SATELLITE INFORMATION ON ORLANDO, FLORIDA

L-13

By John W. Hannah and Garland L. Thomas, Brevard County, Florida, Planning Department and
Fernando Esparza, NASA Kennedy Space Center, Florida

ABSTRACT

An effective means of coordinating the utilization of Skylab and LANDSAT data is use of the Skylab photography to make generalized land use maps of the larger areas, such as counties and regions, followed by use of multi-spectral scanner data from LANDSAT and Skylab, where available, to provide more detailed information for whatever portion of that area may be needed. This approach has been followed for Orange County, Florida, in which case EREP photography was used to prepare a land use map of the county and LANDSAT and EREP MSS data have been used to provide more detailed information on Orlando and its suburbs.

The generalized maps were prepared by tracing the patterns on an overlay, using an enlarging viewer. Digital analysis of the multi-spectral scanner data has been basically the maximum likelihood classification method with training sample input and computer printer mapping of the results.

Local planners have participated: the training samples have been selected by Orange County planners and Orlando City planners, and results have been checked in collaboration with them, using photography and their local knowledge.

Eight classes have been mapped. Tallies are kept of the number of resolution elements assigned to each class. Major streets and highways are drawn in manually by tracing on a light table from a master street map made from information combined from several types of computer-printed maps:

(1) the above classification map;

(2) maps of ratios of two bands; and

(3) maps of density - sliced data for single bands.

Thematic maps, consisting of one of the classes, or a combination of them, with everything else left blank, have been found to be useful and informative. Tracing to produce a basic land use map (omitting some of the real-life clutter) has been found to be easier from the separate class maps than from the composite map. The thematic maps are useful also in providing general information, such as industrial/commercial development patterns, to planners.

It was found that two types of residential areas could be discriminated: (1) the newer sections with higher density and relatively few large trees and (2) an older section with lower density and numerous large trees, designated as wooded residential. The pattern made by those two residential classes is visible on the composite map and is made more evident by a thematic map showing only those two classes. The wooded residential dominates in a fairly compact zone near the center of the city and extending into two relatively affluent suburban towns. The newer, or non-wooded residential can be seen to form a rough ring outside this inner area.

It is interesting to make a thematic map showing lakes, forested areas, and wooded areas; three features which increase the desirability of a residential neighborhood. Again, concentration in the more affluent sectors can be seen.

The maps also point out the not uncommon problem of intensive development outside the jurisdiction of the city responsible for that development. In this case, the subject area of intensive development is not only outside the city but also outside the county.

Change mapping is accomplished by mapping the subject classes, usually industrial/commercial, for different dates, then manually tracing a map to show the changes.

Most of the digital work has been done with LANDSAT data. Skylab MSS data were obtained for a pass over Orlando, but clouds limited the useful coverage to about a third of the metropolitan area.

A land use map of Orange County based on digital classification of LANDSAT data is partially completed. The procedure being followed is to prepare a basic map, to the detail permitted by the data, using the Anderson, Hardy, and Roach numerical designation system, from which the planners can then trace maps of whatever geometric and classification detail they choose. Training samples are selected by the Orange County planners and checking of results is done in collaboration with them.

INTRODUCTION

The Brevard County, Florida, Planning Department, in collaboration with Kennedy Space Center, is engaged in a study to evaluate applications of satellite data to local and regional planning in East Central Florida. Computer programming and use of computer facilities and data analysis facilities of the Earth Resources Branch have been provided by Kennedy Space Center. The methods used are conventional; the distinguishing features of this investigation are the application to specific problems at the local level and the participation by local planners.

It frequently is stated that the principal planning applications of satellite data will be on regional problems. This is perhaps true; but the authors and others have found that there also are useful applications of interest to county and city planners.

Both LANDSAT and EREP data have been used in this investigation. An attempt has been made to correlate the photography and multi-spectral scanner data from the two satellites and find the most appropriate use of each type of data.

As Orlando is the largest city in this region, this report will describe results related to it and its county, Orange. These are early results, subject to further checking, but they illustrate directions for fruitful study.

METHODS

Clouds limited the usefulness of EREP multi-spectral scanner, data for Orlando; so this discussion, for EREP data, will be limited to photography. Land use maps have been made from this photography by enlarging it in a Variscan viewer and tracing the patterns on an overlay placed on the viewing screen. In the case of S190A photography, which was used to make the map described in this report, each of the six films can be used, in turn, with

the overlay to bring out the features most readily seen on each film. Usually one of the infrared bands is used first, to locate the lakes (of which there are many in this area) as reference locations. The color infrared film usually is used next because of the wealth of information which it provides, followed by the color film (particularly useful for urban information), and then the remaining three films.

Land use patterns are mostly well defined; the problems lie mainly in the interpretation of the land uses associated with the various sectors of the pattern.

S190B photography can be used separately to make a land use map, or the further detail which it provides can be used to refine the map made from S190A photography, as was the case for the map described in this report.

Computer classification is used for the LANDSAT multi-spectral scanner data. Our usual procedure is to make a preliminary map from the ratio of the intensities of two bands (usually band 7/band 5) and use it for locating training samples. Training sample selection is usually done by the city or county planners directly concerned, using photography and their local knowledge. This serves the two purposes of providing reliable training samples and initiating indoctrination of those planners in the use of satellite data. The maximum likelihood method (sometimes preceded by a preliminary classification based on shortest distance) is then used to classify the data. Output is in the form of a computer printer map accompanied by a tabulation of characters.

