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Mapping for Censuses and Surveys

The 15 chapters are contained in Statistical Training Document No. 3; study exercises to accompany the 15 chapters are contained in the workbook, Statistical Training Document No. 3W.

Chapter 1. Need for Maps

Chapter 2. Organizing a Mapping Program

Chapter 3. Map Interpretation

Chapter 4. Aerial Photography

Chapter 5. Map Sketching

Chapter 6. Preparation of Base Maps

Chapter 7. Delineation and Control of Enumeration Areas

Chapter 8. Use of Maps in the Enumeration

Chapter 9. Publication Maps and Graphs

Chapter 10. Drafting Operations

Chapter 11. Map Reproduction

Chapter 12. Dealing with Problem Areas

Chapter 13. Mapping for Sample Surveys

Chapter 14. New Developments

Chapter 15. Statistical Areas

Workbook

PREFACE

This document is one of several instruction manuals that are prepared for use by officials and specialists engaged in planning and implementing censuses and surveys in their countries. The document sets forth guidelines and illustrative procedures for a mapping program. It is expected that countries will be able to adapt the materials to their particular needs and resources.

Chapter 1 and 2 are directed to administrators and supervisors of mapping programs in their countries. Chapters 3 and 4 discuss elements of interpretation and use of maps and aerial photographs. Chapters 5 to 9 cover the operational steps in preparing maps—from making a map inventory and acquiring adequate maps to preparing maps and graphs for publication. Chapters 10 and 11 are concerned with technical aspects of the drafting and reproduction of maps. Chapters 12 to 14, as their titles suggest, discuss handling of problem areas, mapping for sample surveys, and new developments, such as satellite imagery and automated cartography. Chapter 15 concludes with a discussion of statistical areas.

The document is divided into chapters, consisting of text and figures. Each figure is identified by the chapter number and a letter suffix. Exhibits are identified by chapter number and sequence number within the chapter.

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Chapter 1. NEED FOR MAPS

1. INTRODUCTION

Maps are needed during all stages of a census or survey. They are needed in planning, in data collection, and in presentation and analysis of the results. Since mapping programs involve inputs of labor, time, and money, the question may arise as to the importance of maps in a census or survey undertaking. The answer is a simple one. The objective of a census or survey is to produce data that are accurate, timely, and useful. Maps are tools which help make this threefold objective attainable.

The need for adequate maps to carry out a census or survey is summarized below; the points are elaborated later in the chapter. Specifically, good maps are required in the various stages of a census for the following reasons:

(1) Planning operations. Reasonably up-to-date maps are needed to set up enumerator assignments, estimate travel time and costs, establish field offices, assign geographic codes so that proper enumeration areas are combined in the statistics for publication areas, and identify segments for sample surveys.

(2) Data collection. Maps of appropriate size and detail are needed to assure complete coverage of an area without any omission or duplication, determine the best route of travel to and within the enumeration area, measure distances, enable the field staff to locate an enumerator or to find a specific housing unit when a return trip is necessary, and serve as a mechanism for showing the progress of the field work.

3) Presentation and analysis of results. Maps are used effectively to relate statistical data with the geographic area to which the statistics apply, make the statistics easier to understand, and assure more use of the data by the public.

Without adequate maps, there is the risk of duplication or omission of areas covered in the census, thus leading to inaccurate results and wrong decisions by the policy makers and data users. Return trips to the field to correct the coverage deficiencies may delay the census results to the point that their usefulness is severely limited. Saving money in map preparation, therefore, may indeed be false economy.

1.1 General characteristics of maps

A map is generally small enough to be handled easily, yet it can show a large area. It permits a person to view at a glance those features which he might otherwise find difficult to see due to the limitations imposed by his size or his location. Thus, an individual can readily see on one map all the countries of the world, the source and mouth of the Amazon River, both sides of the Andes Mountains, or the extent of a large city such as Calcutta or Baghdad; this he could not normally do as a passenger on an airplane, much less on foot.

There are many kinds of maps, each serving a specific purpose. There are maps that show the location of cities, rivers, mountains, or deserts. There are soil and land use maps, geologic and topographic maps, cadastral maps, navigation maps, weather maps, road maps, administrative area maps, transportation route maps, city maps, and individual property maps.

