IN PURSUIT OF THE MAP USER

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INTRODUCTION

Man's uses of maps are highly varied. Some are simple — a simple locational map for a familiar environment is a good example (it serves superfluously as a navigational device, and might be better assayed as an advertisement). Others are exceedingly complex — examples are numerous, the best probably being reference maps which present masses of data for visual integration and correlation. Some operations and activities depend for their success directly on effective map use; in other situations the role of the map is subtle, but no less critical.

While many maps are created every year, there has been too little evaluation of their use and effectiveness. Further, many maps seem to have been developed without real understanding or concern for the map user. The focus of this paper is on the map user, first, with concern for the man-map behavioral system and, second, with several suggestions about research which might help us understand the map user better. For the cartographer, either as a producer or a researcher, the principal issue is that the map user will be reading the maps which have been prepared for him.

USER, MAP, AND ENVIRONMENT

While there are many things that the cartographer can examine to develop an understanding of the map user and the effect of a particular map, the most critical is behavior — the ways in which the user interacts with the environment (by environment we mean simply the world external to the user). A simple model may be helpful in understanding the relationships among man and his cognitive atlas, his behavior, maps and the environment (Figure 1). The center of concern is man himself, with particular focus on his <u>cognitive atlas</u>. The cognitive atlas is the collection of an individual's cognitive maps, those "images" resident within his memory upon which he relies for guidance in carrying out spatial activities

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(Downs and Stea, 1973). There has been a great deal of work done in cognitive mapping, but there is much more to be learned about the origin, development, and use of these maps, and about their role in spatial behavior. How do the maps in a cognitive atlas guide and encourage patterns of spatial behavior? What effect do these cognitive maps have on the decisions which are made about paths from one place to another, about locations for activities, and so on? What is the role in behavior of maps created for the user by cartographers? How have these cartographic maps shaped the maps in the cognitive atlas, and how are these physical artifacts used directly in environmental interactions? What is the effect of different map designs (different graphic structures and visual hierarchies) on the reading of a map and in the retention of mapped information, on the assimilation of information and its subsequent use?

These questions and others are raised not as separate and individualized problems but rather in the context of a man-map behavioral system. It appears that only by considering map use problems in this context is it possible to arrive at the most reasonable map design solutions (Dornbach, 1967).

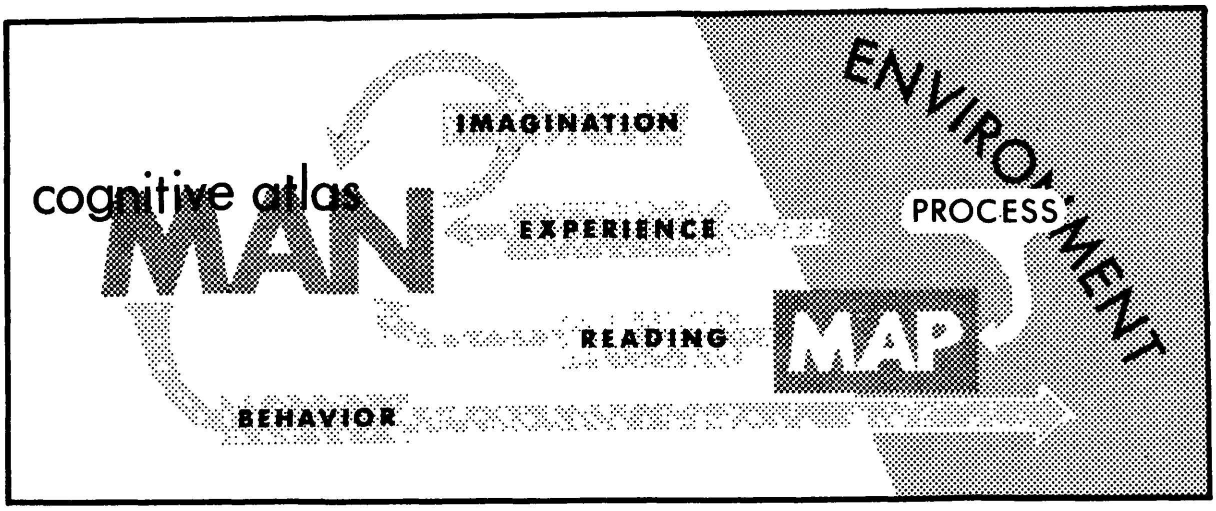


Figure 1. The relationships among man and his cognitive atlas, his behavior, maps and the environment.

IMAGINATION, EXPERIENCE, READING

There are three processes which contribute to the creation of a person's cognitive atlas: imagination, experience, and reading.

By imagination we refer to internal creative activities of the individual. Using the environmental information at his disposal, the map user creates mental images for areas which he has never experienced or "read" about (i.e. has never seen maps of). He takes other maps from his atlas and extrapolates from them, producing a personal image — fictitious to be sure — of areas which he has never seen or heard about. There are an extraordinary number of examples of such creative activity. Post has presented a large number in his ATLAS OF FANTASY (1974). Real world examples are numerous; unexplored areas have served as foci for cartographic expression of imagination — the 1566 map of North America by Zalteri is a good example as are the many cartographic creations representing the "Great American Desert." The role of imagination is an important element in the structure of cognitive maps, from the personal space (home turf) of the child and the economic behavior space of the adult to the cosmographic views of individuals and civilizations.

Experience is the second process by which an individual develops his cognitive atlas. This process has been much discussed and there have been many studies (again, see Downs and Stea, 1973). Experience is the most important process in the creation of cognitive maps of small areas, of the localities where individuals live and work. The process of acquiring information, the development and the continuous modification of the extent, content and structure of an individual's maps of an area is most complex. In order to understand these maps, to determine their characteristics, a variety of different techniques have been used.

Of these techniques the personal sketch map is probably the most important. From Lynch's IMAGE OF THE CITY (1960) to the present time, researchers have been able to learn a great deal about the effect of different spheres of activity and attitudes on individual comprehensions of the environment by having the map user draw a map of an area and its features. Different individuals and groups, or the same individuals and groups at different times, have different cognitive maps. Wood (1973) has shown how cognitive maps develop and evolve in novel environments, while others (including Orleans, in Downs and Stea, 1973) have shown how economic status (and the attendant patterns of mobility), age, and other factors promote differences in cognitive maps and in those aspects of behavior which are highly dependent on use of these maps. Gould, for example, has examined residential preferences, regional images, and environmental ignorance (Gould and White, 1974).

To illustrate the role of experience in map formation, we present two sketch maps of Old Sturbridge Village (an outdoor historical museum in central Massachusetts), drawn by visitors who had been in the village, in the first case, once and, in the second, numerous times (Figure 2). With the maps is a planimetric view of the village, overprinted with a reference grid. This grid has been compiled onto the other two maps to give some indication of how both the extent and the spatial structure of this area have been recalled from the cognitive atlases of these two map users (McCleary and Westbrook, 1974). Note that the sketch maps do not cover the entire area of the village, only those sections of the museum experienced by these visitors. Note further that the space in some areas is much compressed or greatly enlarged relative to the whole.

We can introduce the role of reading by presenting two additional sketch maps of Old Sturbridge Village (Figure 2). These were drawn by two students who had never visited the village but who had studied two different maps of the village as part of a class assignment. With the two sketch maps are small segments of the two maps which they had studied; note that the designs of these maps are markedly different, particularly the graphic hierarchies. The response to the sketch map exercise reflects this difference. The two sketch maps produced were drawn from memory and reflect what these two readers learned from the maps which they studied. It appears that the graphic structures of the maps had a marked effect on the image which the map readers retained. (It is important to note that other students working with the two maps exhibited similar responses and, further, that the two

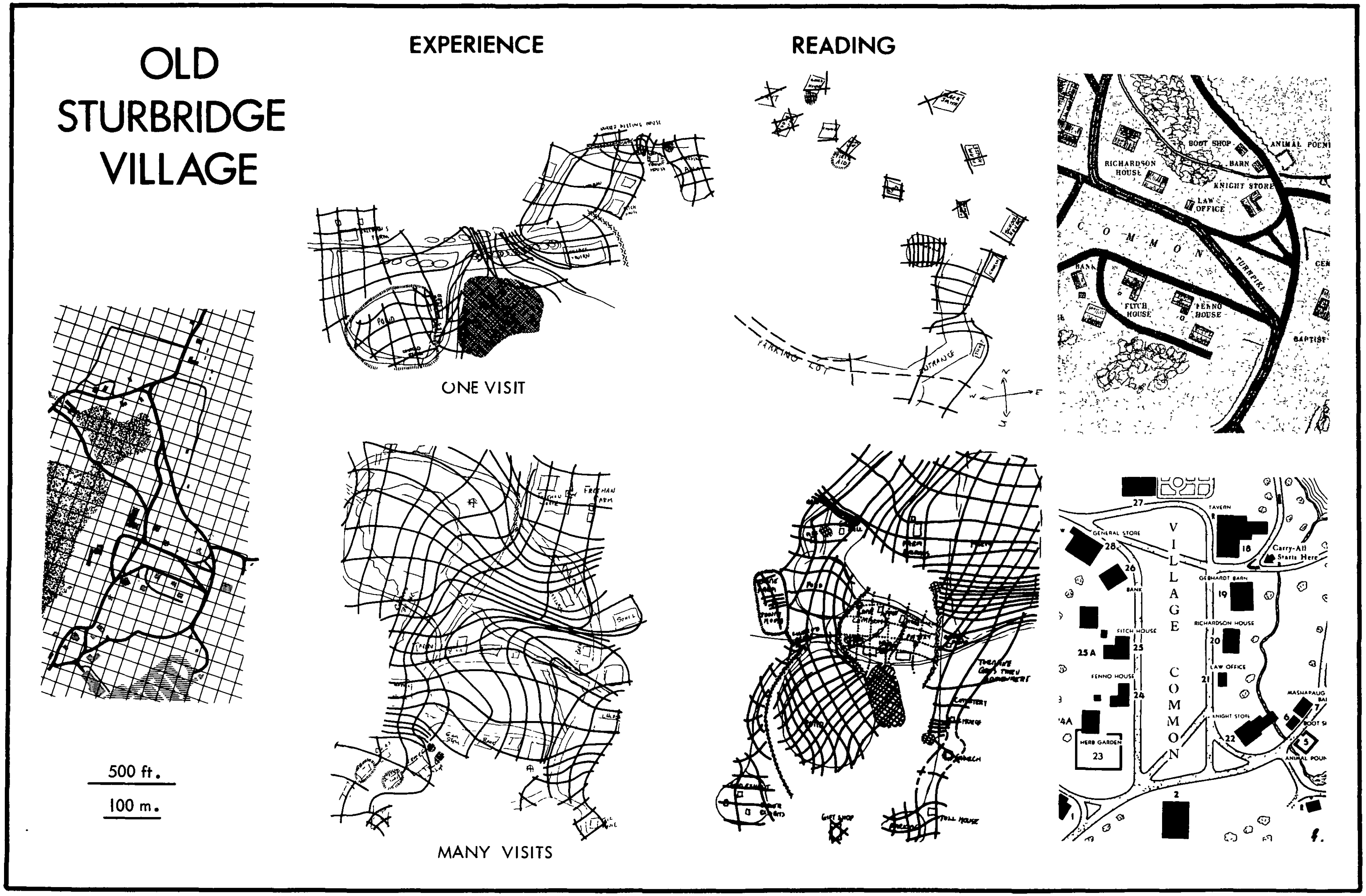


Figure 2. Four sketch maps of Old Sturbridge Village, illustrating the role of experience and reading in the formation of the cognitive map. The grid from the base map (on the left) has been compiled onto the four sketch maps. The two maps at the far right are those studied by the persons who drew the two sketch maps next to them. (See text for additional discussion.)

individuals chosen appear — from the other evidence — to have similar attitudes and "operating styles" in their map-use behavior; thus, the difference in the sketch maps probably reflects principally the characteristics of the maps studied, not the nature of the two users).