RESULTS

County Land Use Mapping

Generalized - The Orange County Planning Department is interested in preparing up-to-date land use maps, and we believe that mapping of the satellite data will be an important part of this process. As a first step, a generalized land use map of the county has been prepared from EREP photography by the method described above. Nine inch EREP enlarged transparencies were enlarged further on the Variscan by a factor of approximately 6, giving a final product with a scale of approximately 1/126,000, a reduced version of which is shown as Figure 1. More detail could have been drawn on this map but was omitted for clarity. Later experimentation with a similar map for another county indicates that more information can be presented satisfactorily if the Variscan enlargement, and the resulting scale of the map, are increased by a factor of two.

The procedure in the case of this map was to prepare it in the manner described above, give it to the Orange County Planners to check for accuracy, then modify it in accordance with their findings. In this case, the modifications were minor.

A map of this type is of limited, general use to a county; but a set of such maps of the individual counties comprising a region is quite useful to regional planners, according to those regional planners with whom we have discussed such maps.

Detailed - A map such as Figure 1, in addition to its direct utility, is also useful in providing correlation and guidance in the next stage of land use mapping: preparation of a detailed land use map. An effective way of doing this is computer classification of multi-spectral scanner data, either EREP or LANDSAT. Since the latter type is more generally available,

it will be used more often, as has been the case for Orange County.

Training samples were selected by Orange County planners, a maximum likelihood classification performed, and a computer printer map produced.

Some planners have difficulty relating to a computer printer map, and most of them find it less "readable" than they would prefer. Hence, at this early stage of development of use of satellite data, at least, it seems desirable to present the results in a simplified form. In our case, this currently is done by tracing the computer character pattern on an overlay, simplifying the map in the process to reduce some of the clutter. Most of the clutter is real (Real-life land use certainly is cluttered.), but land use maps traditionally simplify.

The result of this process for a portion of the western part of Orange County is shown as Figure 2.

While we have referred to this map as detailed, it is possible to include more detail, both geometric and in terms of further division of land use classes, if desired. Within the limits of the capability of the system, the amount of detail presented depends upon the use to be made of the map.

As before, the first version of the map is given to the Orange County planners for their modifications prior to preparation of the final version.

As will be noted, this sector of the county is dominated by citrus groves. Such groves present the most severe classification problems we have encountered to date for two reasons: (1) the spectral characteristics of citrus groves vary widely, and (2) much of the non-urban area with which we are concerned is devoted to citrus. The wide spectral variation apparently is due primarily to the varying amount of sand seen between the trees which, in turn, is a function of the tree size and state of vegetation between the trees. As a result, some citrus gets classified as urban. The fact that this misclassification usually results in a scattering of urban characters, rather than a block, makes this problem less serious than it might seem. In fact, it has proven to be not much of a problem, since the urban normally shows in blocs; and we believe the results are accurate. It does require human intervention in the process, to indicate the known urban regions. This points out the need for human analysis and modification of the computer classification. We believe this feature always is needed but, in this case it is essential.

This method appears suitable for making a detailed land use map of the county, and we intend to do so.

Urban Features

Some characteristics of cities can be studied by means of computer classification maps. Such a map for the central part of Orlando is shown as Figure 3. Eight classes have been mapped: (1) industrial-new construction-bare sand, (2) commercial, (3) residential, (4) wooded residential, (5) undeveloped, (6) trees, (7) water, and (8) marsh. Major streets are drawn in manually on the basis of their visibility on this map and other computer maps. The pattern of major land uses is shown clearly, but the detailed information falls short of that provided by the more time-consuming conventional methods. An important distinction of this type of map relative to the conventional type is that the light reflectivity (and, in the case of the EREP multi-spectral scanner, thermal radiation) provide information

about the physical nature of the scene, while the planner usually needs to know also the economic and social characteristics of the scene, information which cannot be obtained directly from the satellite-produced map. However, the satellite-produced map seems to be an effective base, working from which the planner can obtain the additional information he needs in a selective way at reduced cost in personnel time.

Such a map delineates land use blocs well, so that on-the-ground observation often is needed only to verify or determine the nature of the use, greatly reducing the time required for ground observation.

The fact that the basis of distinction between land uses (or land cover) is based on light reflectance makes the dominant question become that of landscaping versus concrete and roof tops. Basically, then, for example, one bases his distinction between industrial and commercial uses on the relative amounts of bare sand, concrete and vegetation. A look at a few landscaped industrial areas and a few shopping centers that seem to be all asphalt convinces one of the difficulties of separating those two types of land uses. Hence, the separation between those two classes is not accurate. If they are combined into a single class, however, the reliability is improved at the expense of some loss of information content.

While the above characteristic represents a shortcoming from the viewpoint of conventional planning techniques, it represents an advantage in that it provides useful information on environmental features.

For those unfamiliar with computer mapping of satellite data, it should be pointed out that a character on the map corresponds to a resolution element of the sensor, about 60 by 80 meters, or .4 hectares (1.1 acres), for LANDSAT.

