THE DESIGN, IMPLEMENTATION, AND USE OF A STATEWIDE LAND USE INVENTORY: THE NEW YORK EXPERIENCE

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INTRODUCTION

The New York State land use and natural resource inventory is the first statewide inventory that we know of in the present mode. When we started, we had many new tools; we had people's enthusiasm; and we had a state-level agency that was willing to support the work. The Office of Planning Services provided the support. The people with some of the new ideas included Professor Don Belcher, who was at that time the director of the Center for Air Photographic Studies, and Ron Shelton, who is on the staff of Michigan State University. I comprised the third member of the team that was involved with generating this particular project.

We saw an opportunity to try a new approach to developing an inventory of natural resources throughout the state. We had aerial photographs, computers with unusual storage capacities, and numerous available resources such as soil maps and zoning information. The ability to work with computers is definitely recognized in terms of the computer's ability to handle geographically referenced information.

When the opportunity for this project occurred, we had a request for a statewide inventory that would handle nine items of information, which were the usual ones: water, land, public land, farmland, woods, and so forth. As we got into the project and got the interest of many people incorporated into the work, the list of requested items grew to 185. We trimmed the list to about 135 items for this project. We had done other projects that had gone as high as 300 items of information for an inventory.

We found that our initial ideas were slightly naive. For example, no good geographic referencing system existed that would work economically for this type of project. We also discovered that computer programing, although initiated by Carl Stenus' group at Harvard and well underway, was not capable of handling a 50 000-square-mile area with 135 items. We also discovered that no one had given any serious thought to the basic concept necessary to undertake a wide-scale resource inventory of this type.

DESIGN AND IMPLEMENTATION

In considering the overall perspective of what an inventory was going to accomplish for us, we realized that we really wanted to generate something that, in its simplest, most ideal form, would take information from any source (clipboard or satellite); run it through any kind of a process (manual or computer), and, if done properly, produce information of use to any user. This perspective seems to be working as a fundamental concept.

This concept actually ends up with the creation of a warehouse of data from which the user combines things as he sees fit or as he sees a need in a particular case. To make this concept work, the user has to input as much unbiased information as possible. Even the soil map from this concept has acquired a built-in bias that can be a problem at a later date. I have seen very little evidence of anyone paying much attention to the idea of using only unbiased information in this system. After acquiring the information, the user then infers and interprets the information to suit particular needs and problems.

The geographic-location problem was solved rather early. We searched the number of possibilities and concluded that the cheapest, most efficient method to work with for getting a numerical system into a computer was to use the UTM grid system, which divides very economically. This method is available to large areas, such as the entire State of New York. Six digits identify the location as a kilometer; eight digits, as a hectare; ten digits, as an area about the size of a small auditorium; and twelve digits, as an area about the size of a desk. It is a powerful, effective system; it will work cheaply in the computer program that we have; and it provides an excellent location reference approach for us.

In 1968, no computer programing was available. There were some programs that had been developed to use cards in sequence. We experimented with those programs and got up to 9000 cards. We found that getting up to 9000 cards was easy, but to get them into a sequence was difficult. The cards are gone now.

We also realized there is no single best inventory. Any user who wants information prepared for him is going to have his own ideas about data he wants. Thus, we concluded that whoever wants the information is going to be interested in getting something out of it for his personal use. The sources of information are extremely varied, and we have many different sources of information in the system. The basic source for this particular inventory was low-altitude aerial photography, but we can also use other sources. If we can geographically reference it, we can get the information into the program and go to work. About 80 percent of the information came from aerial photographs; about 15 percent came from secondary sources; and about 5 percent came from actual personal contacts with people getting specific kinds of information from their knowledge of the world around them. We can actually locate the information on the map to as small a measurement as feet. We do not pull it out of the computer page and add mode because there isn't any particular demand for it at that scale, as long as we have it available in some form.

The question of accuracy frequently occurs. There is much confusion about geographic referencing in terms of the cartographic characteristics of an inventory; however, what is even more important is the accuracy of the interpretation process itself. The grid-cell idea does provide an excellent locational accuracy level. We acquire the grid cell after we have done the curvilinear mapping so we can go to the polygon system if we want to. We do not have to restrict ourselves to either a grid or polygon system in the early stages of an inventory process.

The knowledge that there are only three good ways to measure things on a map solves many problems. A person can measure things with a line, with a dot or a point, or combine dots and points to make lines for enclosed areas. The entire process then comes down to this question: How do you handle the statistical data or the numbers that go with the lines, dots, and maps?

The classification gave us much more trouble. We depended heavily on the soils people and some of the knowledge that they had developed. We soon realized that the description of the classification unit is the most important item in the entire process. Without description, we really have very little to work on. If the description is done well, it uniquely identifies every item in the inventory. If the description is adequate and unique, then it is easy to come up with a discrete assignment for each of the items. No one item can possibly fall into two categories. If we have a unique description with discrete assignments, then it is possible to go ahead and complete a comprehensive coverage of the entire item. In the New York inventory that we did several years ago, we had a sizable matrix of materials. One-hundred items result in a matrix of 10 000, and we can extract every item in any 1 percentile that we wish. Possibly millions of different kinds of maps can be obtained from the information system. We can incorporate 25, 30, or 40 different factors simultaneously, which means the total is close to a billion.

Another factor that we did not plan on is that we have excellent sampling design possibilities once a standard system is established, especially a grid system on a statewide basis. This opens research opportunities in every other field of land use information: populations, demography, economics, and so forth. Moreover, these opportunities keep expanding as time passes.

