Statewide Transportation Analysis & Research

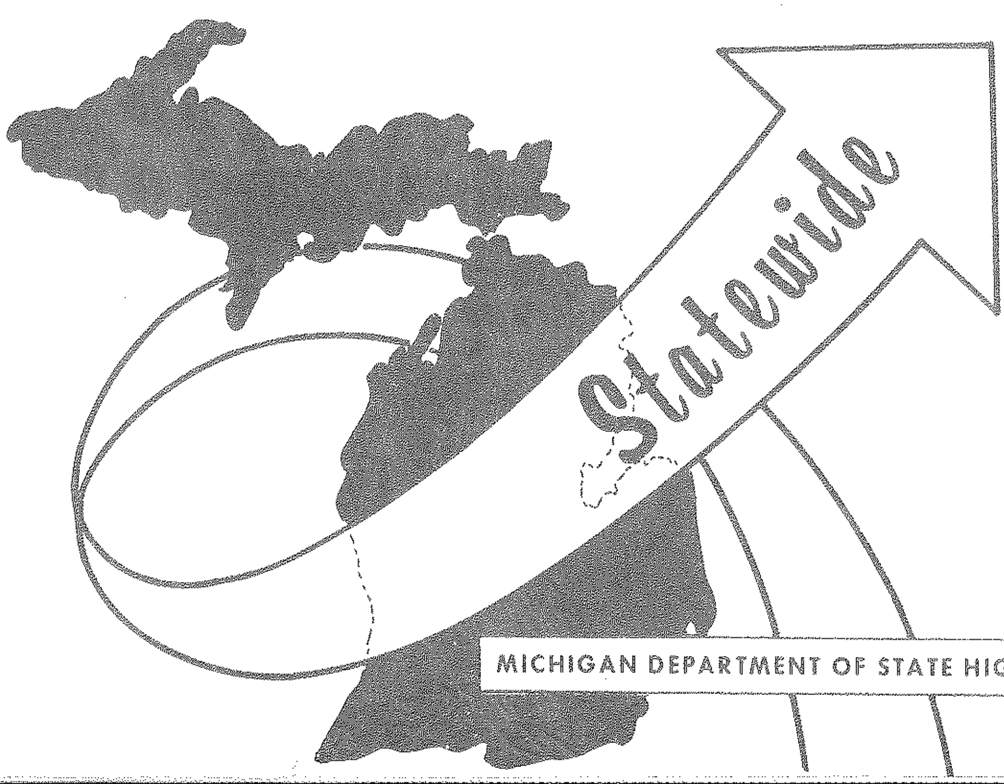
MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING
SYSTEM

VOLUME VI-A

**ENVIRONMENTAL SENSITIVITY
COMPUTER MAPPING**

STATEWIDE TRANSPORTATION PROCEDURES

APRIL, 1974



MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

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OF

STATE HIGHWAYS AND TRANSPORTATION

BUREAU OF TRANSPORTATION PLANNING

MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING
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**ENVIRONMENTAL SENSITIVITY
COMPUTER MAPPING**

STATEWIDE TRANSPORTATION PROCEDURES

APRIL, 1974

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

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

JOHN P. WOODFORD, DIRECTOR

April 9, 1974

Mr. Sam F. Cryderman, Deputy Director
Bureau of Transportation Planning
Department of State Highways
and Transportation
State Highways Building
Post Office Drawer K
Lansing, Michigan 48904

Dear Mr. Cryderman:

The Highway Planning Division is pleased to present Volume VI-A in a continuing series of reports dealing with the development and application of a Statewide Transportation Modeling System for Michigan. This report deals with an automated method of producing shaded environmental-sensitivity maps from ERTS satellite data. These maps can be shaded according to any set of values, whether they be those of a department of highways and transportation, the residents of the region in which the proposed route lies, or any other group of concerned individuals.

A technique such as this might be useful in stimulating public input into the transportation planning process. Environmental analysts might also use it as a "first-cut" tool to identify obviously unsuitable corridors and thereby restrict attention only to feasible alternates.

This modeling application was developed as a natural spinoff from Statewide's Corridor Location Dynamics at a minimal expenditure of manpower and time. The report was written by Mr. Terry L. Gotts of the Statewide Transportation Planning Procedures Section, under the supervision of Mr. Richard E. Esch.

Sincerely,

R. J. Lilly

Richard J. Lilly, Administrator
Highway Planning Division

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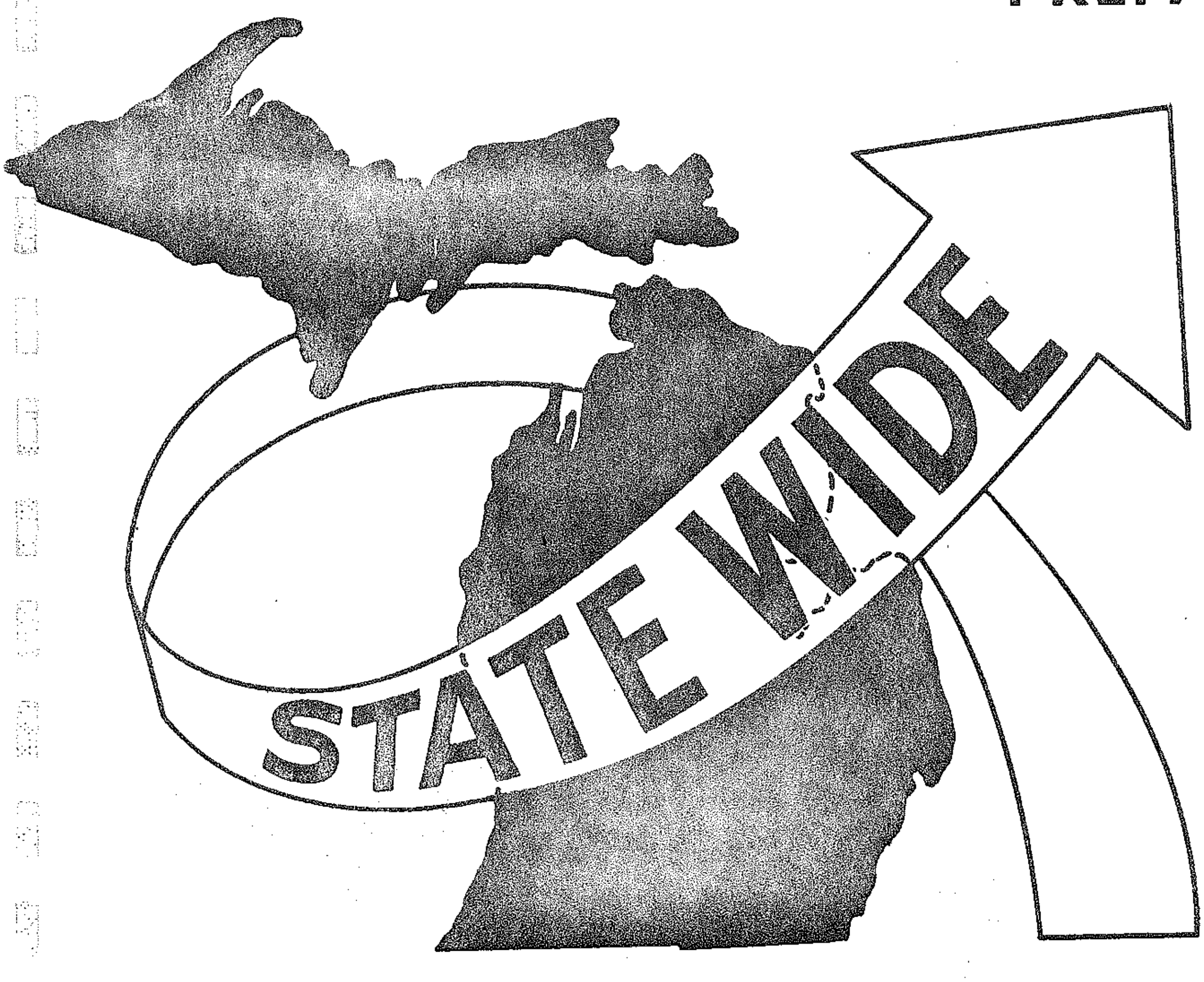
ENVIRONMENTAL SENSITIVITY COMPUTER MAPPING

by

Terry L. Gotts

PREFACE



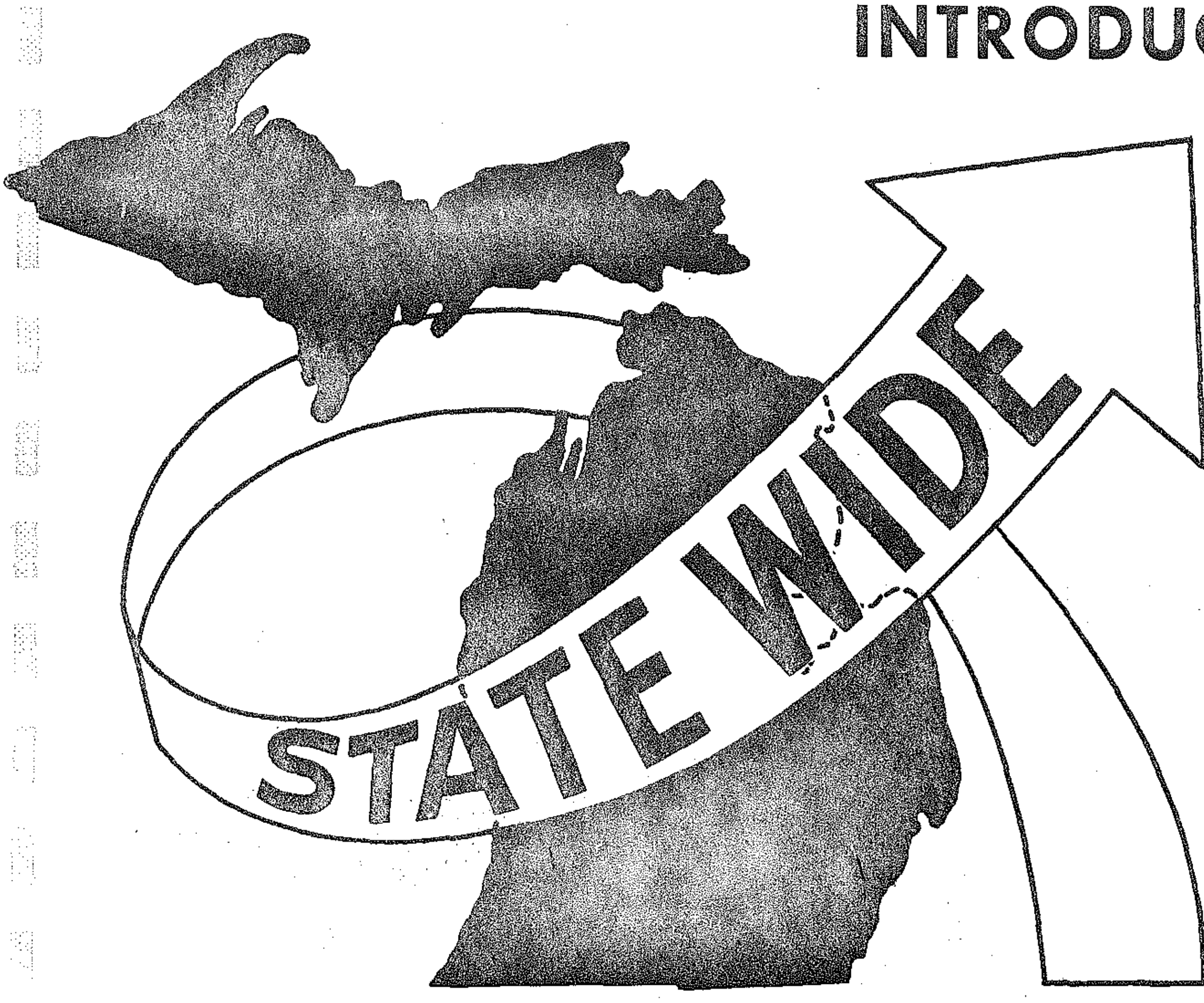
PREFACE

Recent Federal legislation poses several major challenges to state departments of transportation. In highway planning, they are being asked to accomplish tasks which at first seem to be at odds. For example, socio-economic and environmental data should be collected and evaluated concurrently with the actual route selection process; on the other hand, public input to the transportation planning process must be increased, which is often a time-consuming process. The environmental-sensitivity computer-mapping process described here is offered in the hope that it may, after possible further development, become a tool which is useful in fulfilling both objectives.

The automatic sensitivity-mapping program came about as a natural spinoff from an existing Statewide process, Corridor Location Dynamics. Therefore, its development costs were negligible. It also has the advantages of flexibility and consistency and uses the most up-to-date data possible. In addition, its output--a series of shaded maps--could be readily understood and appreciated by anyone.

It is true that many very sophisticated graphic-display systems exist, and no doubt this mapping program could be replaced by any number of them. However, the important thing here is not the program itself; it is a minimal part of the picture. One should instead remember the entire Statewide transportation modeling process: the ability to progress from Earth Resources Technology Satellite (ERTS) data to environmental, travel, and socio-economic impacts automatically, taking into account a range of possible priorities and tradeoffs. That is the main message of automatic sensitivity mapping.