There are many questions about map reading and about map readers. There are many studies, covering different elements of the map and different use situations. For this symposium, for most cartographers, the most important research problems probably lie in the map-reading portion of the map learning (or cognitive atlas development) process. It should be recognized, however, that both imagination and experience operate together with reading in the development and evolution of any individual cognitive map. At some scales, for some places, for any of a number of reasons, one of these three may be much more important than the others, but all three will contribute to the formation of a cognitive map.

While imagination and experience could be explored at greater length, in the balance of this paper we shall devote our attention to map reading and to research problems in this area. The concern here is with methodology and particularly with one technique, the psychophysical law and its use.

THE USER AND HIS TASK

Too often, the cartographer approaches the map user and the map reading research problem with his attention focused on the wrong element. As Dornbach (1967) has pointed out, the research process must proceed with the map user and the map use situation continually at the forefront of the cartographer's thinking. While this has been the case in some research studies, in most it has not.

The research done by experimental psychologists working to understand the process of visual perception has served as the example for cartographers who have explored, for example, the functional relationship between the physical size or tone of a symbol and the value associated with the symbol as perceived by the map reader. If such a relationship can be established, then it can be used in the design of maps. While a number of different experimental methods are available, there is the problem that many of them are not adequately understood and some (unfortunately) have been misinterpreted and used inappropriately by cartographers. Altogether too often the cartographer has begun by asking the wrong question.

If, for example, we consider the analytical procedures available for analyzing quantitative map symbols, where the primary concern is to establish a relationship between a set of symbols varied in size and a continuum of quantitative values, then we can look at two different types of procedures.

In the first, the continuum of values or symbols (or a segment of this continuum) is divided into a finite number of categories; in the analytical procedure the map user (operating as a test subject) partitions the continuum into equal intervals (Engen, 1972). In the second class of procedures, the observer makes a direct estimate of a magnitude, either by assigning to each symbol a value, or by establishing ratios among the stimuli in the series (Stevens, 1975). The first type of procedure is generally called "category scaling" (other names used include "equal-interval scaling" and "partitioning"). The second type of procedure has been called "magnitude or ratio scaling." The important consideration to bear in mind here is the task which the observer carries out; in one case the continuum is divided into a group of categories, while in the other values are assigned to the stimuli throughout the continuum. A third class of scaling procedures, poikilitic measures (which includes the just noticeable difference, or JND), is described by Stevens (1975); poikilitic measures are not applicable to the types of problems discussed here.

Engen (1973), Stevens (1975), and many others have discussed the complexities of psychophysics and have described and analyzed the different scaling methods, particularly the differences between category scales and magnitude scales. Comparisons of the results of studies in which both types of scales have been used have led to the conclusion that an observer's categories or equal-appearing intervals generally are *not* equal. They tend to be narrower at the low end of the scale and wider at the high end. Magnitude or (ratio) scales, on the other hand, do not suffer from this problem.

If categories and magnitudes are one important set of oppositions in the phychophysical analysis problem, then the difference between *estimations* and *productions* are a second. By estimations we refer to a task in which the reader assigns a value to a symbol, based upon his perception of the size of the symbol. By productions we suggest a task in which the reader "creates" a symbol to match a value. Important here is a conclusion stated by Stevens (1975,32): "A typical pair of experiments that employed both estimation and production . . . (shows) that magnitude estimation produced a power function with an exponent . . . that falls slightly lower than the slope produced by magnitude production . . . A similar effect occurs in all matching experiments." (The exponent referred to here is "a kind of signature that may differ from one sensory continuum to another," in the equation " $\psi = K\phi^B$", where ψ is the sensation magnitude, ϕ the stimulus magnitude and K a constant which depends on the units of measurement (Stevens, 1975, 13).)

The questions which then arise are the following: If a map user, presented with a map, is expected to extract from this map by "reading" values for individual symbols or for groups of symbols relative to one another (e.g. ratios of symbol sizes), then the symbols on the map should be scaled using a functional relationship derived from an experiment set up in that way. Further, since the user's task is to *read* the symbols, estimating values for them, then the symbol scale should be established on the basis of an estimation task, not a production task.

For example, Flannery (1971) developed an algorithm for scaling the size of graduated circles, so that the physical area of the circle and the map reader's perception of it would be consonant with the quantitative values represented. The procedure for scaling the circles was developed based on tests in which map readers were asked to estimate the sizes of circles presented on maps. With the data from these map reading exercises in hand, Flannery set down a procedure to scale circles so that the tendency to underestimate circle size differences would be "corrected." Other experiments have demonstrated the same tendency for circle-size difference underestimation (e.g. Ekman, Lindman and William-Olsson, 1963), while in one study Flannery's algorithm was found to improve the user's reading of this symbol (McCleary, 1963).

In contrast to the studies of the graduated circle, there are a series of studies of the gray scale. Kimerling (1975) (and a number of others before him) has attempted to "determine the functional relationship between the tone of a screen gray area and its perceived value" (119). Recognizing that the method of testing would have an effect on the functional relationship derived, Kimerling developed his scale using the philosophy that "one should choose the testing technique which most nearly parallels the cartographer's method of choosing equal intervals of gray . . . that . . . most closely follows the cartographer's method of gray scale subdivision" (124). The method chosen for his testing was for the subject to produce a gray scale by arranging from a large array of gray patches a series of nine (a category-scaling procedure).

It is interesting to note that many of the gray scales produced show results similar to Kimerling's; indeed, he concludes that his is so similar to that derived by Munsell that the relationship derived in his work "should be abandoned in favor of the well-known Munsell equal value scale" (125). Munsell derived his scale by using a category-scaling procedure, a production task. It appears that only Stevens (1957) and Chang (1969) have derived scales using estimation tasks and their results are different enough from all of the others to raise a number of questions about the readability of many of the gray scales commonly used. Like Flannery, Kimerling sought to develop an algorithm which would aid the cartographer in the preparation of maps; in this case, however, the test results are based on an unrealistic map reader task — we would probably not find the average map user reading the map in the manner Kimerling structured his test.

We have made no effort here to explain the basic aspects of psychophysics or to account for all of the work that has been done; this has been done by a number of authors, particularly Stevens (1975). The intention here is to suggest two things. First, psychophysics is an exceedingly useful methodology for studying many aspects of the map-reading process; Engen points out that "empirically, the power function is probably as well established as is possible for any quantitative relation involving the whole man, and better than any other in psychology" (84). It has proved to be a very versatile methodology and has been applied to many types of data, including attitudes and opinions. Second, it is imperative that cartographers use the methodology correctly and certainly from the proper perspective. We cannot expect effective map use (and behavior) if our symbol scaling (or any other aspect of map design) is based on a relationship derived from a testing program which has asked different or inappropriate questions. The questions which are asked should not parallel the cartographer's method for choosing or producing a symbol, but rather match what the user will do when he confronts the map.

GROUPS AND INDIVIDUALS

Different map users exhibit different "styles" in handling map data. Chang (1969) suggested, from a psychophysical perspective, the possible varieties of individual responses which can occur in the map reading process. For example, while most people will tend to underestimate the physical area of graduated circles, a few will estimate circle sizes correctly or overestimate the quantities represented.

There are many questions concerning individuals. Is everyone alike in their map reading characteristics, or are we all different? Is there one group of people who can be expected to respond with intragroup uniformity, distinctive in their responses from other groups? Most research efforts using the psychophysical law have looked only at groups; results from tests have been aggregated and the average "readability" of different symbols described. From what individual results were these averages derived? How much variability was there? Two experiments suggest directions for further investigation.

A group of 27 college students participated in a magnitude estimation experiment, "reading" the values of 33 graduated circles on six small map-like figures (Figure 3). Group estimates, expressed in terms of the value of the exponent in the psychophysical law, ranged from .68 to .87 for the six different figures; these results are consistent with the findings in other research on graduated circles. Individual exponents (shown in the lower part of Figure 3) ranged from .41 to 1.20. Some individuals proved to be consistent underestimators (the map user who provided the lowest single estimate, .41, had a range of exponents from .41 to .51 and proved to be not only the lowest estimator but also the most "consistent" in the group). Only one reader made estimates which followed closely the group average. There was one consistent "high-estimator," (range, .92 - 1.18) — he was actually reading the circles almost "correctly." Others showed much variability in their exponents on the different figures; two of these are shown in Figure 3.

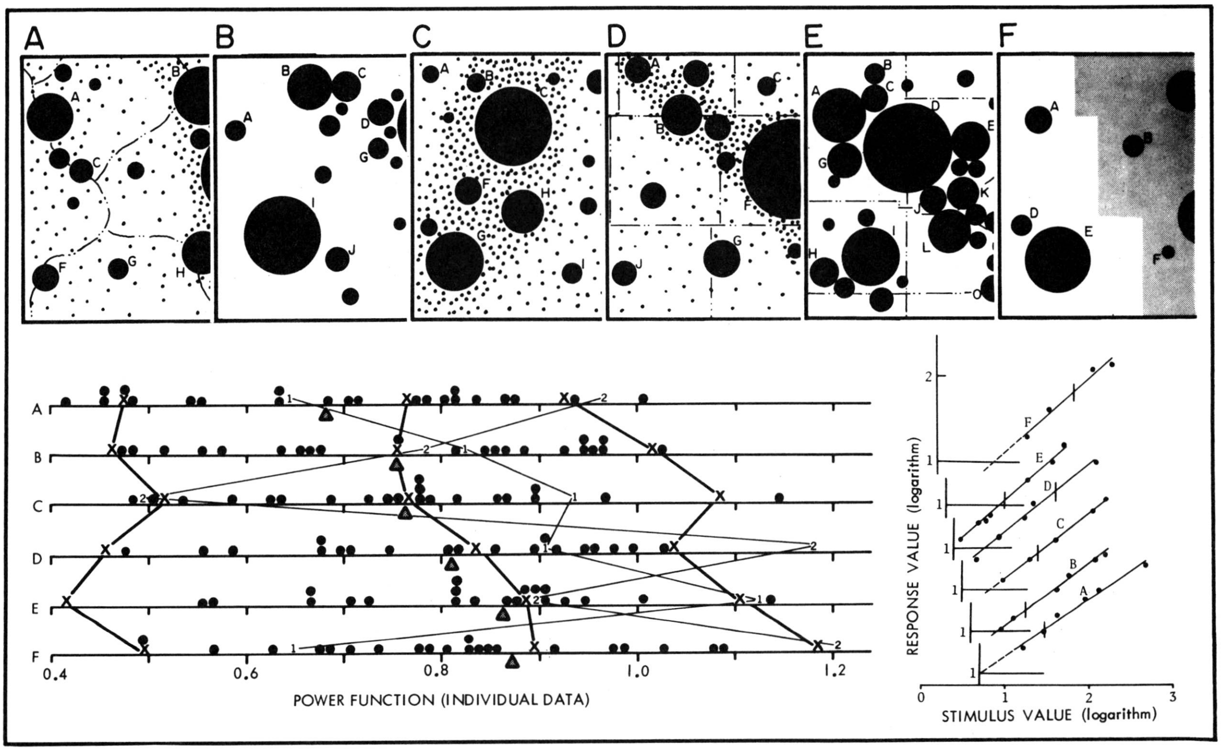


Figure 3. A map symbol experiment. Subjects were asked to estimate the sizes of four to seven circles in the six figures, using one circle in each figure as a standard (e.g. "If circle F represents 30 people, how many people do these circles represent: G, A, I, B, D, and E?"). Left diagram presents power function (psychophysical exponent) for subjects for each figure; the exponents for the lowest (and most consistent) estimator, for the highest estimator, and for the one nearest the group average (this average is indicated by the triangles) are shown, along with the more common (and highly variable) pattern of two other test subjects (see text for additional explanation). Right figure presents average group relationships of the six tests, with individual circles and location of the standard indicated.

There are a number of questions which arise about this test, the test subjects, and the results. While it is not the most advanced research into the problem, it certainly does indicate that there are a number of issues to be investigated, particularly why some readers provide consistent estimates and why others exhibit a great degree of variability. Further, why is it that some readers estimate sizes well above or below both the actual physical size and the average tendency; Cox (1974) provides some ideas, but more remains to be done.