The process that we developed has many products, such as hand-drafted maps, that we make available to the general public for a reproduction cost. The process has record books; all raw data have been maintained in depth. We can produce statistical lists on computers; we can produce computer printout maps; and we can provide information for almost any application with which a user might want to be concerned.

New York is a large state, and figure 1 is an illustration of what happens when people look at something from fifty different points of view. Various items in the inventory can be specifically identified and located. Figure 2 shows a lock in one of the major canal systems. Because the location of our delicate resource areas (fig. 3) is very well defined, we can pinpoint them very accurately and develop a very detailed analysis of them. Public service units, such as waste disposal plants (fig. 4), are easily located. A colonized pipeline (fig. 5) or anything that dissects the countryside can be represented as a linear feature. Many varieties of land use are represented in figure 6; for example, we have the only inventory of frogponds that we know of. We have contour ditches and different kinds of forest, land, housing, and transportation. We can put in flood plains and a number of these certain items at the same time. Commercial strip development goes into a separate category, whether it is a roadside market (fig. 7) or some other kind of operation. Waste disposal, whether from mining (fig. 8) or other sources (figs. 9 and 10), is very readily located. We have many recreational facilities in the form of bungalow colonies through out parts of the state (fig. 11), and each facility gets a separate type of classification among the recreational units. Figure 12 is a ski resort in the northern part of the state in the Keene Valley. The entire area can be mapped, or we can include it as woodland. Shoreline development along lakes (fig. 13) is no problem. The planners who are interested in the freshwater bodies can easily find those that have been developed. The cottages can be identified either in linear features or in point data. For recreational sites like the small marina shown in figure 14, we can provide the number of boats.

Pollution can be represented in three different ways. We can locate the point; we can locate the linear extent of it along the shoreline of a freshwater body; or we can locate it in terms of the area of the water surface that was affected as shown in figure 15. The technique for obtaining this information is manual. We use a manual drafting technique with which we can input these data for as little as $0.04 per kilometer. Figure 16 shows a comparison of LANDSAT and Skylab imagery; either can be used. We have technical developments that have allowed us to extract this information at very little cost from very wide areas and to incorporate this kind of information in a computer storage system. The raw data are stored in bookcases and are available to anyone. In approximately 3 minutes, we can explain to anyone how to find his or her particular area and work on the raw-data materials. The maps for reproduction are stored simply and economically and are reproduced at about $5 or $6 per print for outside users. Figure 17 is an example of what the map looks like on Mylar. A user can simply overlay it on a topographic map to obtain the topographical information and all the other areas needed. We can also provide the computer printout (fig. 18).

We have used a variety of input systems. The system shown in figure 19 cost us $36 000, and we could produce a map using this digital input from the computer system for approximately $255 to $260. If we used the system shown in figure 20, which is a $1.98 abacus, we could get the map cost down to $45 or $50. By using the system illustrated in figure 21, which is a $0.03 piece of plastic, we could get the map cost down to $28. We use the latter system, which is the cheapest, because it can still be done, even with the increase in wages, for less than $35 per map.

The products are made basically with curvilinear features, and then a grid system is applied over the curvilinear features. We do not apply the grids first. We have point and area maps; for example, figure 22 is an area map of land use. The topographic map behind it is the most accurate means of measurement that we have. It is not used for any other information. Figure 23 is an example of the completed map ready for reproduction.

All the map work is field checked, and we have had an accuracy level of above 94 percent on the decisionmaking process for the state as a whole. We have obtained an accuracy as high as 95, 98, and 99 percent in some areas. The transfer is eyeballed; therefore, everything has to go on the topographic map for accurate measurements. The interpretation is straightforward, using only pocket stereoscopes and pencil work. The aerial photointerpreters are encouraged to use as much backup material as they can get. From people in the field, we gather data that will be incorporated on the topographic map to broaden the accurate use and interpretation process.

A very simple problem developed when we started to revise the classification system that is illustrated in figure 24. In a recent project, the researchers requested that we increase the number of forest-cover types from 4 to about 16. The result was a very high degree of complexity throughout the whole State of New York. This one request might increase the cost of doing another statewide inventory by as much as 25 to 40 percent. Classification of major problems is even more complicated. In this classification and description, the products are actually prepared and separated; we stack them up and run them onto a number of different resource output cards.

In terms of design concepts, we have found the following 11 steps to be very important:

1. The overall design of the project in relation to its uses
2. The classification based on the needs and resources of value
3. Data acquisition
4. Geographic referencing
5. Data processing
6. Data storage
7. Data retrieval
8. Application
9. Warehousing of raw data
10. Development of a user service
11. Documentation of the entire operation

This last step includes the computer program, the techniques for doing the work, and, above all, a photographic atlas of the land uses that have been recorded at that time. Without this atlas, we do not really have a resource inventory, and if we fail to take time to create this atlas concept, it is impossible to do the work over again. Ninety percent of our thousands of applications and requests are for map overlays, whereas only 10 percent are for the computer products.

APPLICATION

The total cost of the New York State inventory, which was done from 1968-70, was $10 per square mile for 135 items, computerized and geographically recognized. We did 6300 square miles in the summer of 1974. Not including the computer phase, we were still able to do 104 items for $10 per square mile. In 1975, we made an estimate for a statewide inventory that will cost between $12 and $15 per square mile for 140 items. To get satellite information into the system through our manual output products costs about $0.04 per square kilometer for level 1 category from a 671 image.

