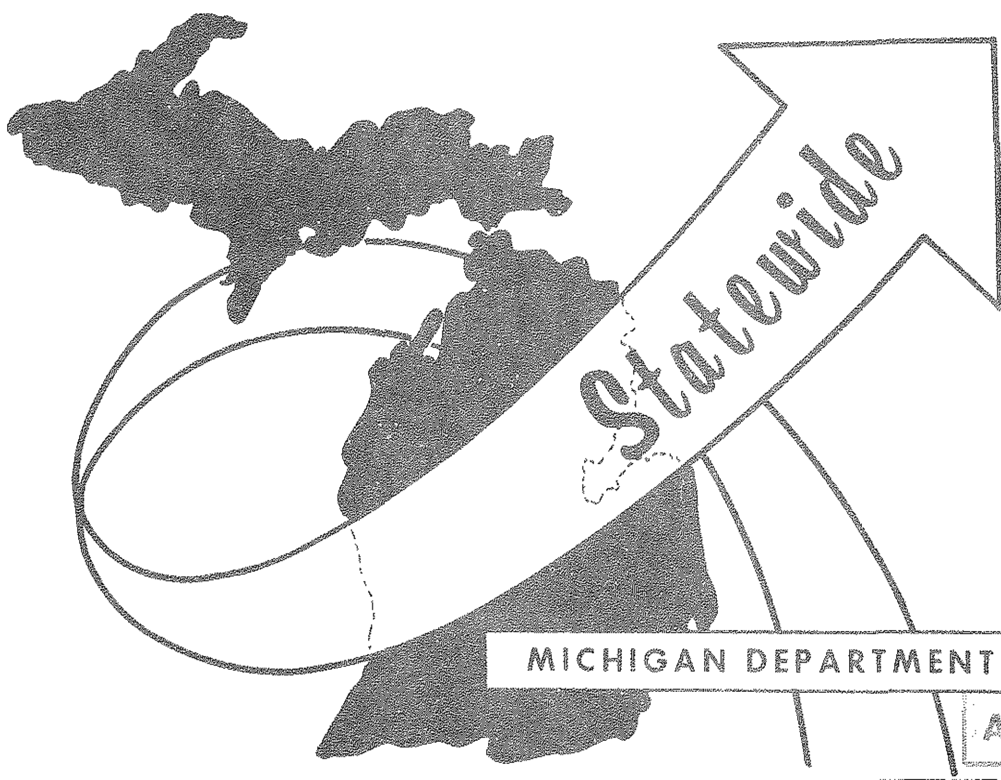
Statewide Transportation Analysis & Research

MICHIGAN'S
STATEWIDE TRAFFIC
FORECASTING MODEL

VOLUME I-J

SERVICE-AREA MODEL

AUGUST, 1973
STATEWIDE STUDIES UNIT



MICHIGAN DEPARTMENT OF STATE HIGHWAYS
AND TRANSPORTATION

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STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS

STATE HIGHWAYS BUILDING - POST OFFICE DRAWER K - LANSING, MICHIGAN 48904
JOHN P. WOODFORD, STATE HIGHWAY DIRECTOR

August 7, 1973

Mr. Sam F. Cryderman
Engineer of Transportation Planning
Transportation Planning Division

Dear Mr. Cryderman:

The Transportation Survey and Analysis Section is pleased to present a report entitled "Service-Area Model". Once the model is fine-tuned to a given set of facilities, a user may gauge the effects of new highway construction on the probable area of influence of each facility in his set. This may contribute to the involvement of other state agencies and members of the private economic community in the transportation planning process.

Moreover, the model could allow a highway department to provide input to facility planning in other units of state government. The proposed location of a new airport, for example, might generate excess traffic on an already-overloaded segment of highway. Such cooperative analysis efforts might assist both a highway department and other state agencies in planning for the future more efficiently.

The Service-Area Model and the accompanying report were prepared by Terry L. Gotts of the Statewide Studies Unit, under the supervision of Mr. Richard E. Esch.

Sincerely,

Keith E. Bushnell

Keith E. Bushnell
Engineer of Transportation
Survey and Analysis Section

MICHIGAN THE GREAT LAKE STATE

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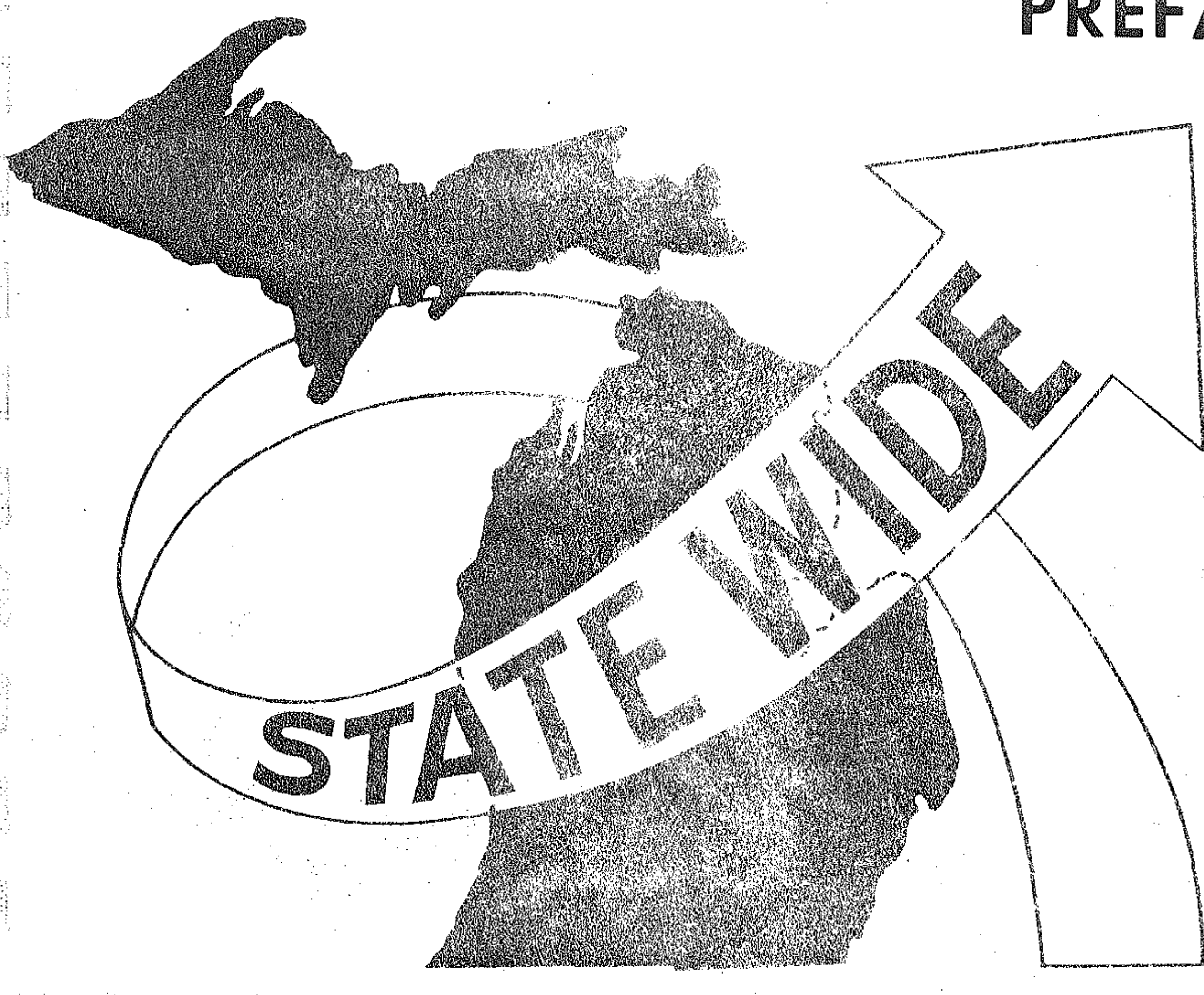
PREFACE



PREFACE

This report is the ninth in a series of reports dealing with the applications of the Statewide Modeling Process. The preceding members of the series are:

Volume I-A--Workshop Topic Summaries

I-B--Traffic Forecasting Applications: Single and Multiple Corridor Travel Analysis

I-C--Model Applications: Turnbacks

I-D--Proximity Analysis: Social Impacts of Alternate Highway Plans on Public Facilities