INTRODUCTION



INTRODUCTION

In the automatic sensitivity-mapping process, shaded land-use maps are produced from ERTS-A or ERTS-Followup data on a computer. For any given set of priorities, a summary map is also produced of relative area sensitivities. Once the process is set in motion, the analyst needs only specify a set of priorities for the eight land-use types which can be identified. After studying the maps produced, he may, if he wishes, shift his priority weightings to see whether the change has an effect on which areas are considered "sensitive". In this way, both planners and laymen may begin to investigate the effect of tradeoffs on possible corridor locations easily and quickly.

The method offers several advantages over manual methods:

1. It uses current data. The ERTS satellite passes over Michigan once every eighteen days. Although cloud cover may invalidate data on some passes, the frequency of collection assures that up-to-date data will always be at hand.

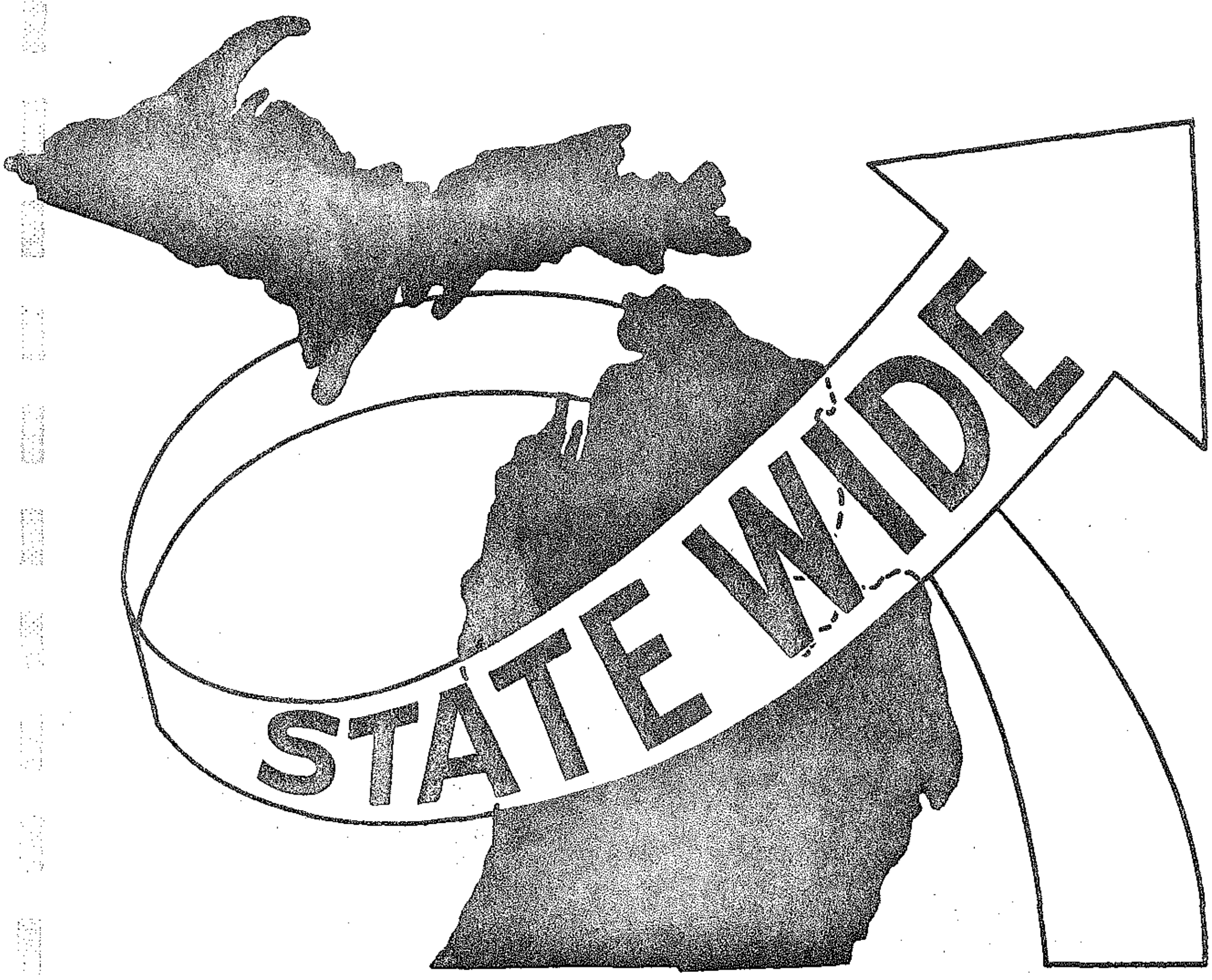
2. Its output is pictorial. Environmental sensitivity maps are produced automatically on a line printer, reducing the necessity for hand-coloring and shading. Moreover, pictures generally are most useful in stimulating feedback from the public.

3. It is consistent. Since ERTS "sees" in the same way in every part of the state, human inconsistency in data collection can be minimized. Thus the planner is free to concentrate his expertise on the evaluation of a consistent data set, rather than on the data collection process.

4. It is flexible. As has been mentioned, one may vary the priorities which he puts on the various land use types and test how the areas designated as "sensitive" are affected.

A mapping program such as this would be most useful as a "first-cut" tool. It would allow detailed environmental analysis to be concentrated on only a few feasible corridors, instead of being spread over feasible and non-feasible corridors alike.

METHOD OF ANALYSIS



METHOD OF ANALYSIS

The flow chart in Figure 1 shows the sequence of operations from satellite to map. First, the Environmental Research Institute of Michigan (ERIM) processes ERTS-A or ERTS-Followup digital four-channel output. Next, a pattern-recognition program developed by ERIM uses training sets to translate the readings on the four channels to predominant land-use categories (see Figure 2). This is done for each registration point, or "pixel", so that the limit of resolution is 1.1 acres. As each pixel is classified, it is tagged with a chi-square goodness-of-fit statistic for later reference. Research is presently underway to recognize additional land-use types.

After the recognition tapes are transmitted to Statewide, a computer program examines the chi-square value associated with each pixel; if a value does not indicate at least 95% confidence in the category classification, that pixel is relabeled "not classified". In this way, the probability of classification error is minimized. The data may now be used as is or summarized to an arbitrary grid system. For example, a user may wish to consider "macro-points" three pixels wide and two pixels deep; in this case, another program is used to accumulate the number of acres in each land-use category which lie inside each 3x2 rectangle (see Figure 3).

The grid summary is then input to the Corridor Location Model, which selects a set of optimal corridors based on the user's priorities. As part of its output, the model generates digital land-use maps on disk, such as the one printed out in Figure 4. The numbers represent the percent of land in each rectangle which fall into the land-use category shown. In addition, the program weights the categories by the user's priorities to produce a digital composite sensitivity map (Figure 5). The mapping program then uses

Figure 1: MAPPING PROCESS DATA FLOW

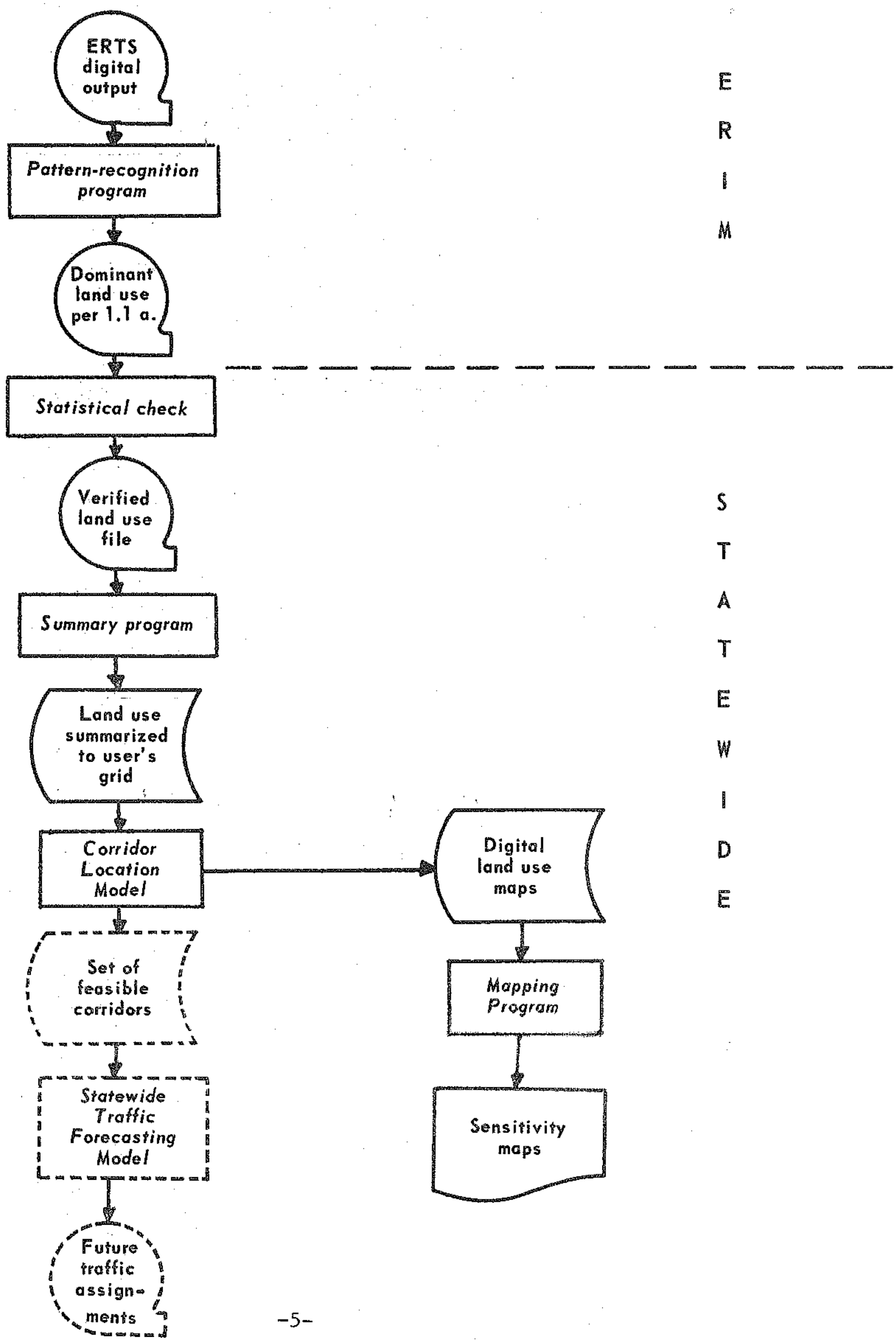


Figure 2:

PATTERN-RECOGNITION LAND USE CATEGORIES

URBAN AREA

OPEN AREA (INCLUDES SNOW COVER)

WATER

MARSH LAND

CONIFER FOREST (JACK PINE)

CONIFER FOREST (WHITE PINE)

HARDWOOD FOREST (MANAGED)

HARDWOOD FOREST (UNMANAGED)

Figure 3: EXAMPLE OF SUMMARY TO A 3 x 2 - PIXEL RECTANGLE
(Not from actual data)

Note: each small rectangle represents a pixel
(area = 1.1 acres)

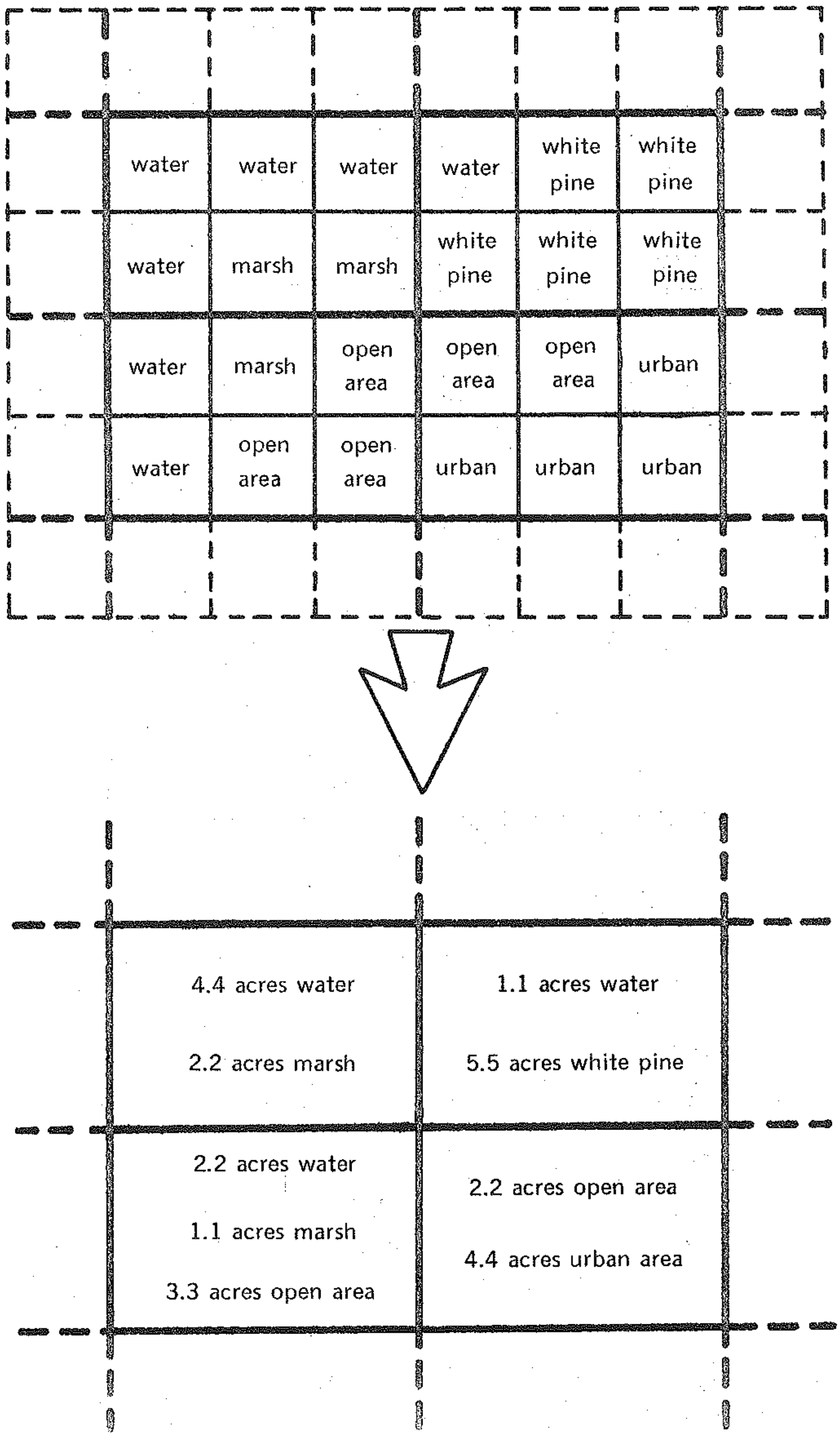


Figure 2:

Figure 4: Digital Map

WATER

94	94	94	94	94	94	94	51	0	0	36	0	0
100	100	100	100	74	98	100	100	26	0	37	0	0
100	100	100	100	79	83	100	100	99	85	3	0	0
100	100	100	100	100	100	100	99	100	100	20	0	0
100	100	100	100	91	84	97	91	100	100	56	0	0
100	98	42	13	1	0	2	86	100	100	84	2	0
100	54	0	0	0	0	0	2	30	90	100	97	41
100	26	0	0	0	0	0	0	0	12	43	31	2
100	38	0	0	0	0	0	0	0	2	0	0	0
59	12	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	3	0	0
26	25	0	0	0	0	0	0	0	4	19	11	0
98	45	0	0	0	0	0	0	0	0	0	2	0
53	2	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2	0	0
0	1	0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	4	5	0	0	0	0	0	0
0	0	12	0	0	0	0	0	0	3	0	0	3
0	1	32	1	0	0	0	0	0	15	38	2	0
0	26	13	0	0	25	0	0	0	18	37	1	0
0	19	20	0	2	1	0	0	0	0	0	0	0
0	1	48	0	0	0	0	0	9	0	0	0	2
0	0	57	12	0	0	0	0	11	7	0	2	12
0	0	15	73	5	0	0	0	2	0	38	1	0

Figure 5: Composite Digital Impact Map

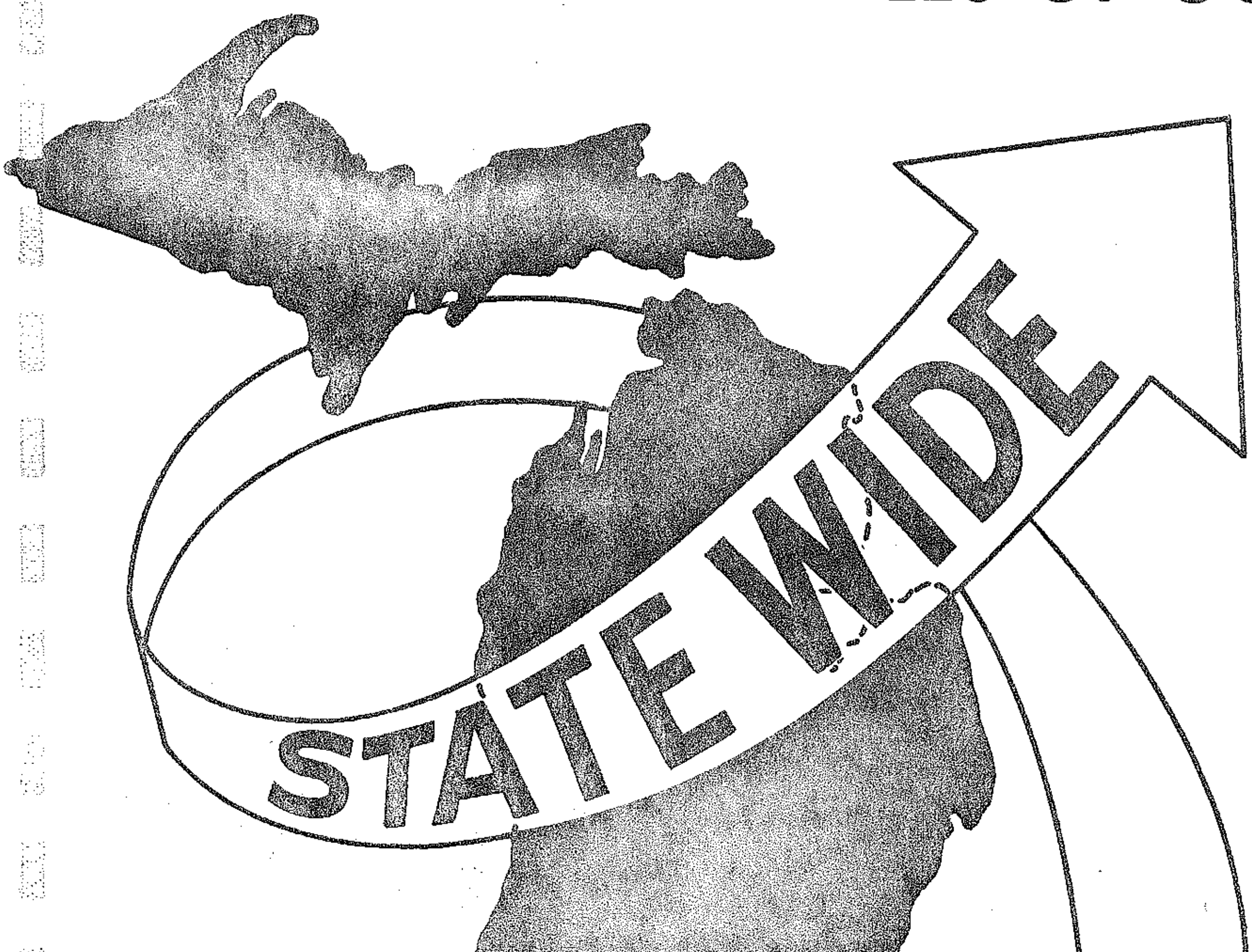
LOCATION DETERMINANT--COMPOSITE

-47	-47	-47	-47	-47	-47	-47	-44	-49	-50	-43	-38	-21
-50	-50	-50	-50	-47	-49	-50	-50	-48	-47	-44	-45	-20
-50	-50	-50	-50	-47	-47	-50	-50	-50	-48	-41	-48	-25
-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-39	-44	-25
-50	-50	-50	-50	-48	-48	-49	-47	-50	-50	-47	-43	-24
-50	-49	-46	-43	-42	-48	-46	-47	-50	-50	-49	-41	-22
-50	-45	-27	-39	-41	-41	-45	-33	-42	-44	-50	-49	-21
-50	-43	-25	-32	-38	-34	-18	-18	-25	1	-3	-34	-17
-50	-41	-17	-21	-21	-19	-1	-21	-20	-23	-27	-32	-12
-37	-27	-28	-25	-16	-22	-3	-12	-24	-41	-28	-37	-14
-19	-33	-32	-25	-22	-32	-28	-33	-24	-18	-27	-25	-15
-44	-43	-31	-24	-19	-31	-22	-1	-28	-20	-29	-21	-14
-49	-45	-20	-21	-23	-29	-21	-11	-9	-5	-14	-18	-8
-41	-35	-27	-23	-25	-15	-19	-13	-11	-4	-5	-13	-4
-23	-24	-23	-32	-21	-14	-11	-14	-12	-1	3	-6	-4
-14	-15	-27	-25	-18	-18	-25	-13	-3	-14	-17	-20	10
-15	-5	-20	-22	-19	-24	-17	-19	-25	1	2	9	-9
-11	-18	-20	-19	-16	-24	-17	-12	-14	-20	-43	-44	-9
28	-9	-21	-22	-34	-24	-28	-39	-25	-29	-28	-22	-13
19	12	-26	-24	-25	-24	-18	-37	-21	-30	-31	-20	-10
-3	7	-18	-26	-23	-28	-24	-17	-9	-29	-34	-18	-11
-4	-12	-24	-22	-17	-15	2	-12	-24	-33	-28	-23	-17
-4	-8	-33	-19	-31	-27	52	23	-30	-34	-29	-26	-7
-9	12	-23	-13	-43	-37	-13	-9	-34	-34	-37	-29	-15
24	55	21	-38	-32	-34	-14	-19	-34	-29	-40	-26	-15

these digital files to produce shaded maps.

Note that once the Corridor Location Model has produced a group of possible "best" routes, it automatically updates the Statewide Highway Network File. Future traffic assignments are then generated for the entire state as if a road had been built within the first corridor, then as if the road lay in the second corridor, and so on. The reader is encouraged to read Statewide Transportation Analysis and Research Volume VI, entitled Corridor Location Dynamics.

EXAMPLES OF OUTPUT



EXAMPLES OF OUTPUT

The region selected for a test site is in the northern part of Michigan's Upper Peninsula (Figure 5a); it is rectangular, approximately five miles wide by sixteen miles long, with its long axis running roughly northeast to southwest (this rotation will be corrected to north-south in subsequent scans). It should also be noted that the area is summarized to 8-by-16-pixel rectangles, so that some foreshortening is evident; again, this is at the user's option.

The first eight maps are pictorial representations of the relative percentage of land in each rectangle which belongs to the land-use type on the map. The important thing to remember in viewing these maps is that the shading denotes relative concentrations of each land use type. The urban area map (Figure 6), for instance, depicts the proportion of urban area in each rectangle; in the sparsely-populated upper peninsula, as little as 17.7% urban area was given the darkest shading in this case. However, the shading levels, as well as the actual symbols used in the map, are input by the user. Thus the user may elect to use such a map to show either the absolute or relative proportion of urbanized area in each rectangle.

The best map to use for orientation is probably the water display in Figure 8. The dark area at the top of the figure is Lake Superior; the white portion in the upper right-hand corner is the tip of Grand Island. As in the other maps, the shading is entirely at the user's option.

(Continued after Figure 13)