We have encountered a few major problems. One problem is simply sustaining support. Some other states have taken an active role in developing state land use systems. Another problem is that classification theory is essentially being overlooked and is undeveloped. Cooperation among state, federal, and local agencies brings problems in most cases. A technology transfer in the form of user services is almost nonexistent throughout the country, which is the biggest flaw in the whole system if we are to make progress in the future.

In summary, the higher the degree of sophistication of a system, the fewer users there will be. In addition, the greater the number of items, the greater the need for less sophisticated means. It is impossible to put points in very short lines in this process;

yet, it is critically important in a land use inventory. Obviously, the higher levels of government will be able to use the more sophisticated systems much more easily than the lower levels.

Cartographic accuracy and interpretation accuracy are misused and misconstrued concepts. Our greatest concern should be the interpretation accuracy rather than the cartographic accuracy. The testing of an inventory is rare, and few inventories contain any clue to their accuracy level. The testing of the talent that produces the inventory is even more rare. I've never found an instance when two people doing the same part of a job were evaluated against each other.

Most of us may be overlooking many of the good products that some labor-intensive opportunities still offer for dealing with the large volume of resource information. Another point that many of us overlook is that not every land use information system is automatically transferable to other parts of the country or other parts of the world.

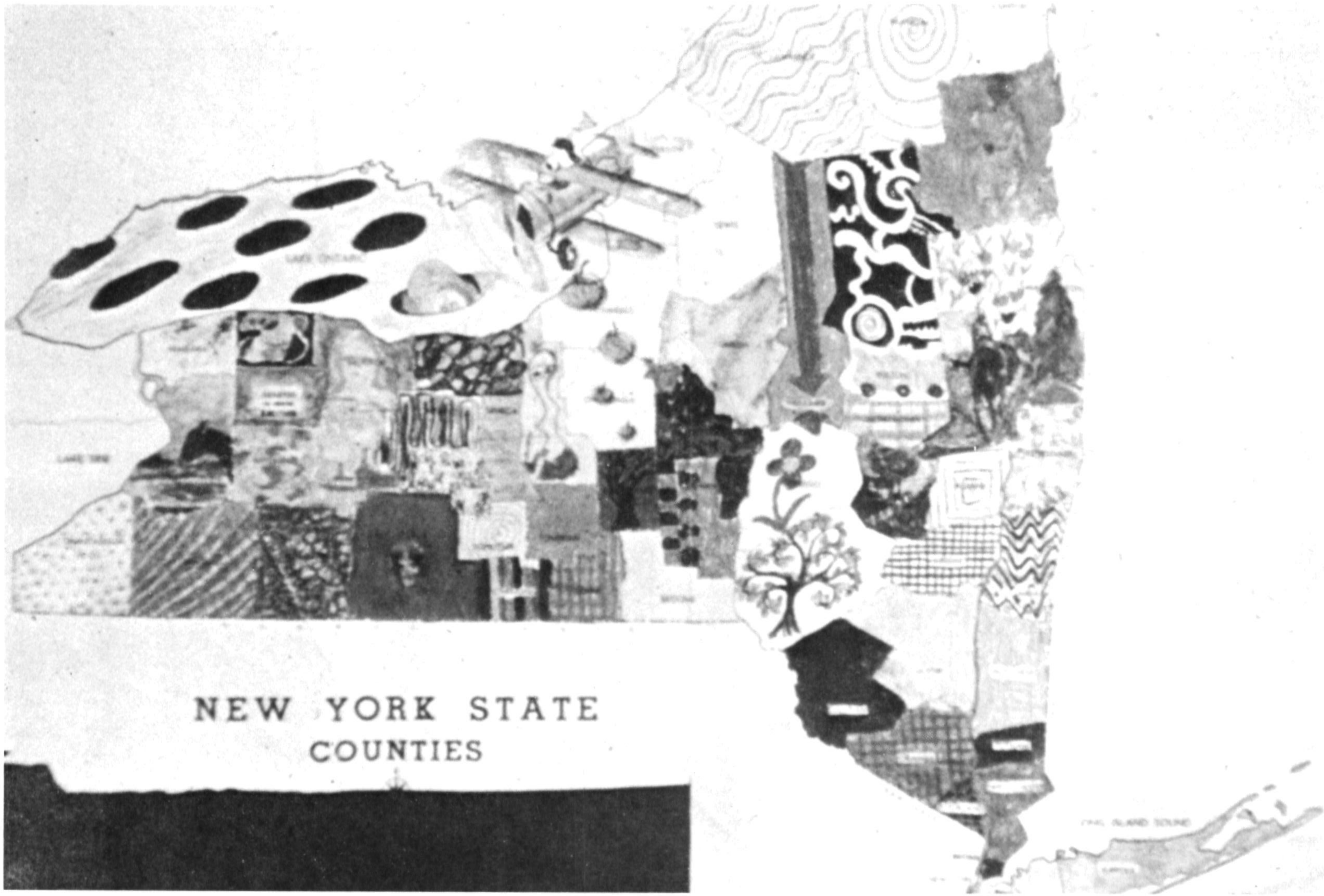

Figure 1. A divergent inventory of New York State counties.

Figure 2. A lock in a major canal system.

Figure 3. A delicate resource area.