I-E--Cost Benefit Analysis

I-F--Air and Noise Pollution System Analysis Model

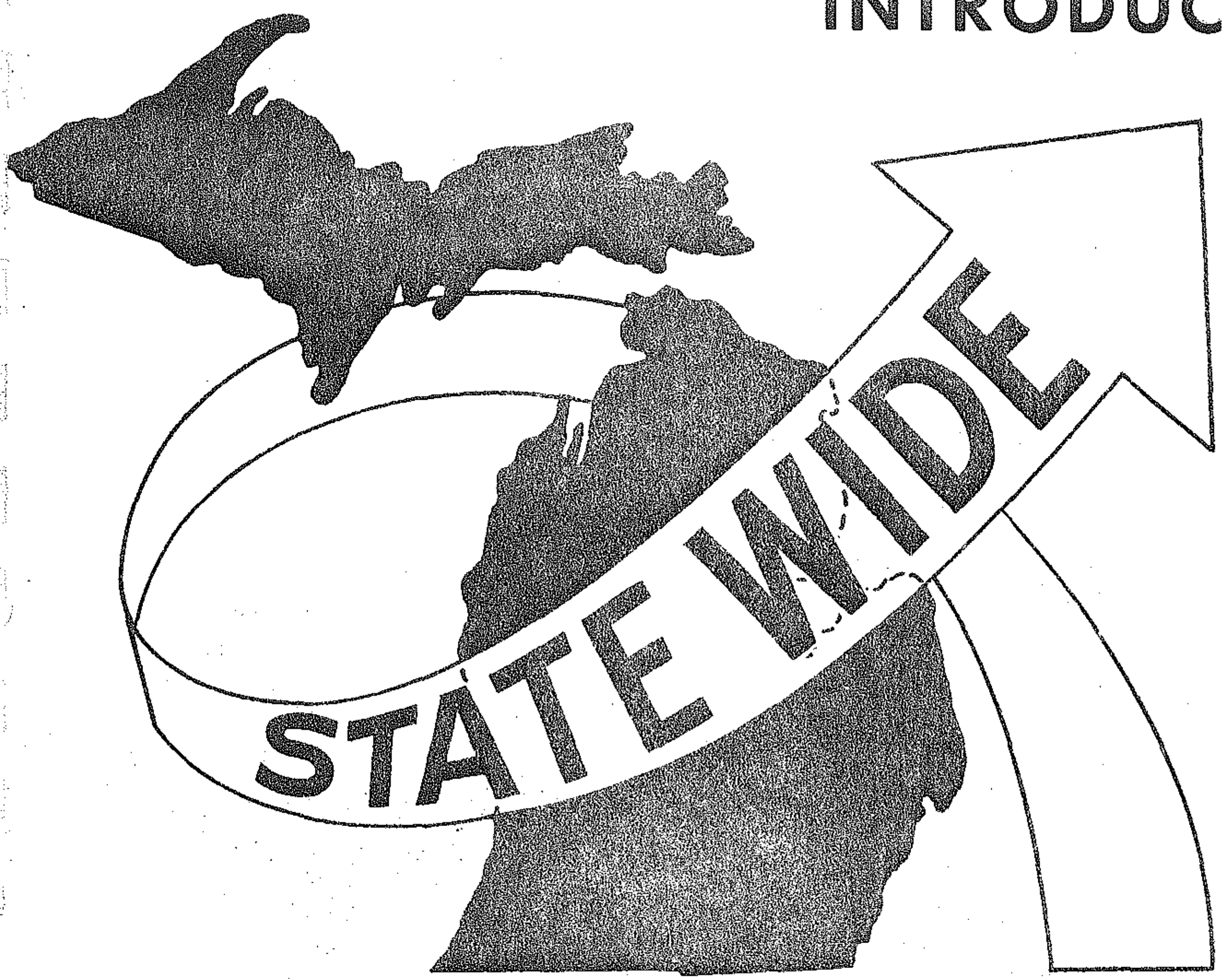
I-G--Transportation Analysis Psychological Impact Model

I-H--Level of Service Systems Analysis Model: A Public interaction Application

The Service-Area Model is an attempt to monitor the effects of alternate transportation plans on the probable regions of influence of each member of a facility set. It also allows facility planners to test the effects of adding or deleting facilities or changing service capacities. Therefore, the model could facilitate multi-departmental participation in the transportation planning process by combining both capabilities. For example, an airport planner might be able to see that if a new freeway is constructed, the increase in demand on one of his airports might be great enough to justify an increase in the number of flights to that airport; on the other hand, he could test the effects of adding flights to certain other airports so as to offset the projected shift in service patterns.

This technique might also be useful in actively involving private business and industry in the planning process. In some cases, these interests can be quite vocal about highway planning questions; this might provide them with additional data on which to base opinions. Other members of the commercial sector who have heretofore remained silent might be stimulated by seeing a projected freeway's impacts on their businesses. In any event, the Service-Area Model could be used to facilitate public involvement in transportation planning.

INTRODUCTION

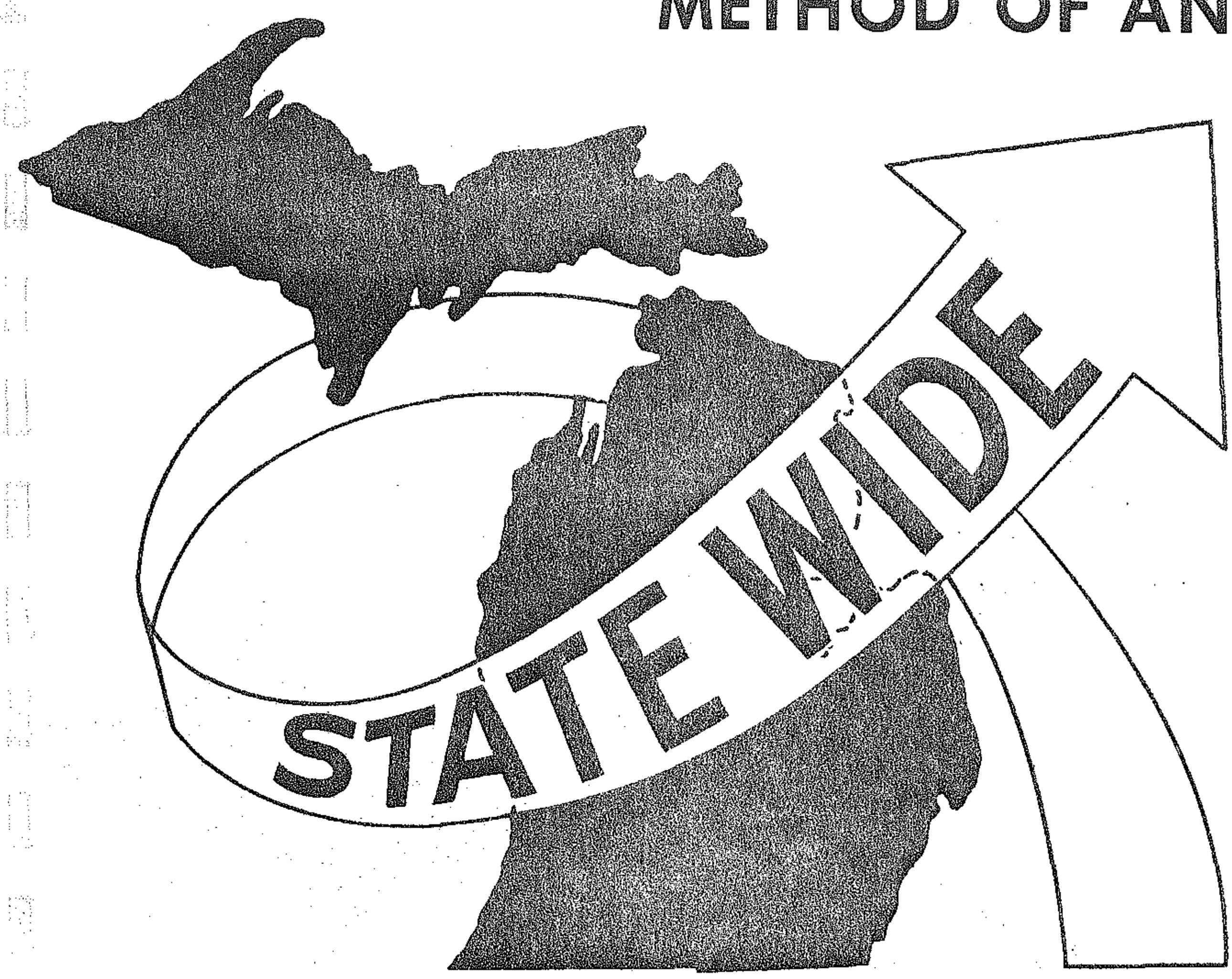


INTRODUCTION

Stimulated by the output of the Proximity Analysis process, many users of the Statewide Modeling System have begun to ask whether the area of influence of a particular facility can be identified. Given a particular set of facilities and some region of the state, is it possible to identify which facility will most probably be used by residents of the region?