Figure 5a:
Scan Region

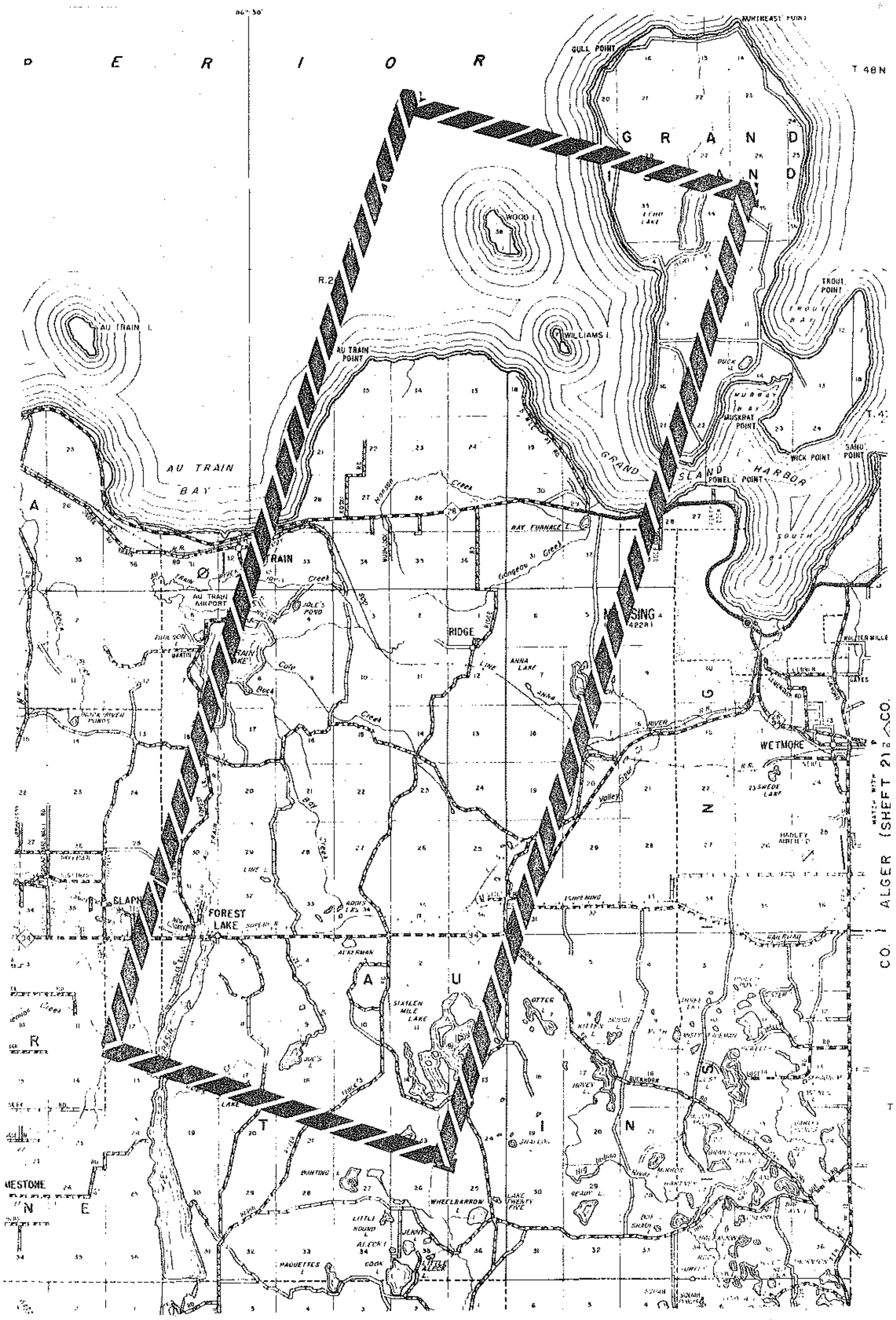


Figure 6: Urban Area

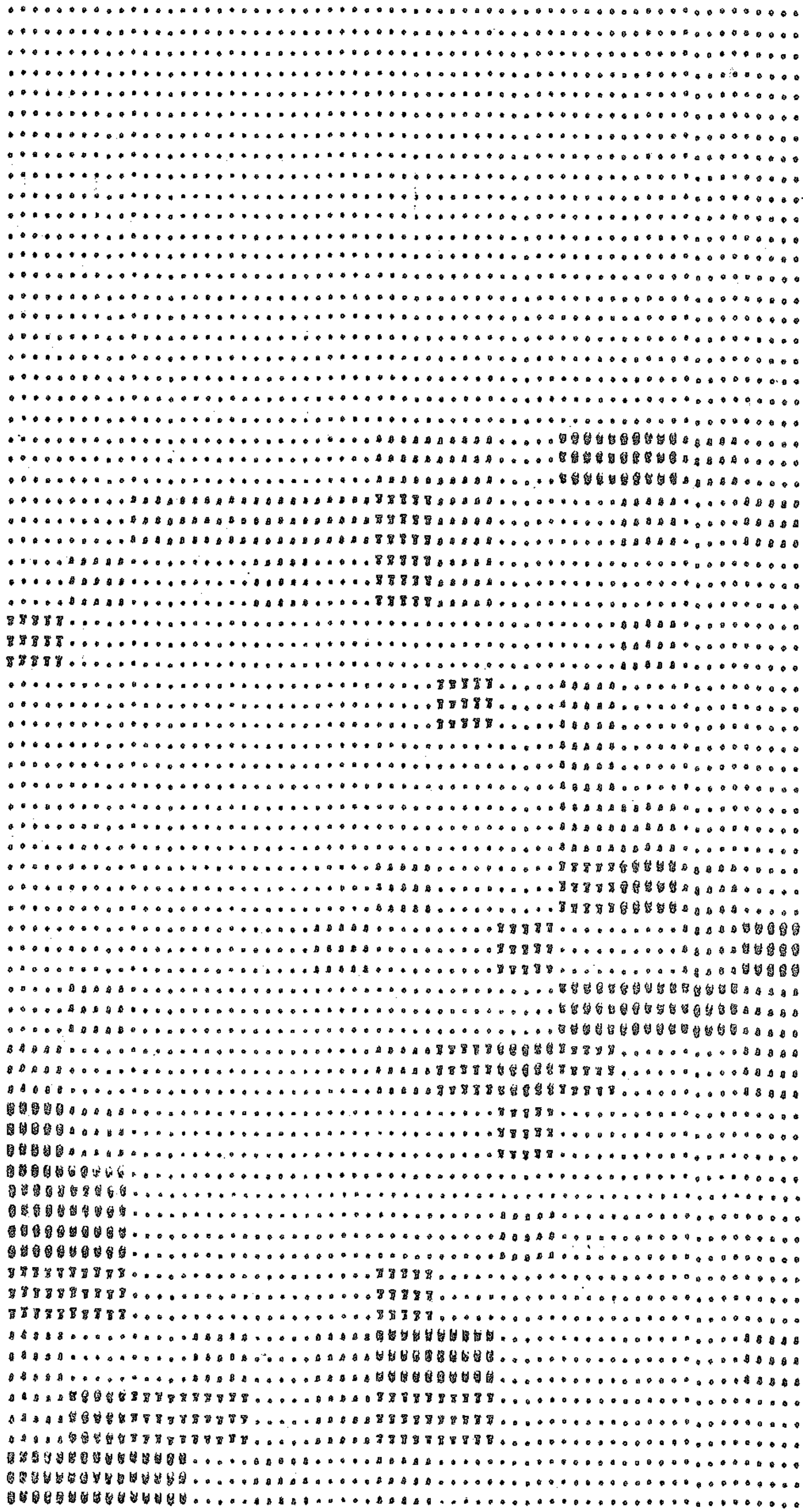


Figure 7: Open Area

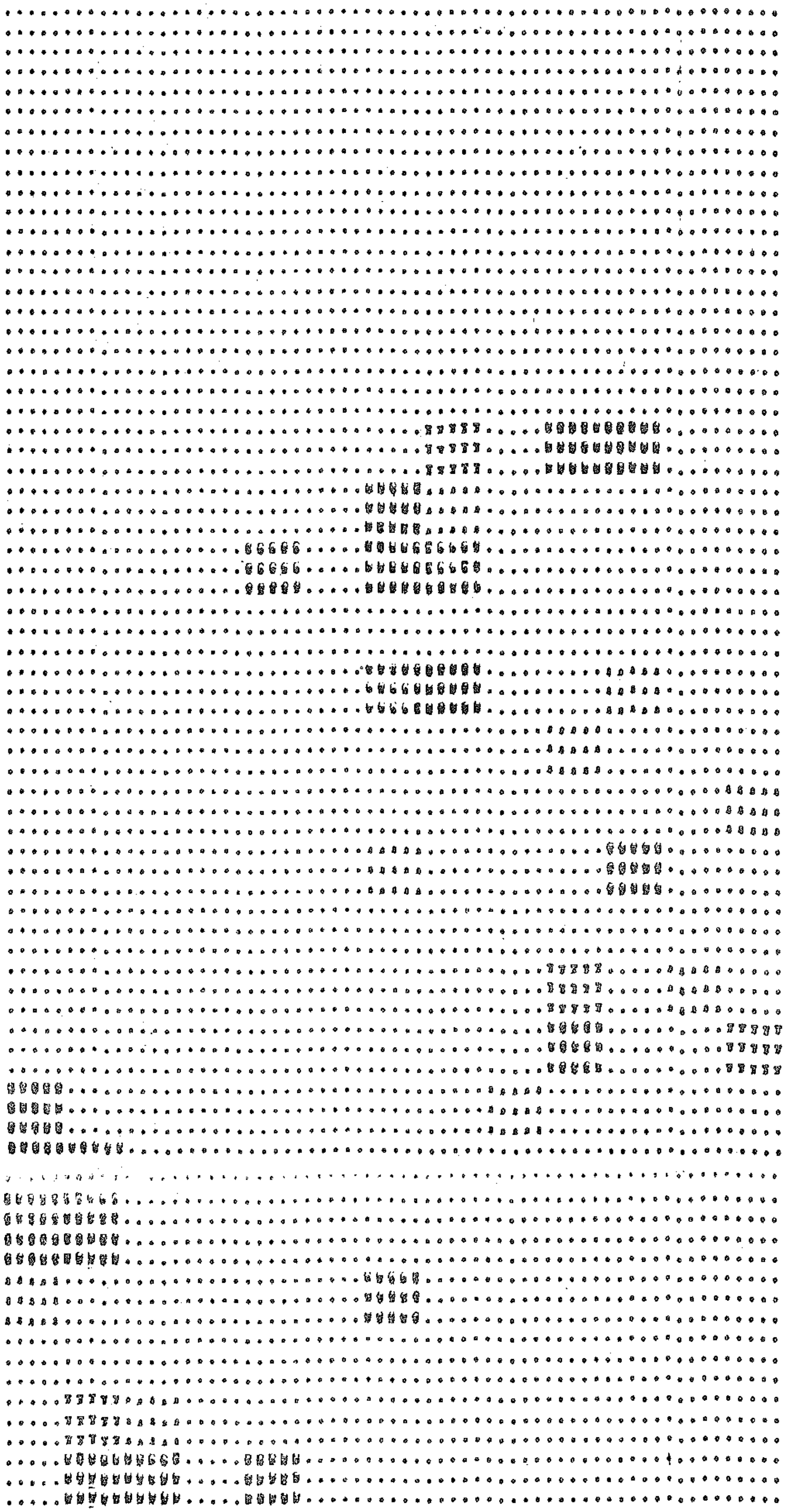


Figure 8: Water

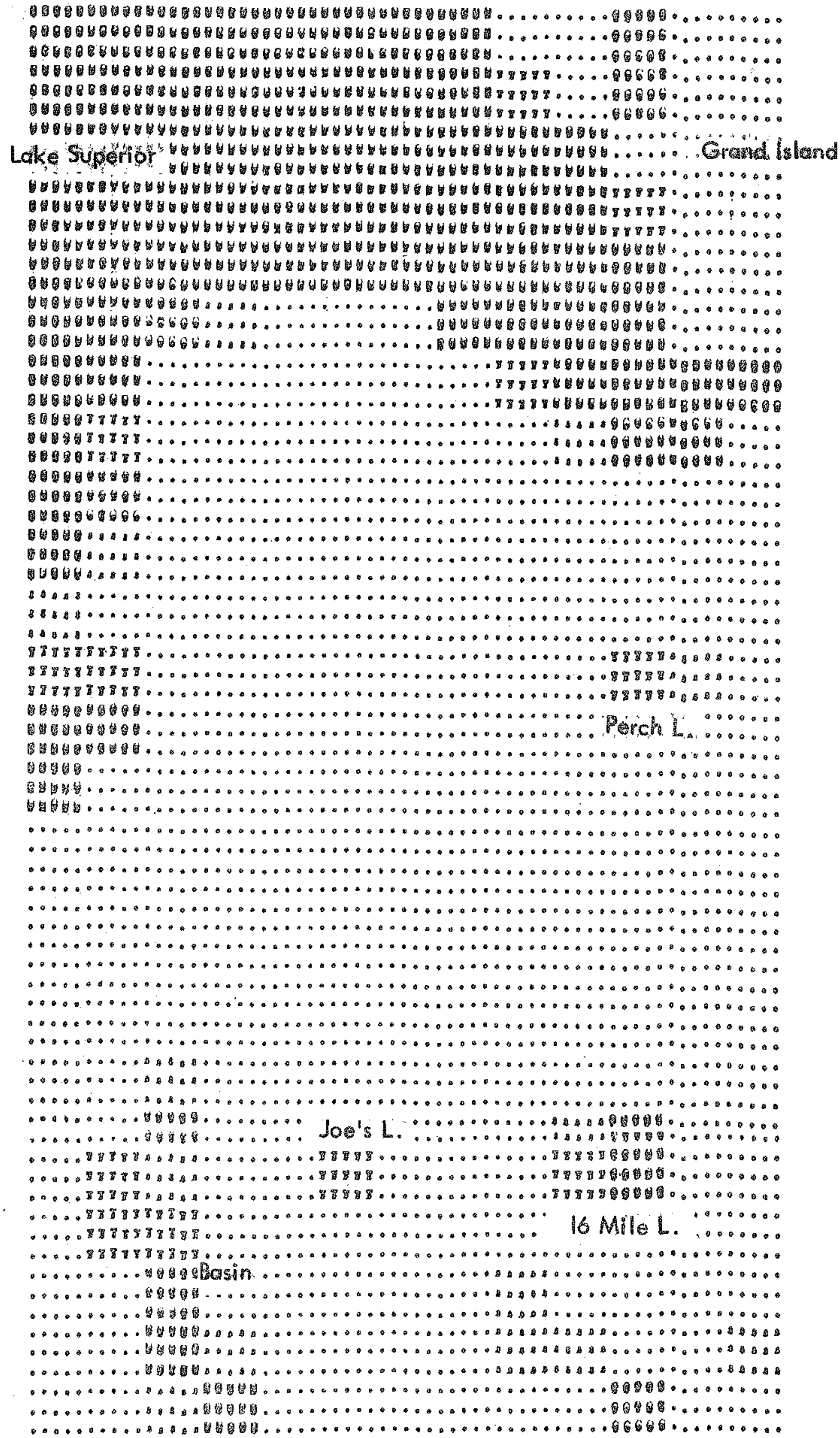