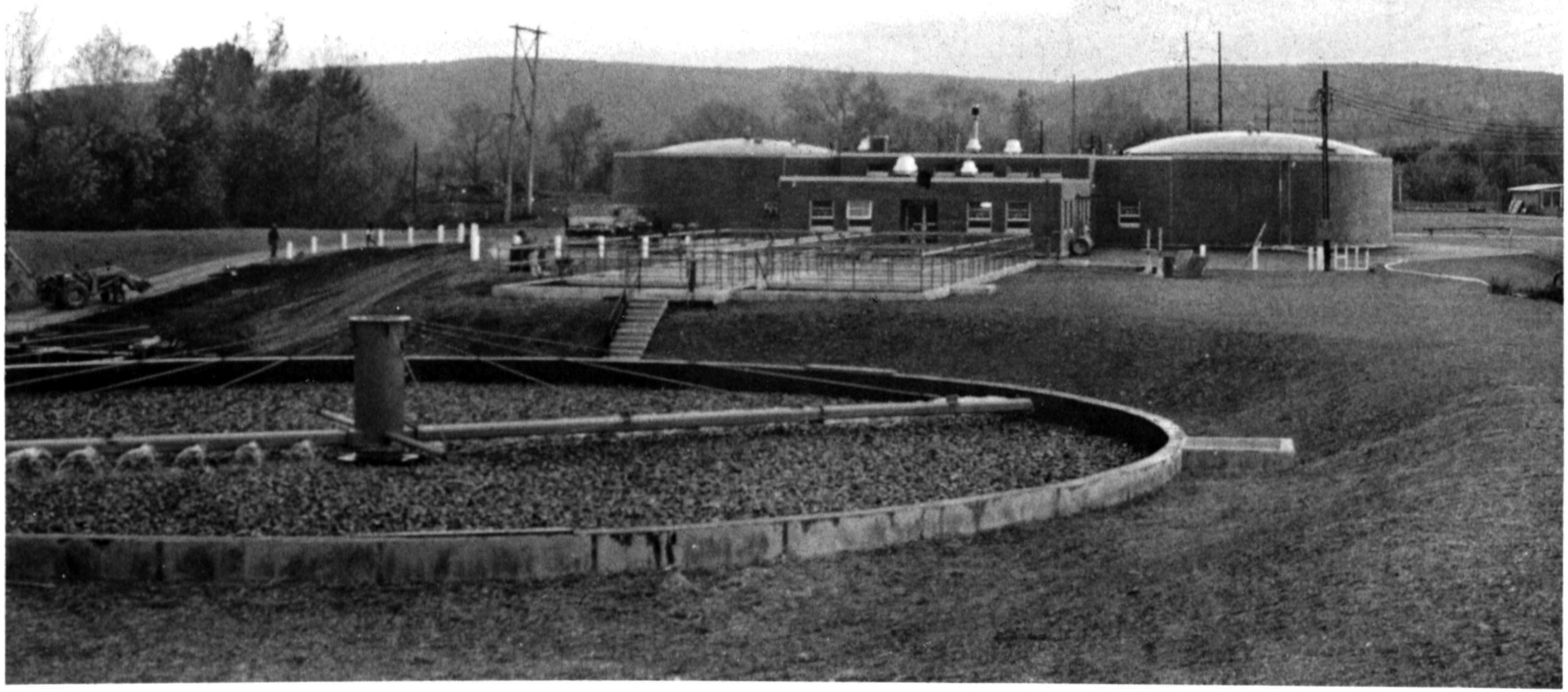

Figure 4. One kind of public service unit: a sewage plant.

Figure 5. A colonized pipeline forms a linear feature.