Until now, it was not feasible to answer such questions by means of a model. In this report a model is presented which, when particularized to a user's own facility set, can specify the service area of each facility. Moreover, once a user "calibrates" the model to his own situation, he can test the effect of adding or deleting a facility from his facility set. This makes possible rapid analysis of facility service area. In a relatively short time, a planner can see the changes in service areas resulting from adding a facility at a number of alternative locations. This information, used in conjunction with Proximity Analysis, should be a powerful tool in facility location planning.

METHOD OF ANALYSIS



METHOD OF ANALYSIS

The Statewide Travel Forecasting Model divides Michigan into 508 analysis subareas, or "zones". The zone system is shown in Figure 1. Under the model's assumptions, all travel in Michigan is assumed to take place on a network composed of all state trunkline and certain selected secondary roads, shown graphically in Figure 2. In fact, this assumption is a fairly good one, since recent Federal and state studies have shown that this network carries at least 85% of all trips made in Michigan.

The Travel Forecasting Model calculates the shortest-time paths from each zone to every other zone, known as a set of "trees". It then calculates the average driving time from each zone to every other along these trees. The file of these zone-to-zone travel times is called a "skimmed tree" file and is a principal input to the Service-Area Model.

Once a user has entered his set of facilities into the Statewide Public and Private Facility File, the facilities are aggregated to the zone level. That is, if there are two or more facilities lying in one zone, they are treated as one macro-facility having a "service capacity"--for example, number of beds in the case of hospitals--equal to the sum of the capacities of all facilities in that zone. For more information on the Statewide Facility File, consult Statewide Transportation Analysis and Research report Volume VIII, "Statewide Public and Private Facility File".

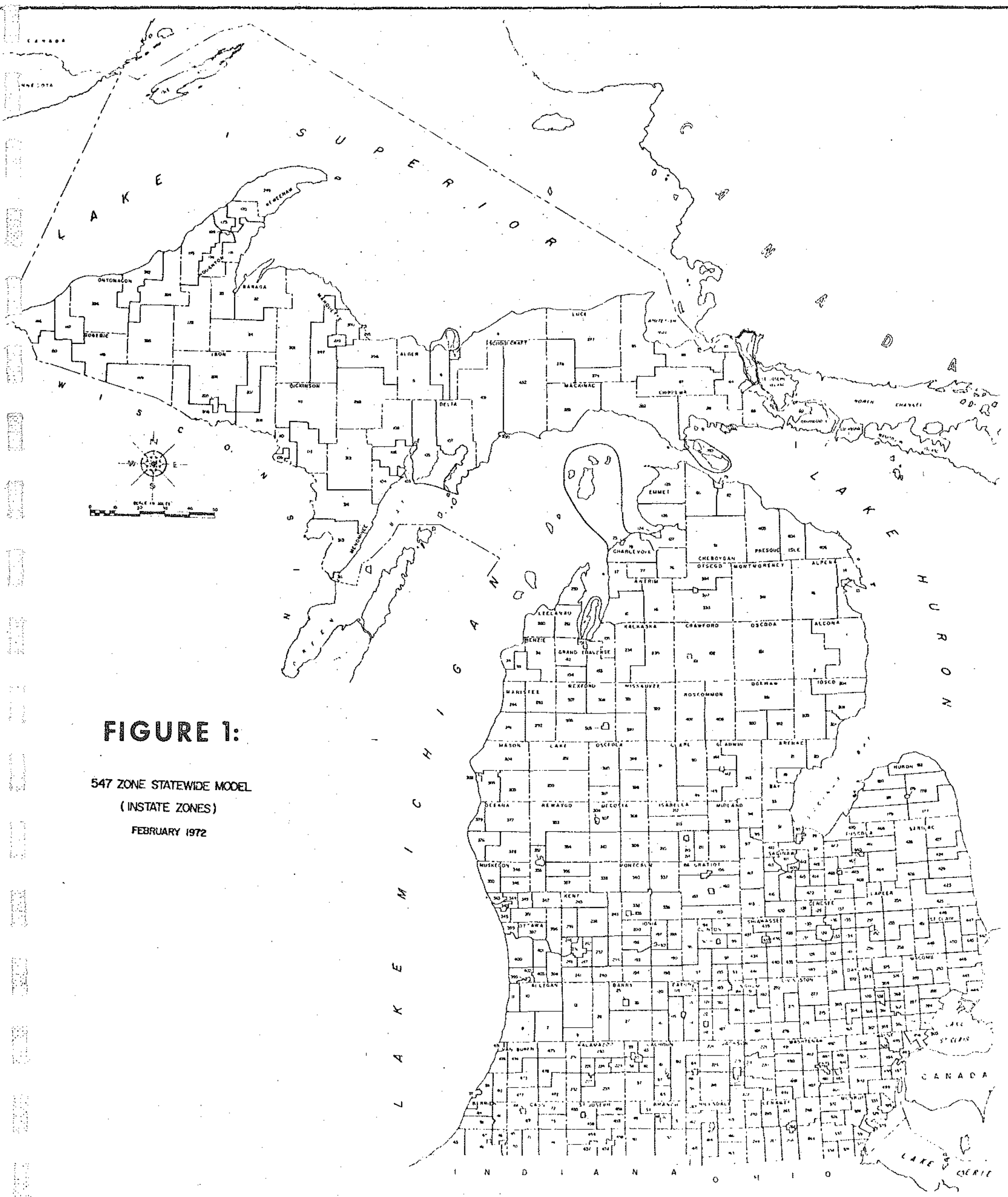


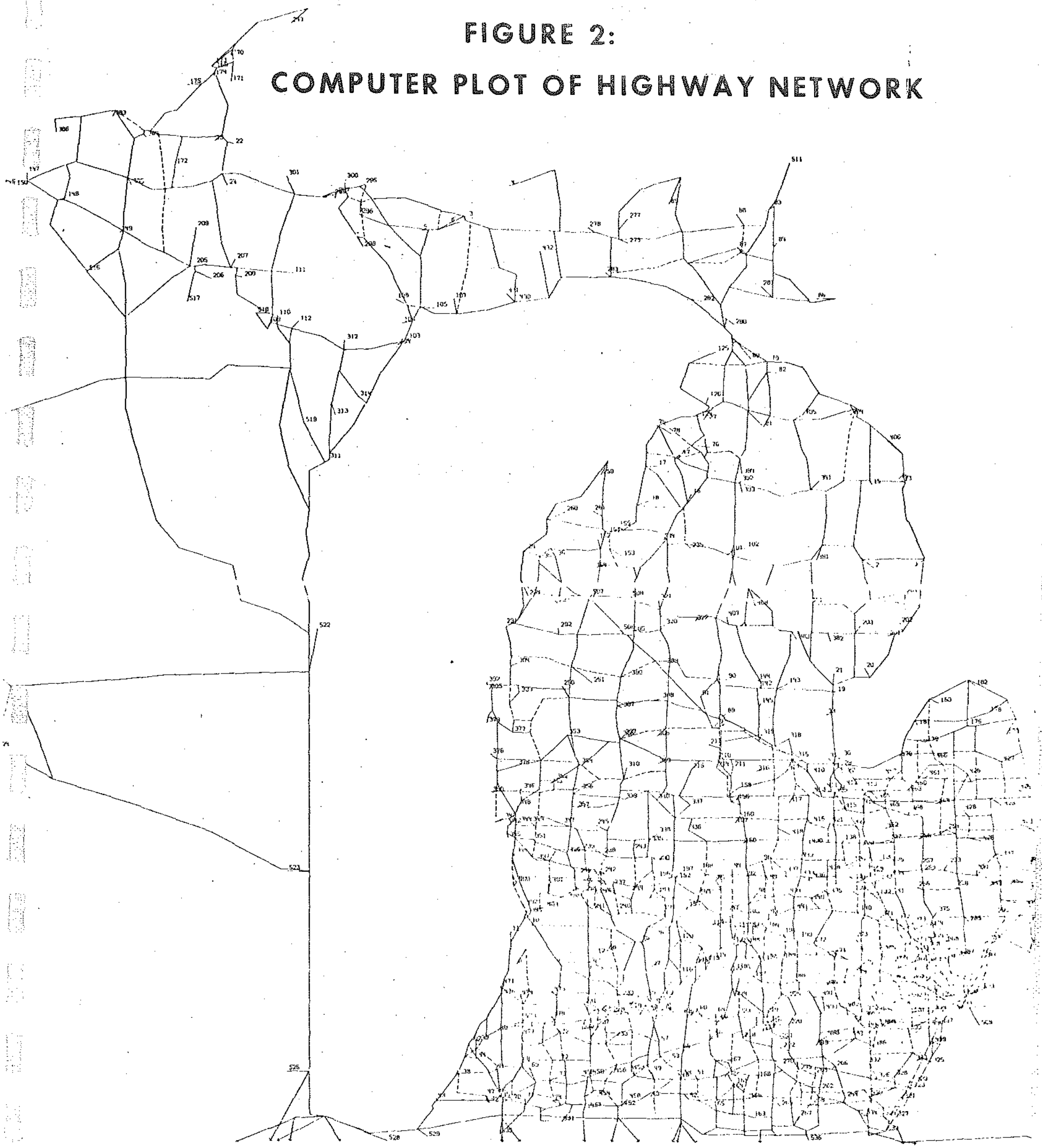
FIGURE 1:

547 ZONE STATEWIDE MODEL

(INSTATE ZONES)

FEBRUARY 1972

FIGURE 2:
COMPUTER PLOT OF HIGHWAY NETWORK

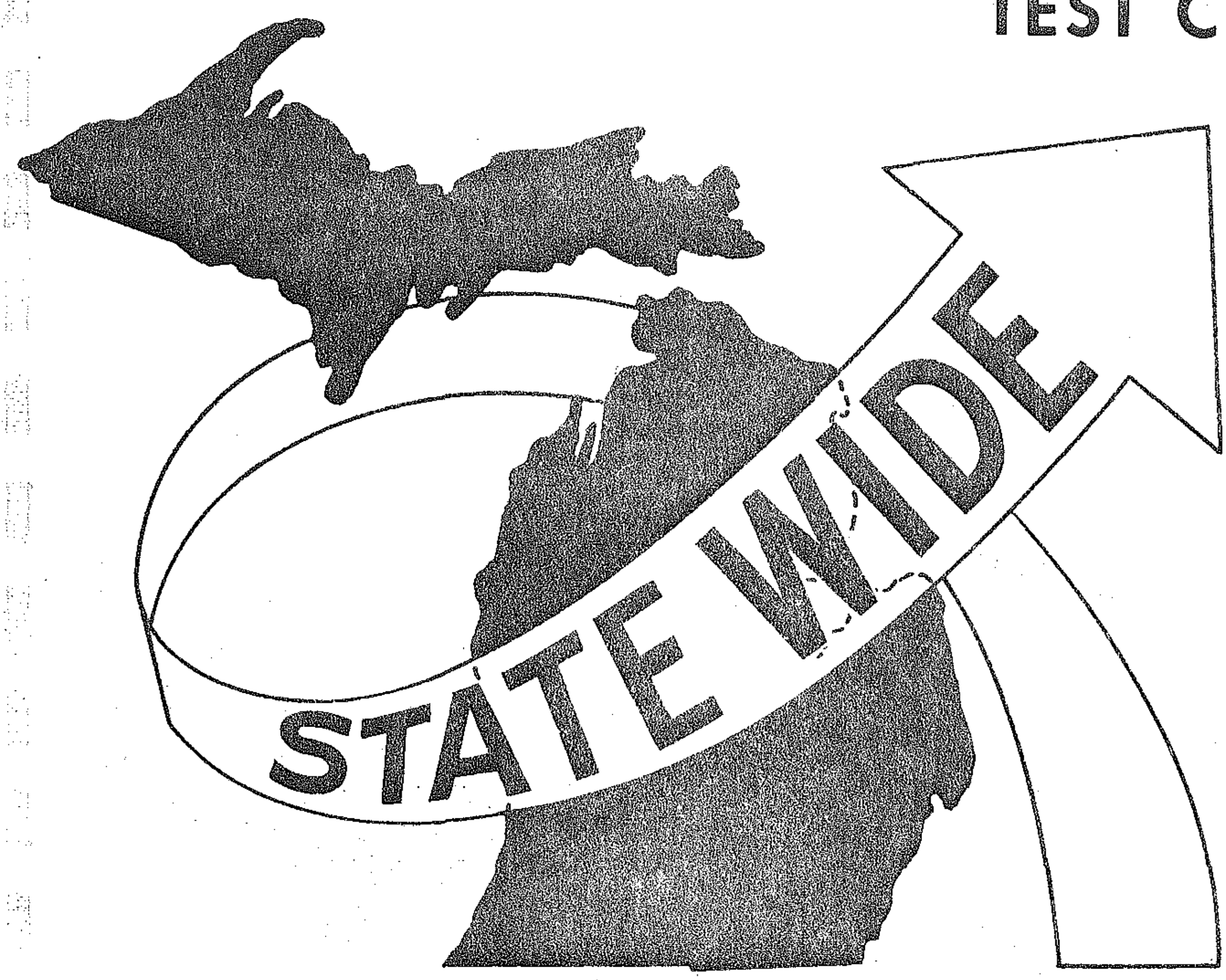


Using these two inputs--facilities aggregated to zone level and skimmed trees--the program begins to examine every zone of Michigan to ascertain to which macro-facility the residents of the zone would most probably go. The basic algorithm of the Service-Area Model states that the attractiveness of a macro-facility to the residents of zone 1, for example, is directly proportional to the capacity of the facility and inversely proportional to some power of the driving time between the facility and zone 1. More precisely, the process calculates for zone 1 an "attractiveness weight" for each macro-facility zone; this weight is calculated by the formula

$$W = \frac{\text{capacity of macro-facility}}{(\text{driving time from macro-facility to zone 1})^{\alpha}}$$

where α ("alpha") is a user-supplied, positive constant. The residents of zone 1 would be assumed to use the macro-facility having the largest attractiveness weight for them. The process is then repeated for zone 2, zone 3, and so on.

TEST CASE



TEST CASE

As an example of how the forecasted service areas change in response to changes in the relative importance of time and to changes in capacity, Michigan was assumed to be served by exactly ten air-carrier airports. A list of the ten, with capacities expressed as number of passengers enplaned in 1970, appears in figure 3.

The map in figure 4 shows the service areas which result when the attractiveness of an airport to a zone of residence is assumed to be directly proportional to the capacity of the airport and inversely proportional to the square of the driving time separating them. Each shading represents a different airport. The darkest area, which covers most of the state, is the service area of Detroit Metropolitan Airport ("Metro") under these assumptions. If this model were calibrated to airport data, this would say that people are willing to use their local airport as long as they need not expend too much travel time reaching the airport. After a certain point, a person would seem to be willing to trade extra travel time for the convenience of being able to get a flight when he wants one, a product of Metro's superior capacity.

Figure 5 depicts the service areas which result when attractiveness is made inversely proportional to the fourth power of travel time, rather than the square; as always, attractiveness is directly proportional to capacity. Obviously, the service areas shown are a dramatic change from those in figure 4. Because travel time is so much more

FIGURE 3:
AIRPORTS INCLUDED IN TEST CASE

Name	Capacity
Capacity City (Lansing)	238,165
Escanaba Municipal	28,169
Bishop (Flint)	156,992
Traverse City Municipal	72,835
Kalamazoo Municipal	125,736
Kent County (Grand Rapids)	437,220
Marquette County	49,050
Muskegon County	124,451
Tri-City Freeland	277,596
Detroit Metropolitan	7,339,397