An entirely different map reading task can be used to gain further insight into the characteristics of the individual map reader. Map readers were asked to draw boundaries between dots and groups of dots at positions where they felt the density of dots differed (Jenks, 1973, has reported on similar research). The actual arrangement of dots was random, but there was an overall uniformity of density in different parts of the test figures (Figure 4). Where differences in density were great (twice or more) between the different parts of the figure, boundaries followed a common path. Where the density difference between large regions was slight, and sometimes lost in the "noise" of the randomness of the distribution, the boundary lines were scattered across the surface.

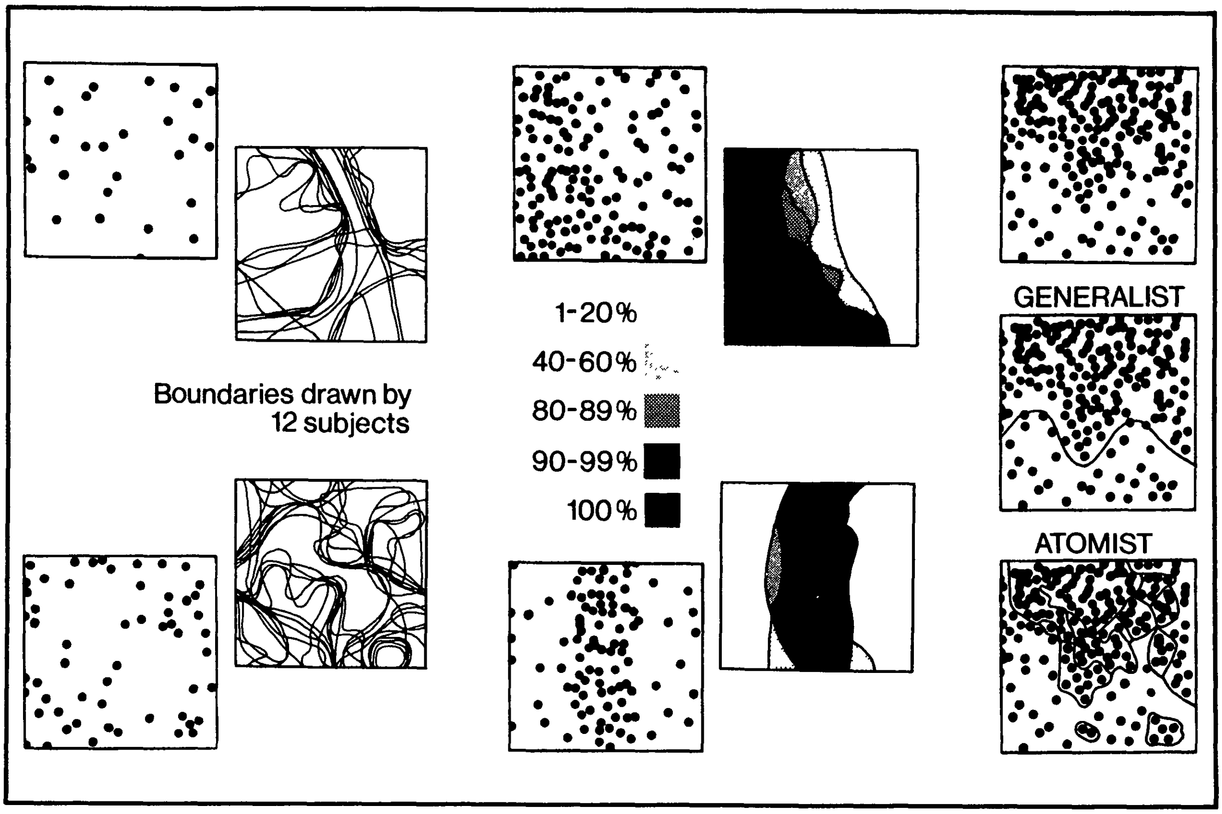


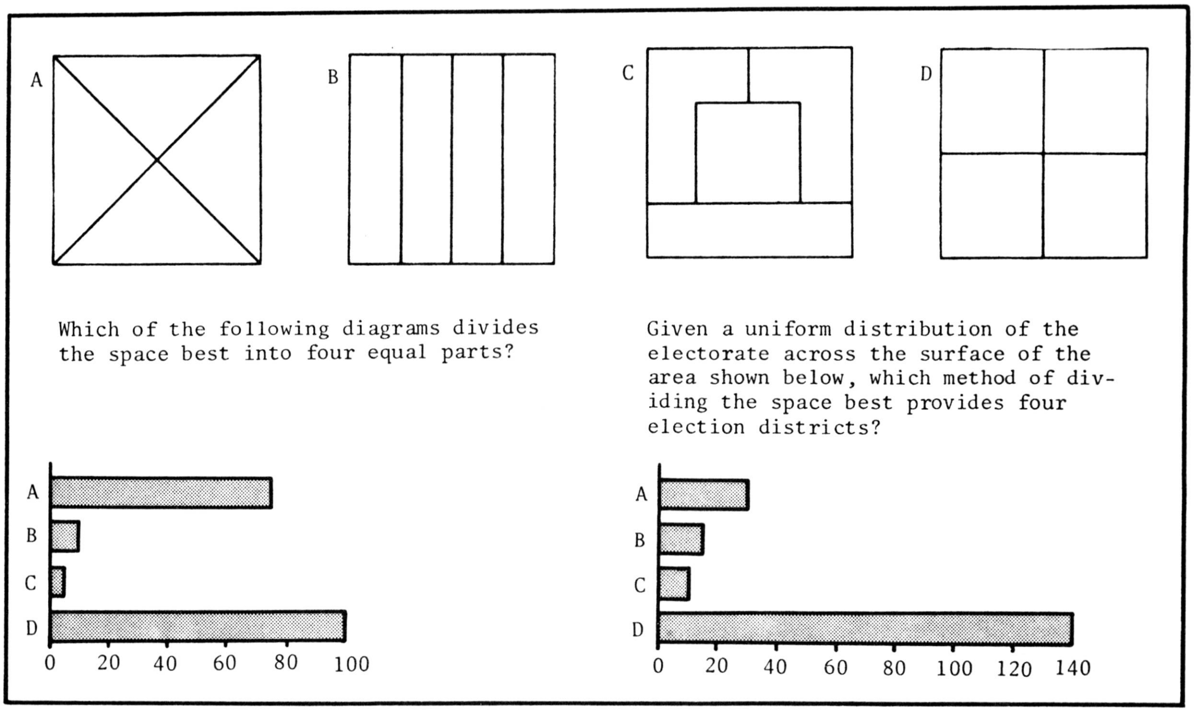
Figure 4. Selected results from a dot-density regionalization experiment. Subjects were asked to "draw boundary lines within each box which will separate dots into zones of different densities." On the left, two boxes and the boundaries drawn by 12 subjects. In the center, the percentages of 41 subjects grouping dots into zones on the left side of the top figure and around the center in the bottom one. On the right, a sample test box, the boundaries drawn by a generalist and an atomist.

With regard to individuals two distinct styles emerged as they carried out the task. These approaches are designated, for lack of a better terminology, the atomist and the generalist. For the generalist the lines are schematic and the "attitude" expressed by the boundary line drawn suggests a reductionist view of the image. The atomist, on the other hand, seems obsessed with detail and may have lost sight of the overall pattern of density. This tendency was exhibited by readers in other map reading tasks, and seems to characterize groups of map readers. No larger program of research has been developed to circumscribe further these two tendencies and define other characteristics of their practicioners.

Further research problems arise from questions which Lewis Rosenthal and I have directed to more than four hundred map users in the last few years. The ultimate aim of our work is to develop a better understanding of the use of maps and the role of maps in forming and reflecting spatial attitudes and behavior.

The two questions which we shall examine here are related to the four diagrams shown in Figure 5. These four diagrams, with their labels, appeared alone on a page with the question. In the experiment, which involved a total of twenty questions, the two questions here were the fourth and the thirteenth in the series.

> "Question 4. Which of the following diagrams divides the space best into four equal parts?"
>
> "Question 13. Given a uniform distribution of the electorate across the surface of the area shown below, which method of dividing the space best provides four election districts?"



Which of the following diagrams divides the space best into four equal parts?

Given a uniform distribution of the electorate across the surface of the area shown below, which method of dividing the space best provides four election districts?

Figure 5. Two questions from an experiment on the use of maps and spatial attitudes. (See text for further explanation.)

Note, first, that the four areas within the four squares are equal in size. Second, in the administration of the test, the order of the four squares was varied so that A did not appear first all the time, and so on. This alteration of order in the presentation of the figures had no effect on the choice in either question. What was different was the choice of the square on the two different questions.

In question 4, half of the map users chose D; most of the others chose A (few chose B or C). In question 13, three-quarters of the users chose D. Of the rest most chose A, with very few selecting B or C. Why? Quite honestly, we do not know. This, and other results from this test, suggests that the same space is different in different contexts. Preliminary sorting, in an attempt to ascertain individual patterns of response (sorting into atomists, generalists, and others) has raised further questions. The whole experiment suggests an extraordinary number of other research questions (among which is whether the order of the two questions has an effect — what if we had switched 4 and 13?).

CONCLUSIONS

This paper is, as a whole and in its separate parts, a suggestion. A model (so general that the term may be misapplied) has been suggested to help in understanding the map user, his cognitive atlas, and — ultimately — his behavior. We have attempted to sort out three activities by which the reader develops his cognitive atlas, looking in depth at the reading process.

We suggest that the cartographer look carefully at the methods of the experimental psychologist and, in particular, at the psychophysical power law. Psychological techniques have been used in a number of studies by cartographers, but in some cases the techniques appear to have been inappropriate or misapplied. The criterion here is the map user — one cannot ignore this most important element in the cartographic process. It is not only important, it is absolutely essential, that systems and standards for map design and symbolization be based on and developed from the perspective of the activities of the user.

Understanding of the user as an individual has been neglected. Perhaps we ask too much when we suggest a program to find out if there are individual differences. We know that such differences exist. We know that there is a great deal of variation in individual responses to similar types of map problems. To develop a reasonable and effective understanding will be time-consuming, frustrating and maybe impossible. It may, in the long run, not even be important.

What will be important about the work is that it should make us more aware — more aware of the user in the broadest possible way — more aware of the map production process and the need to do more than simply put data onto paper.

In an era when more maps than ever before are being produced and used, used to make decisions and direct behavior, used to alter both the physical environment and social and economic systems, it is imperative that we find out more about those who use maps, about those who will "behave" and "decide" using maps, about their abilities and attitudes. Their literacy, is the question. Cartographers need to know what and how well map users read, and then they will be able to write — and educate — accordingly.

