Statewide Transportation Analysis & Research

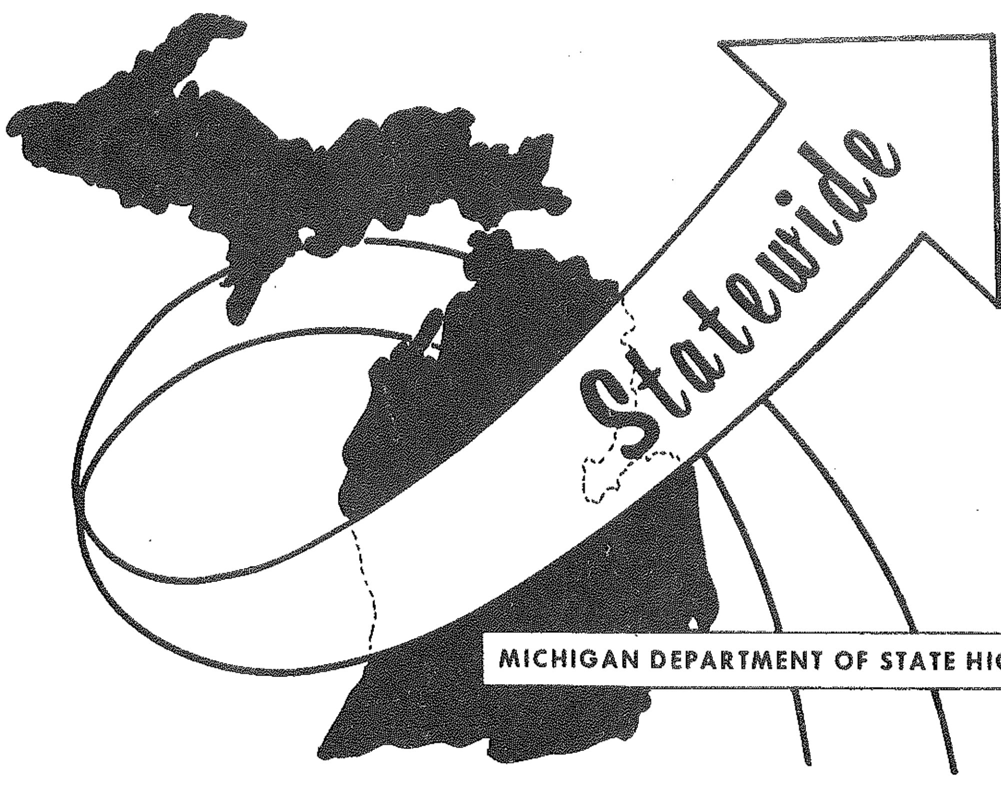
MICHIGAN'S STATEWIDE TRANSPORTATION
MODELING SYSTEM

VOLUME XIII – A

MULTI–MODAL MOBILITY
AND
ACCESSIBILITY ANALYSIS

STATEWIDE RESEARCH & DEVELOPMENT

NOVEMBER, 1974



MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

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OF

STATE HIGHWAYS AND TRANSPORTATION

BUREAU OF TRANSPORTATION PLANNING

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STATE HIGHWAYS BUILDING – POST OFFICE DRAWER K – LANSING, MICHIGAN 48904

JOHN P. WOODFORD, DIRECTOR

November 26, 1974

Mr. Sam F. Cryderman
Deputy Director
Bureau of Transportation Planning

Dear Mr. Cryderman:

The Highway Planning Division is pleased to present Volume XIII-A of the Statewide Transportation Modeling System series of reports. It is the first report in a sequence which will implement the developing statewide multi-modal transportation mode. Entitled "Multi-Modal Mobility and Accessibility Analysis," the report documents an analysis procedure which enables one to measure the accessibility of selected groups of the population to travel modes such as rail, bus, and air. The process utilizes existing tools created for use with the statewide highway model, adjusting the analysis procedure so as to better deal with and resolve such multi-modal transportation issues as improvement of public mobility and goods movements, abandonment of stations or lines, etc. In view of the growing concern for improved public transportation and freight service, such procedures should be of special interest to transportation planners.

The procedure described in this report was developed by Miss Joyce Newell, who is a member of the Statewide Interagency Procedures and Development Section, managed by Mr. Richard E. Esch.

Sincerely,

R. J. Lilly

Richard J. Lilly, Administrator
Highway Planning Division

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"MULTI–MODAL MOBILITY AND ACCESSIBILITY ANALYSIS"

by

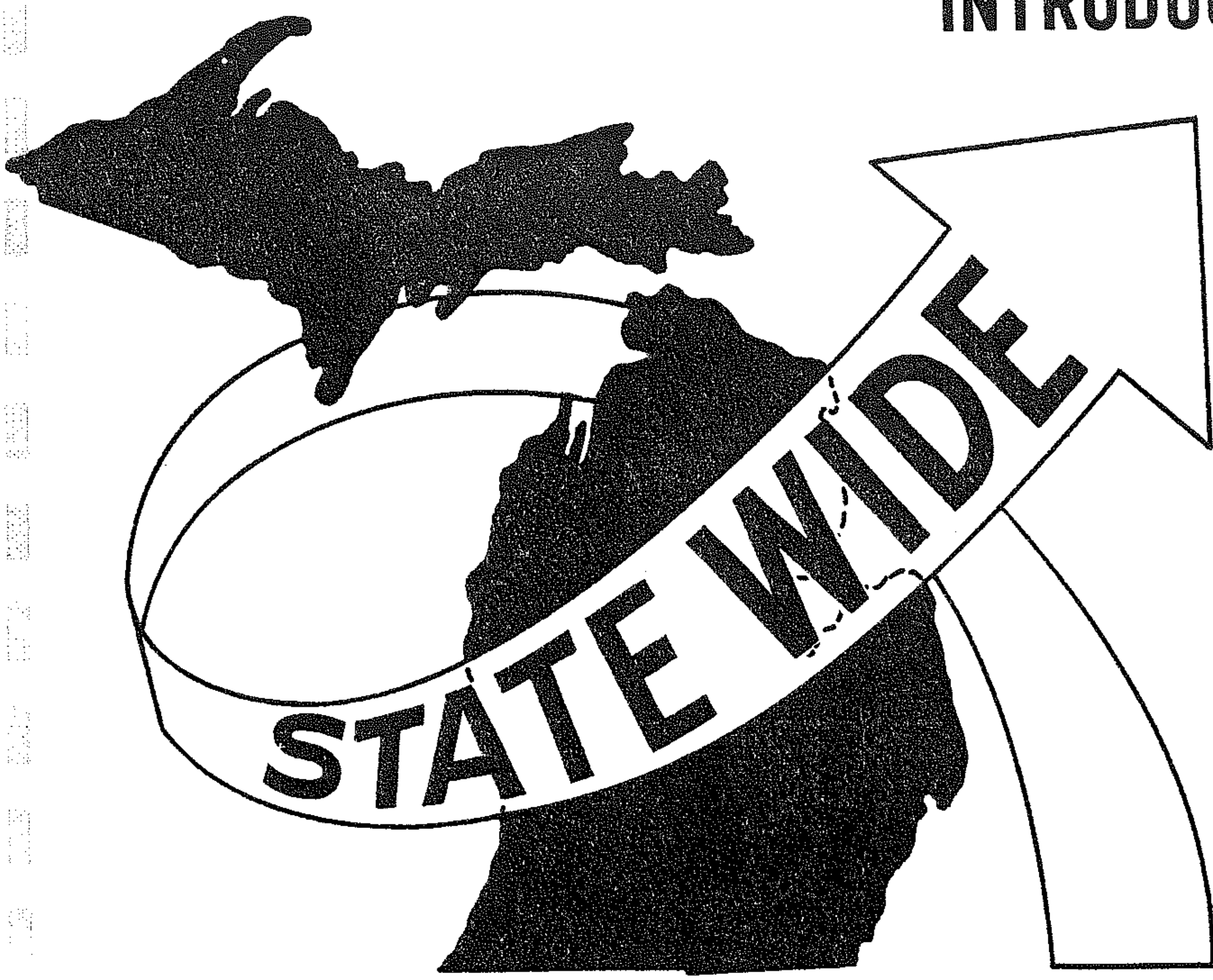
Joyce A. Newell

PREFACE

PREFACE

This report is the second in a series dealing with the growing multi-modal statewide transportation system for Michigan. The first report (Michigan Goes Multi-Modal) described in detail the development of the main battery of multi-modal system analysis programs. This report demonstrates a practical, yet simple, application of such a system using the existing, well-developed highway planning analysis battery. Such applications can place at one's disposal data, collected through years of experience, time and effort, for immediate use in the new model. Most important, of course, applications such as the one about to be described here can be used to help answer some very relevant and important questions concerning statewide transportation and mobility. Such issues include the accessibility, or potential demand, upon a rail station or bus terminal; the relative potential importance of a given segment of rail tracks; the expected impacts of various prospective changes in the highway, rail, bus, or air systems; and the accessibility of other facilities, such as truck terminals, to desired stations or lines. In view of the growing concern for the improvement of public transportation, such planning aids should prove to be a valuable asset. The ease with which such applications can be made, while of secondary importance, is, nonetheless, a very important consideration. As will be shown, a large variety of these useful analysis measurements may be obtained to aid in statewide, multi-modal planning.

