7,497	762.6	4,636	2,480	111.9	56,963	28,049	461.7	76,409	38,026	1,336.2
Montana	4,939	12,472	7,609	309.0	4,543	2,916	82.2	13,104	7,843	200.8	30,119	18,368	592.0
Nebraska	7,742	22,881	11,898	757.6	2,183	1,303	70.2	10,577	5,965	236.0	35,641	19,166	1,063.8
Nevada	3,030	5,485	4,591	91.4	725	607	26.9	4,276	3,542	74.3	10,486	8,740	192.6
New Hampshire	3,038	1,900	950	7.9	990	494	7.6	3,655	1,950	16.7	6,545	3,394	32.2
New Jersey	2,637	5,904	2,927	58.0	8,188	3,889	8.5	25,527	12,124	19.9	39,619	18,940	86.4
New Mexico	1,140	1,164	747	30.6	2,960	1,863	77.5	8,990	5,664	177.7	13,114	8,274	285.8
New York	13,903	60,620	32,030	101.4	53,814	26,708	38.1	157,758	72,736	507.1	272,192	131,474	646.6
North Carolina	3,233	21,351	10,419	388.6	3,893	1,820	55.7	29,705	13,904	388.4	54,949	26,143	832.7
North Dakota	2,552	3,552	1,784	662.8	1,087	544	185.2	7,789	4,047	494.5	12,428	6,375	1,342.5
Ohio	4,763	17,329	7,971	106.6	12,249	5,931	42.8	86,822	41,698	123.7	116,400	55,600	273.1
Oklahoma	6,517	12,661	7,159	187.1	5,621	2,962	80.5	14,151	7,514	169.4	32,433	17,635	437.0
Oregon	1,695	1,602	956	30.8	817	465	9.8	12,634	7,640	188.2	15,053	9,061	228.8
Pennsylvania	2,749	13,425	5,478	4.1	42,549	20,357	64.0	82,882	41,325	240.0	138,856	67,160	308.1
Rhode Island	1,948	2,227	1,113	26.5	1,133	566	5.3	9,831	4,912	22.2	13,191	6,591	54.0
South Carolina	2,741	9,392	5,237	203.0	3,309	1,622	204.6	14,459	7,260	243.4	27,160	14,119	651.0
South Dakota	854	6,354	3,793	380.6	2,026	1,092	99.4	8,581	4,983	469.2	16,961	9,868	949.2
Tennessee	3,848	11,152	5,554	329.2	7,657	4,459	189.3	30,621	13,392	312.1	49,430	23,405	830.6
Texas	8,366	6,416	3,213	114.0	9,543	5,142	319.3	60,292	33,044	810.0	76,251	41,399	1,243.3
Utah	633	2,860	2,191	44.7	708	532	8.1	10,562	8,057	159.4	14,130	10,780	212.2
Vermont	657	3,315	1,777	38.6	269	135	.2	8,294	4,181	45.5	11,878	6,093	84.3
Virginia	499	11,112	5,049	150.3	7,041	3,107	94.1	29,738	14,347	194.6	47,891	22,503	439.0
Washington	1,274	9,160	4,804	116.4	1,643	860	43.1	16,254	8,553	113.8	27,057	14,217	273.3
West Virginia	3,930	7,554	3,804	40.4	4,730	2,386	3.9	13,447	6,733	98.9	25,731	12,923	143.2
Wisconsin	3,503	7,209	4,027	122.5	5,972	2,960	79.5	25,386	12,816	271.1	38,567	19,803	473.1
Wyoming	382	1,537	992	23.1	1,928	990	29.4	7,510	4,864	165.6	10,975	6,846	218.1
Hawaii	1,249	3,221	1,580	7.8	41	21		10,818	5,176	13.9	14,080	6,777	21.7
District of Columbia	678	7,538	3,529	6.0	3,071	1,338	.1	10,069	4,730	3.1	20,678	9,597	9.2
Puerto Rico	3,638	10,540	4,839	51.2	304	147	2.0	13,532	6,498	38.7	24,376	11,484	91.9
TOTAL	183,682	555,264	290,776	9,955.8	318,051	160,020	3,649.8	1,351,995	679,038	12,527.2	2,225,310	1,129,834	26,132.8

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