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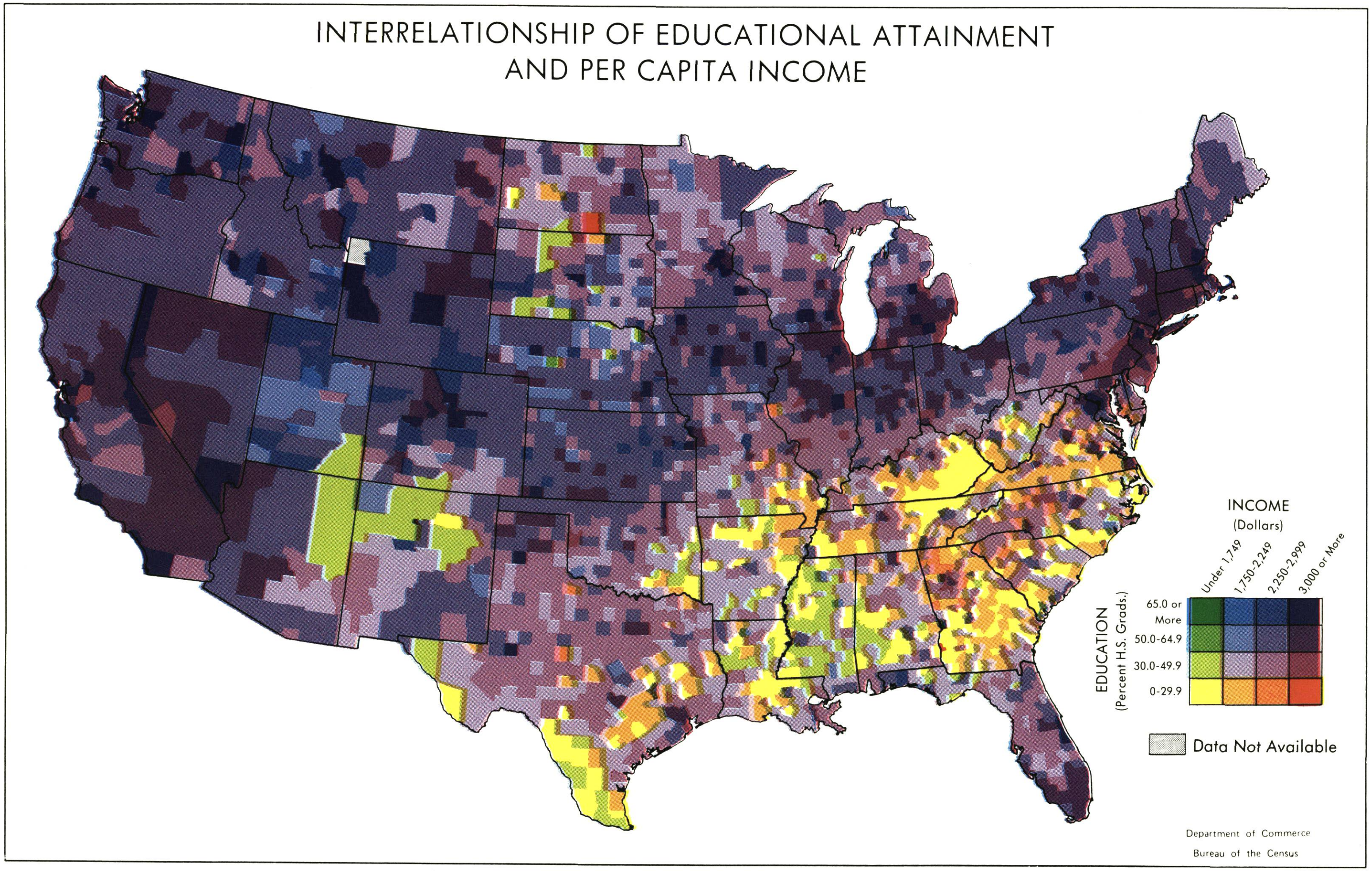
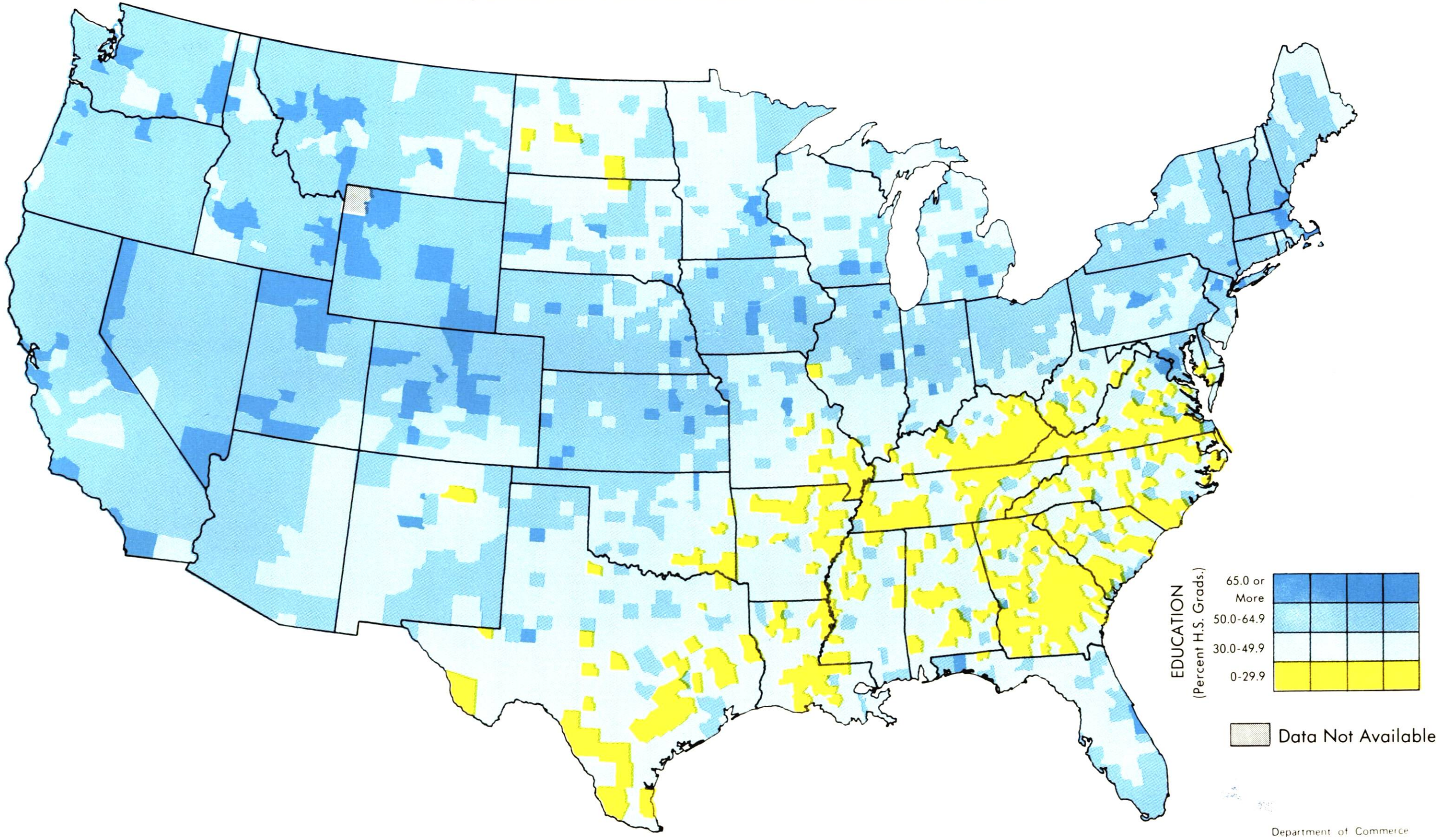


Figure 1. An example of a two-variable cross-map produced by the Bureau of the Census. (See pages 21 and 289.) Figures 2 and 3 on the following pages illustrate the individual maps that were used in preparing the cross-map.

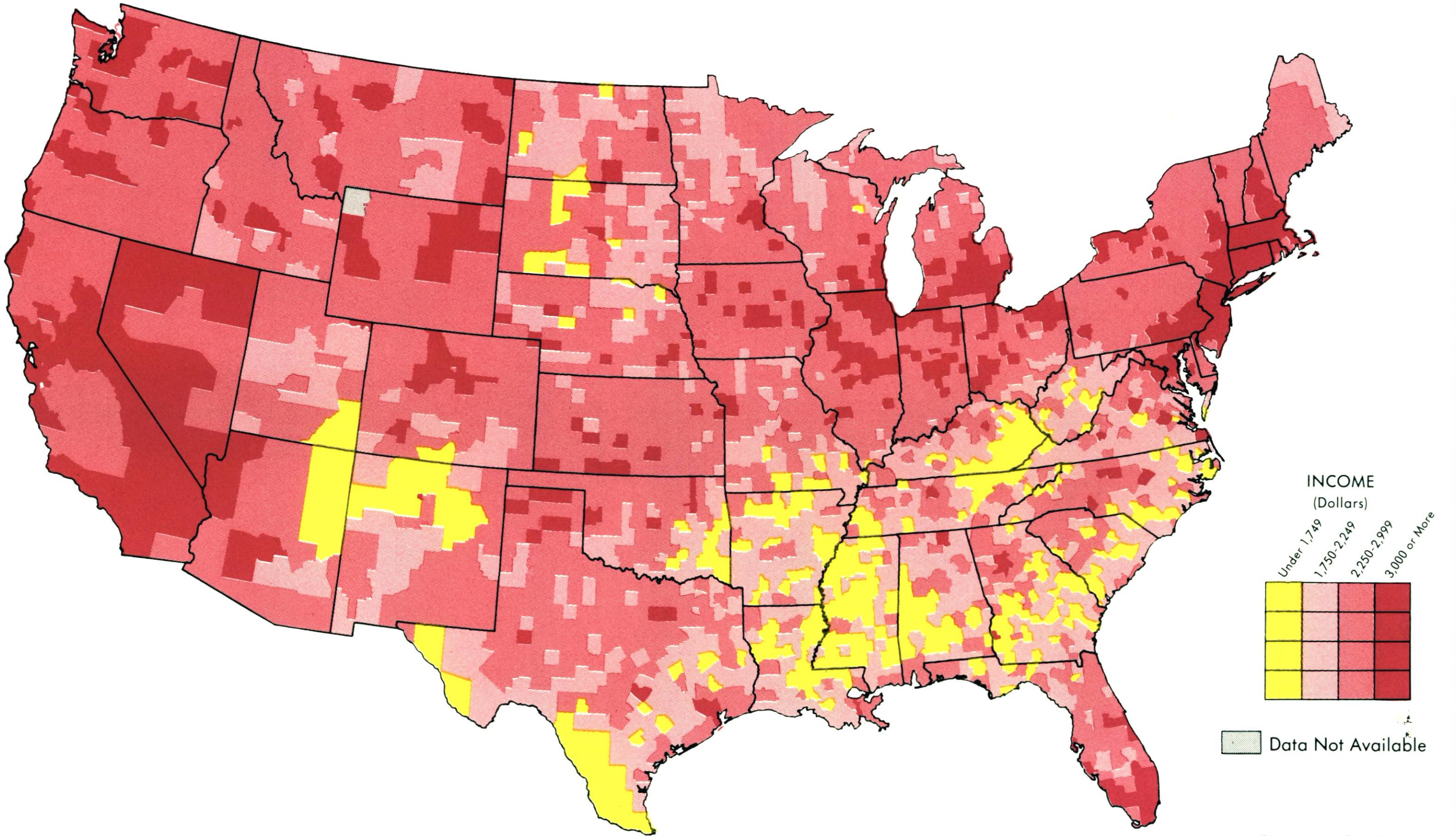
HIGH SCHOOL GRADUATES AS A PERCENT OF PERSONS 25 YEARS OLD AND OLDER: 1970



Department of Commerce
Bureau of the Census

Figure 2.