INTRODUCTION



INTRODUCTION

The development of a statewide multi-modal system for Michigan was discussed in detail in the Statewide Studies report of July 1974 entitled "Michigan Goes Multi-Modal". As that report indicates, the multi-modal system was designed to resemble the existing highway planning analysis battery. The air, bus, and rail network descriptions are nearly identical to the highway network, which makes it possible to obtain the multiple benefits of using analytical tools which were developed for the highway system. The 547 zone system, now used extensively with the statewide highway network for statewide planning analysis, may also be used with these new networks. Thus, using the existing, finely developed tools of the highway analysis battery and three important information files which will be discussed later, many necessary and very desireable applications can be made relatively quickly and easily.

This report deals with the simple adaptation of the multi-modal system which allows one to effectively use the proximity analysis method, now commonly in use in statewide highway planning analysis, to aid in evaluation of the multi-modal systems. Several samples have been included demonstrating the accessibility of each rail station, bus terminal, and airport in the northwest region of Michigan. The use of existing tools makes this application available now for any desired region, and it should be available on a statewide level within a very short time.

SYSTEM ANALYSIS PROCESS

SYSTEM ANALYSIS PROCESS

The statewide transportation model divides the State of Michigan and the surrounding states into 547 areas called zones (see Figures 1 and 2). For each zone a center of population, or "centroid", has been located. The characteristics of a given zone are assumed to be accumulated at its centroid. These zone characteristics have been collected and stored on two major information files: a socio-economic data file and a public and private facility file. A sample of the socio-economic file is found in Figure 3, while Figure 4 is the current list of all available facility files. A third major information file is the statewide highway network. This file consists of a coded description of all Michigan trunklines and selected county roads. Each segment of road ("link") is identified by a "node" number at each endpoint of the segment, and generally extends between two consecutive intersections. Other special links, called centroid links, are included which connect each zone centroid to the highway network. The highway file also contains various link descriptions such as speed, distance, type of road, etc. A computer plot of the highway network is shown in Figure 5.

Using the above three information files and a process called proximity analysis, it is possible to evaluate the accessibility of selected services for any desired group of people. To accomplish this, "trees" or paths must be built which connect a zone of interest to any other zone(s) of interest. These paths are selected to minimize a desired impedance. Most generally the average travel


547 ZONE STATEWIDE MODEL
(INSTATE ZONES)
DECEMBER 1972
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
CANADA
WISCONSIN
INDIANA
OHIO
LAKE ST. CLAIR
LAKE ERIE
MINNESOTA
NORTH CHANNEL