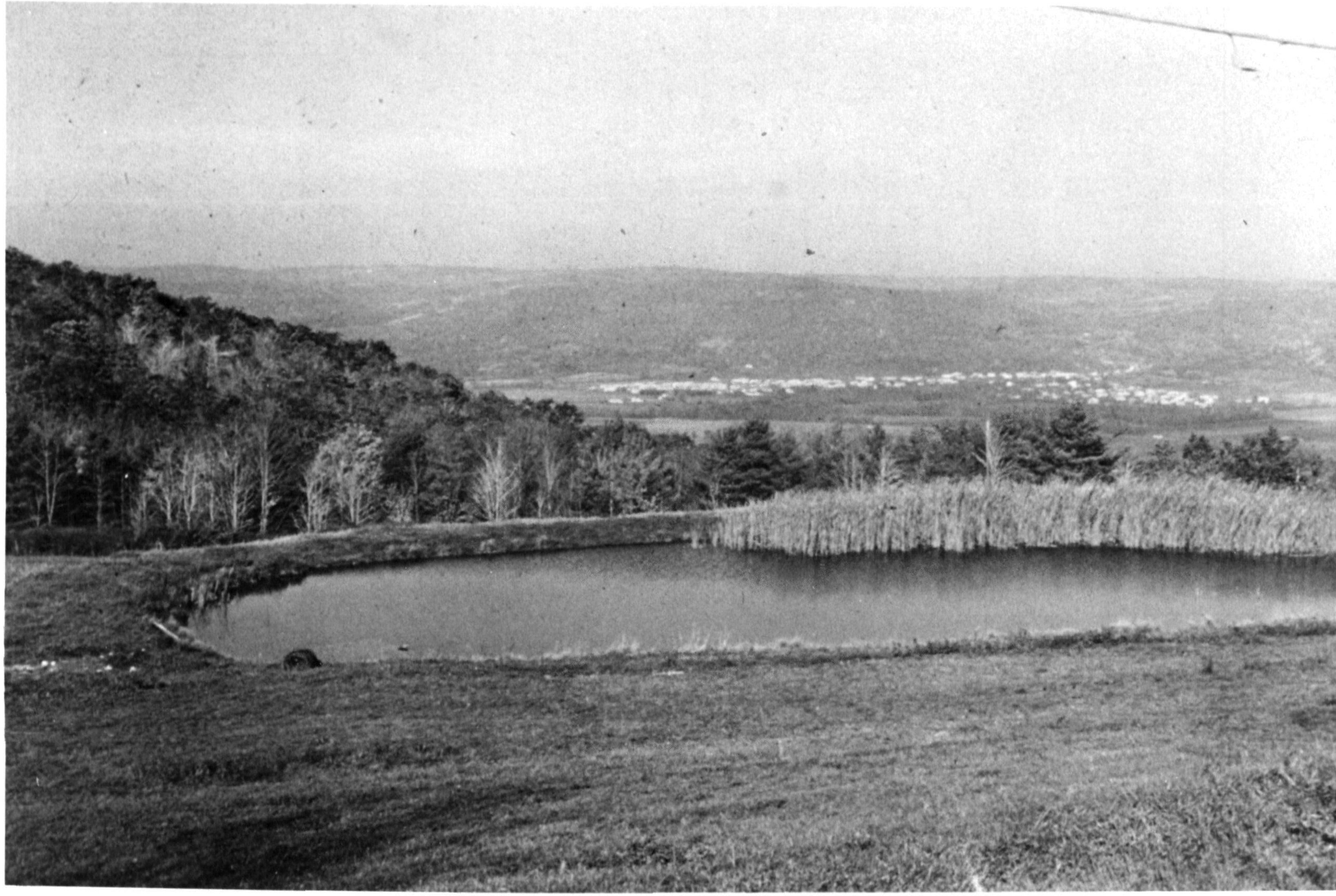

Figure 6. Various examples of land use in a limited area. A frogpond is in the foreground.

Figure 7. A type of commercial development.

Figure 8. Waste disposal from mining.

Figure 9. One example of solid waste disposal.

Figure 10. Not exactly a landfill, but a necessary kind of land use.

Figure 11. A type of recreational development.

Figure 12. A ski resort.

Figure 13. Shoreline development along a lake.

Figure 14. A marina.

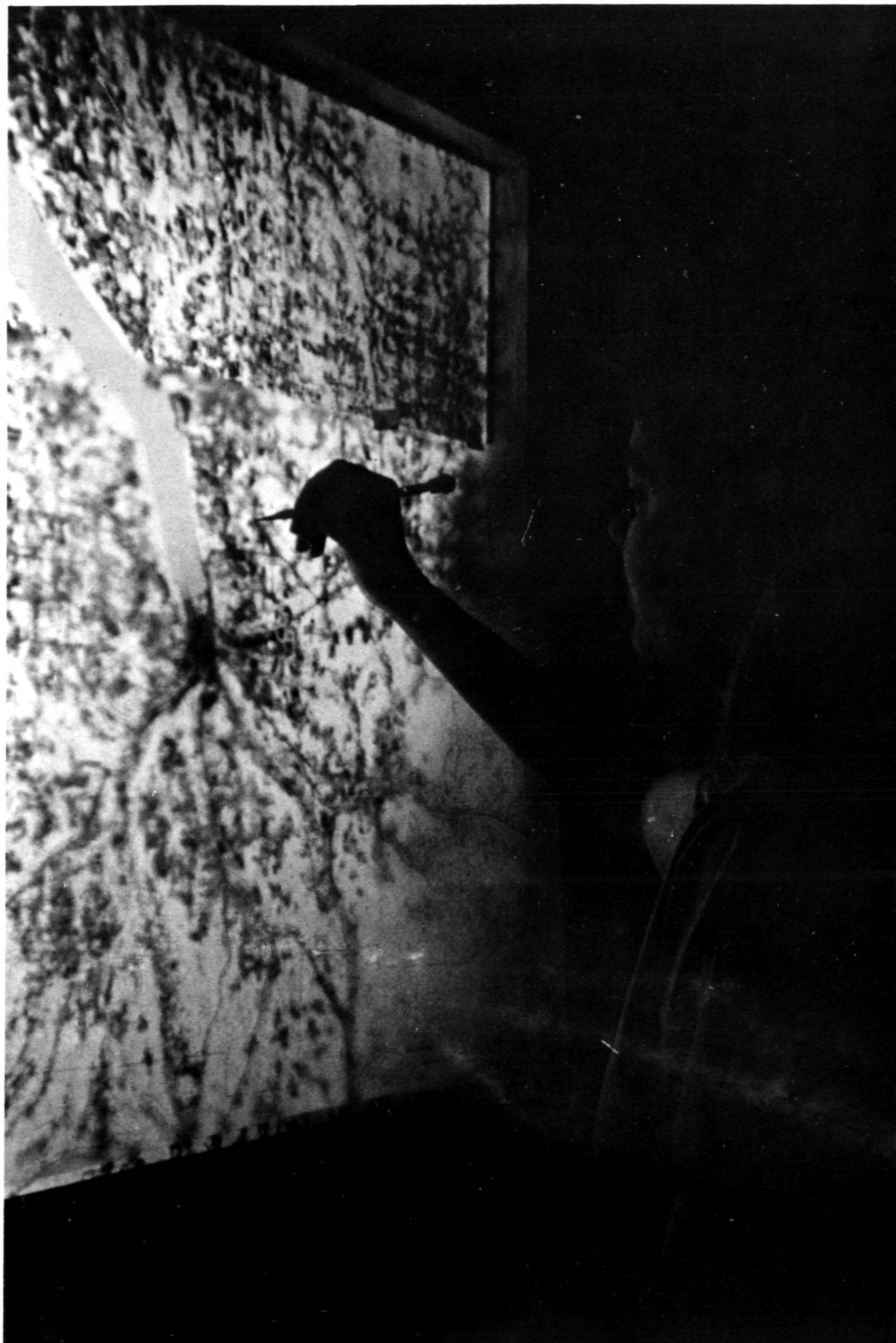

Figure 15. One method of locating pollution.