PER CAPITA INCOME: 1970

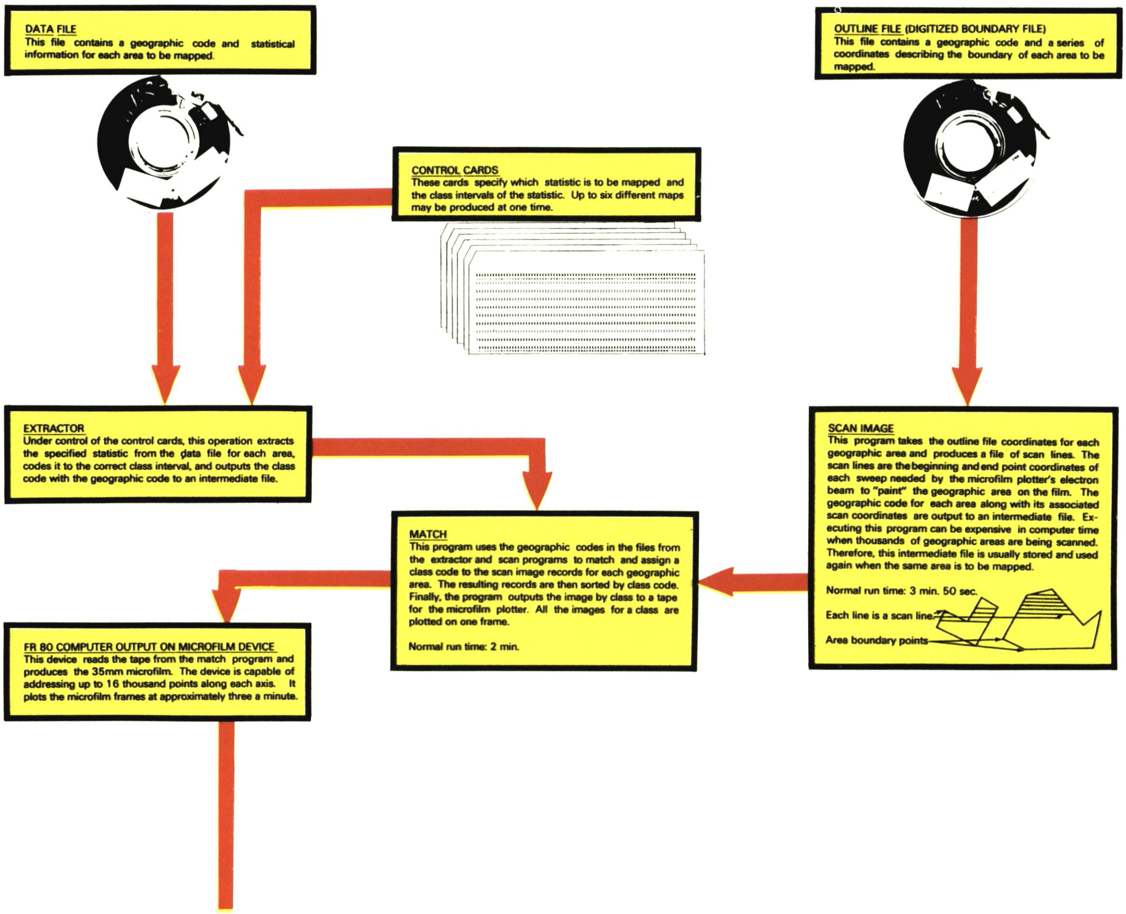


Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census

Figure 3.

MICROGRAPHIC MAPPING AT THE CENSUS BUREAU

Translation of Census data files and digitized boundary files to maps via computer output on microfilm.



DATA FILE
This file contains a geographic code and statistical information for each area to be mapped.

OUTLINE FILE (DIGITIZED BOUNDARY FILE)
This file contains a geographic code and a series of coordinates describing the boundary of each area to be mapped.

CONTROL CARDS
These cards specify which statistic is to be mapped and the class intervals of the statistic. Up to six different maps may be produced at one time.

EXTRACTOR
Under control of the control cards, this operation extracts the specified statistic from the data file for each area, codes it to the correct class interval, and outputs the class code with the geographic code to an intermediate file.

SCAN IMAGE
This program takes the outline file coordinates for each geographic area and produces a file of scan lines. The scan lines are the beginning and end point coordinates of each sweep needed by the microfilm plotter's electron beam to "paint" the geographic area on the film. The geographic code for each area along with its associated scan coordinates are output to an intermediate file. Executing this program can be expensive in computer time when thousands of geographic areas are being scanned. Therefore, this intermediate file is usually stored and used again when the same area is to be mapped.

Normal run time: 3 min. 50 sec.

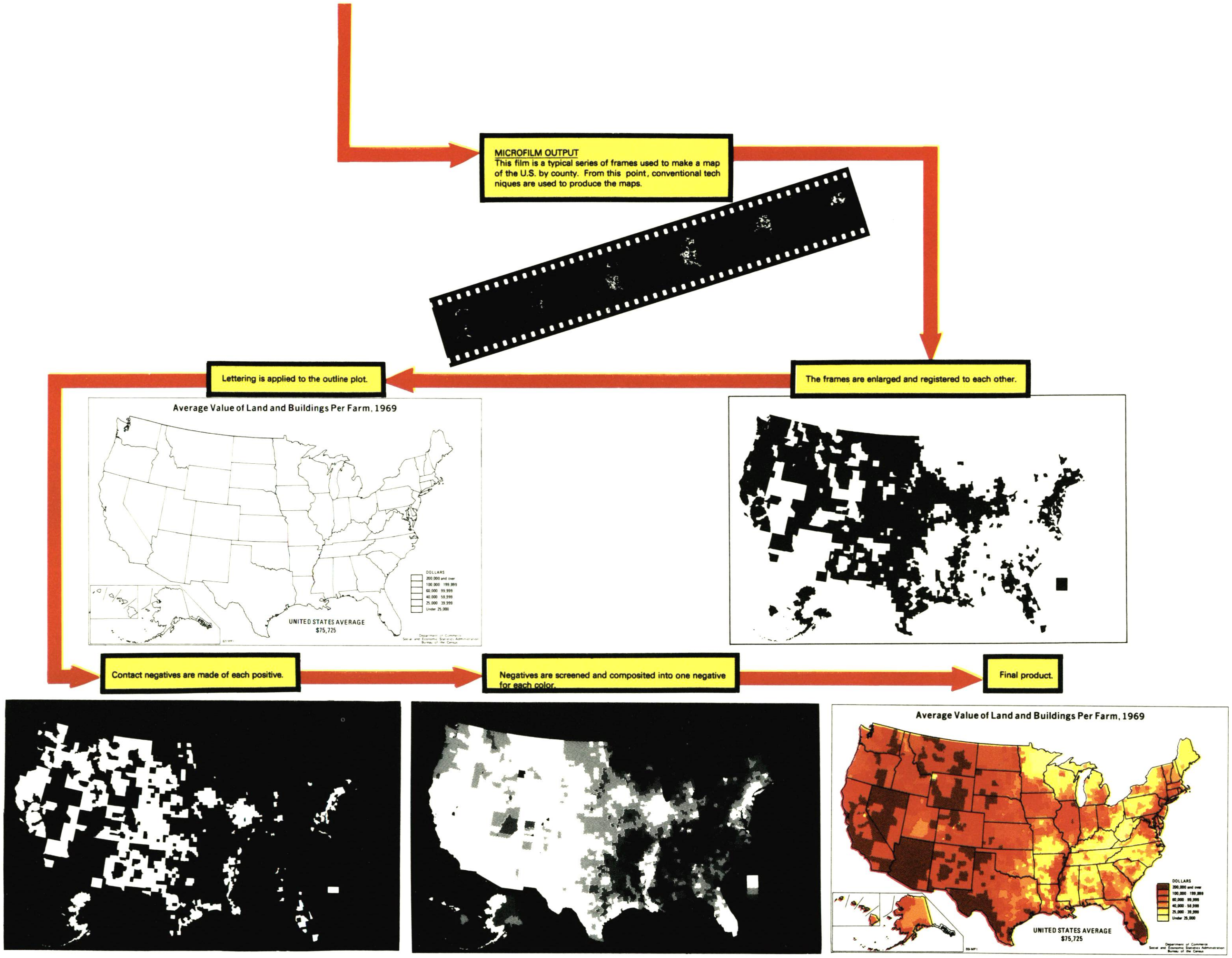
Each line is a scan line.

Area boundary points

MATCH
This program uses the geographic codes in the files from the extractor and scan programs to match and assign a class code to the scan image records for each geographic area. The resulting records are then sorted by class code. Finally, the program outputs the image by class to a tape for the microfilm plotter. All the images for a class are plotted on one frame.

Normal run time: 2 min.

FR 80 COMPUTER OUTPUT ON MICROFILM DEVICE
This device reads the tape from the match program and produces the 35mm microfilm. The device is capable of addressing up to 16 thousand points along each axis. It plots the microfilm frames at approximately three a minute.



MICROFILM OUTPUT
This film is a typical series of frames used to make a map of the U.S. by county. From this point, conventional techniques are used to produce the maps.

The frames are enlarged and registered to each other.

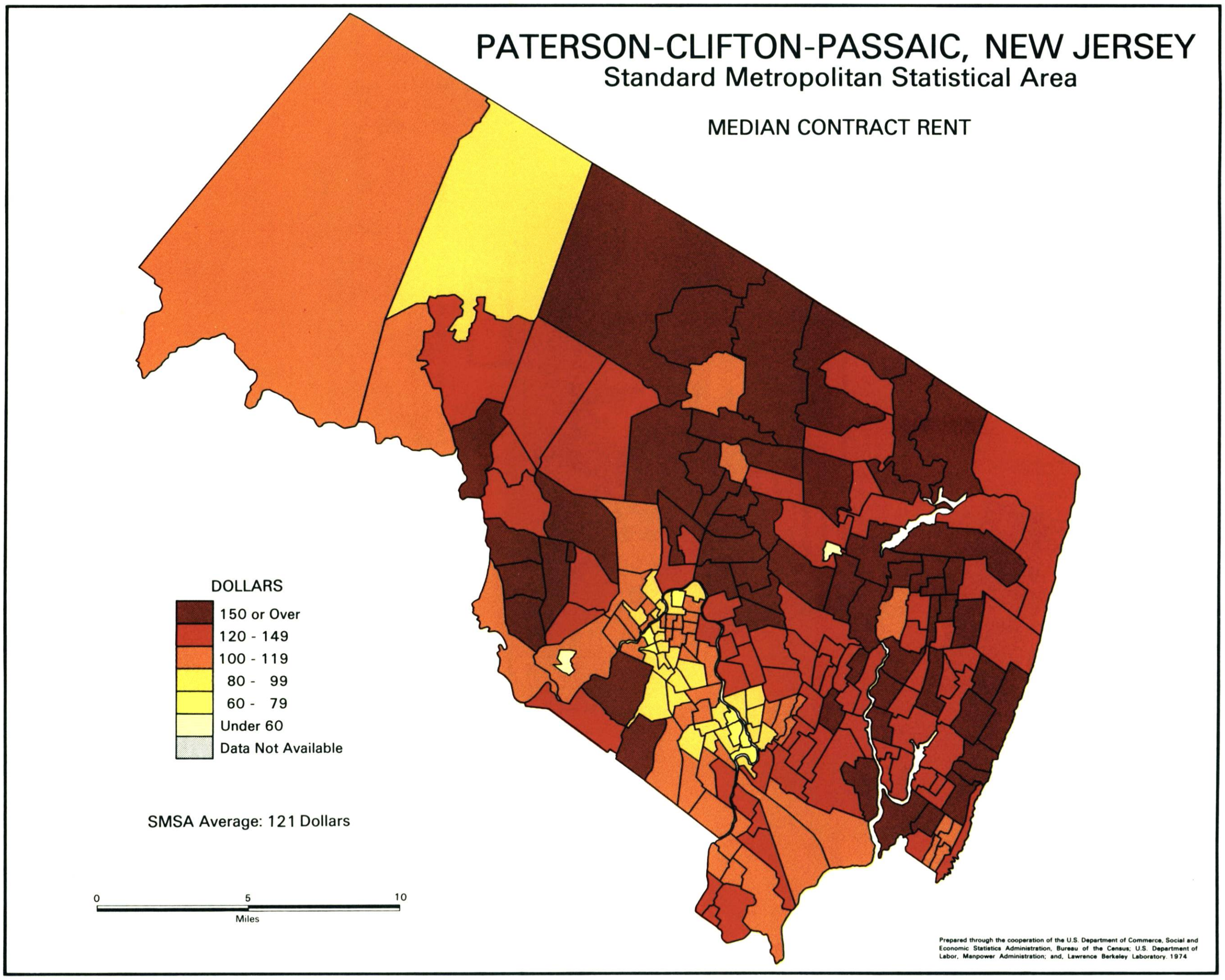
Lettering is applied to the outline plot.

Contact negatives are made of each positive.

Negatives are screened and composited into one negative for each color.

Final product.

Figure 4. A diagram of the computer mapping system at the Bureau of the Census. (See pages 123-125.)