FIGURE 1

MICHIGAN'S TRANSPORTATION MODELING SYSTEM

547 ZONE
OUTSTATE ANALYSIS ZONES

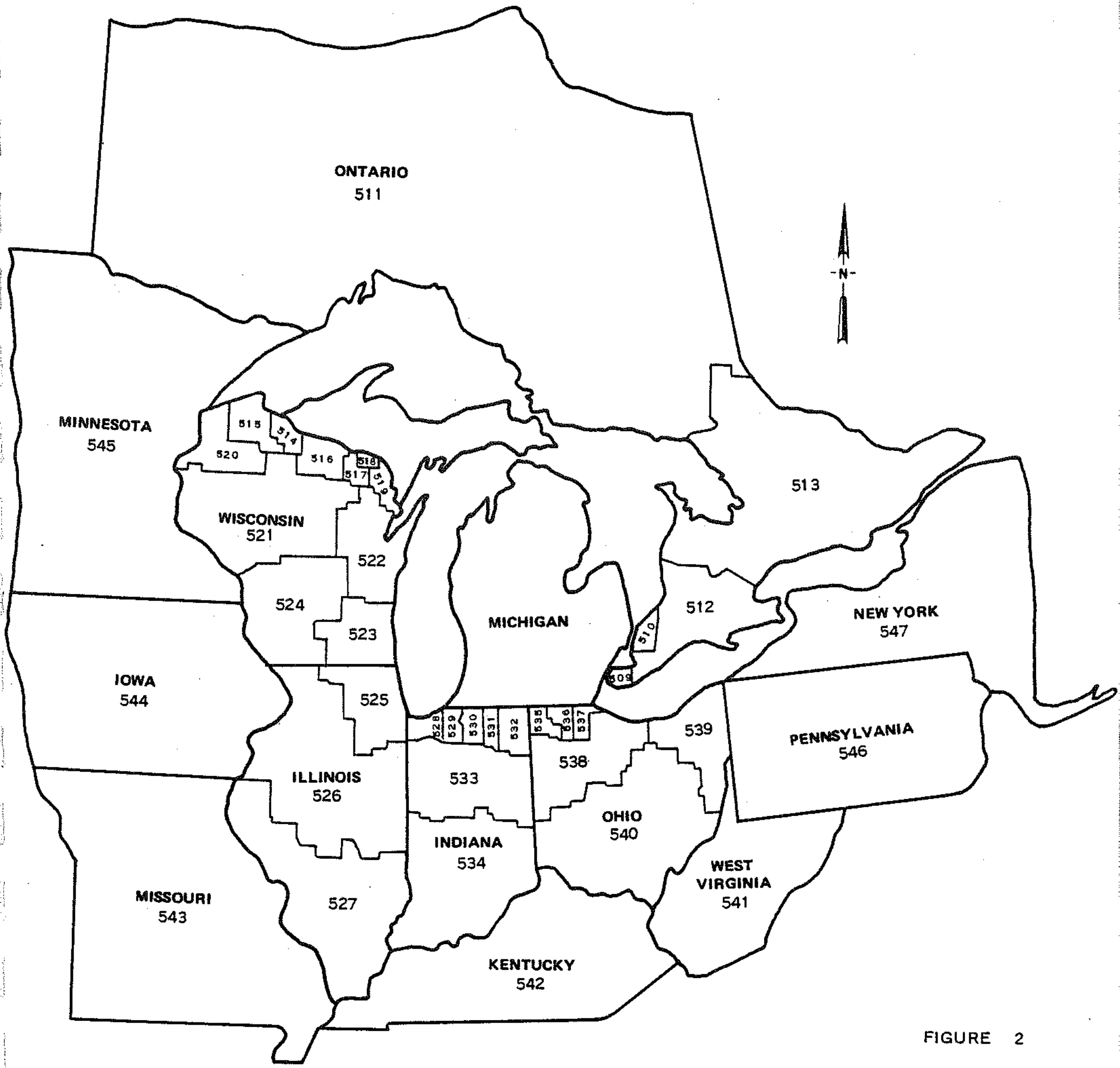


FIGURE 2

STATEWIDE
SOCIO-ECONOMIC DATA FILE

GENERAL CHARACTERISTICS OF POPULATION

SCHOOL ENROLLMENT BY TYPE OF SCHOOL
YEARS OF SCHOOL COMPLETED
CITIZENSHIP BY AGE

INCOME CHARACTERISTICS OF POPULATION

FAMILY INCOME
INCOME BY OCCUPATION AND SEX
RATIO OF FAMILY INCOME TO POVERTY LEVEL

LABOR FORCE CHARACTERISTICS OF POPULATION

EMPLOYMENT BY AGE
EMPLOYMENT BY OCCUPATION AND SEX
EMPLOYMENT BY INDUSTRY AND SEX

SOCIAL CHARACTERISTICS OF POPULATION

AGE BY SEX
TYPE OF FAMILY
MARITAL STATUS

STRUCTURAL CHARACTERISTICS OF HOUSING

YEAR STRUCTURE BUILT
UNITS IN STRUCTURE
STORIES IN STRUCTURE

EQUIPMENT CHARACTERISTICS OF HOUSING

AIR CONDITIONING
TYPE OF HEATING FUEL
SOURCE OF WATER

OCCUPANCY CHARACTERISTICS OF HOUSING

OCCUPANCY / VACANCY STATUS
NUMBER OF PERSONS IN UNIT
NUMBER OF PERSONS PER ROOM

AREA CHARACTERISTICS

LAKE FRONTAGE
ASSESSED VALUATION
WATER AREA

*THOSE ITEMS LISTED HERE ARE SAMPLES TAKEN FROM THE COMPLETE FILE WHICH CONTAINS 76 CATEGORIES WITH OVER 800 ITEMS

FIGURE 3

STATEWIDE FACILITY FILE

AIRPORTS
AMBULANCE SERVICE
BUS TERMINALS
CAMP GROUNDS, PUBLIC AND PRIVATE
CERTIFIED INDUSTRIAL PARKS
CITIES OVER 30,000 POPULATION
CITIES OVER 5,000 POPULATION
CIVIL DEFENSE TERMINALS
COLLEGES, NON-PUBLIC
COLLEGES, PUBLIC COMMUNITY
COLLEGES AND UNIVERSITIES, PUBLIC 4 YEAR
CONVENTION CENTERS
GAME AREAS
GOLF COURSES
HIGH SCHOOLS
HISTORIC SITES
HOMES FOR THE AGED
HOSPITALS
MAJOR COMMERCIAL CENTERS
MANUFACTURERS
MENTAL HEALTH CENTERS
NEWSPAPERS, DAILY
NEWSPAPERS, WEEKLY AND BIWEEKLY
NURSING HOMES
PORTS
RAIL TERMINALS
SECRETARY OF THE STATE OFFICES
SEWAGE TREATMENT FACILITIES
SKI RESORTS
SNOWMOBILE TRAILS
STATE PARKS
STATE POLICE POSTS
TOURIST ATTRACTIONS
TREASURY OFFICES
TRUCK TERMINALS
UNEMPLOYMENT OFFICES
WEATHER SERVICE STATIONS-NATIONAL
WHOLESALE TRADE CENTERS

FIGURE 4

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

1970 HIGHWAY NETWORK

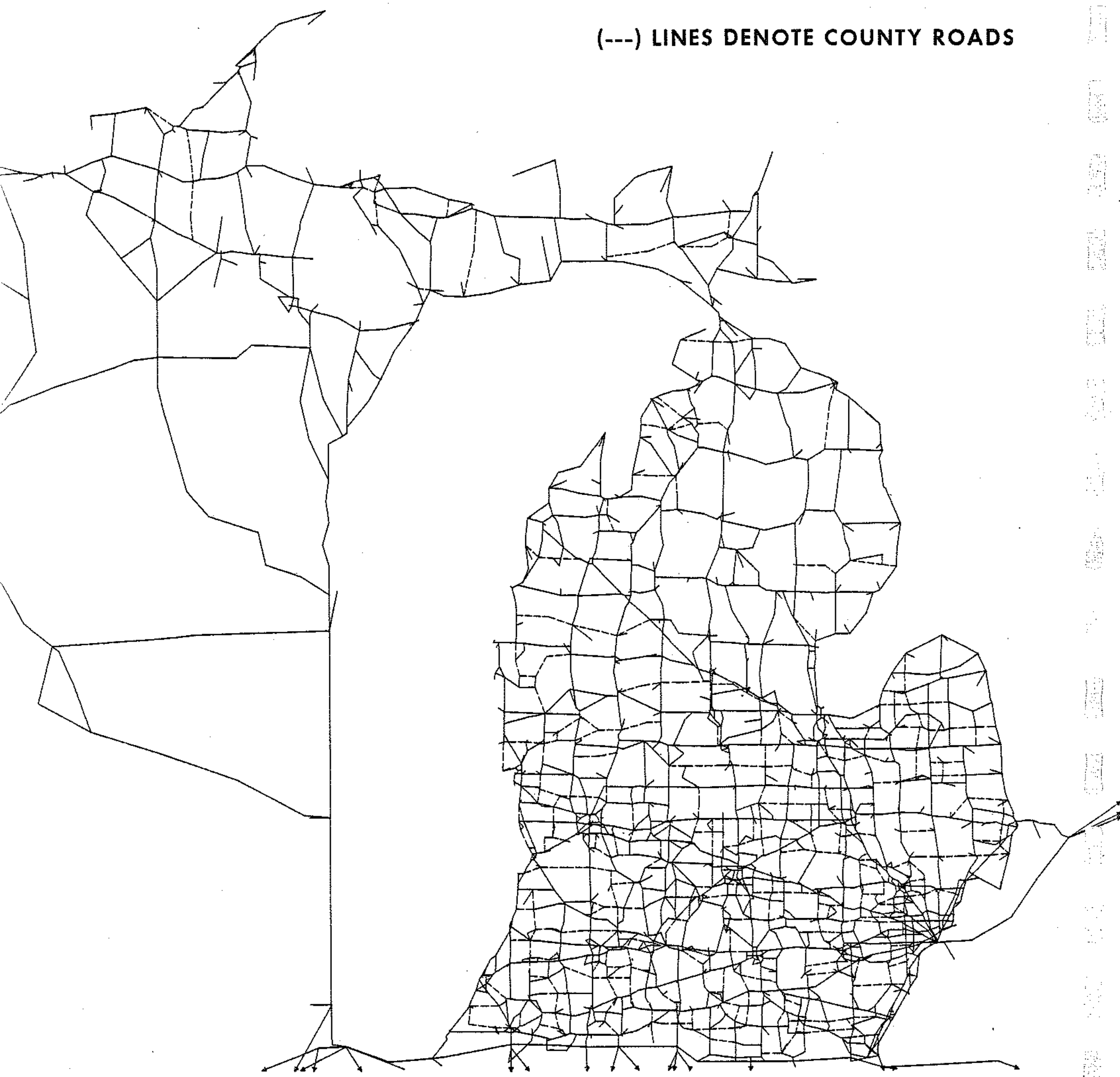


FIGURE 5

time, as determined by the distance and effective speed given for each link, is used to select the minimal paths. The time between two zones is assumed to be that time required to travel between the two zone centroids. If the centroid of a zone is a given time from the centroid of another zone, all persons residing in one zone are assumed to live within that traveling time of all persons in the other zone, although portions of the zones may be closer or further apart. Since the total population of a zone is assumed to reside at the centroid (center of population for the given zone) no travel times within a zone can be calculated. However, intrazonal travel times may be estimated as a constant for each zone and added through a program called TPMOD. Any facility of interest is also assumed to lie at the zone centroid; thus distance and travel time to a facility from all other points within that zone cannot be calculated, so are assumed to be zero. The zone centroid and its accompanying assumptions are necessary and in most instances are sufficiently realistic when using the 547 zone system. Those problems which do exist now should be alleviated by a 2300 zone system, now in the development stage.

Once the trees or paths between all desired zones have been completed in compliance with the above assumptions, the trees are "skimmed" to select the zone-to-zone travel time. These times are then used in the proximity analysis process. This process searches in the selected time band(s) of each facility for zone centroids. The "value" assigned to the zone(s) (centroids(s)) within the desired time radius of the facility are then accumulated. Since the facility is located at the zone centroid, the value assigned to that zone is included in the final sum for that facility. The "values" assigned to each zone are generally selected to represent a desired segment of the zone's population, so for each facility, the final value represents the number of people in the given population segment who reside in zones whose centroids are accessible within the chosen time band(s) to the centroid of the zone containing the facility.

As should be apparent, selecting "unreasonably" small time bands may easily lead to very gross errors which would invalidate any subsequent assumptions or interpretations. The same would be true if one wished to compare two time bands of nearly the same size. The proximity analysis method has been used successfully with intervals as small as 15 minutes; smaller intervals are not recommended. The 2300 zone system now being developed should make possible the use of smaller intervals. For the present, however, a simple technique has been developed which helps increase the accuracy of the above process.