A simple random sampling of characters on this map and a similar map of a smaller city, when checked by the local planners against photography and their local knowledge, gives an overall accuracy of 86% for the eight classes shown. An accuracy of 90% is attained if the eight classes are reduced to six by combining the industrial and commercial classes, which cannot be reliably separated anyway, and by combining the two types of residential.

As discussed above, a computer map like this, while realistic, is too confused for many purposes. Hence, it is useful to produce a simplified map by tracing techniques, as shown by Figure 4. We believe this map has sufficient accuracy and detail to be of use to city planners, at least as a starting point for a more accurate map.

Advantages of handling data in digital form include the facility of numerical analysis, where appropriate, such as character counting to determine areas, and the flexibility in processing the data and presenting results. For example, once a classification has been made, it is relatively simple to prepare thematic maps of any of those classes or combinations of them. Such thematic maps present new perspectives and often are instructive and useful.

Orlando calls itself "the city beautiful", not without some justification, perhaps the primary justification being the numerous lakes and trees, made more evident when seen from above. A thematic map of Orlando lakes is shown as Figure 5.

A bonus from the classification is the distinction between residential types. The older residential sector located near the central business district, especially to the east of it, and extending into the affluent "bedroom suburbs" of Winter Park and Maitland has an abundance of large trees, so we have designated it as wooded residential. (Only the northeast quadrant of the city is shown.) This can be seen in Figure 4 and in the residential thematic map, Figure 6, where the dashed line is intended to delineate the sector which is predominately wooded residential. The new residential sectors, designated simply as residential, have fewer trees and can be seen in Figure 6 to form something of a ring around the core of the city. If one is interested in mapping the most desirable residential sectors, he might make a thematic map of lakes, trees, and wooded residential (northeast quadrant only): Figure 7.

An important type of thematic map is that showing industrial and commercial as a single class (southeast quadrant only shown): Figure 8. In addition to the central business district, this map shows a concentration of commercial activity at a large shopping center area (Colonial Plaza-Fashion Square) on east highway 50, heavy strip commercial along highway 50, scattered activity (much of it industrial) throughout the western half of the city, industrial and commercial activity along highway 441 leading northward out of the city, and strong activity, mostly commercial and new construction along highway 436 north of the city. This last activity is in rapidly developing Altamonte Springs--not only another city but also in another county (Seminole). A map such as this points out clearly that, regardless of political boundaries, the metropolitan area is an economic entity; and a unified planning program is needed.

It is interesting to use classification maps such as these to compare the development pattern of Orlando with the classic textbook patterns (1). Features of the Concentric Zone pattern are seen in the central business district, wooded residential, and non-wooded residential classes discussed above. Features of the Sector pattern are seen in the industrial sector directed outward from the central business district toward the northwest in the vicinity of U. S. highway 441, in the wooded residential sector extending northeastward into Winter Park and Maitland, and in commercial development along several major arteries. Multiple Nuclei features are some commercial centers (Colonial Plaza region, Winter Park central business district and Mall, Altamonte Springs commercial region), and industrial centers (e.g. the industrial park south of the city). In addition, in common with many other U. S. cities, Orlando can now be seen to have a partial "belt", which has some resemblance to the Concentric Zone feature. In this case, the belt is highway 436, running from McCoy Airport northward and then westward and having an associated buildup of commercial and high density residential development. The regions of rapid development are roughly equidistant from the central business district, with access aided by freeways, and with much of the development outside the taxing jurisdiction of the community which provides the reason for the development.

Another type of thematic map which is useful to planners is one which shows relative reflectance of the sectors of a city (density slicing of band 5), which may be regarded as intensity of development, Figure 9. Basically, this is a rough measure of the relative amount of concrete and rooftops visible from above(i.e. concrete versus vegetation). Generally, this pattern corresponds to that of the industrial-commercial map. One interesting additional area with relatively high reflectance is the rather large Pine Hills residential sector, which does not have many large trees. A map of this type can tell a planner what sectors of his city need attention.

Change-Monitoring

Probably the application which has created the most interest among planners to date is change-monitoring. A simple technique can be used, and the results appear useful. Usually, the process involves some method of comparing classification maps for the two dates of interest. Automated computer methods can be used, but our experience is that the reliability of classification is such that the human can more reliably detect changes by looking at the two maps overlayed on a light table. Figure 10 shows the results of comparing Orlando classification maps (northeast quadrant only shown) for two dates: September 6, 1972 and April 28, 1973, an interval of almost eight months. In this case, an 8-class map for the later date was compared to an industrial-commercial thematic map for the earlier date. We find that some human judgment is needed in comparing patterns. We do not feel that, at this stage of development, the results should be accepted without verification, which, however, is usually not difficult. At the time of this writing, 58 of the 90 changes noted have been checked by photography followed by ground observation where needed, and we feel fairly confident of nearly all of the interpretations and have found four definite errors, three of which are due to bad scan lines, a problem which is less serious with more recent data. This is two years after the second date; more prompt checking would reduce the difficulty and improve the accuracy of ground checking. When appropriate photography is available, its use can greatly reduce the amount of ground checking needed. This appears to be an effective and relatively inexpensive method of up-dating land use maps--perhaps even detailed maps of urban areas, although certain changes which do not involve appreciable land-clearing or addition of concrete surface or roof tops might be missed. The procedure needs further evaluation.