1.2 General uses of maps

Some maps contain information that helps people to determine direction, distance, and location; they assist in the identification

of many man-made and natural features on the ground. On other maps, a person can see the boundaries of a province or district, the arrangement of streets and location of important buildings in a city, the areal extent of a river basin or forest, or the boundaries of fields of crops on agricultural holdings. Most maps resemble photographs in that they show what actually is on the ground; they differ in that maps use symbols and show only those features or characteristics of the landscape which the cartographer (map designer) chooses to include.

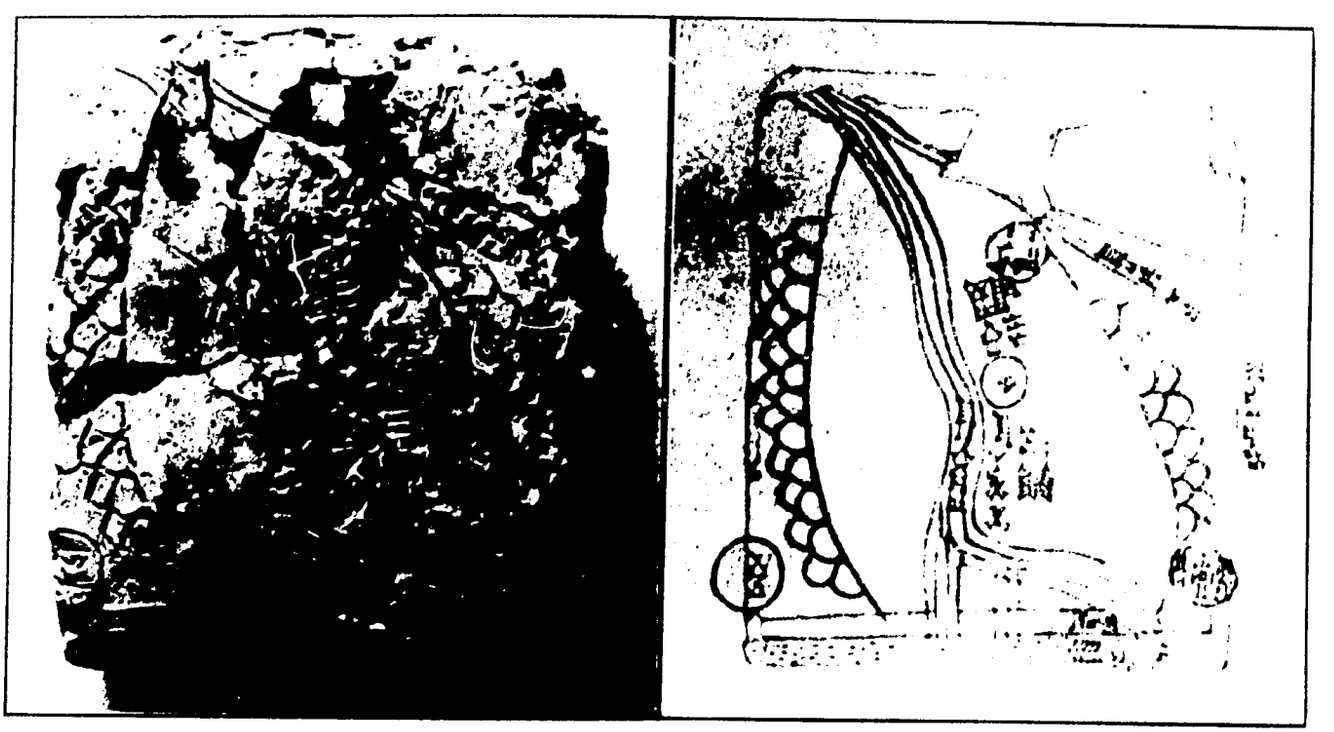
Maps also provide a means by which statistical information can be presented simply and effectively. Such presentation of population, housing, or agricultural data can add a new dimension to the understanding of census and survey results--an understanding which statistical tables are frequently unable to portray.

Many kinds of maps are used in statistical undertakings, either directly or indirectly. This manual is concerned with the types of maps that are relevant to census and survey activities. For simplicity, the discussion in chapters 1 to 12 pertains to censuses; the discussion in chapter 13 deals with mapping for sample surveys.