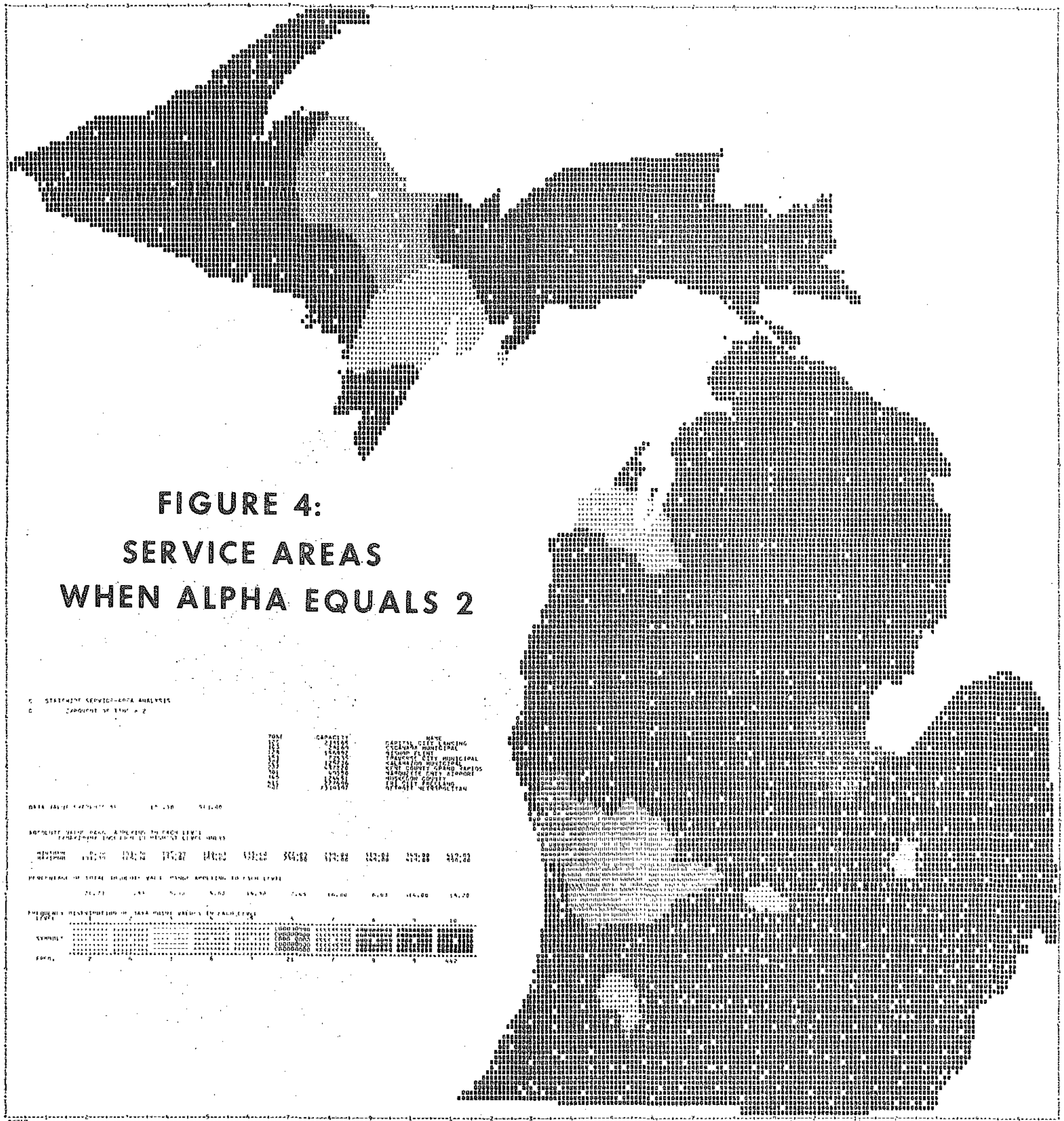


FIGURE 4:
SERVICE AREAS
WHEN ALPHA EQUALS 2

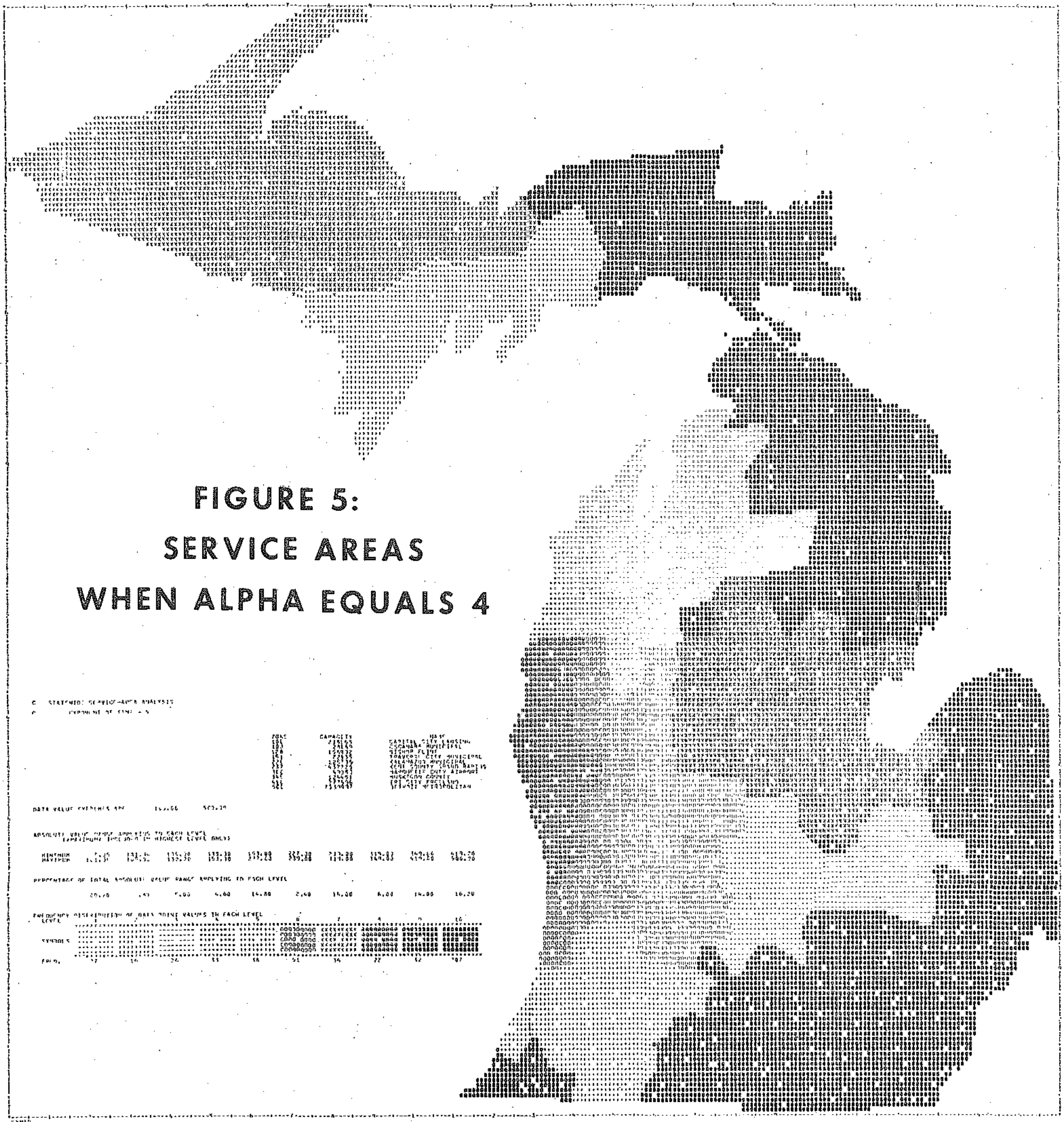


FIGURE 5: SERVICE AREAS WHEN ALPHA EQUALS 4

important in the situation shown in figure 5, smaller airports tend to "serve" larger geographical areas around them and the influence of Metro is greatly decreased. When travel time is made even more important (figure 6), Metro's service area shrinks even more and the other airports' service areas expand accordingly.

To show the effect of increasing the service capacity on the service area of an airport, the number of passengers enplaned was increased by 100,000 at Flint Bishop, Kalamazoo, and Lansing. This simulates the increasing of the number of flights departing from these airports. In this test, the exponent of time was set at two. By comparing figure 7 (the base data) with figure 8 (with the increased capacities) it can be seen that the service area of Flint Bishop has expanded only slightly, because it is so close to Metro. However, the service areas of Kalamazoo and Lansing have expanded considerably. Thus, if the model shown in figure 7 had been previously calibrated to airport data, figure 8 would show the results of adding additional flights to these three airports.