Figure 9: Marsh Land

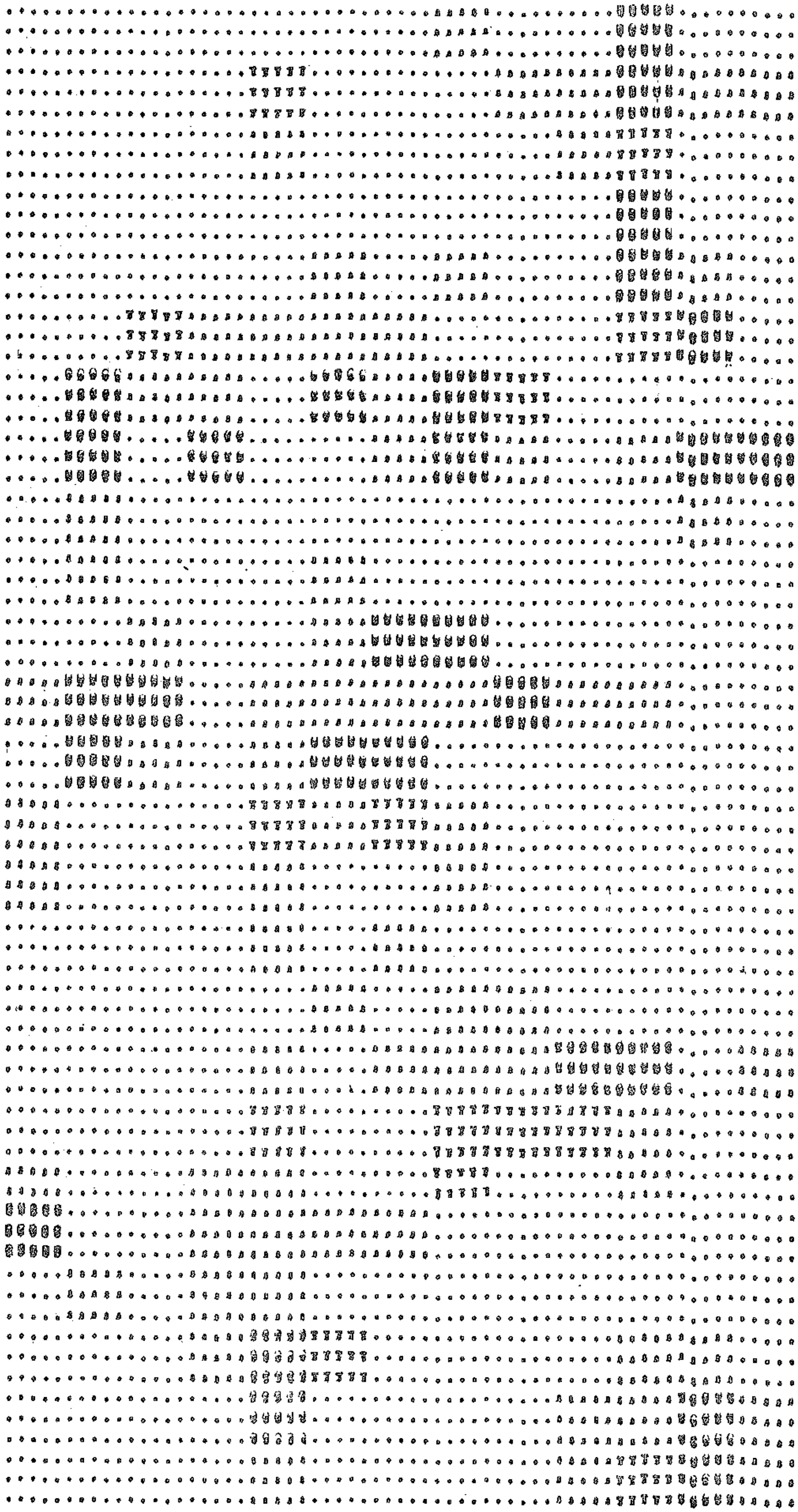


Figure 10: Conifer Forest (Jack Pine)

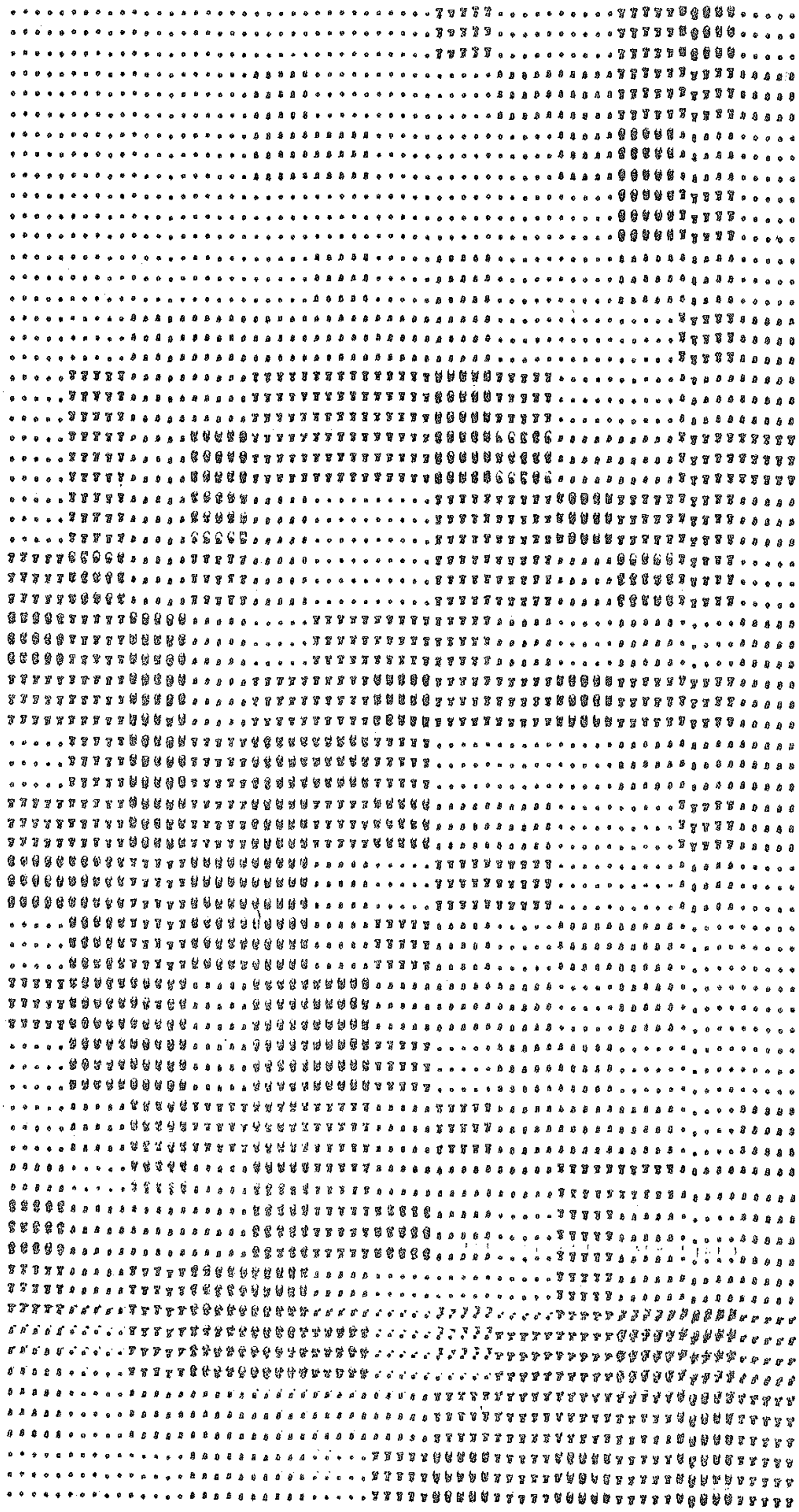


Figure 11: Conifer Forest (White Pine)

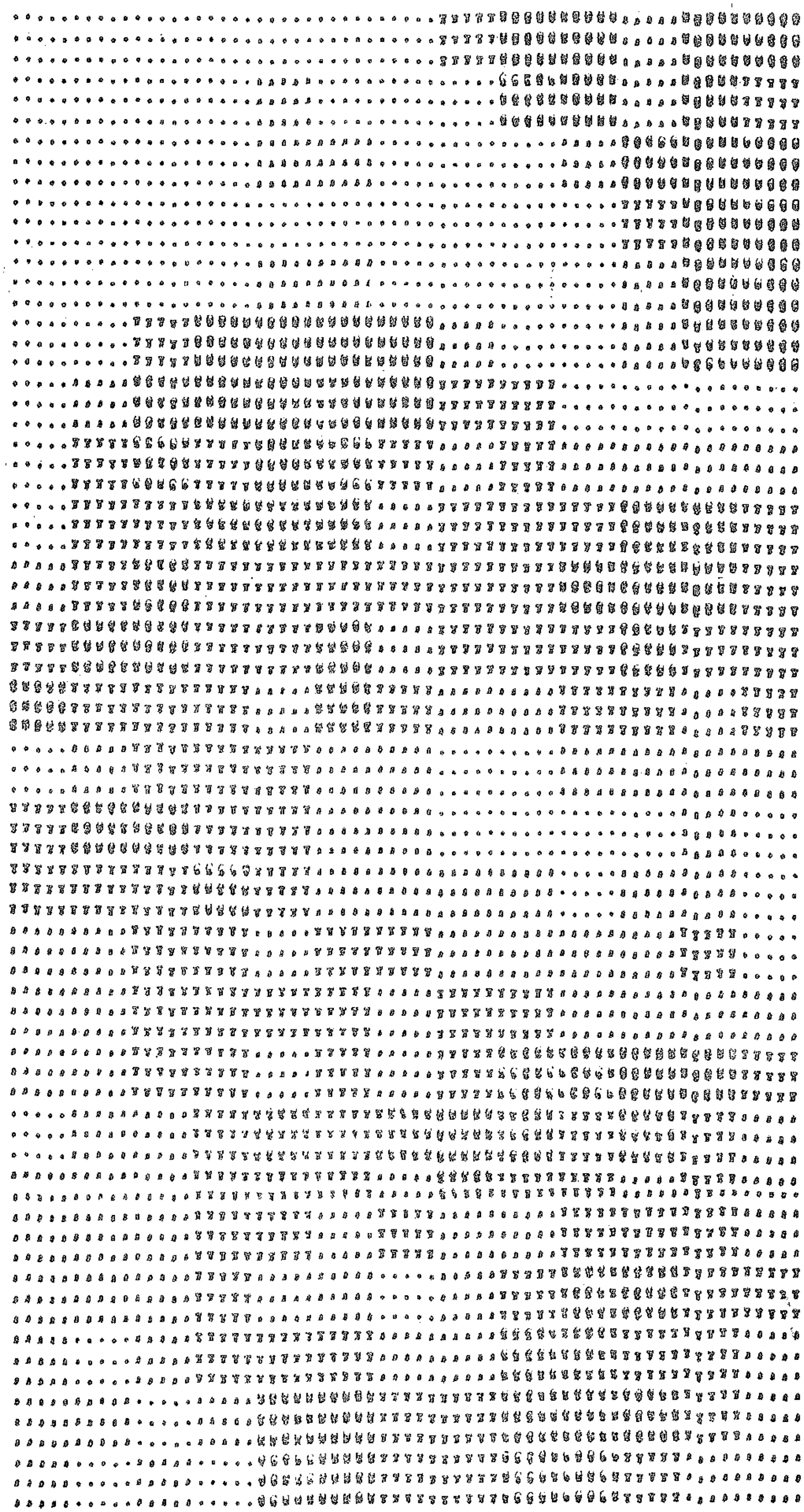


Figure 12: Hardwood Forest (Managed)