To use this technique, each facility is connected to the highway network via one or more additional links. If the facilities are numbered beginning at 548 each facility may be treated as a zone centroid. These new "zones" are then used to build trees to all other zones - a short task since only the trees originating at the new zones need be built (see Figure 6-a). These new facility-zones are assigned a value of zero, so if a facility happens to lie far enough away from all "real" zone centroids, the final

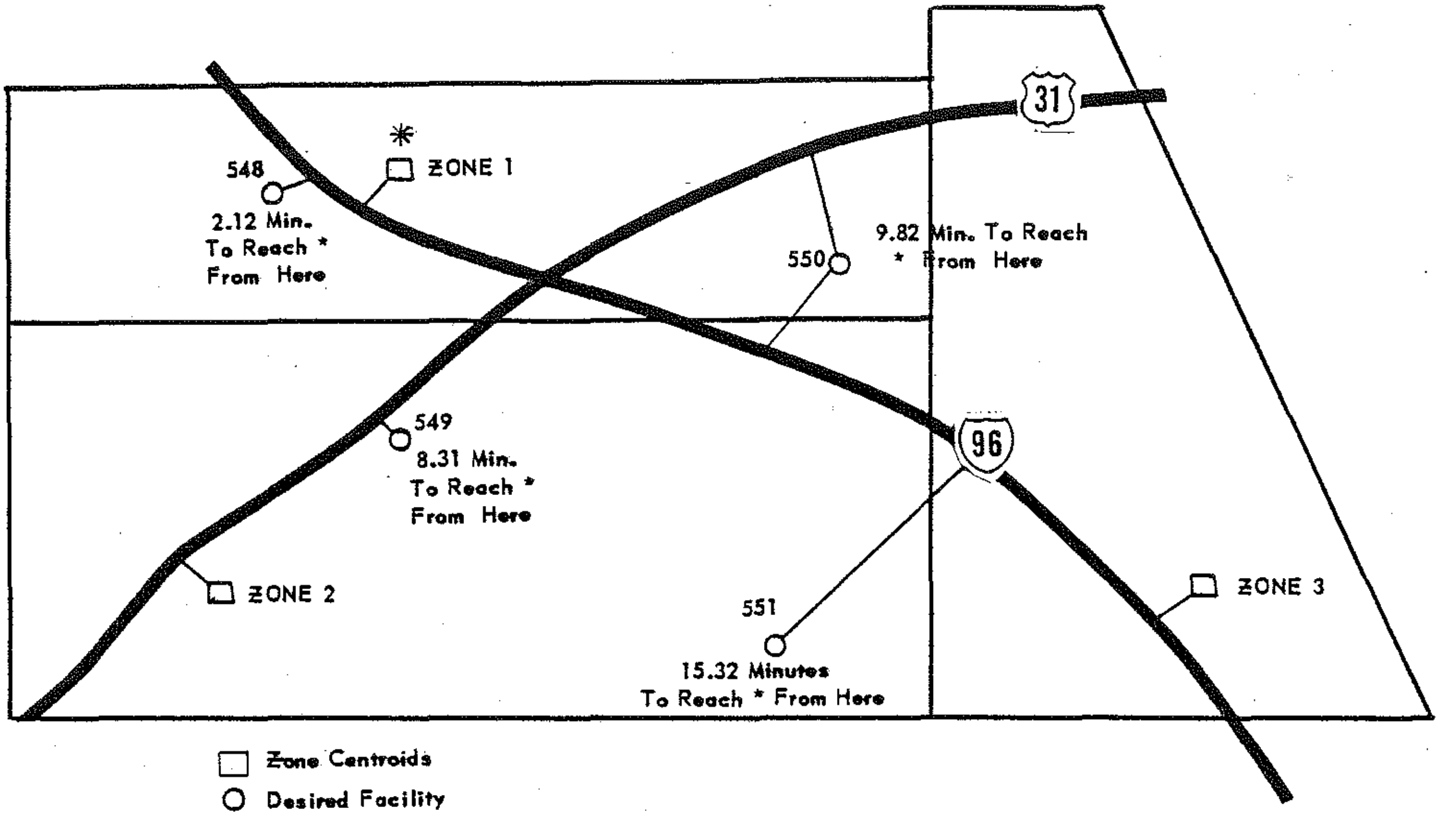
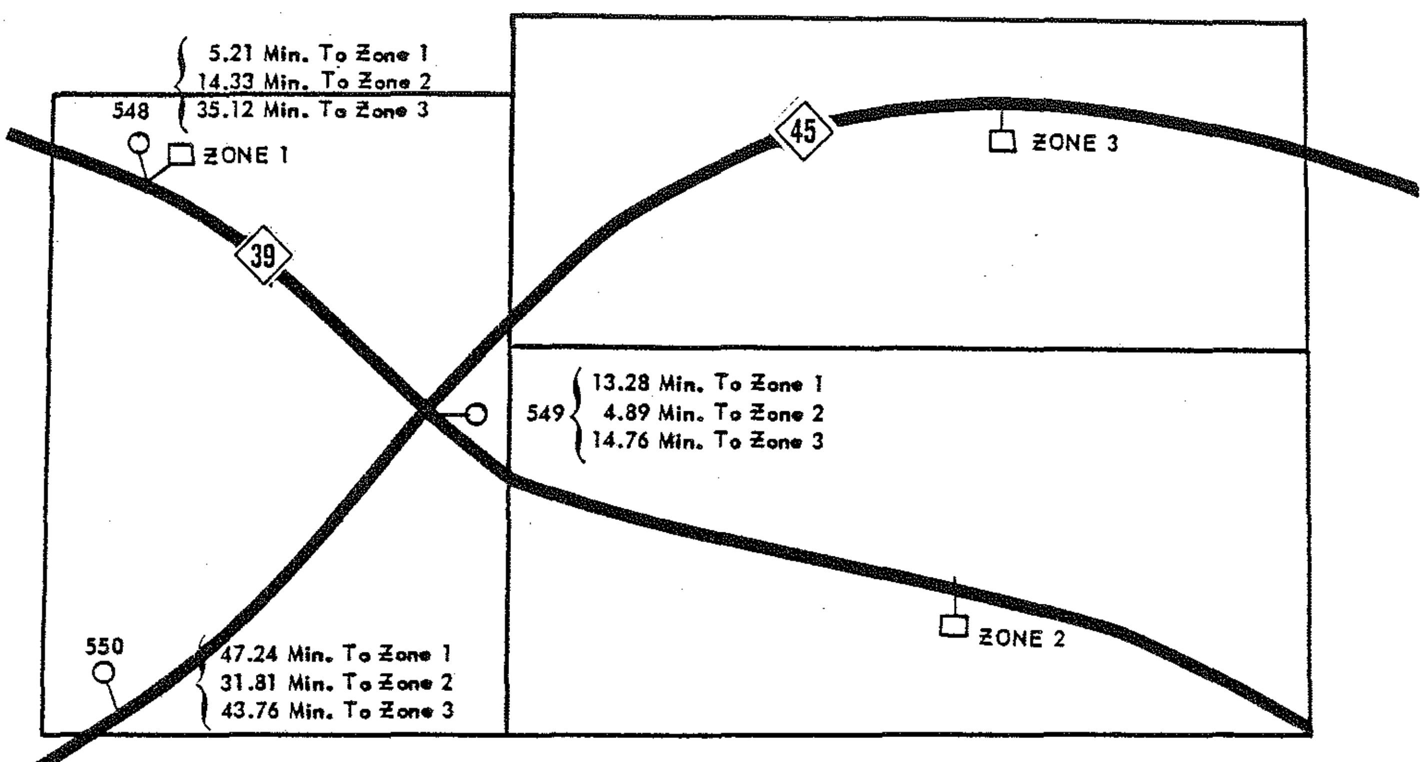


Figure 6a



Station 548 is Accessible to Zones 1 & 2 within 15 Min.

Station 549 is Accessible to Zones 1, 2, & 3 within 15 Min.

Station 550 is Not Accessible to Zones 1, 2, or 3 within 15 Min.

Figure 6b

accumulated value for that facility may be zero. Naturally, such a value should not be interpreted to mean that no one from the chosen group of people live within the selected traveling time of that facility. However, it can cautiously be reasoned that the facility is most likely in a sparsely populated location relative to other locations within that zone and nearby zones, since the centroids, or centers of population, of those zones are outside the selected time band(s). Facilities in the outlying areas of a zone which before were reassigned to the zone centroid, and thus possibly much closer to or further from surrounding centroids, are now placed in a more accurate position relative to the surrounding population. In this way, two facilities on opposite sides of one zone may easily show very significant differences in the number of persons accessible within a selected driving time (see Figure 6-b). This was obviously impossible when all facilities in a zone were assigned to that zone's centroid. This feature becomes particularly useful when one wishes to obtain some relative measure of the importance of each facility.

NORTHWESTERN REGIONAL TEST

STATE WIDE

NORTHWESTERN REGIONAL TEST

The technique described above has been applied in three illustrative examples. The northwestern, ten county region of the lower peninsula of Michigan was selected as the sample area to be used. Rail stations, bus terminals, and airports were the chosen facilities. The kinds of analysis completed in these tests can be used to measure the relative potential demand for various multi-modal routes or stations.