(a) LANDSAT (b) Skylab

Figure 16. A comparison of LANDSAT and Skylab imagery.

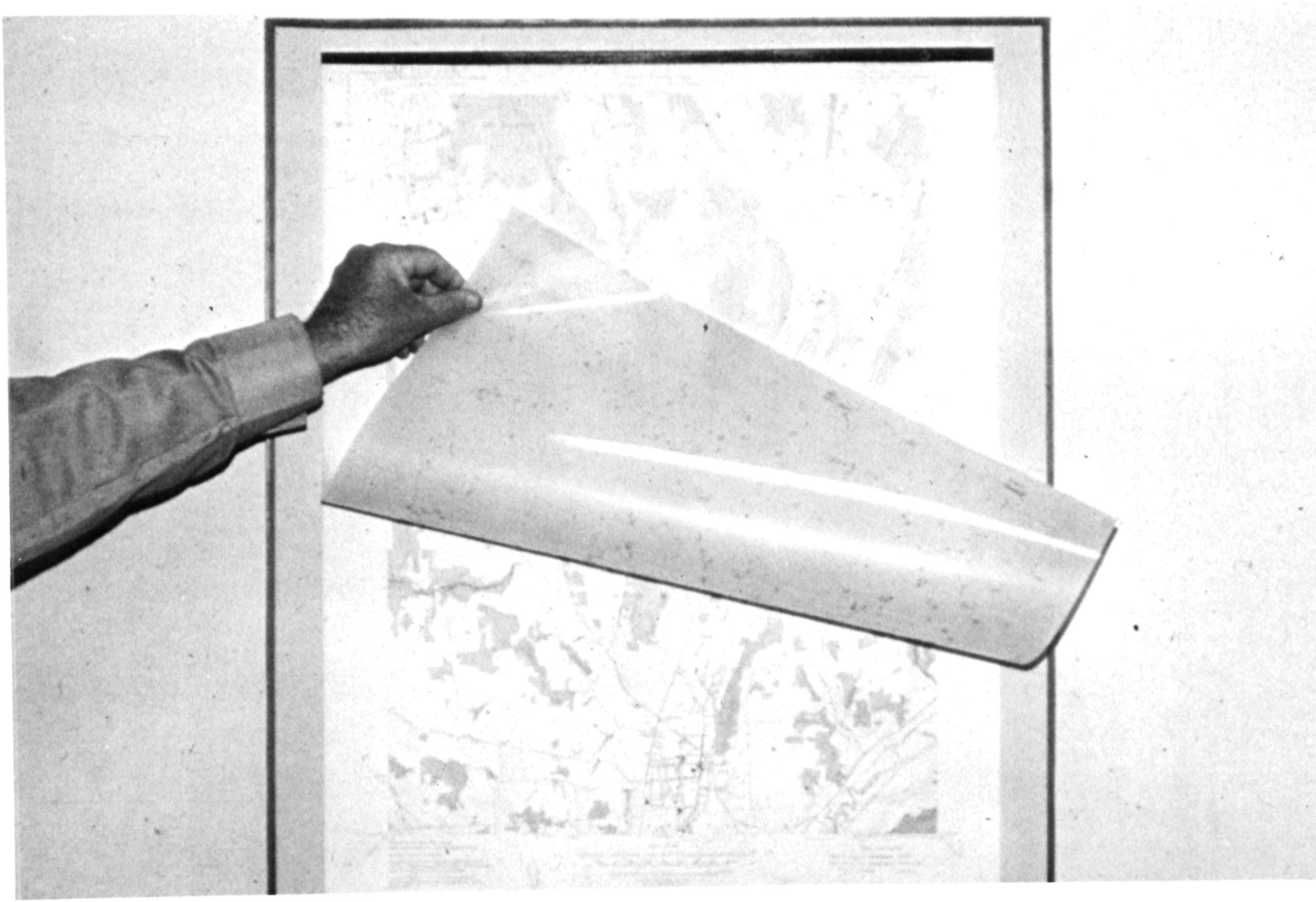

Figure 17. Example of a Mylar map.