The period in this case was one of rapid development in the Orlando area, so the changes are more numerous than normal.

In addition to the up-dating of land use maps, this kind of map provides other benefits for the planner, such as showing him readily when specific land-clearing and construction jobs have begun, showing him the state of development of specific large projects, such as large residential developments, and giving him an overview which indicates the areas of highest development activity. This map, for example, shows major activity in three areas: (1) in the southwest quadrant, toward Disney World; (2) along the north-south portion of highway 436, where many new condominiums were being built, and (3) in Altamonte Springs (north of the city), where much commercial and residential development was occurring.

In addition to new developments, two other interesting changes are shown on the map: Two lakes were filled with silt at the second date and, therefore, do not appear as lakes. Lake Lawn, north of highway 50 was being dredged to fill in land for a park and its level lowered in a rejuvination procedure, and it appears as commercial. Lake Underhill appears as industrial, as it was filled with silt due to the East-West Expressway under construction through it at the time.

One portion of the East-West Expressway was under construction on the first date, and shows on the first map; another portion was under construction on the second date, and both portions show on that map.

CONCLUSIONS

On the basis of our experience to date, it is our opinion that computer classification, accompanied by human interpretation and manual simplification, can produce land use maps which are useful on a regional and county and, for special purposes, a city basis.

We believe change-monitoring to be potentially an effective application of such data at all planning levels.

At the present state of the art, caution should be used lest too much reliance be placed on strictly automated methods. Computer methods should be closely coordinated with human evaluation and checking, both because it improves effectiveness and because it increases "saleability" to the planners.

We have found that, generally, planners are interested in the possibilities; and most planning departments will cooperate by assigning one of their members to assist in preparing training samples and evaluating results. Collaboration by the planners also has the important effect of accelerating their acceptance of satellite data.

ACKNOWLEDGEMENTS

James J. Millard, of NASA Kennedy Space Center, has done the bulk of the programming of the computer programs used in this work and has been responsible for the computer runs.

Robert Stark and Scott Henderson, of the Orange County Planning Department, and Dale Smith, of the Orlando Planning Department, have collaborated by preparing training samples and checking results.

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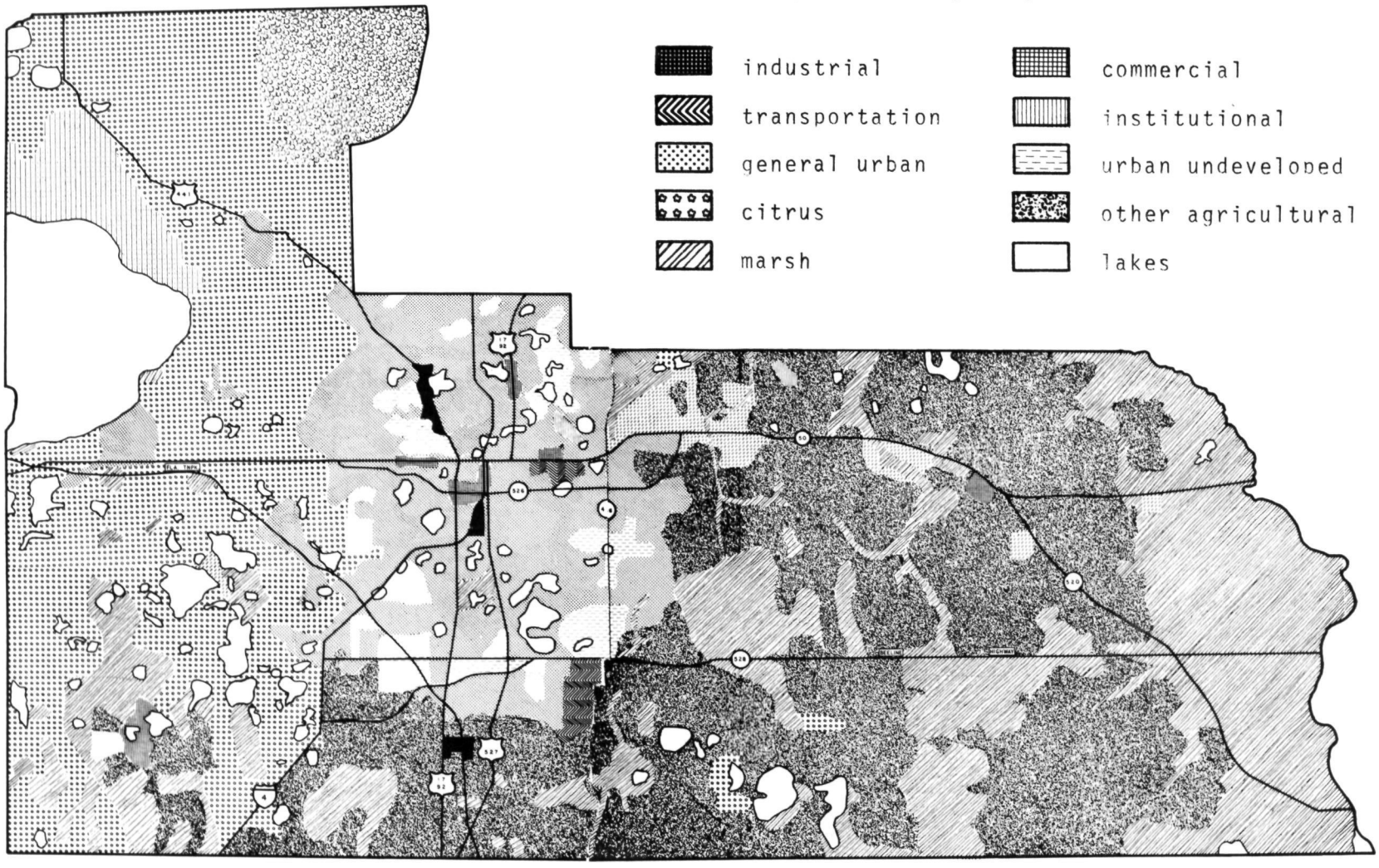