2. *HISTORICAL BACKGROUND*

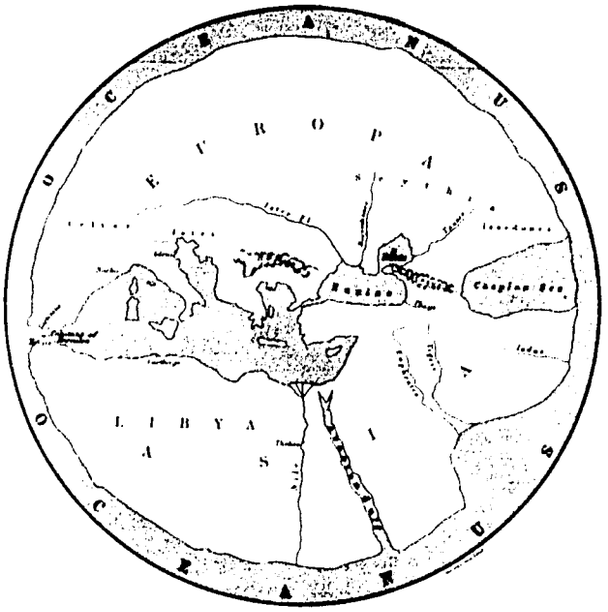
Maps have been in use for thousands of years. Kings, nobles, and other men of power have used them to show the extent, location, and boundaries of their land holdings. One of the earliest maps still in existence is a Babylonian clay tablet, dated about 2500 B.C., which shows the location of a man's estate (see figure 1a). Presumably, the estate covers land on both sides of the river and extends to the mountains (indicated by the symbol ∩). The tablet is one of a series of

Figure 1a. BABYLONIAN CLAY TABLET AND SKETCH MAP SHOWING AREA AND BOUNDARIES OF AN ESTATE



Source: "Bulletin of the American Schools of Oriental Research," No. 42, April 1931, p. 8. Courtesy of U.S. Library of Congress. Original map is in the Semitic Museum, Harvard University, U.S.A.

Figure 1b. THE WORLD ACCORDING TO HECATAEUS: 520 B.C.



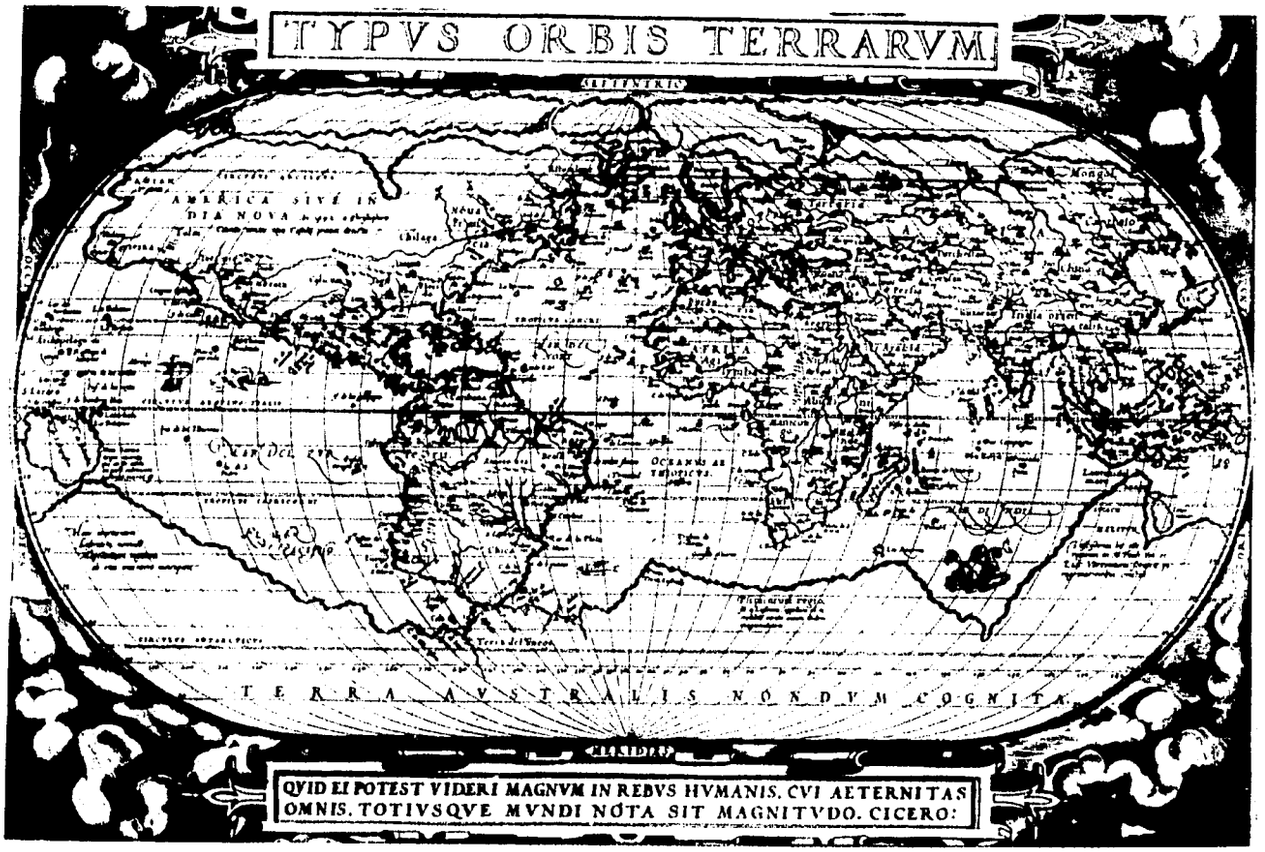
Source: Bunbury, E.H. "History of Ancient Geography," Vol. 1, Plate 2, 1879. Courtesy of U.S. Library of Congress.