For the first example, each of the eighty-four rail stations from the rail network (including several which have been abandoned) was connected to the highway network each as an additional zone. This step is depicted in Figure 7 where rail tracks are shown with a dashed line. (The solid lines connected at only one end denote centroid links.) From the resulting revised network, the minimal zone-to-zone paths from each station/zone were built and "skimmed". The socio-economic file was used to find the number of employed persons in each zone. The proximity analysis was then used to calculate the number of employed people within fifteen and thirty minutes of each rail station. The results obtained can be seen in Figures 8a-b. From this table it can quickly be seen which stations are closest to the greatest number of employees. Thus, for example, if some rail stations in Benzie County must be abandoned, this viewpoint would definitely include Wallin among the most likely choices. Naturally, however, this decision should be tempered with many other pieces of information about Wallin before it is abandoned. Such information might include the tonnage originating at or destined for the

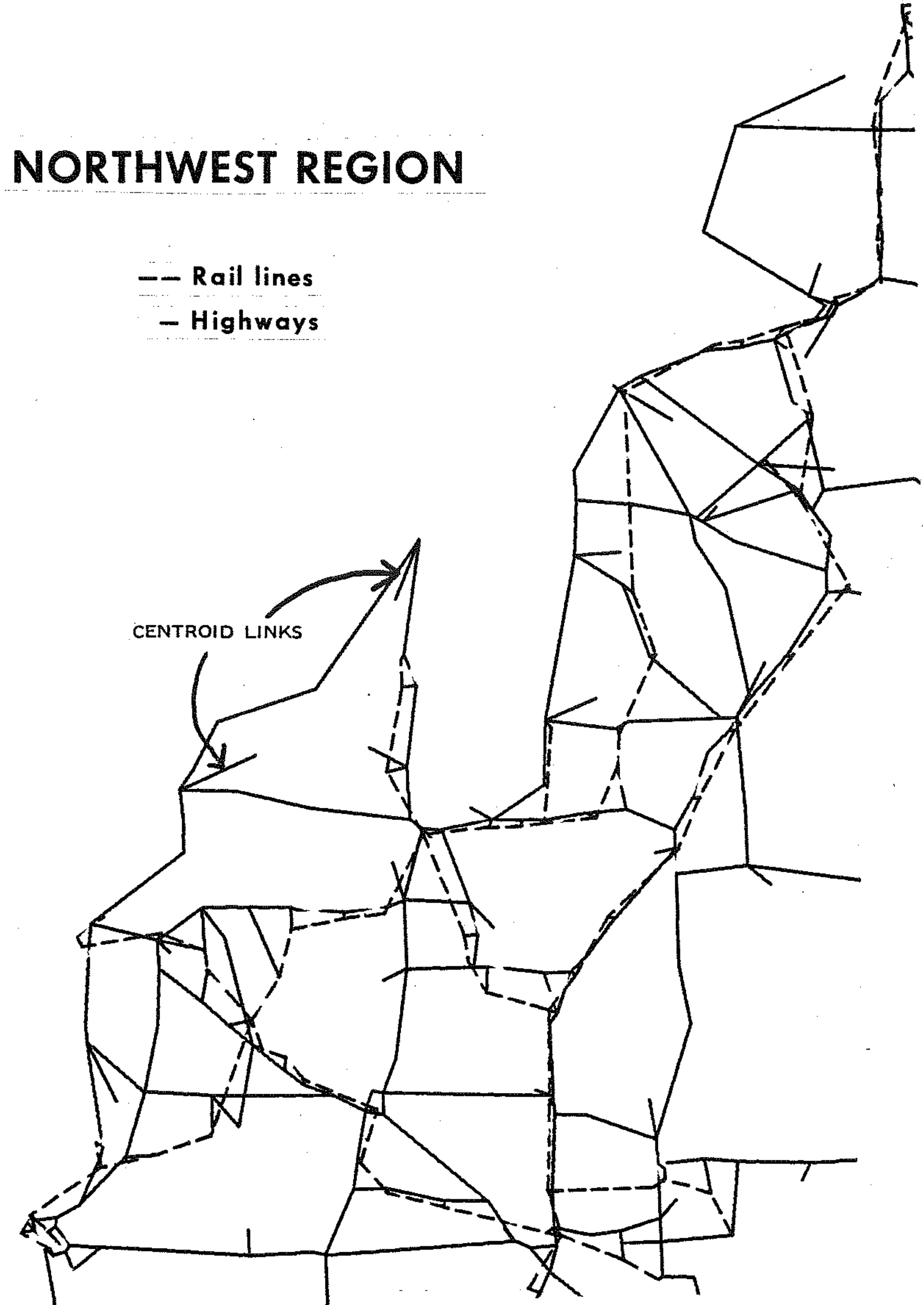


FIGURE 7

station being considered, the rail company using that station, the location of nearby industries and the kind of products they ship, the distance to neighboring stations, etc.

Proximal symaps of the proximity analysis results were also prepared (Figures 9 and 10). As the table in Figures 8a-b indicates, each station has been assigned a number representing the number of employees accessible within each driving time band (fifteen and thirty minutes). The symaps show this information in a pictorial form which can prove very helpful as a public involvement tool. A proximal symap looks at each point within the region, then searches for the nearest facility (in this case rail stations) using straight line distances. It then assigns to that point the shading dictated by the value assigned to that nearest facility. Thus, one should not assume that all points within the same shaded section as a given station are within the given driving time of that station. For example, in Figure 9, one should not assume that Glen Haven is fifteen minutes from the rail stations in that darkly shaded area. Glen Haven is included in that darkly shaded region <u>only</u> because the nearest station (via straight line distances) is accessible to 10,000-18,000 employees within fifteen minutes driving time. Thus, these symaps should not be used to make inferences about any points other than the rail stations themselves. For each rail station, the area surrounding it is shaded according to the number of employees within fifteen (or thirty) minutes of the station. The legend shows the range of values for each shading symbol. In Figure 9 those stations in the vicinity of Traverse City are shaded very

County	RAIL STATION	0-15 MIN.	0-30 MIN.
MISSAUKEE	McBain	2196	6239
	Lucas	4823	7796
	Missaukee Park	1718	7601
	Sandstown	1718	7601
	Lake City	1718	6654
	Vener Jct.	0	2246
	Falmouth	0	2246
WEXFORD	Caddillac	5131	9263
	Hobart	5131	9263
	Harrietta	0	906
	Boon	0	5700
	Missaukee Jct.	4408	8252
	Harlan	569	1073
	Mesick	569	2241
	Yuma	834	8252
	Manton	834	8252
ANTRIM	Antrim	1254	2656
	Mancelona	1254	3925
	Alba	1254	2345
	Elmira	0	5479
	Central Lake	0	2386
	Ellsworth	1269	6869
	Bellaire	0	2426
	Alden	0	1254
	Elk Rapids	1658	10944

RAIL STATION	0-15 MIN.	0-30 MIN.	County
Stronach	4827	5164	MANISTEE
East Lake	4827	8056	
Filer City	4827	6442	
Oak Hill	4827	6442	
Manistee	4827	6442	
Parkdale	4827	8056	
Onekama Jct.	0	6104	
Norwalk	0	7913	
Kaleva	504	1073	
Copemish	504	3919	
Pomona	0	3083	
Chief Lake	0	4827	
Marsh Station	0	5164	
Onekama	1277	6104	
Rapid City	0	2116	KALKASKA
Barker Creek	0	9516	
Leetsville	2435	2656	
Kalkaska	1402	3591	
South Boardman	1181	2236	
Charlevoix	3965	8819	CHARLEVOIX
Boyne Falls	463	5236	
Walloon Lake	2413	7255	
Clarion	2413	7255	
Bay Shore	3627	9488	
Boyne City	463	5359	

FIGURE 8a

County	RAIL STATION	0-15 MIN.	0-30 MIN.
EMMET	Petoskey	2413	7200
EMMET	Mackinac City	884	4617
EMMET	Carp Lake	0	4013
EMMET	Levering	0	4013
EMMET	Pellston	0	3110
EMMET	Brutus	0	6657
EMMET	Alanson	1533	6657
EMMET	Oden	3110	6657
EMMET	Conway	5523	6657
EMMET	Kegomic	5523	5523
EMMET	Bay View	5523	5986
EMMET	Lamson	2413	6737
LEELANAU	Hatchs	8819	13247
LEELANAU	Leelanau	0	10087
LEELANAU	Suttons Bay	0	10087