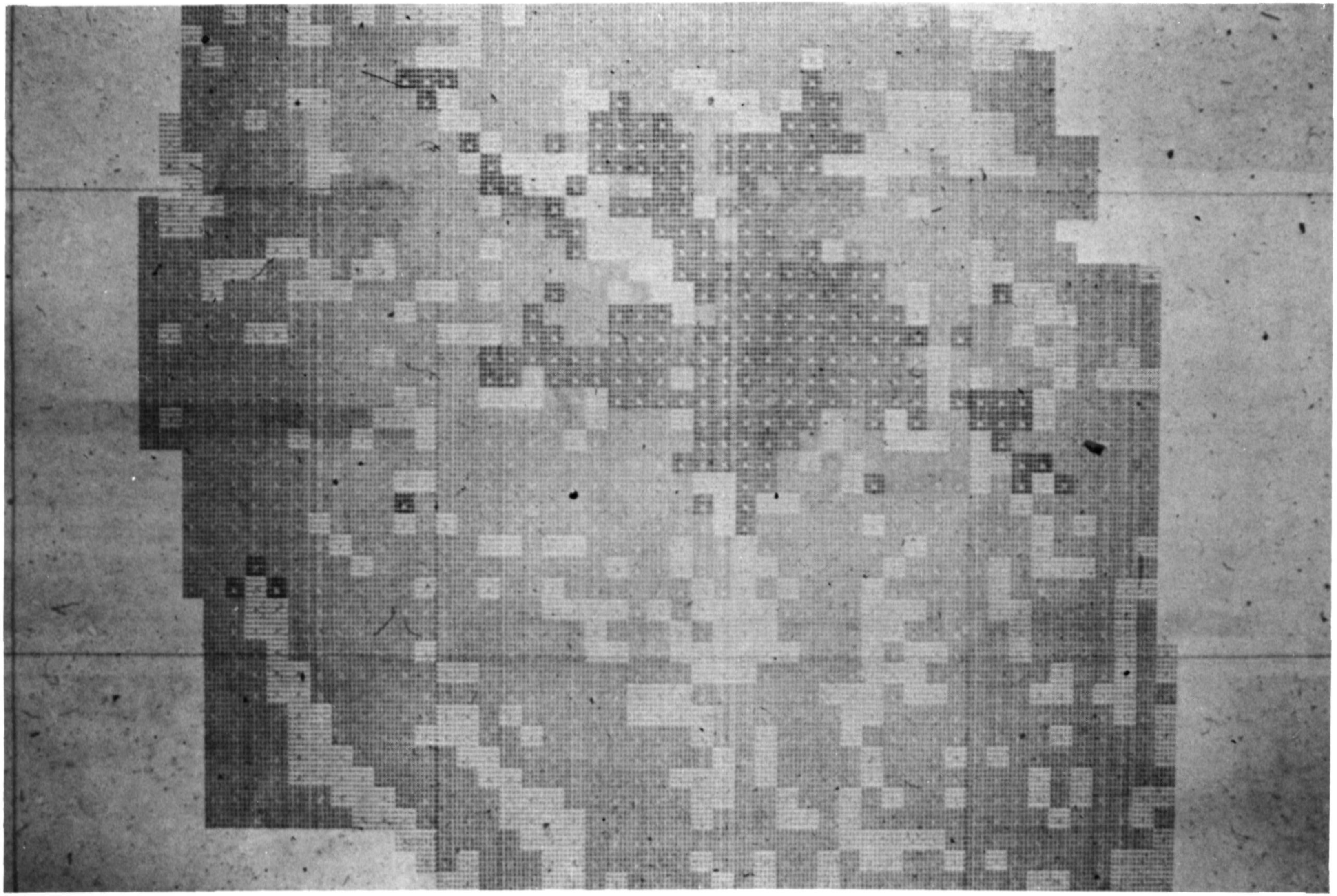

Figure 18. Example of a computer printout.

Figure 19. Digital input system.

Figure 20. Abacus input system.

Figure 21. Plastic input system.

Figure 22. Area map of land use.