Figure 1. Orange County Generalized Land Use

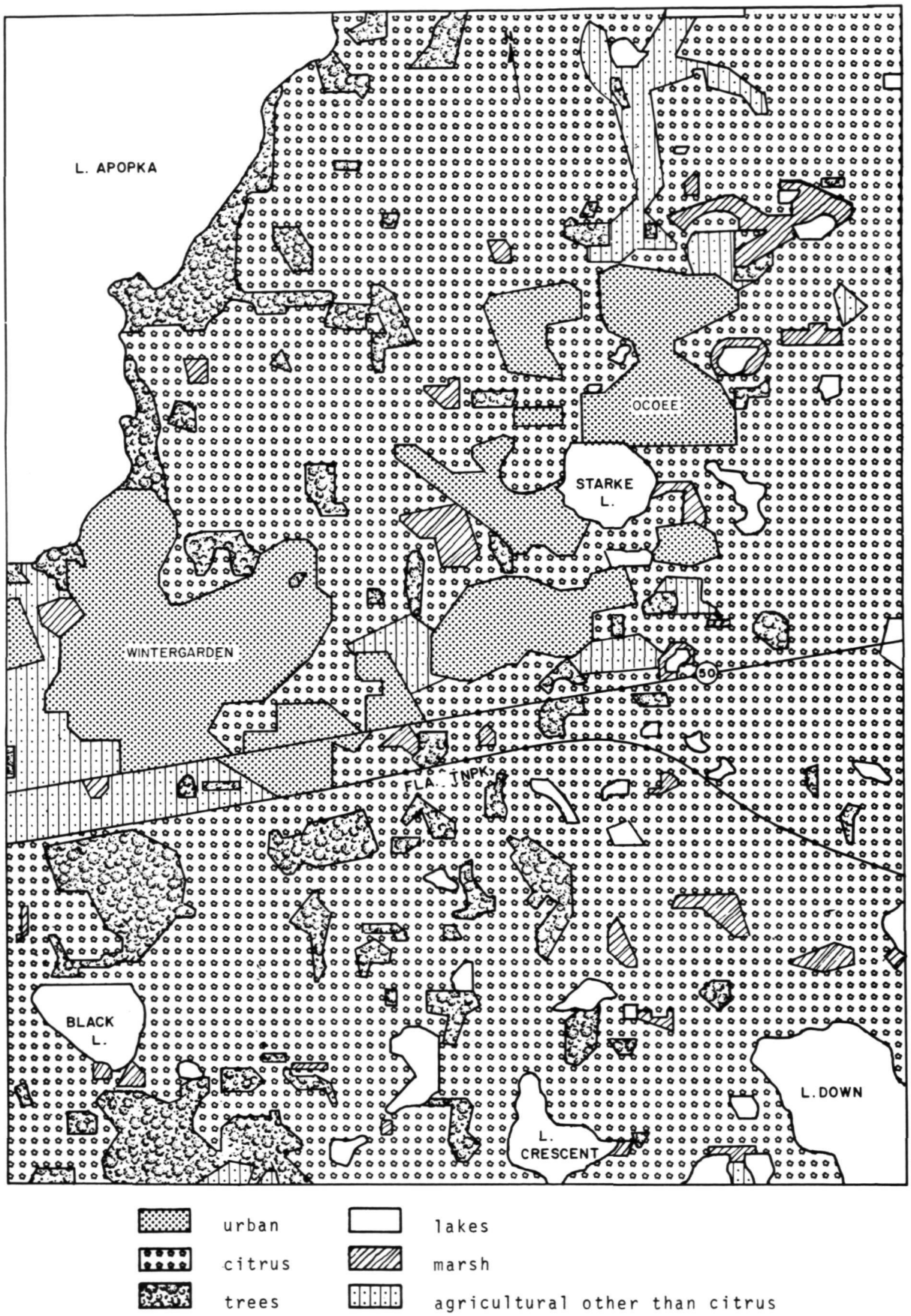


Figure 2. West-Central Orange County simplified from computer map 1674

B	industrial	T	trees
*	commercial	.	undeveloped
X	residential	S	marsh
/	wooded residential	blank	lakes