County	RAIL STATION	0-15 MIN.	0-30 MIN.
GRAND TRAVERSE	Traverse City	9754	16052
GRAND TRAVERSE	Grawn	10672	17458
GRAND TRAVERSE	Mayfield	1867	13808
GRAND TRAVERSE	Interlocken	3493	17458
GRAND TRAVERSE	Kingsley	0	14276
GRAND TRAVERSE	Summit City	0	6528
GRAND TRAVERSE	Walton Jct.	834	5589
GRAND TRAVERSE	Fife Lake	0	4216
GRAND TRAVERSE	Acme	8114	17953
GRAND TRAVERSE	Bates	935	12593
GRAND TRAVERSE	Williamsburg	935	10953
BENZIE	Frankfort	2141	4123
BENZIE	Elberta	2141	4123
BENZIE	Beulah	2846	3350
BENZIE	Weldon	1305	3350
BENZIE	Thompsonville	0	3919
BENZIE	Homestead	2010	2846
BENZIE	Wallin	0	705
BENZIE	Bendon	0	12682

FIGURE 8b

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

CONCENTRATION OF EMPLOYED PEOPLE AROUND RAIL STATIONS

NORTHWEST REGION

Fifteen minutes

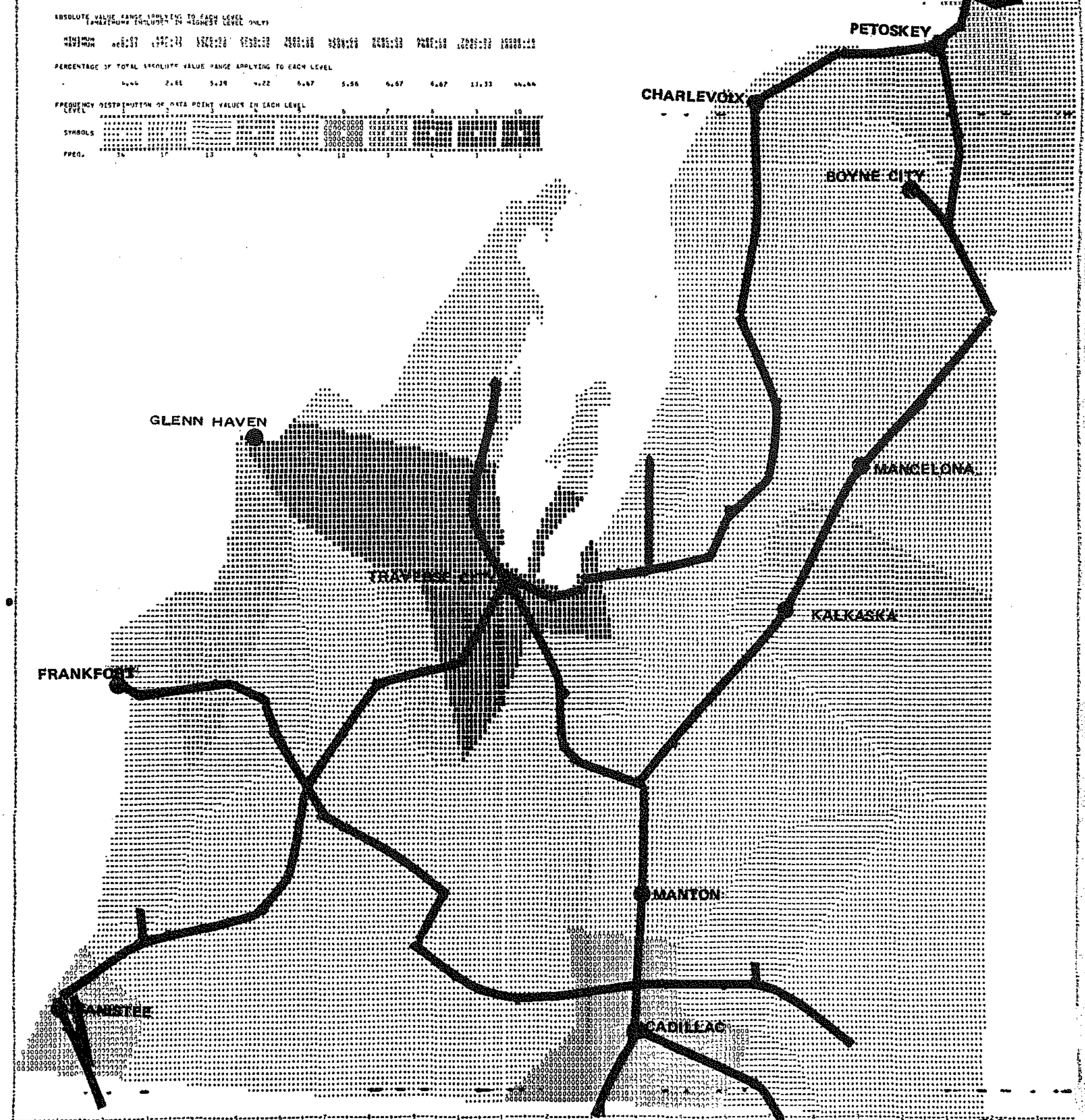


FIGURE 9

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

CONCENTRATION OF EMPLOYED PEOPLE AROUND RAIL STATIONS

NORTHWEST REGION

Thirty minutes

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MAXIMUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

4.44	2.61	5.39	4.22	6.67	9.96	6.67	6.67	13.33	44.44

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	X	[illegible]	[illegible]	[illegible]
FREQ.	1	8	2	9	12	5	10	14	11	13

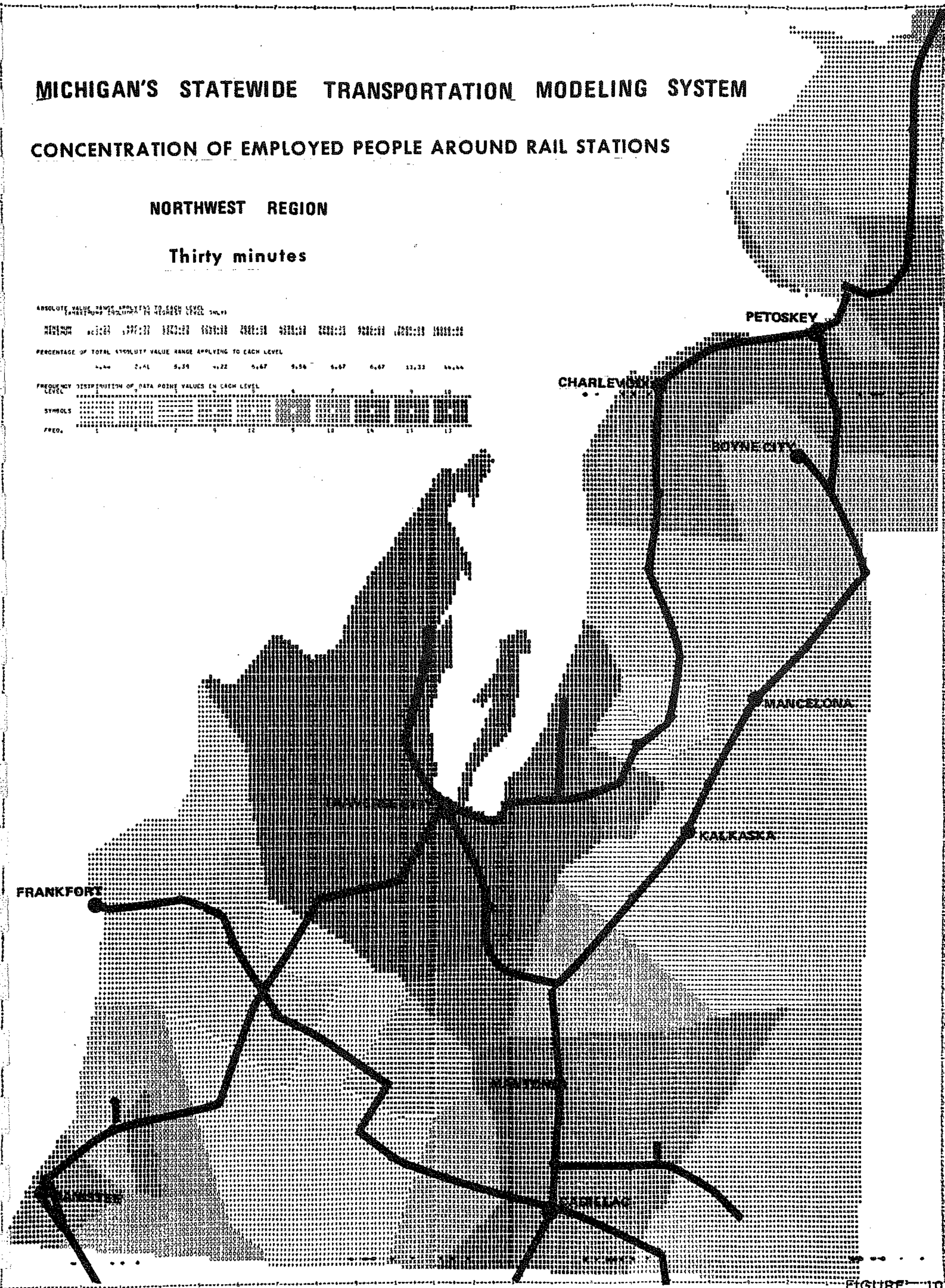


FIGURE 10

darkly indicating that those stations are within fifteen minutes driving time of more employees (10,000-18,000) than any other stations, all of which received lighter shading symbols. Such information should be no great surprise, since Traverse City is the largest city in the northwest region.