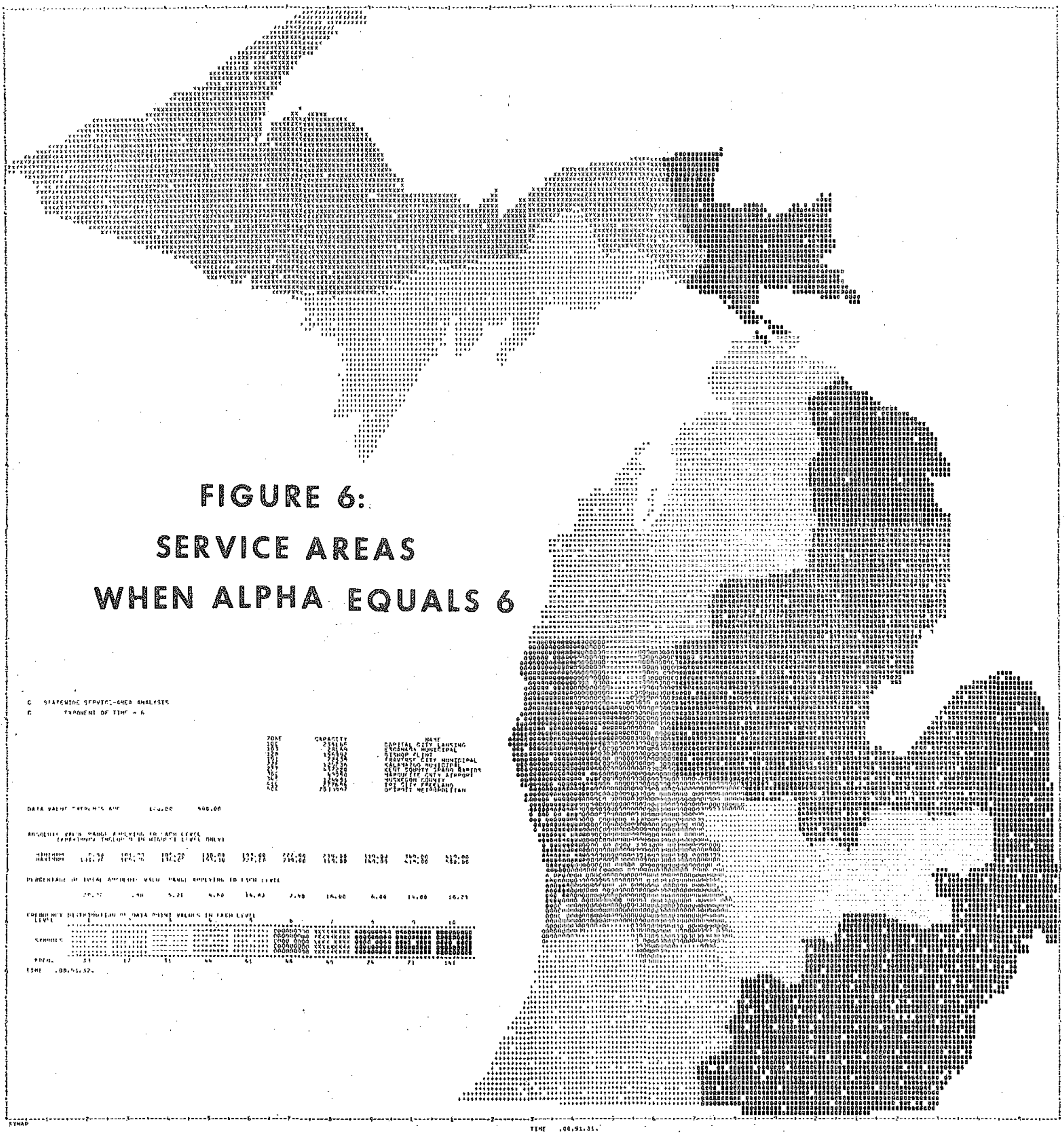


FIGURE 6: SERVICE AREAS WHEN ALPHA EQUALS 6

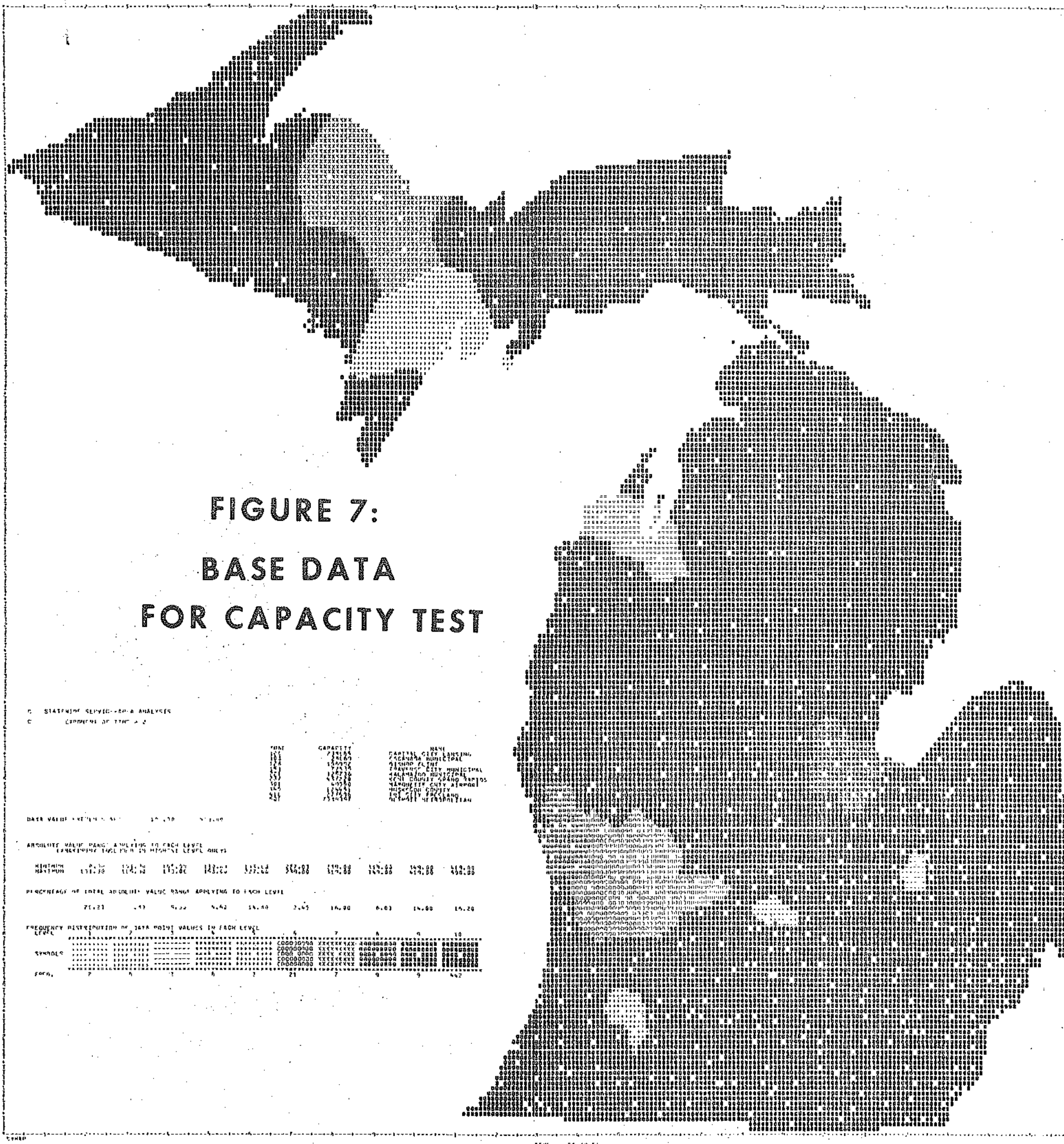


FIGURE 7:

BASE DATA FOR CAPACITY TEST

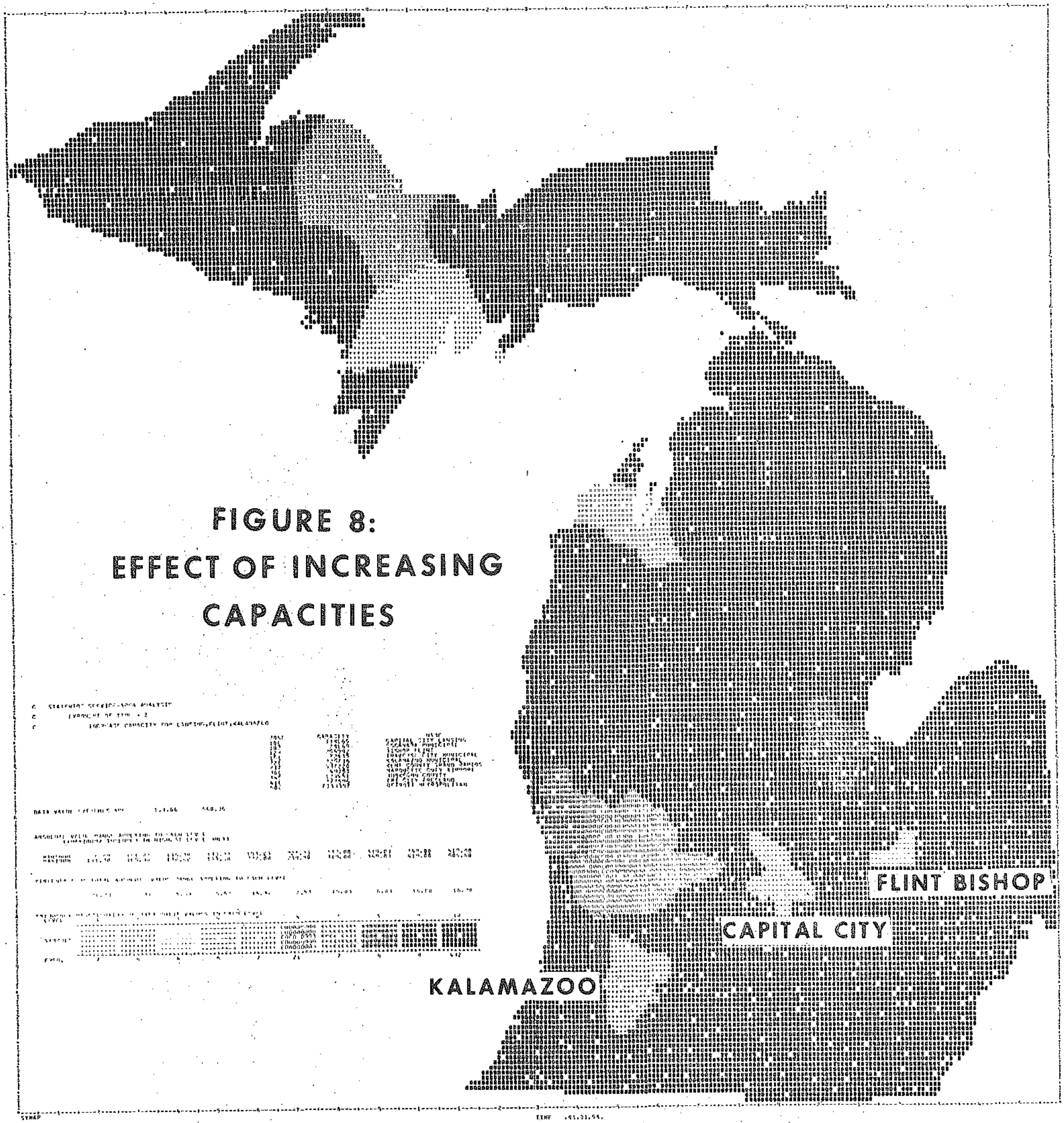
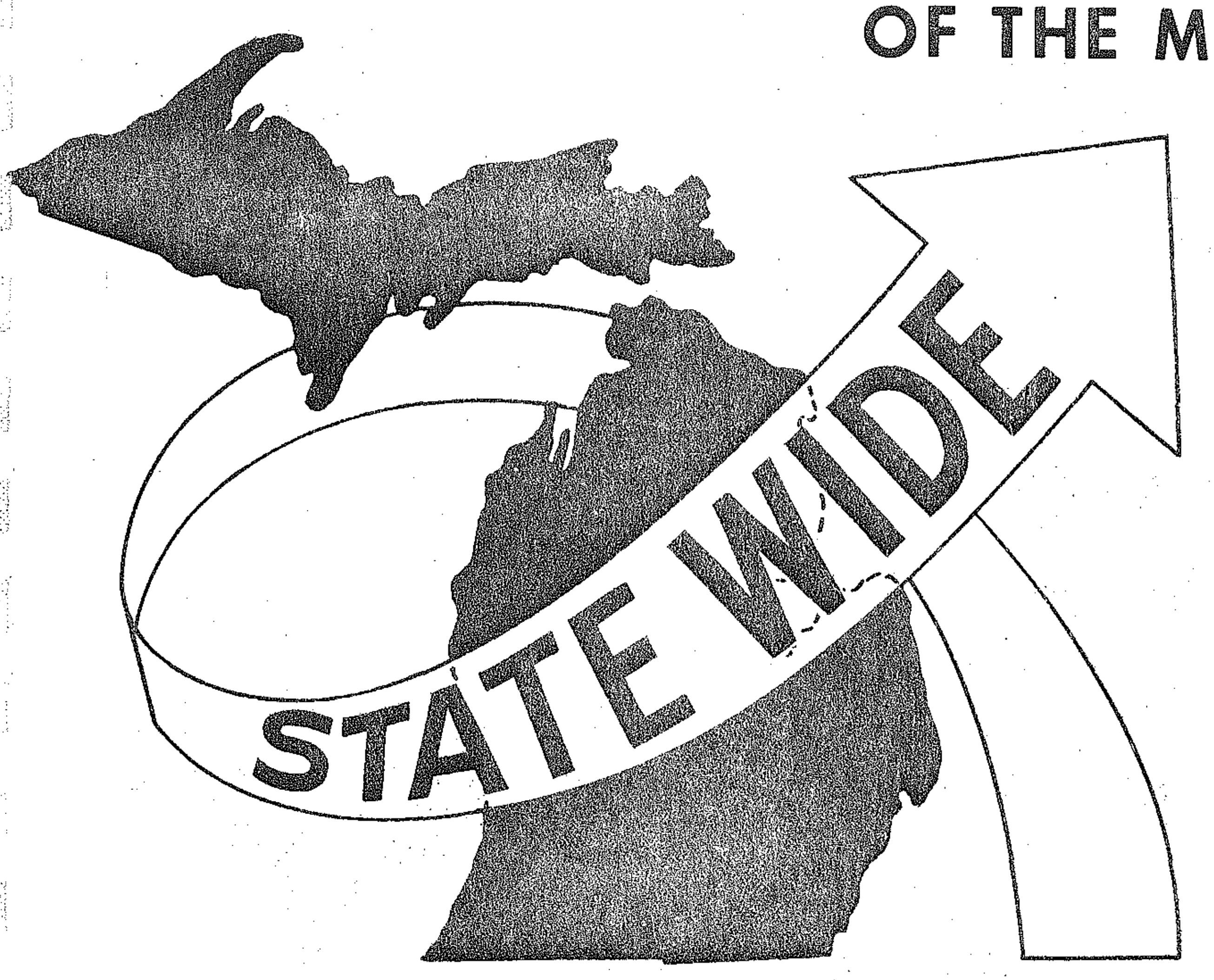


FIGURE 8:
EFFECT OF INCREASING CAPACITIES

CALIBRATION OF THE MODEL



CALIBRATION OF THE MODEL

As has been stated before, the service-area model is facility-specific: it must be fine-tuned to each user's facility set. This apparent drawback is actually a plus, however. Instead of one model which works moderately well on a number of facility sets, each user gets his own tailor-made model which works very well for his own facility set; and in the final analysis, each user is most concerned with the accuracy of his own results.