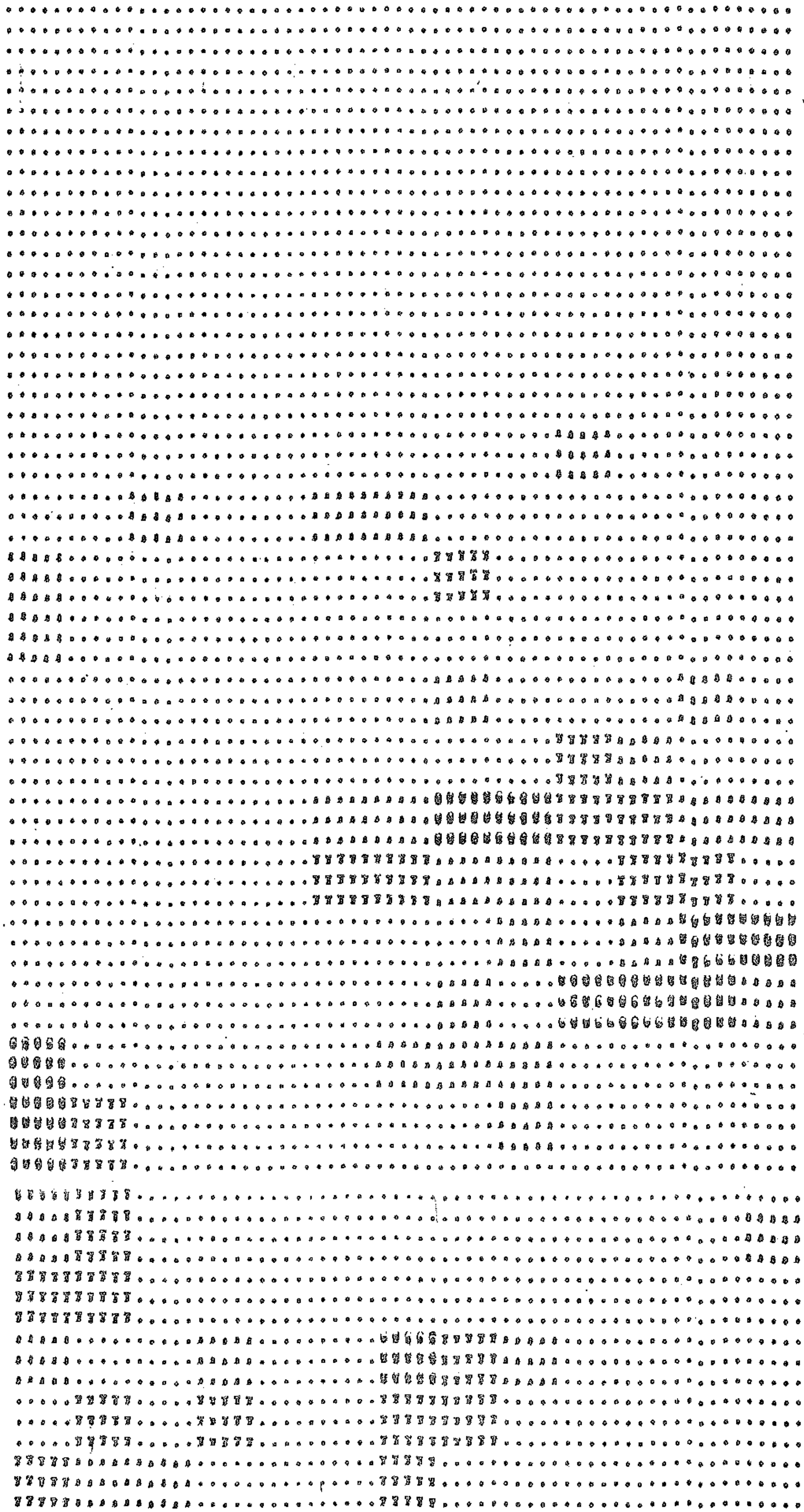
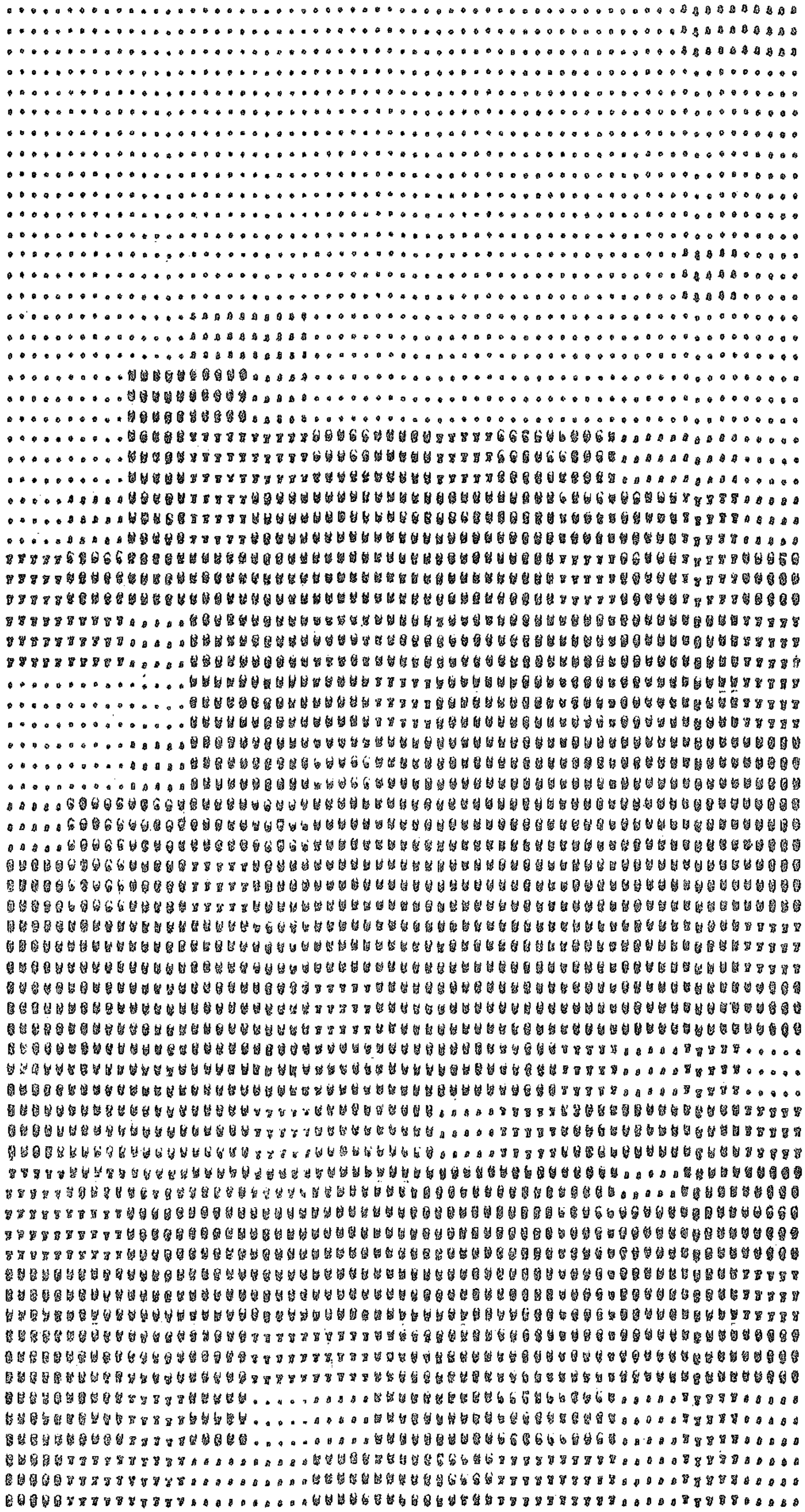


Figure 13: Hardwood Forest (Unmanaged)



The actual environmental impact maps are shown in Figures 14 and 15. Figure 14 holds if the objectives of the residents of the region result in the following desirability weightings, on a scale from -100 (least desirable for road construction) to 100 (most desirable for road construction):

Factor	Weight
Urban Area	20
Open Area	5
Hardwood Forest (Unmanaged)	-5
Water	-10
Jack Pine	-5
Marsh Land	-2
White Pine	-5
Hardwood (Managed)	-5

It appears that a route from point A to point B on the map should follow the general orientation shown in order to avoid as much white pine and marsh as possible. However, when the weightings are changed to deemphasize hardwood forest and jack pine and to put more value on marsh land and white pine, the map of Figure 14 is produced. The weightings for this map are as follows:

Factor	Weight
Urban Area	20
Open Area	5
Hardwood Forest (Unmanaged)	-2
Water	-10
Jack Pine	-2
Marsh Land	-10
White Pine	-10
Hardwood Forest (Managed)	-5

In a case like this, a route orientation such as the one shown on the map might come under consideration.

Obviously, many weightings are possible. Each will result in a slightly different impact map. It is important to stress that testing a priority weighting in this way need not be a costly, lengthy process; each of the maps shown was produced in less than one minute of computer time.

Figure 14: Environmental Sensitivity Map (Weighting #1)

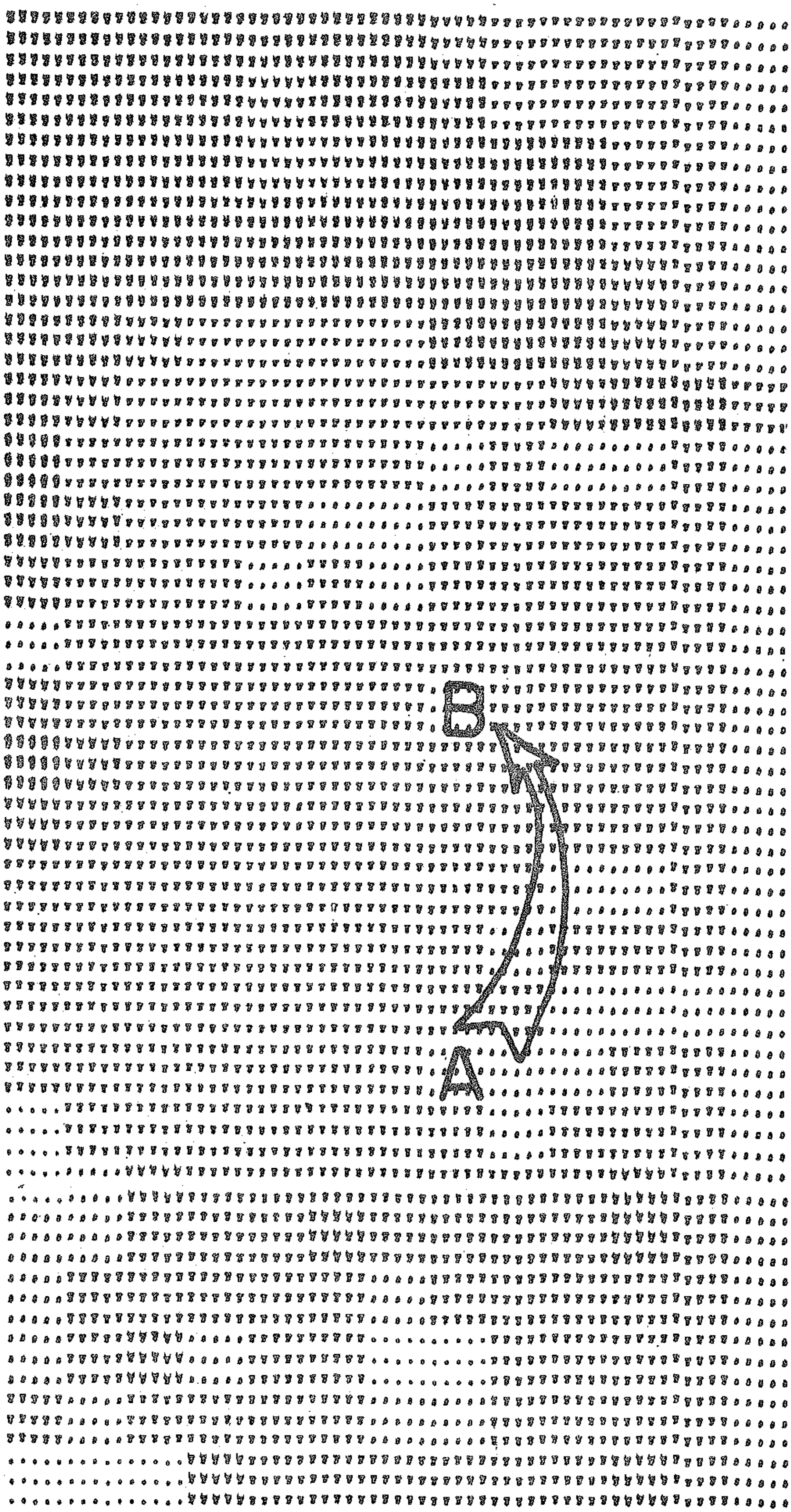
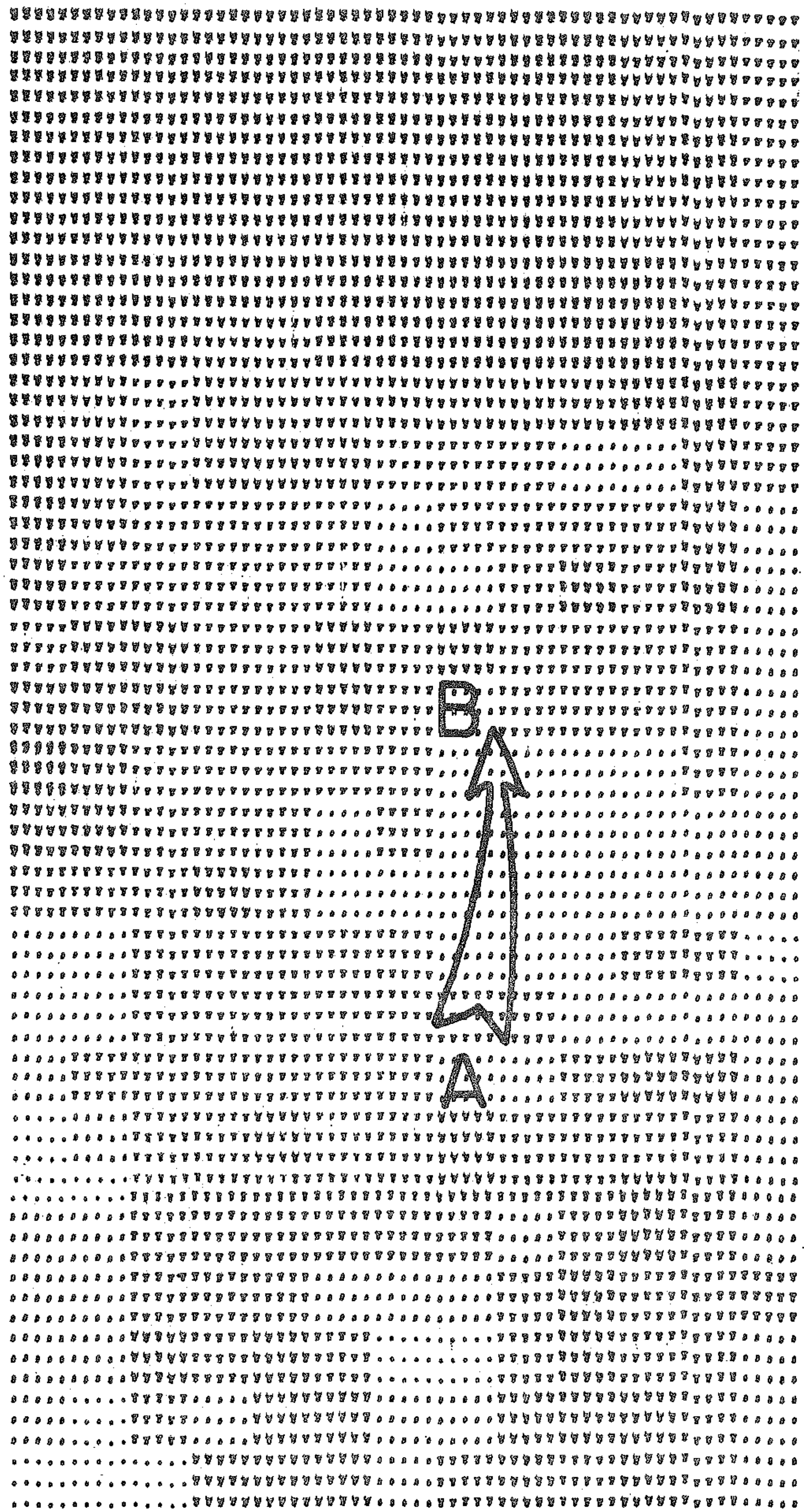
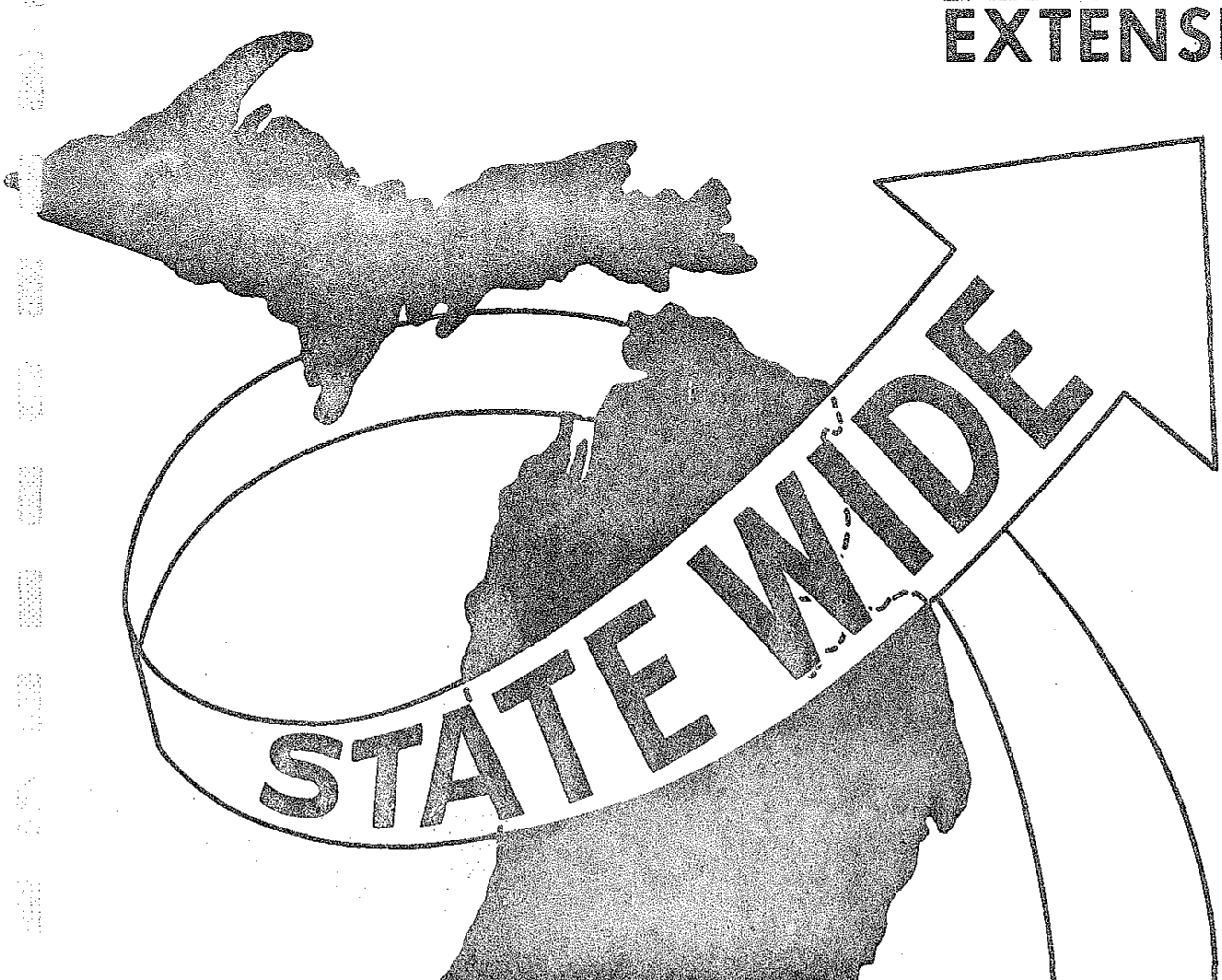