These symbols not only enable one to spot quickly those stations which are relatively inaccessible, but also to easily compare the accessibility of whole sections of track. If one were attempting to decide which of the two lines entering Petosky from the south should be upgraded, Figure 10 would seem to indicate that improving the tracks through Charlevoix would benefit more employees and hence probably more industries than upgrading the tracks through Mancelona, and Figure 9, by seeming to be nearly impartial to either system of tracks, indicates that the above decision is reasonable. Other information may often be required to make a final decision of this sort but the process described in this document is the beginning of statewide multi-modal planning.

For selected purposes, it might be desirable to use some measure of accessibility other than the total number of employees. One could very easily use other criterion selected from the data files mentioned earlier. Such selections might be the number of employees of certain industries such as mining, metal industries, agriculture, etc. Other possibilities include the number of truck terminals, manufacturers, commercial centers and, if passenger service is contemplated, total population or subgroups such as the elderly or the handicapped may be used.

The second example replaced rail stations with bus terminals. Consulting the bus network (created by using "The Official Bus Guide Manual"), twenty-three bus terminals or stops were located in the northwest region. Because buses are typically more concerned with potential passengers than with freight, total population was selected instead of the total number of employees. The proximity analysis results are shown in Figure 11 and the resulting proximal symaps in Figures 12 and 13. These symaps should be interpreted in the same manner as were the rail symaps.

The final example is a proximity analysis using the three air carrier airports of the northwest region with total population. The results of this example are displayed in Figure 14. Because of the small number of airports, a symap was deemed unnecessary. Each of the three airports were assigned no people within the fifteen minute travel time band. This is largely explained by reflecting that airports are generally located on the outskirts of relatively major centers of population. The centroids of their respective zones would be located at the assumed center of population, which most likely would be more than fifteen minutes from the outskirts of the city (and the airports). It also can be noted that the Pellston airport was not even accessible within thirty minutes. This is one example of the possible error caused by the assumptions which the system must make and which should be corrected by a 2300 zone system instead of the 547 zone system. However, close examination of the Pellston area indicates that the number of people residing there is very small (one reason for the coarse zones in that area) thus considerably reducing the severity of the approximation error. If

BUS STATION	0 - 15 MIN.	0 - 30 MIN.
Alanson	9234	19732
Bay View	15576	19095
Bear Lake	0	27382
Benzonia & Beulah	8593	10310
Boyne City	5656	15517
Boyne Falls	0	21841
Buckley	1937	38654
Cadillac	15118	29263
Charlevoix	10885	26529
Chum's Corner	30074	51561
Elk Rapids	7915	32251
Frankfort	6467	12243
Honor	6022	17977
Interlochen Corner	9384	52195
Kalkaska	5272	13382
Levering	0	22697
Mancelona	3509	12467
Manistee	13422	23527
Manton	2662	24732
Mesick	1937	17803
Pellston	0	21129
Petoskey	10464	28431
Traverse City	36959	46198