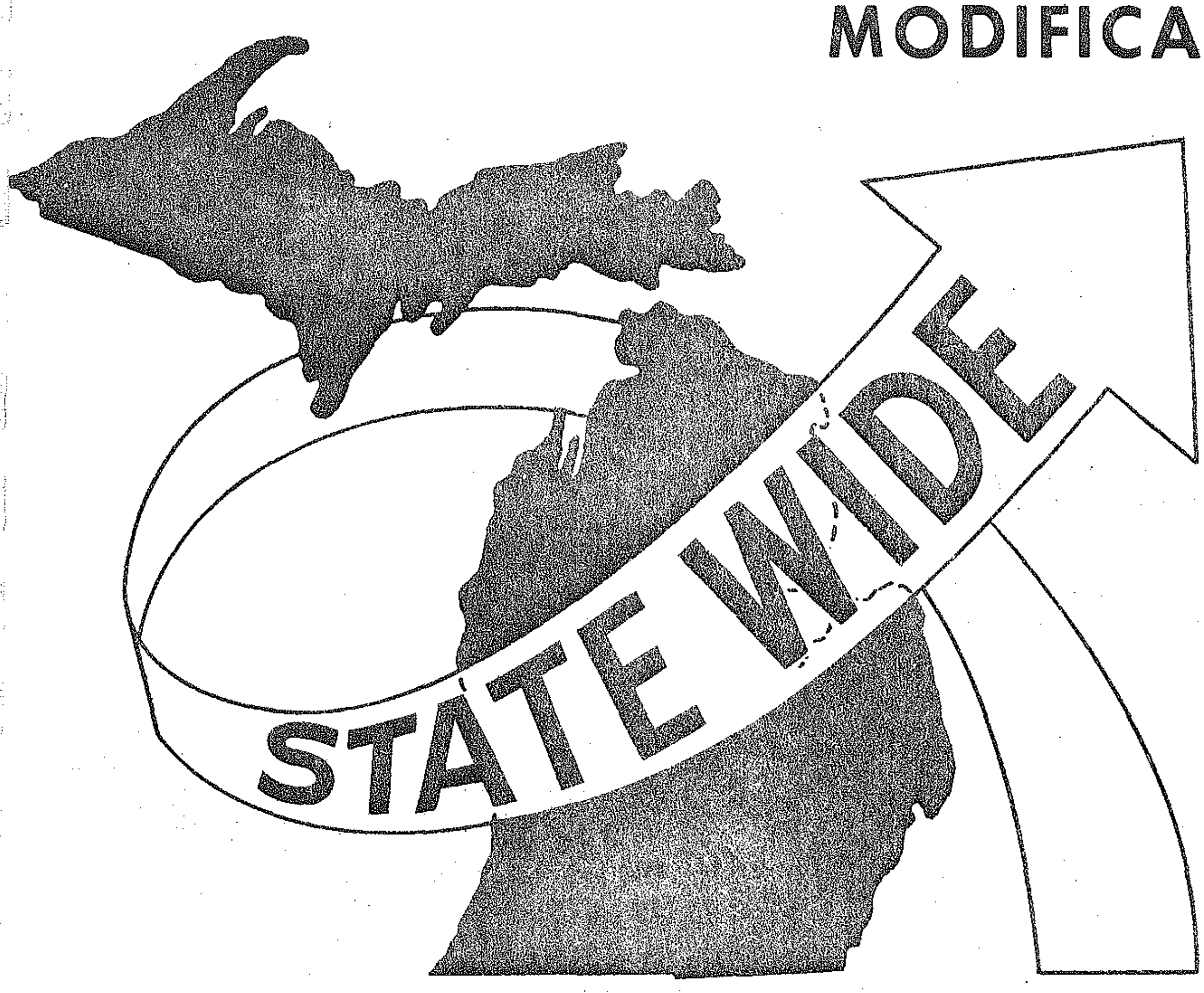
The first step in calibrating the service-area model is to choose the variable which best describes capacity for the user's own facilities. For example, the capacity of an airport might be expressed as the number of passengers enplaned on an average day. The capacity of a state park might be its total number of campsites. Capacity measures a facility's drawing power, its ability to attract people.

Step two is the data collection phase. Each facility in a facility set must get an idea of where its customers live; the location of origins need be specified only at the Statewide zone level (refer back to figure 1). This is an important step in model calibration.

Finally, the actual calibration of the model is accomplished by the correct selection of the only parameter, α ("Alpha"). Alpha is a measure of the importance of driving time in influencing a person's choice between facilities. Larger values of α correspond to greater weight being placed on driving time as a factor in facility choice.

At this time, there is no known statistical estimator of α; that is, there is no function of capacity and driving time which has been shown to estimate α consistently and efficiently. Therefore, the choice of α for a particular facility set must be made by trial and error. A user must tinker with values of α until the estimated service areas match those observed in the data collection phase.

FUTURE MODIFICATIONS



FUTURE MODIFICATIONS

Future modifications to the service-area analysis will be largely dependent upon feedback from potential users. However, three possibilities suggest themselves immediately.

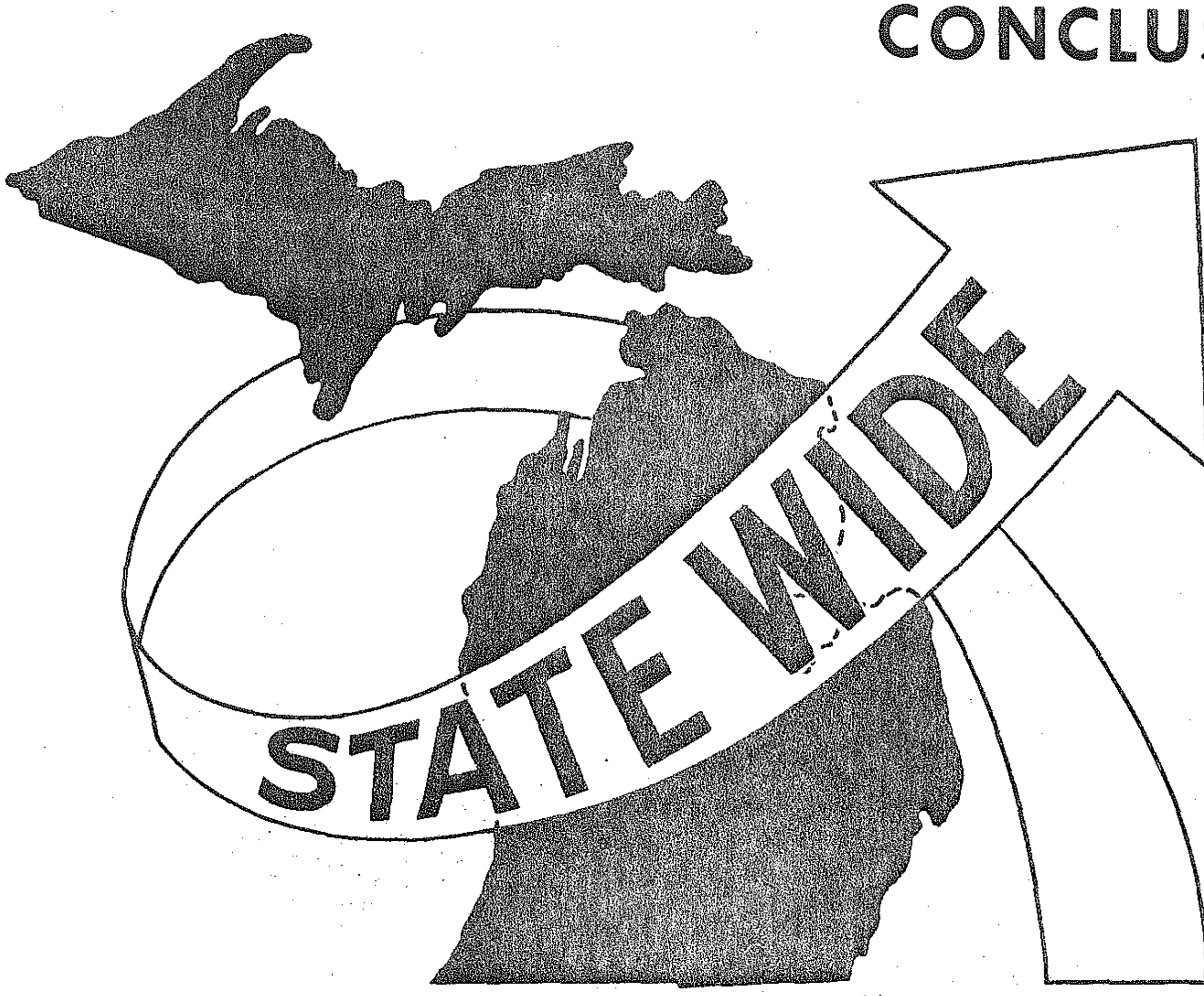
First, it may be necessary to permit the user to input one value of alpha for each zone of the system; this would allow him to vary the importance of driving time for each area of the state. It is possible that for some facility sets, this capability would have to exist in order to achieve model calibration. This program modification is relatively minor in degree of difficulty.

Second, the program should be able to read in actual data and output an evaluation of the degree of calibration for each value of alpha chosen by the user. This would give an indication of how to pick the next value of alpha in the trial-and-error process. Ideally, this modification could be made in conjunction with the first modification.

Finally, some users--commercial concerns in particular--may wish, based on their marketing research, to specify a maximum driving time beyond which virtually no customer would use a facility no matter how much capacity it had. For instance, it may be determined in the airport example that a person would not drive more than two hours to get to Metro no matter how quickly he could get a flight once he reached the airport. This may result in some areas of the state being "unserved"; that is, areas whose residents probably will not use any member of a particular facility set.

The Statewide Studies Unit is interested in any other ideas which would make the Service-Area process more powerful. Any suggestions to that end would be appreciated.

CONCLUSION



CONCLUSION

As an offshoot of the Proximity Analysis process, the Service-Area Model was developed to calculate the probable level of influence of each member of any facility group. It allows a planner to test rapidly the probable effects of adding or deleting a facility from his existing system or of increasing or decreasing the service capacity of one or more of his facilities. Used in conjunction with Proximity Analysis, the Service-Area Model could be a powerful tool in facility planning.

Moreover, it can be a tool for promoting the cooperation of other state agencies and private businesses in the transportation planning process. Using the model, it would be relatively easy to gauge the effects of alternative transportation plans on a set of businesses or service agencies. For example, a supermarket chain which is otherwise apathetic about a proposed freeway might gain interest if it could be shown that the expressway could expand the areas the chain would probably serve.