Figure 15: Environmental Sensitivity Map (Weighting #2)



EXTENSIONS



EXTENSIONS

The incorporation of ERTS data into the Statewide information system is presently being amplified. Work is underway by ERIM and Statewide to associate each ERTS-pixel with an (x,y)-coordinate; this will enable ERTS data to be summarized to any irregular region whose boundary coordinates are known. In particular, it will be possible to summarize data in either of the Statewide Transportation Modeling System networks, the 547-zone system shown in Figure 16 or the 2300-zone system shown in Figure 17.

The addition of coordinates will also allow the accurate superposition of the road network of either modeling system (see Figures 18 and 19) over a shaded ERTS map. This will certainly be helpful in referencing the data to existing landmarks.

Finally, once so summarized, the ERTS data can be integrated with other Statewide information files which presently exist or are being developed (see Figure 20). One file is an inventory of the percentage of each township in each of twelve broad soil types. Another is a file of the amount of land area in each of four classes of agricultural potential; this potential is based upon the soil type itself, not its current use. A third, presently nearing completion, provides the type of topography by township. Finally, an inventory of nine land-use types by township is currently being edited.

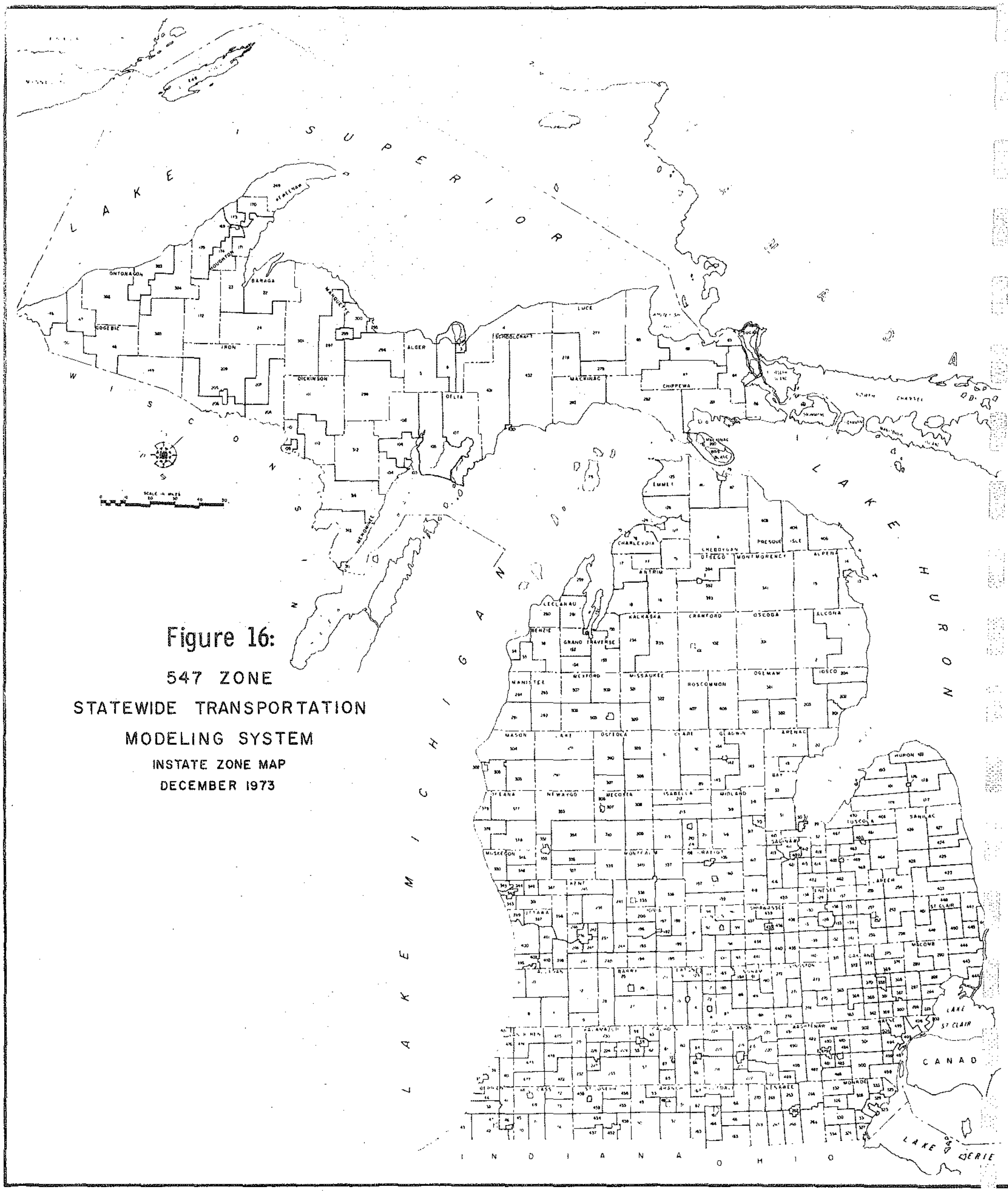


Figure 16:

547 ZONE

STATEWIDE TRANSPORTATION MODELING SYSTEM

INSTATE ZONE MAP

DECEMBER 1973

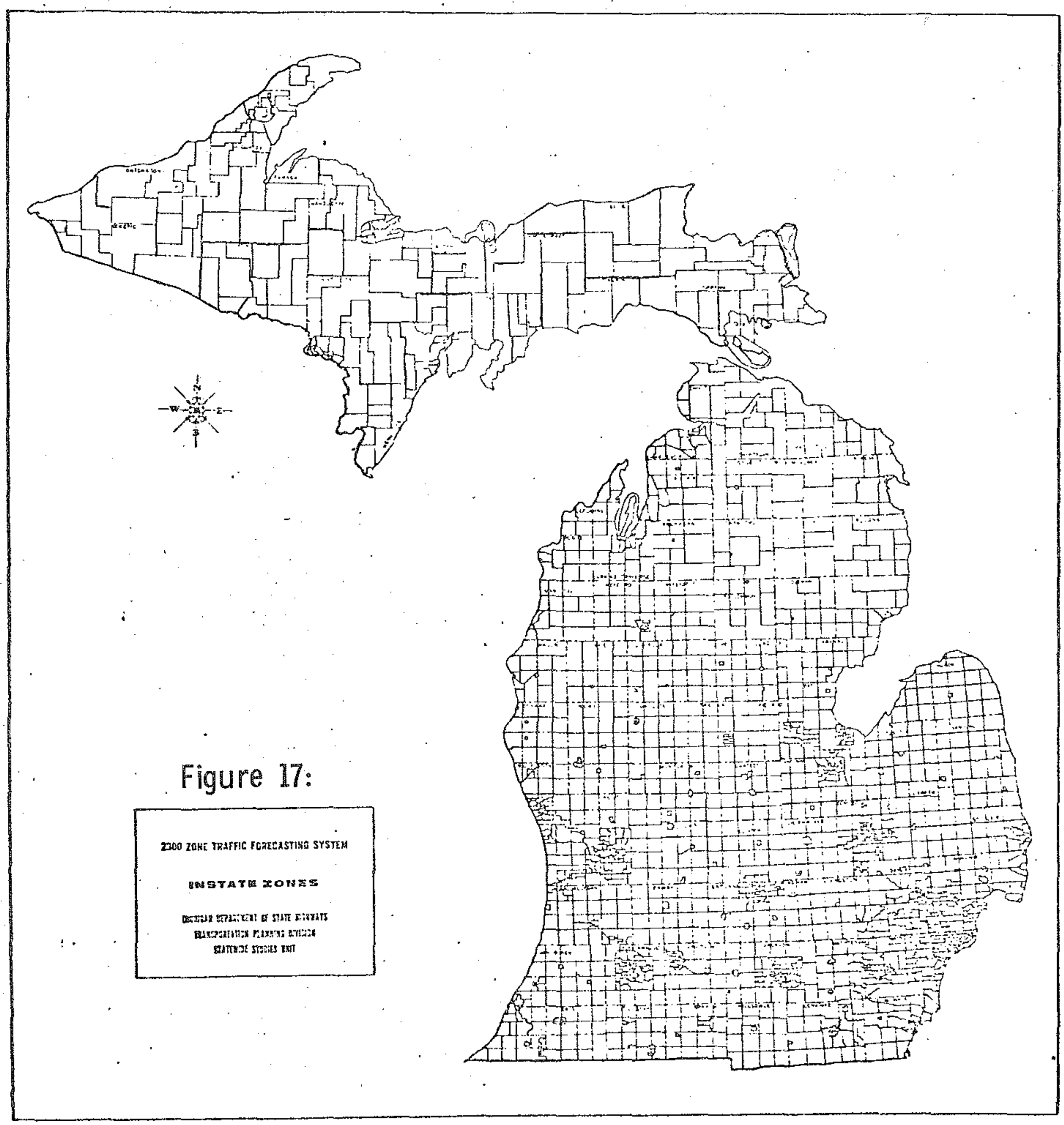


Figure 17:

Figure 18: 547-zone Network Plot

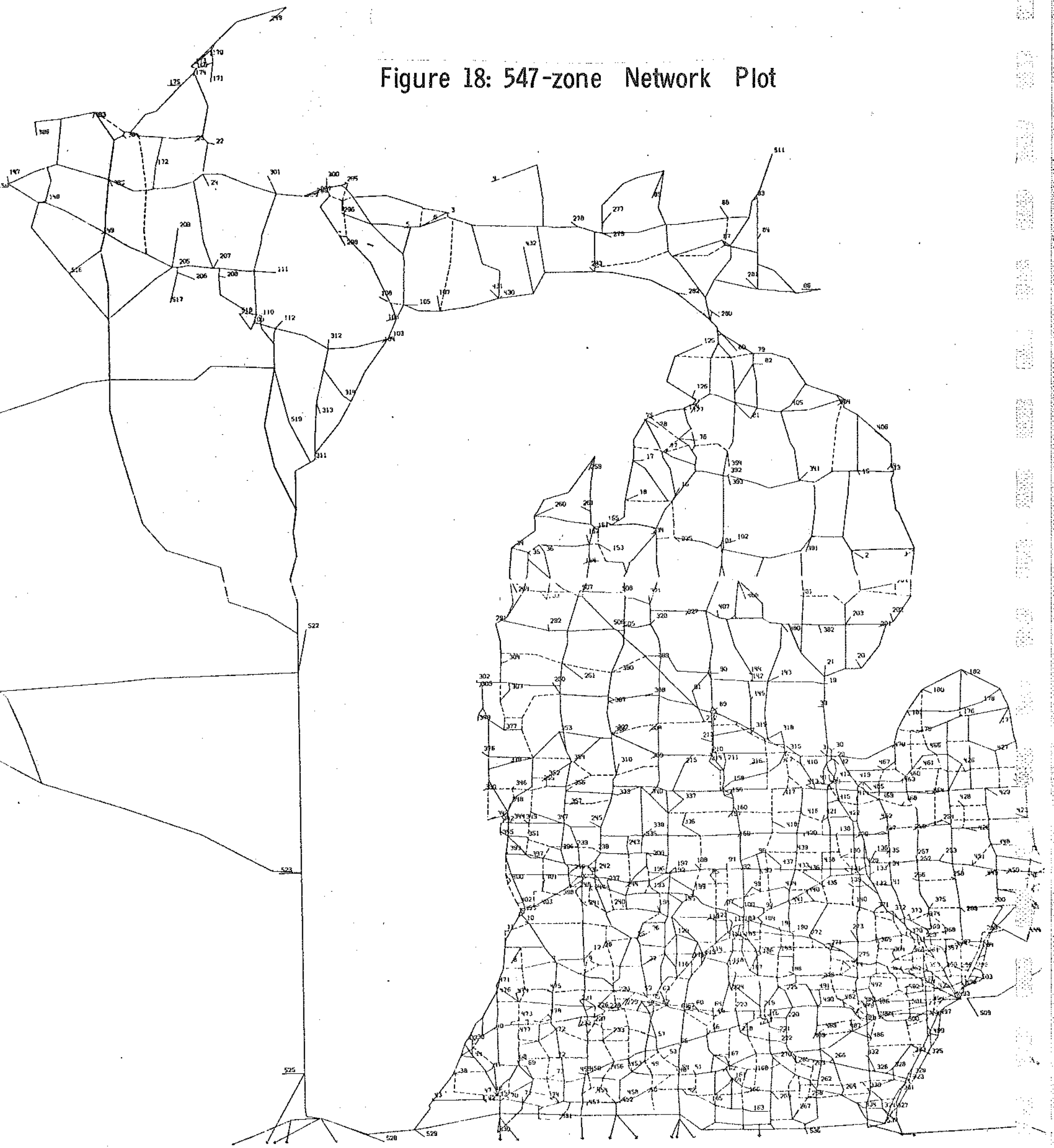


Figure 19: 2300-zone Network Plot

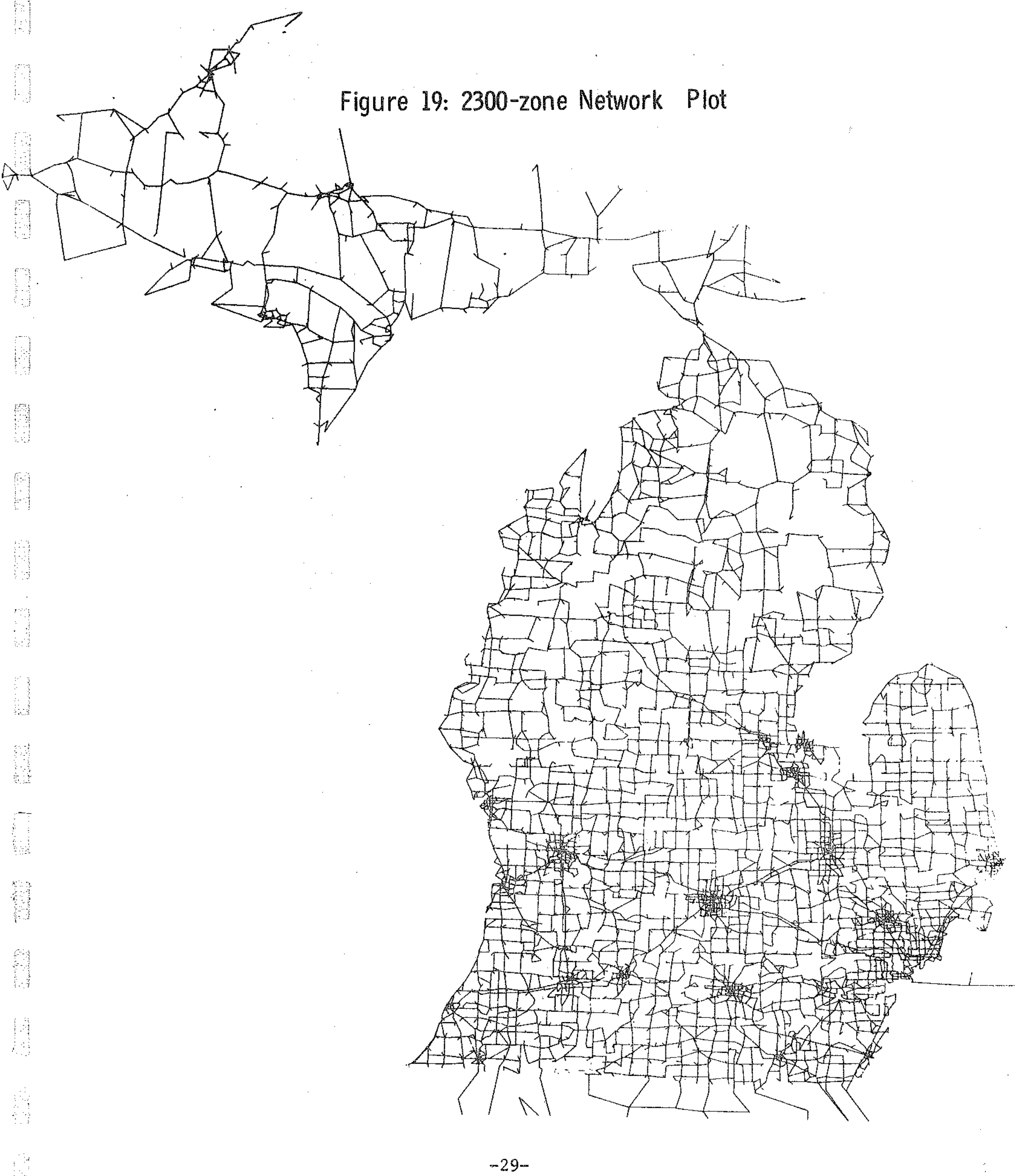


Figure 20: Township-Level Data Files

SOIL TYPES

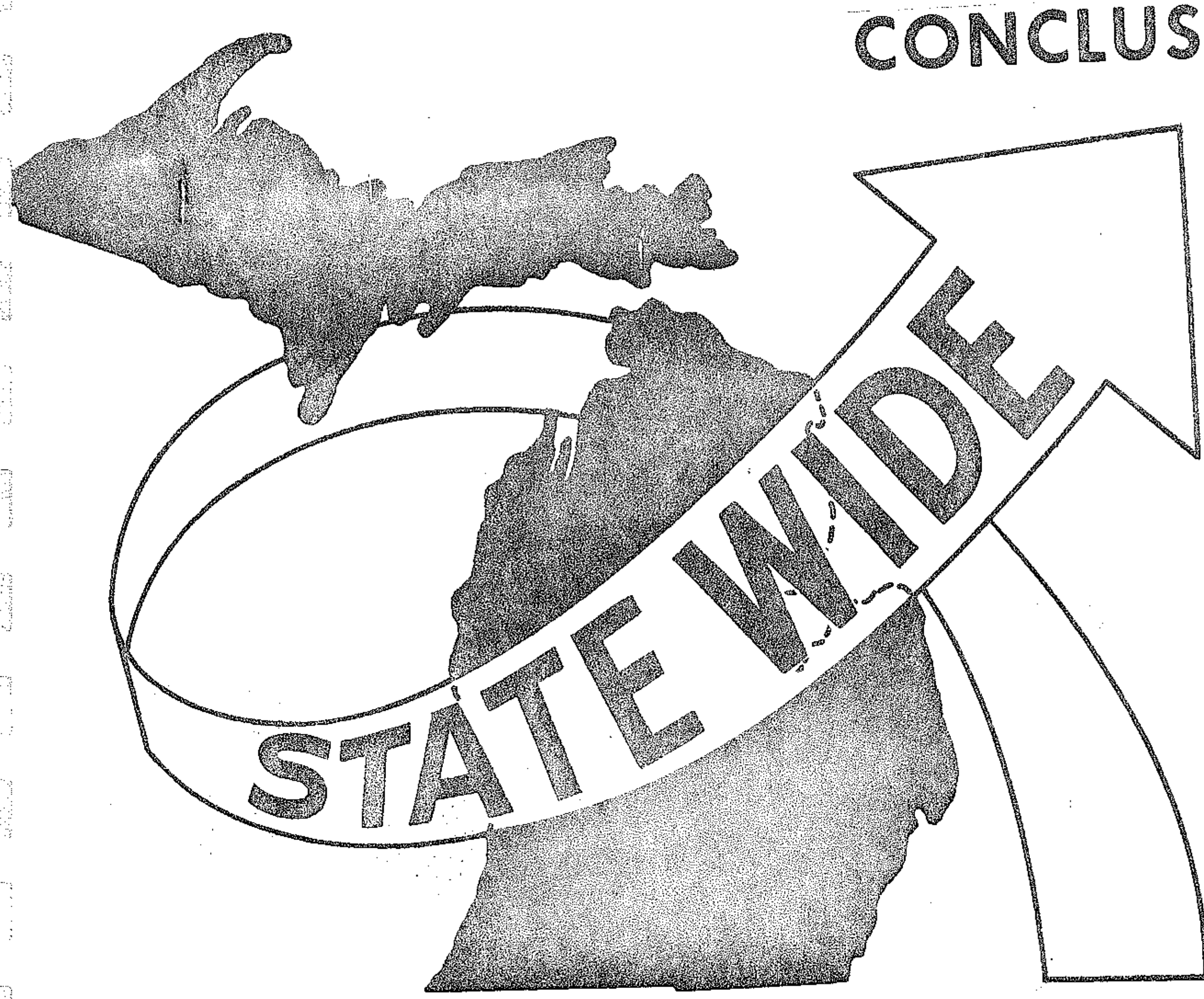
AGRICULTURAL POTENTIAL

TOPOGRAPHY

LAND USE

1. State and Federal Land
2. Privately - Owned (Not for Development)
3. Privately - Owned Farms
   (Able to be Developed)
4. Public Utilities
5. Military Installations
6. City
7. Small-Tract Subdivision
   with Small Sub-Acre Plots
8. Township or County Land
9. Water

CONCLUSION



CONCLUSION

The automated environmental sensitivity-mapping program is a spinoff from the Statewide Corridor Location Dynamics. It offers the potential of producing environmental sensitivity maps automatically for use as a "first-cut" tool, that is, as a device for ruling out unfeasible corridors. It spotlights the ability of the Statewide transportation modeling system to progress from satellite data to forecasts of travel, socio-economic, and environmental impact measurements in an efficient, consistent manner.

Furthermore, the mapping process lends itself to effective stimulation of public involvement in transportation planning. Since its output is pictorial, it can translate the opinions, goals, and objectives of the residents of a region into a map of sensitive areas. People can thus see the effects of their opinions on the location of a proposed highway; environmental analysts can restrict their attention to feasible corridors only, thus possibly eliminating unnecessary work.

Hopefully, this report may serve as a jumping-off point for future discussions. Anyone having questions or comments about the mapping program or any other facet of the Statewide transportation modeling system is urged to contact:

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Lansing, Michigan 48904

or telephone him at: (517) 373-2663.