Figure 3. Central Orlando

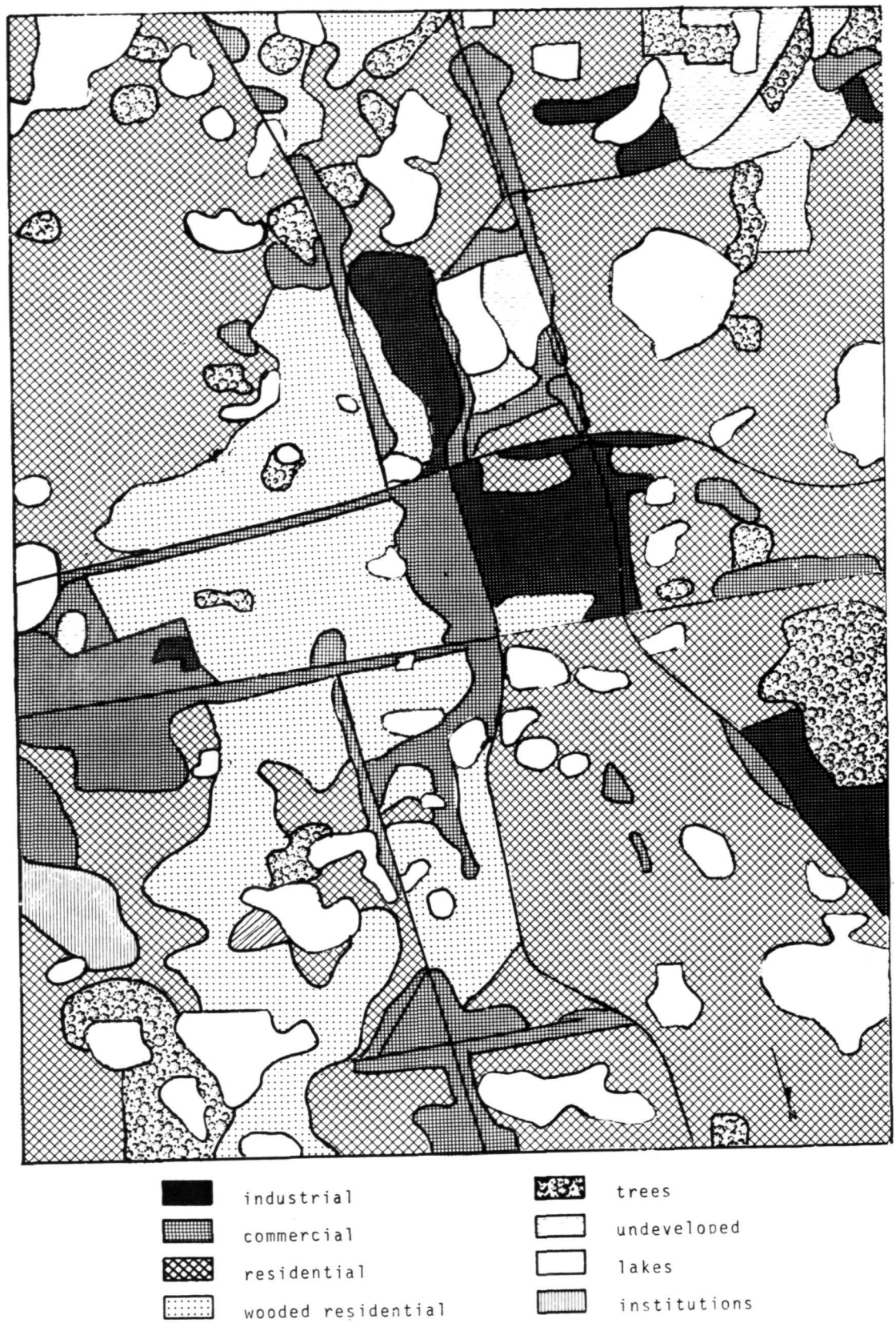


Figure 4. Central Orlando simplified from computer map

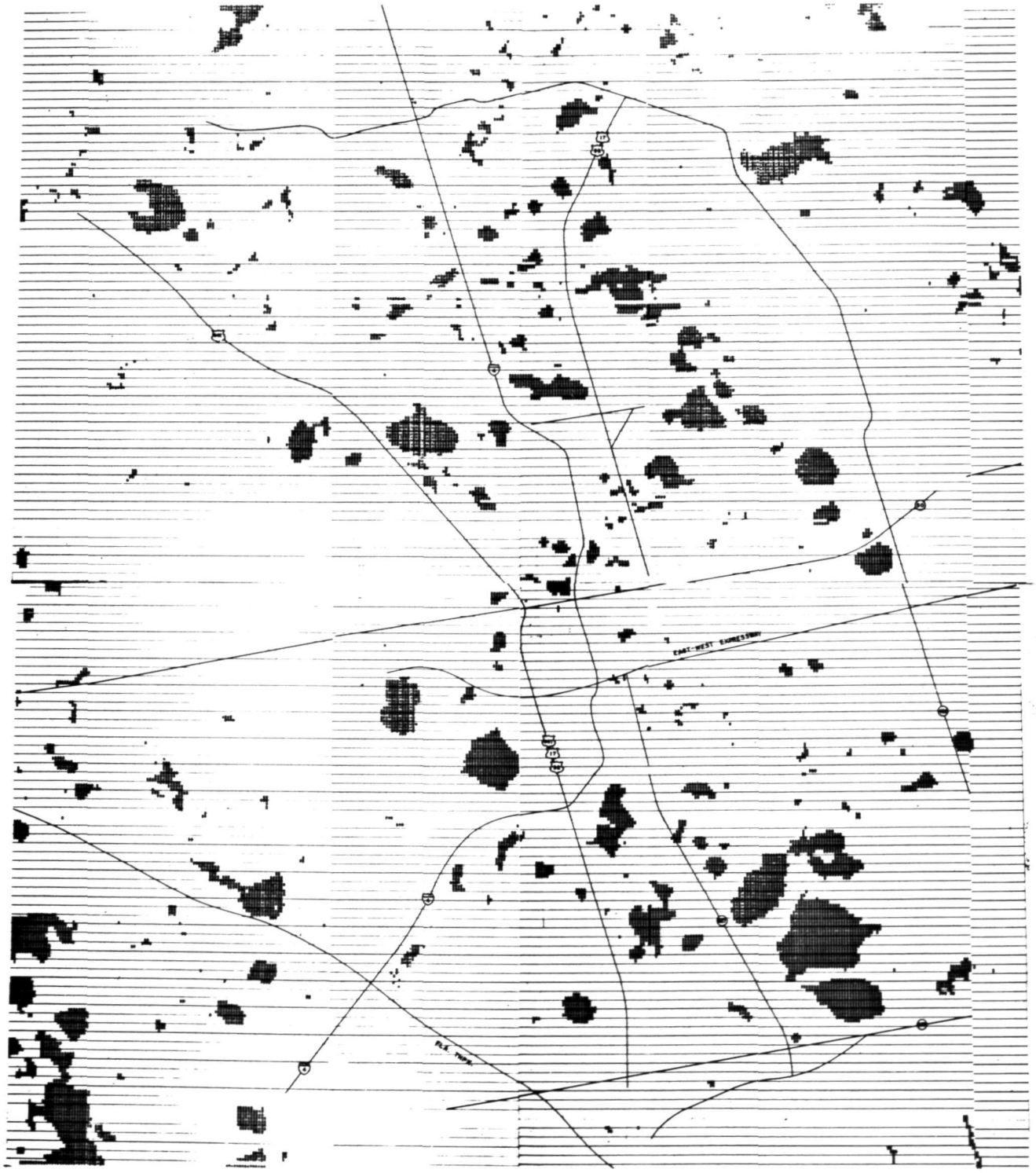
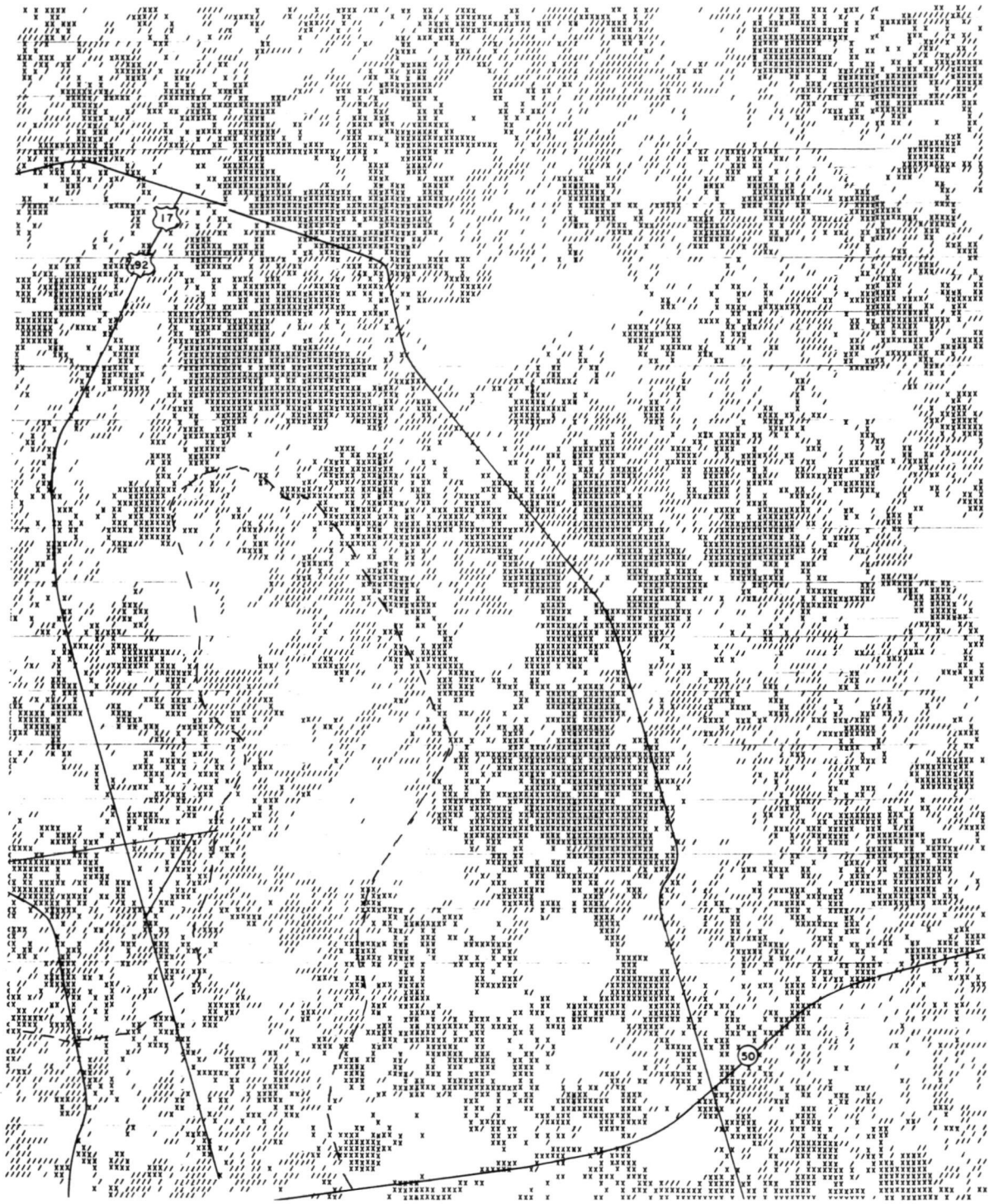
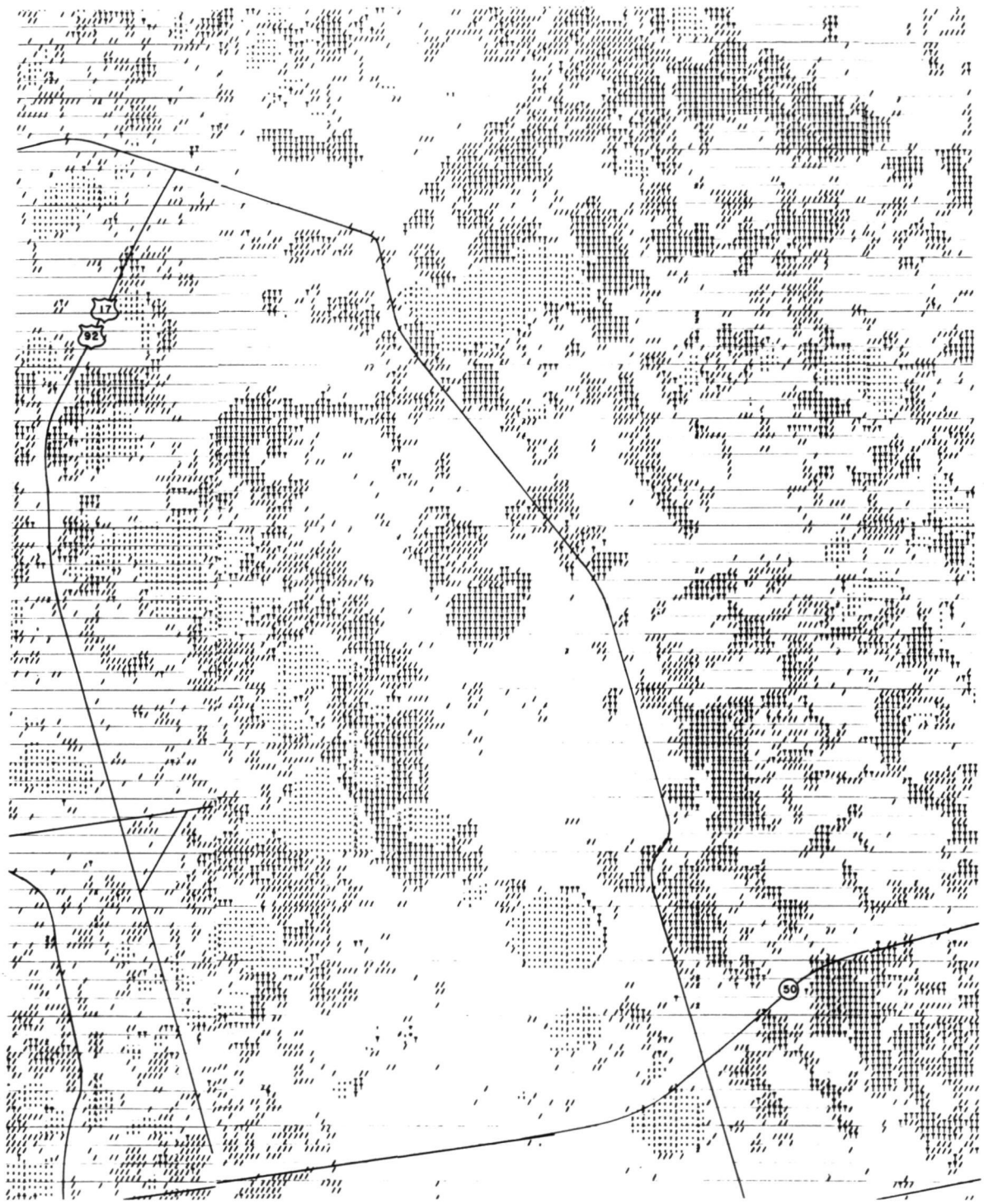


Figure 5. Orlando's Lakes



X residential
/ wooded residential

Figure 6. Residential thematic map of Orlando



/ wooded residential
T trees
. lakes

Figure 7. Thematic map of most desirable sectors of Orlando

B industrial-commercial
everything else blank

Figure 8. Thematic map of Orlando showing industrial and commercial land use as a single class

Figure 9. Intensity of development

Figure 10. Changes: September 6, 1972 to April 28, 1973