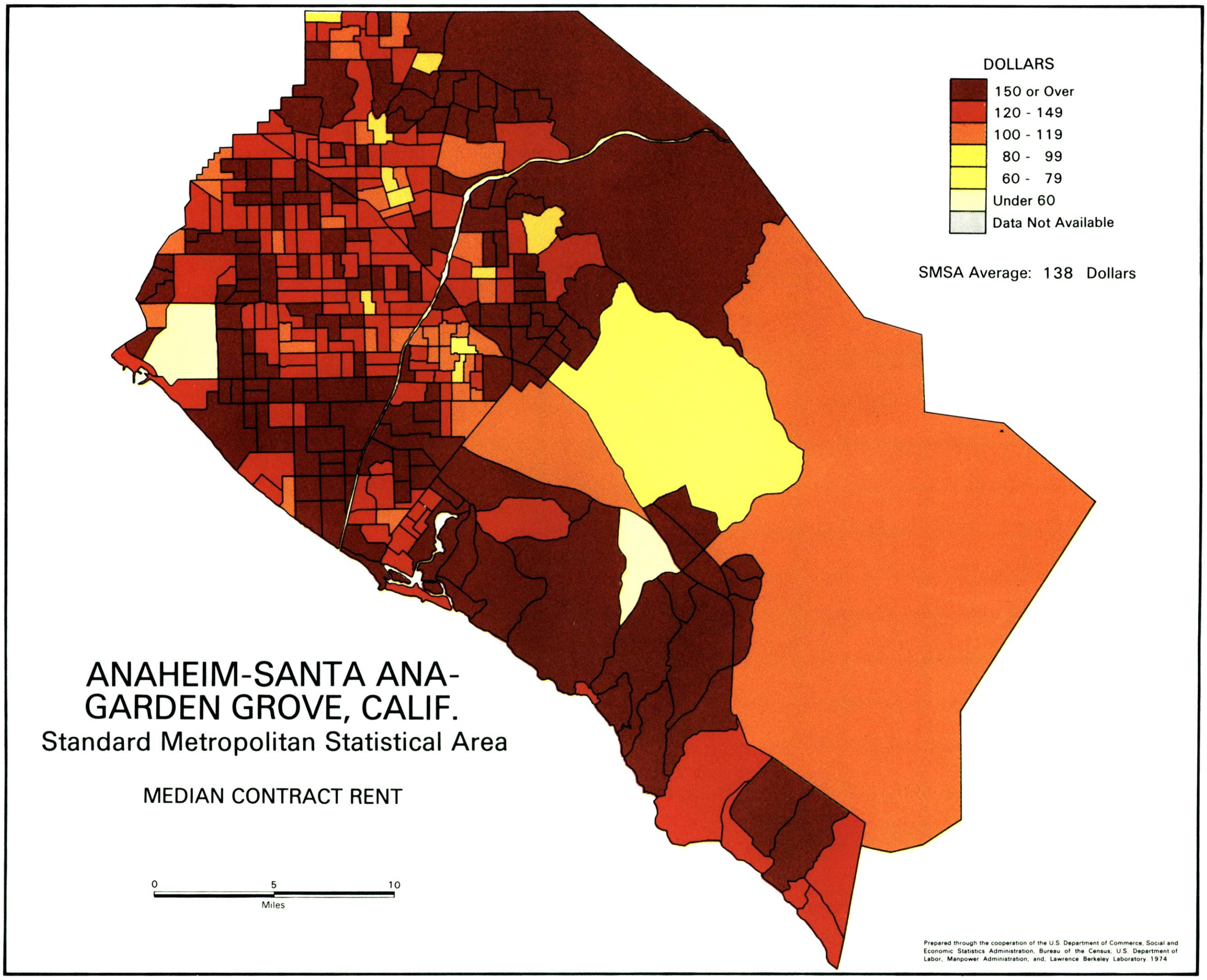


PATERSON-CLIFTON-PASSAIC, NEW JERSEY
Standard Metropolitan Statistical Area

MEDIAN CONTRACT RENT

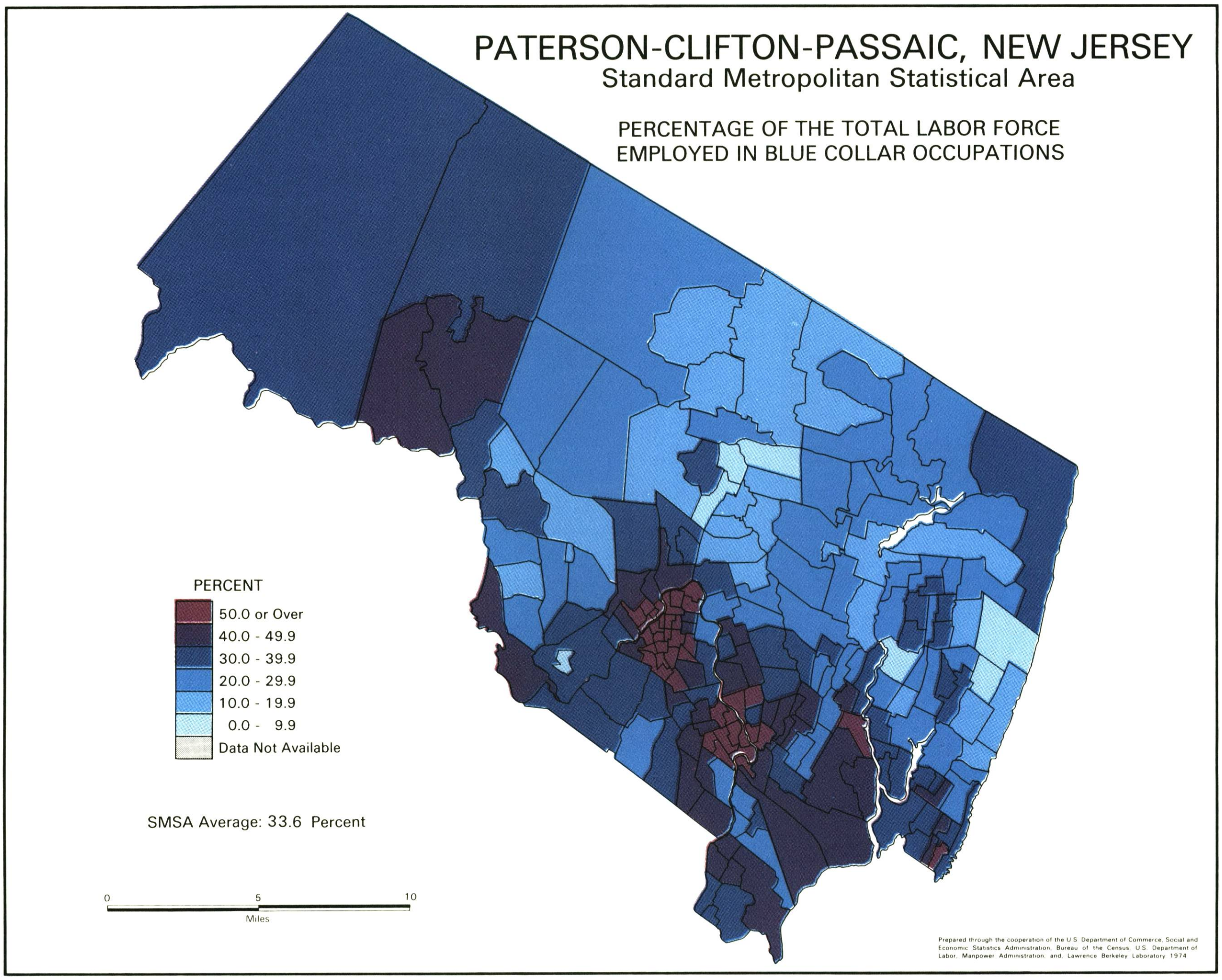
Prepared through the cooperation of the U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census; U.S. Department of Labor, Manpower Administration; and, Lawrence Berkeley Laboratory. 1974

Figure 5. This figure, as well as Figures 6, 7 and 8, are reduced examples of the Census Bureau's Urban Atlas Series, described on pages 162-168.



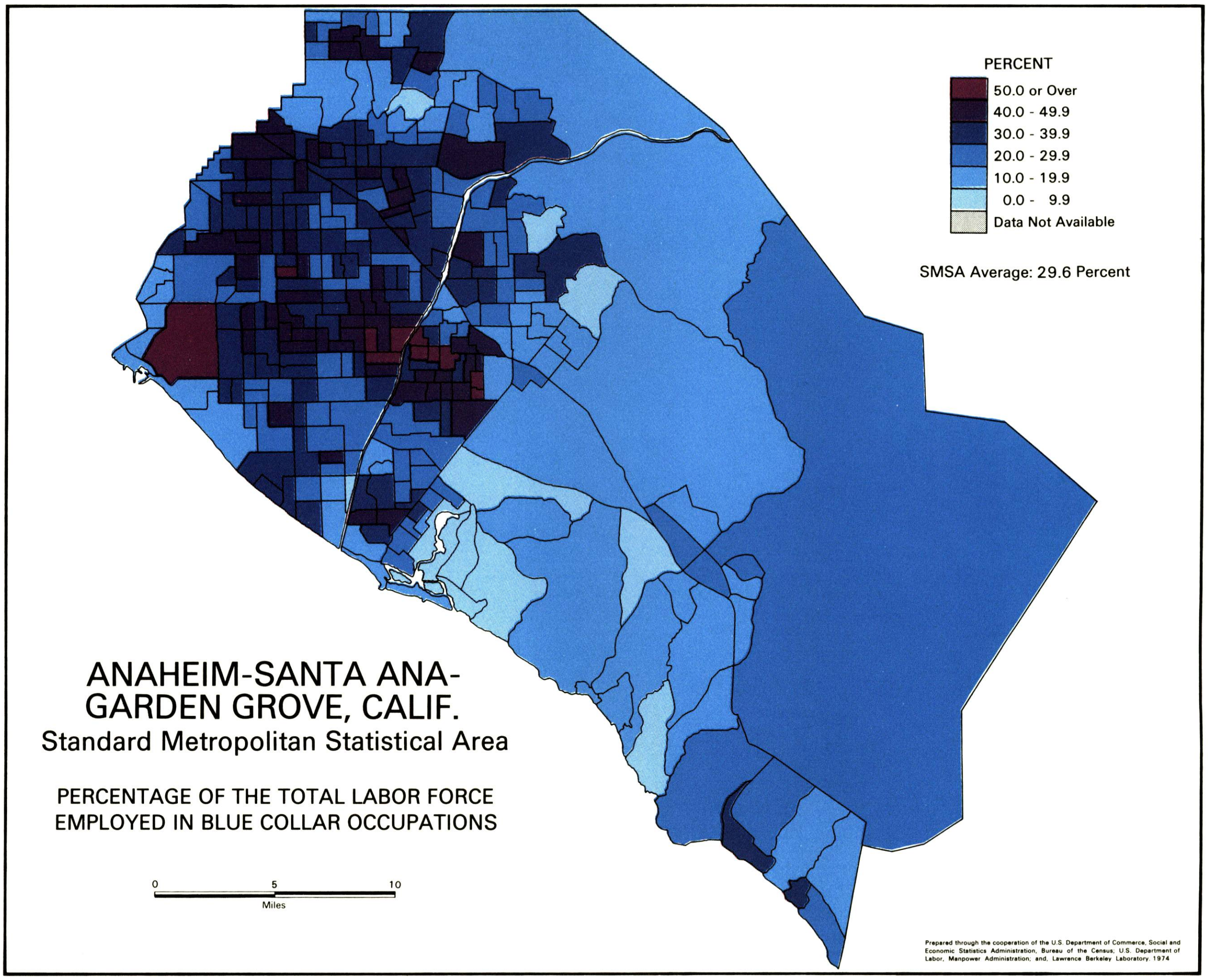
Prepared through the cooperation of the U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census; U.S. Department of Labor, Manpower Administration; and, Lawrence Berkeley Laboratory. 1974

Figure 6. The Urban Atlas Series was designed to provide a descriptive graphical presentation of basic social indicators from the 1970 census.