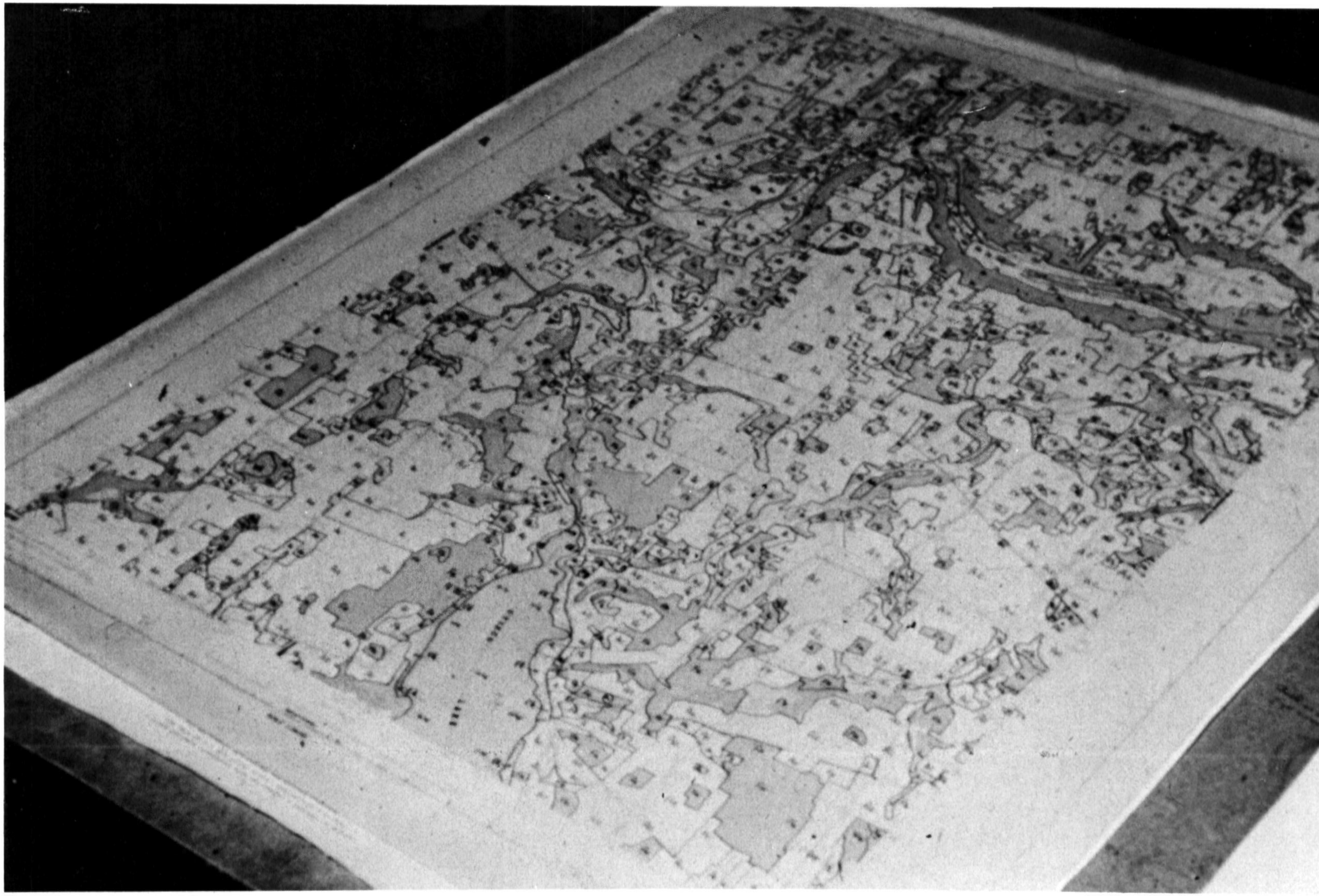

Figure 23. Completed map ready for reproduction.

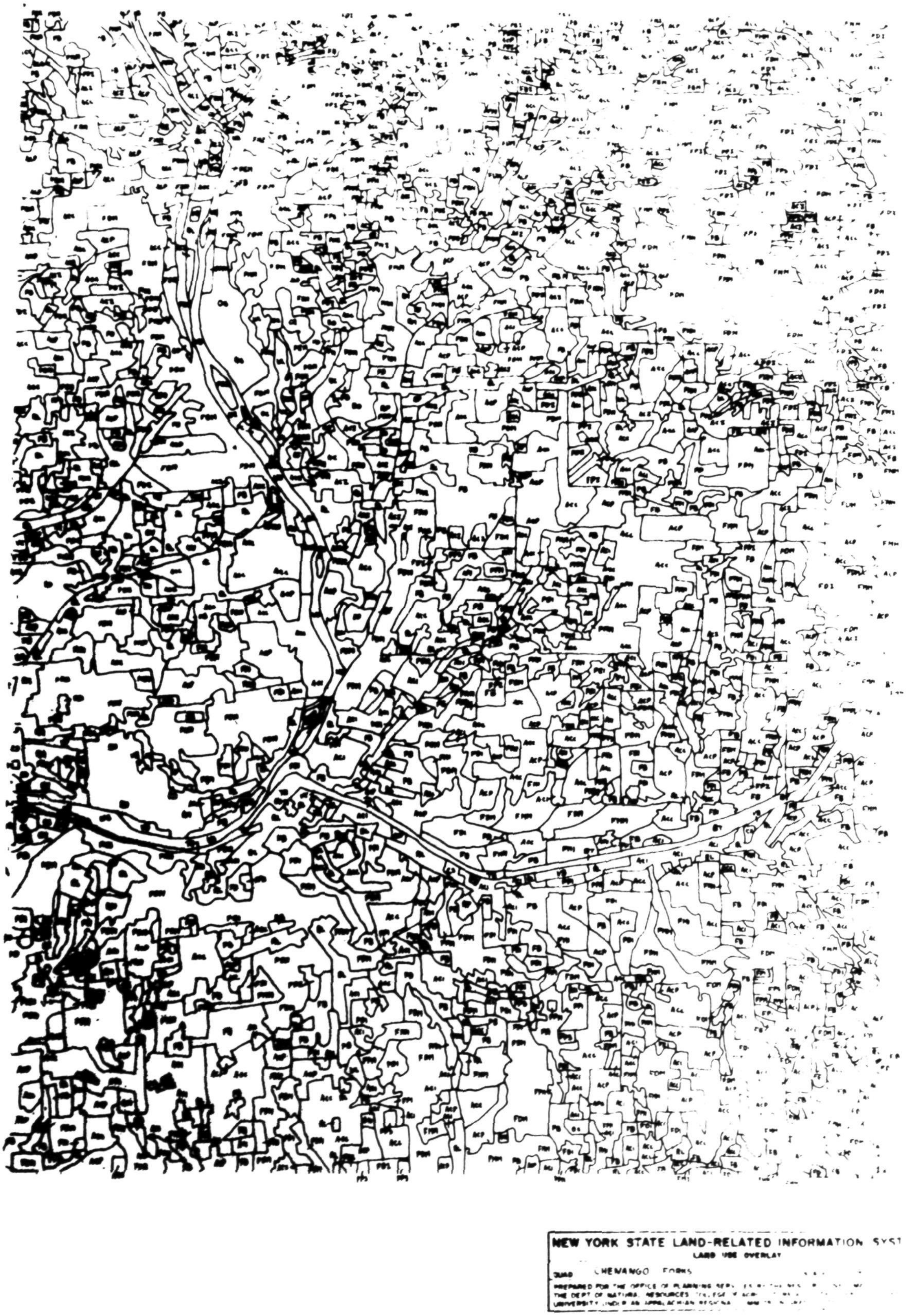

Figure 24. Classification system.