FIGURE 11

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

POTENTIAL BUS STATION DEMAND WITHIN FIFTEEN MINUTES

NORTHWEST REGION

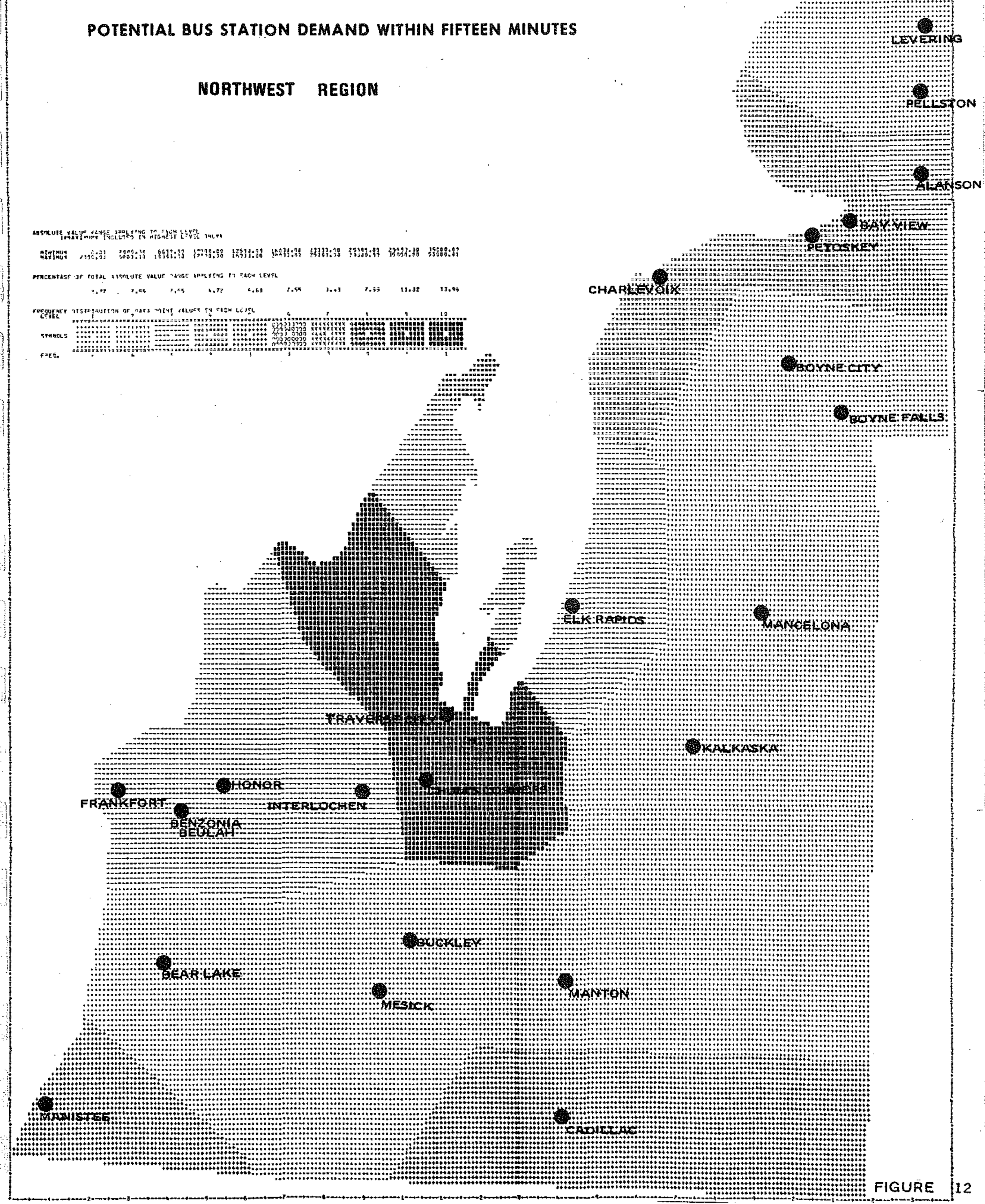


FIGURE 12

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

POTENTIAL BUS STATION DEMAND WITHIN THIRTY MINUTES

NORTHWEST REGION

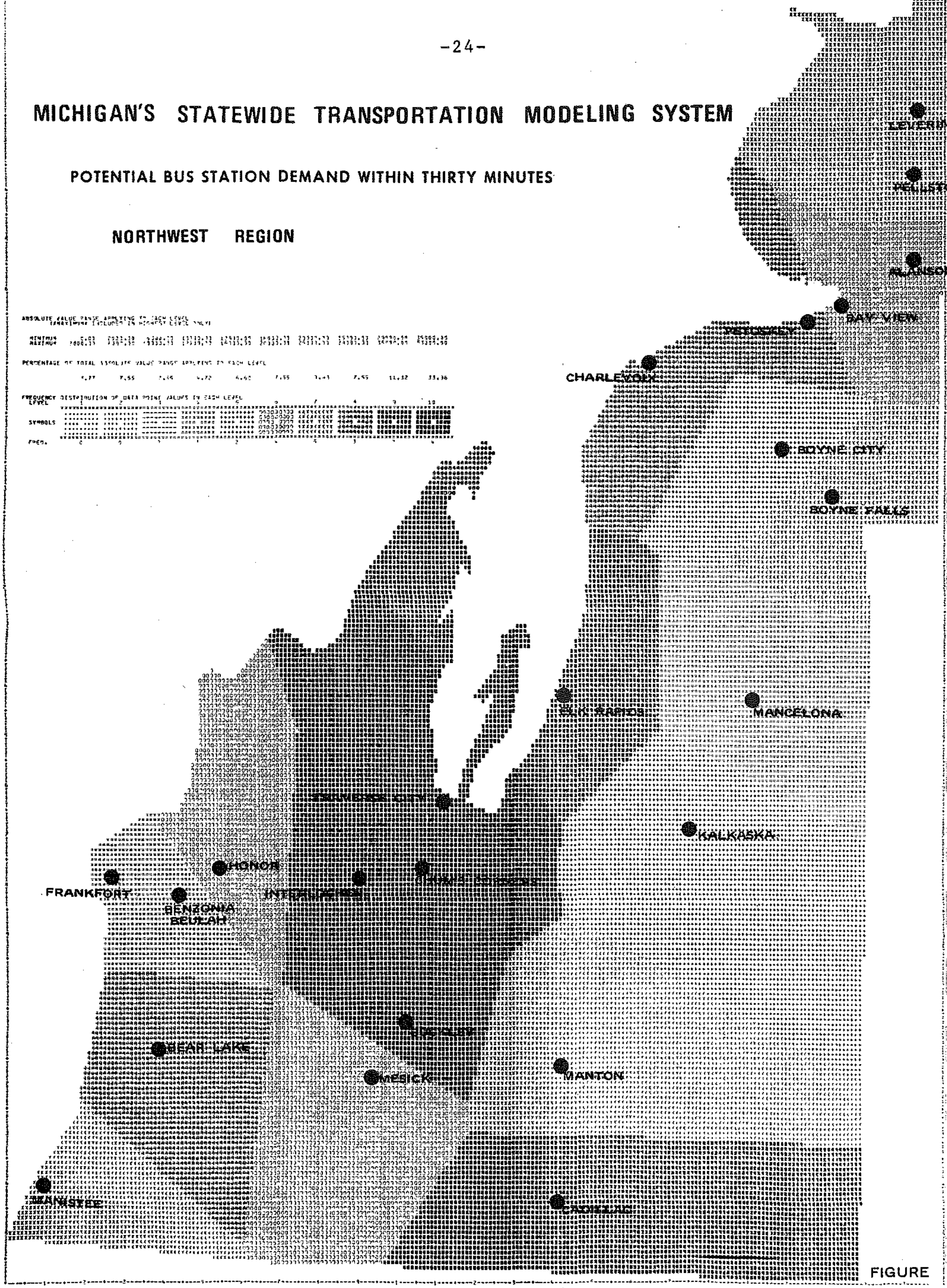


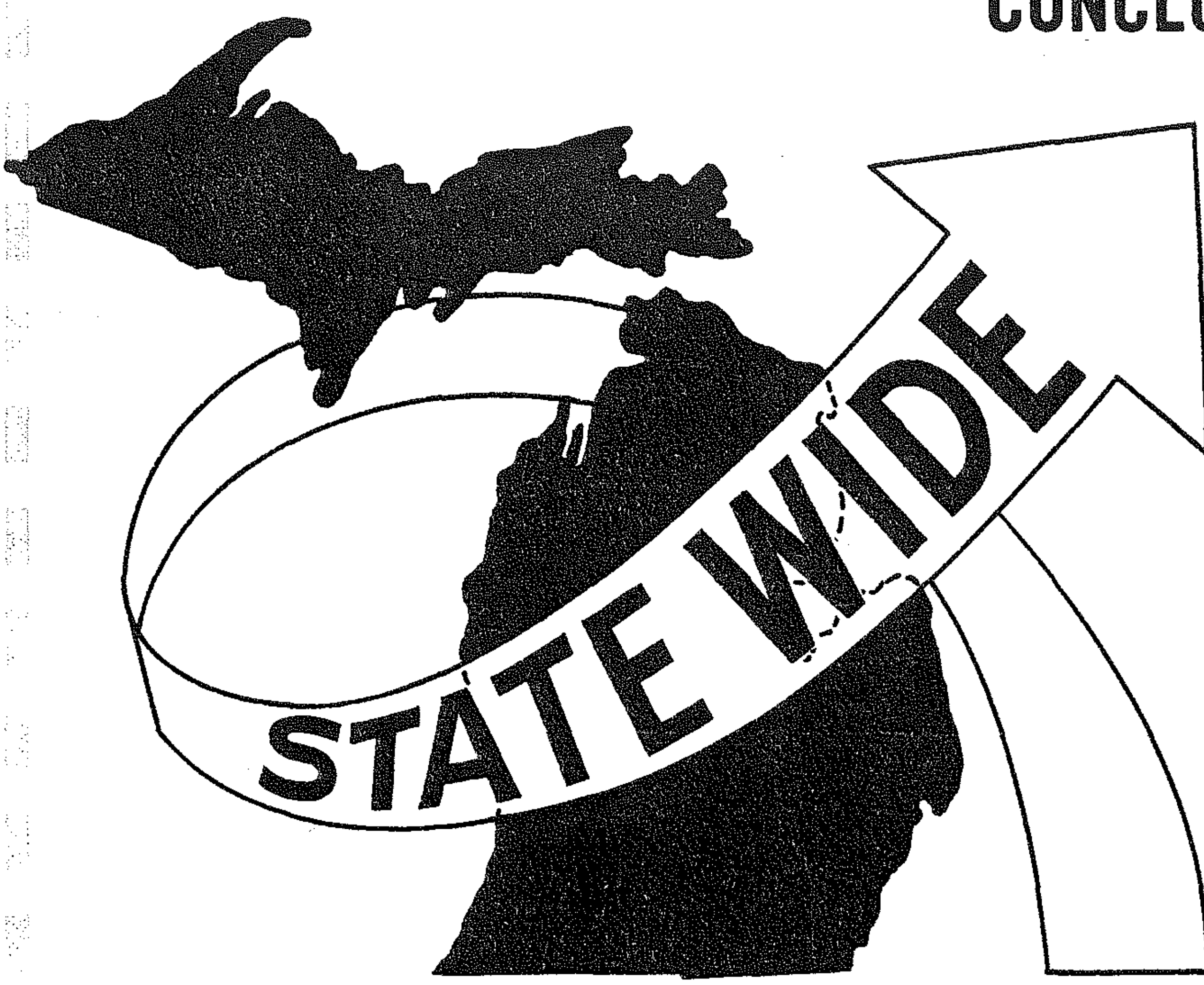
FIGURE 13

one were to use a slighter larger time band, that error would become even more negligible. It would also seem reasonable to use larger time bands for airport accessibility than for bus terminals, for example, because of the smaller number of air carrier airports and the generally longer air trips. The main emphasis still has not been destroyed in this example. No one would seriously question the conclusion that Pellston is "easily" accessible to a relatively very small number of people. Of course, this does not mean that the Pellston airport should be abandoned, for it might well be very important to that small portion of the population. The strong suggestion of using other criteria, in conjunction with the proximity analysis results, which was made in reference to rail stations applies also to airports (and bus terminals).

AIRPORT	0 - 15 MIN.	0 - 30 MIN.
MANISTEE	0	13422
PELLSTON	0	0
TRAVERSE CITY	0	20690

FIGURE 14

CONCLUSION



CONCLUSION

Whenever decisions must be made, they can be made more wisely when more relevent data is available. The simple technique described above for an extended use of the proximity analysis method and the examples discussed above should demonstrate another source of relevant information. Because of the growing interest in travel modes other than auto, the process should have special relevance at this time. The ease with which the examples were produced should further enhance the method's value. This simple use of the multi-modal system in conjunction with the already well developed highway system is only a preview of many more applications to be made available as the multi-modal system expands.

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