Prepared through the cooperation of the U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, U.S. Department of Labor, Manpower Administration; and, Lawrence Berkeley Laboratory 1974

Figure 7. The Urban Atlas Series, of which this map is an example, graphically presents by census tract 12 data items for the 65 largest standard metropolitan statistical areas. Individual census tract outline maps are included with each atlas to assist the user in relating the statistics to local landmarks and specific locations.



Prepared through the cooperation of the U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census; U.S. Department of Labor, Manpower Administration; and, Lawrence Berkeley Laboratory. 1974

Figure 8. This example from the Urban Atlas Series was produced by automated cartographic techniques.

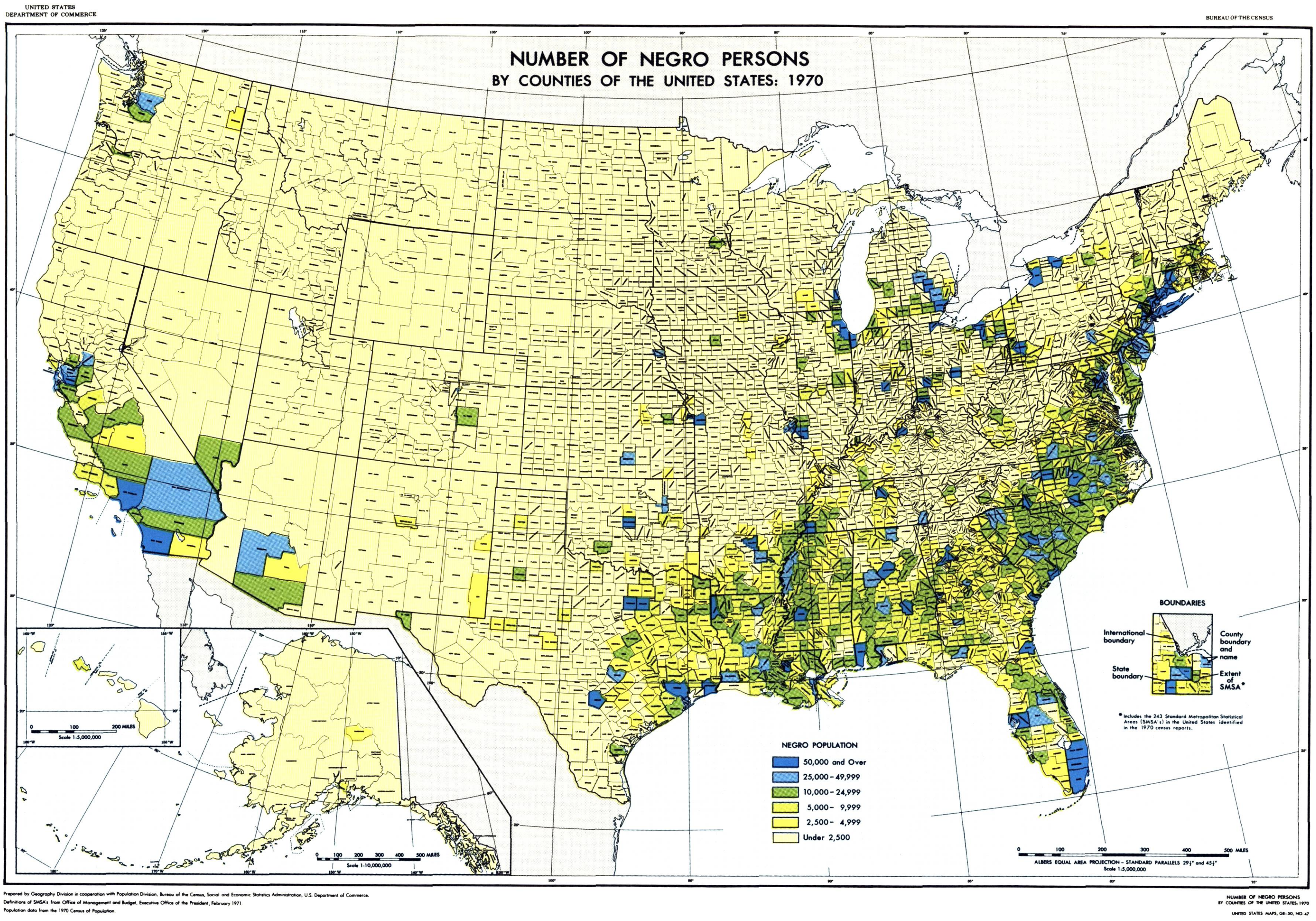


Figure 9. An example of a choropleth map from the Census Bureau's GE-50 Series. (See p. 179.) A large county like Los Angeles is more prominent than New York City's 5 counties, which are relatively small in area but which have a much larger Black population.

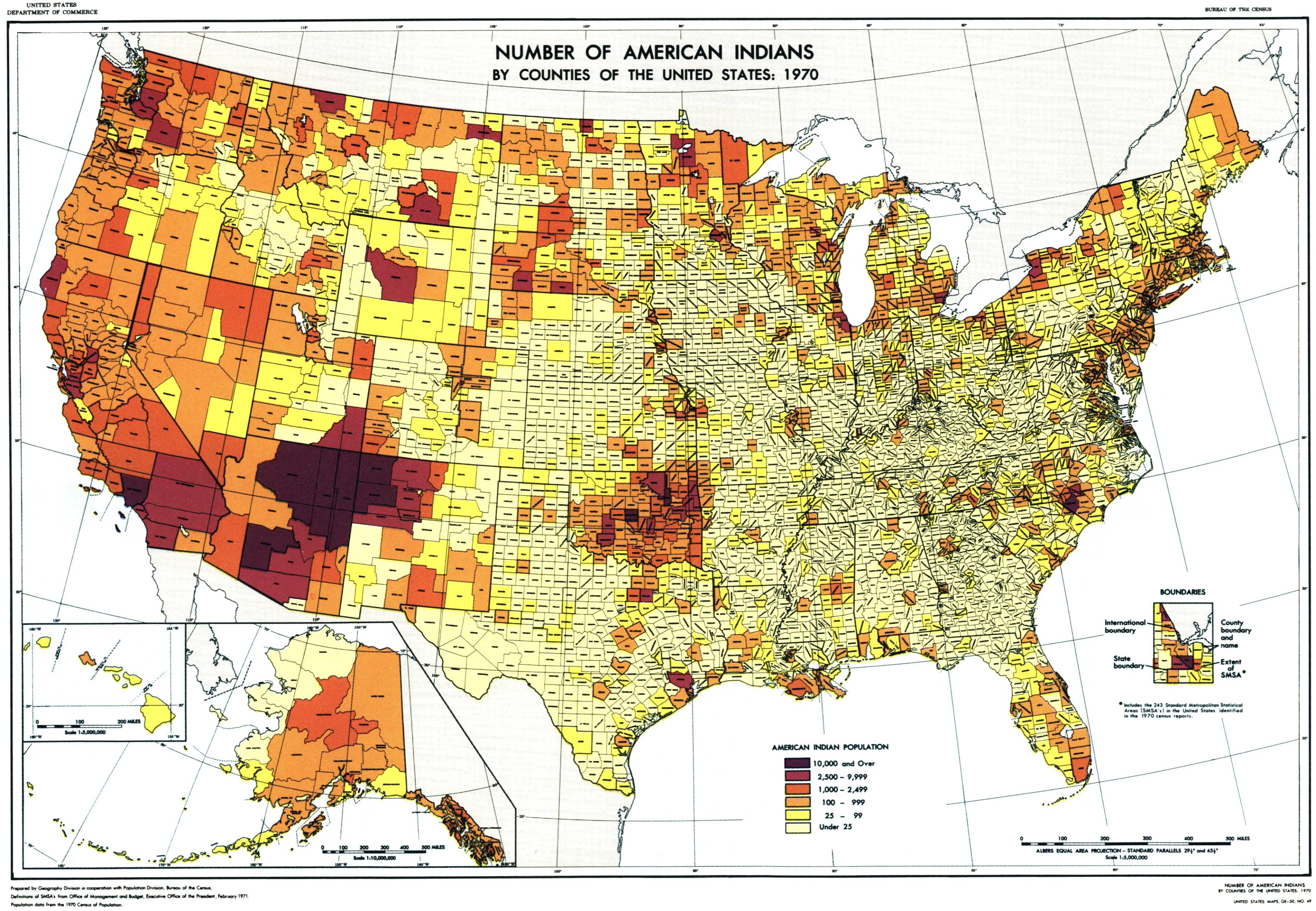
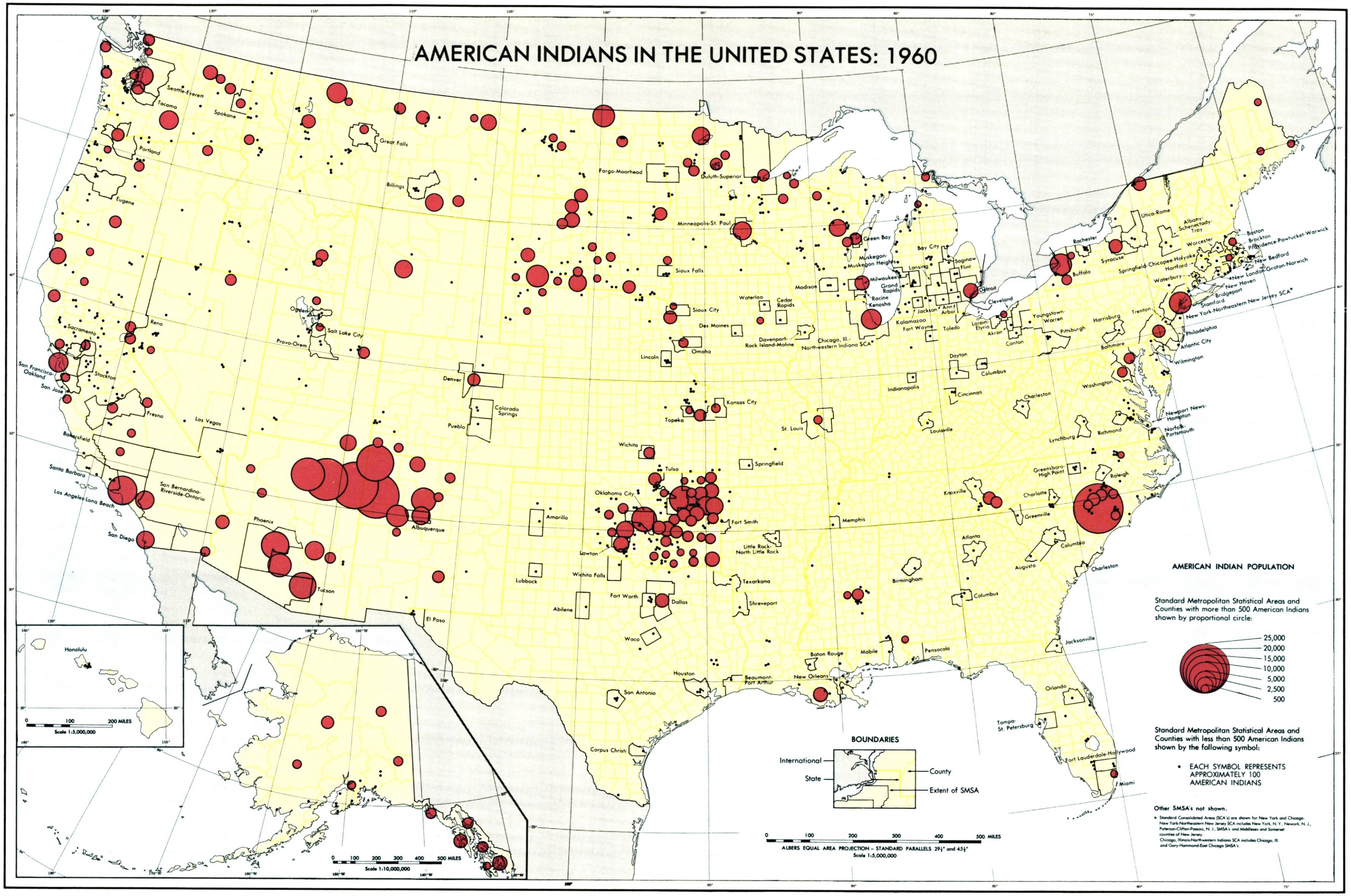


Figure 10. Another example of the GE-50 Series. Compare to Figure 11 on the following page.

UNITED STATES
DEPARTMENT OF COMMERCE

BUREAU OF THE CENSUS
UNITED STATES MAPS, GE-50, NO. 14



Prepared by the Geography Division, Bureau of the Census, U.S. Department of Commerce.
Population data from the 1960 Census of Population.

AMERICAN INDIANS IN THE UNITED STATES: 1960

Figure 11. This map illustrating 1960 census data used graduated circles. This method seems to provide a more accurate picture since it does not emphasize those large counties with low population densities such as in Nevada or Oregon.

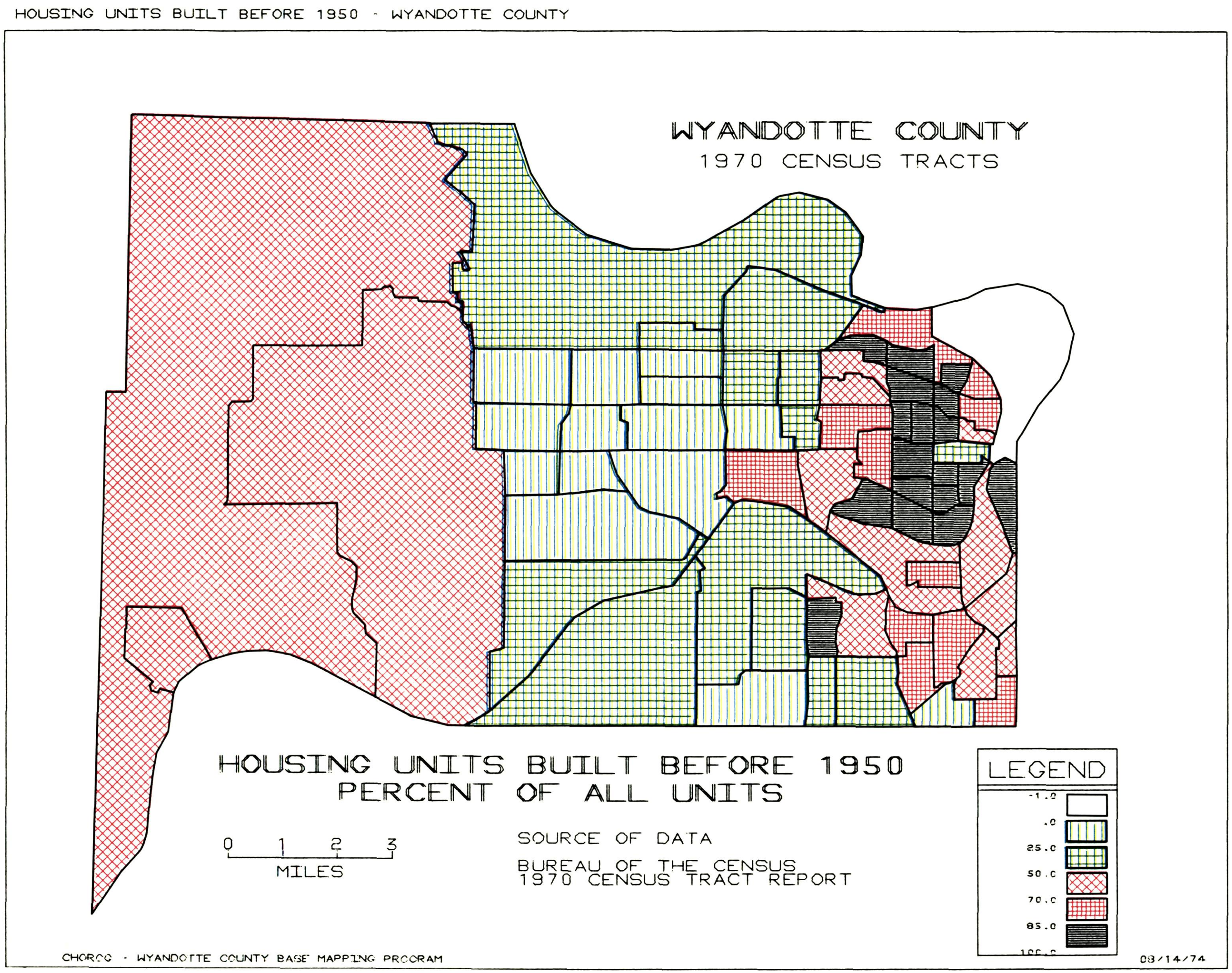


Figure 12. An example of a pen plotter - produced map showing housing units built before 1950 in Wyandotte County, Kansas. (See pp. 469-481)

SMOOTH TRANSITIONS

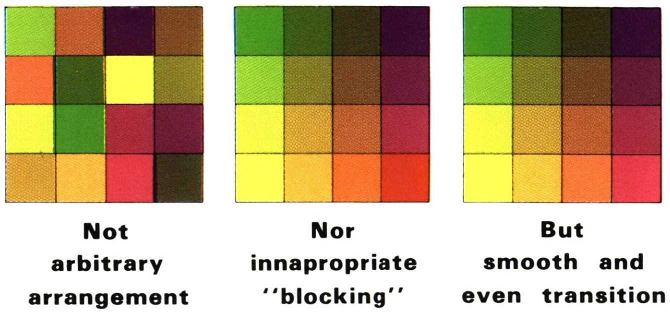


Figure 13

RELATIONSHIP TO SCATTER DIAGRAM

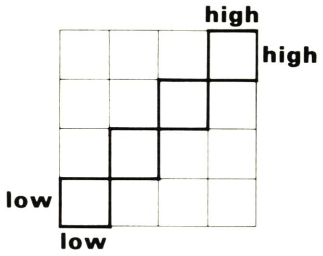


Figure 15

INDIVIDUAL CATEGORIES AND INDIVIDUAL DISTRIBUTIONS

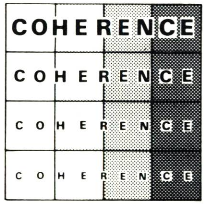
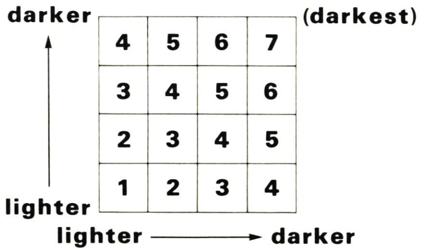


Figure 14

VALUE PROGRESSION



4	5	6	7
3	4	5	6
2	3	4	5
1	2	3	4

Figure 16

Figures 13-16 illustrate the presentation on "The Organization of Color on Two Variable Maps." (See pp. 289-294.)

EMPHASIS ON EXTREMES

(Saturated or dark corner cells)

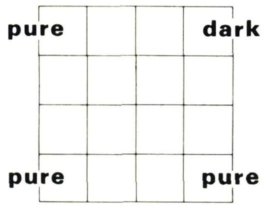


Figure 17

POSITIVE AND NEGATIVE RESIDUALS

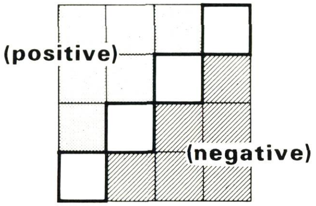


Figure 18

COHERENT DIAGONALS

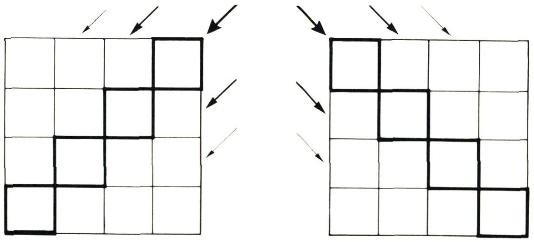


Figure 19

NESTED CATEGORIES

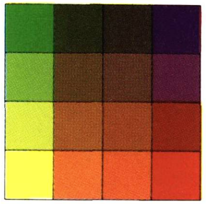


Figure 20

CATEGORIES BASED ON COMPARABLE STANDARD DEVIATION UNITS

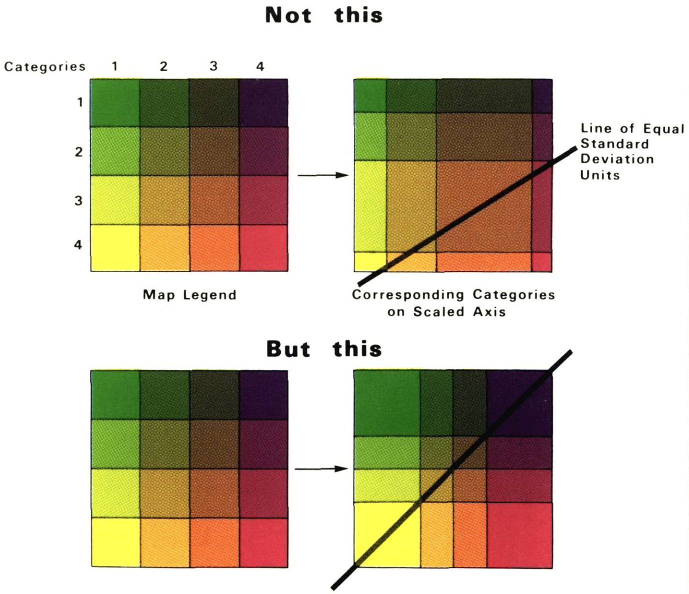


Figure 21

Figures 17-21. See pages 289-294 for the text accompanying these illustrations.

SINGLE COLOR COMBINATIONS FOR EACH CATEGORY

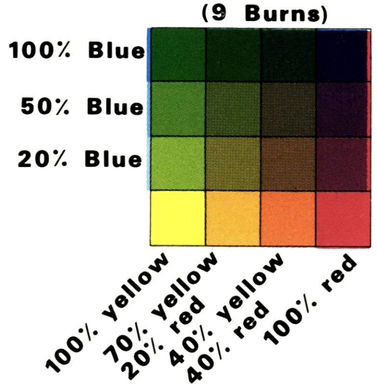


Figure 22A

DEMONSTRATION OF THE METHOD

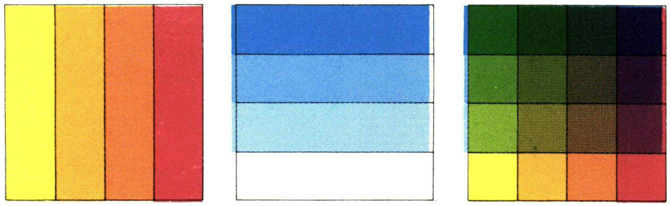


Figure 22B

VISUAL ADJUSTMENTS

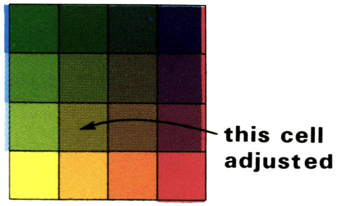


Figure 23

NUMBER OF CATEGORIES

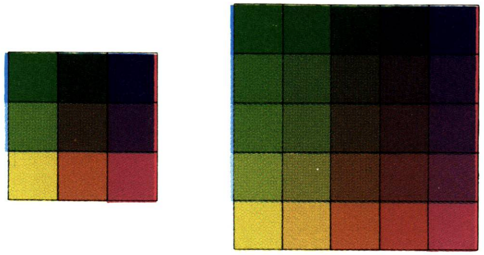


Figure 24

ALTERNATIVE CODING

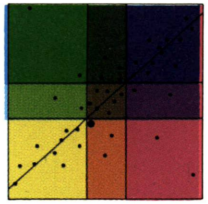


Figure 25A

ALTERNATIVE CODING

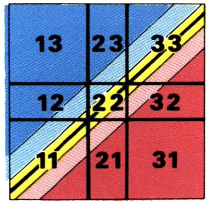


Figure 25B

Figures 22-25. See pages 289-294 for the text accompanying these illustrations.