tablets which, when put together, show the estates that made up a village or region. The whole Nile Valley was mapped by ancient Egyptians to show the location of property lines; some of these maps still exist on papyrus rolls.

The world according to Hecataeus, a Greek historian who traveled widely, is shown in figure 1b. His known world was flat and circular; it had two continents, surrounded by an ocean.

Increasing accuracy in cartography is apparent from a comparison of any current world map with those that were prepared long ago. Major developments, however, did not take place until roughly the 16th century, as a result of the voyages of many explorers and the invention of the printing press (see figure 1c). Copies of a single map could be

Figure 1c. WORLD MAP BY ORTELIUS: 1570 A.D.



Source: Theatrum Orbis Terrarum Atlas, 1570. Courtesy of U.S. Library of Congress.

printed fairly easily and cheaply during a period when the demand for maps was increasing. With the passage of time, maps became more detailed, specialized, and accurate. Yet they still served the same basic purposes as the earlier maps.

An interesting form of a primitive map is shown in figure 1d. It was made by an Eskimo hunter even before the people had a written language. Animal skin represents the sea, and pieces of wood depict the islands. The map not only shows the relative location and size of each island but also serves as a guide for navigators when traveling from one island to another.

Recently, interested individuals and groups have encouraged a greater output of specialized maps. These are intended for a wide variety of purposes, such as weather forecasting, oil exploration, forest management, mineral conservation, traffic flow control, and urban planning. Census maps are also specialized maps. It has been only within the last century that the need for good census maps has been recognized. Originally, census taking was quite simple; the heads of families and adult males were required to come to a central location to be registered for taxation or military service. As life styles changed and the need for detailed data increased, censuses became more complex. The statistics gathering agencies assumed the job of finding people by locating their homes and agriculural holdings. Census mapping thus came into use as a means of showing the location and the boundaries of areas to be enumerated and as a means of showing the routes to be followed by census enumerators when canvassing their areas. Maps also came to be used effectively in publications which graphically show statistical results of a census or survey.

Figure 1d. PRIMITIVE MAP MADE BY AN ESKIMO HUNTER

(Sea is represented by animal skin and each island by a piece of wood)

Source: Courtesy of U.S. Library of Congress.

Improvements in showing distance, direction, and size and shape of land forms have resulted in highly reliable and useful present day maps. New tools and techniques are constantly being developed in order to update and to further improve the accuracy of maps; for example, satellite imagery is now used to construct new maps in some cases or to provide additional information which can be added to existing maps.

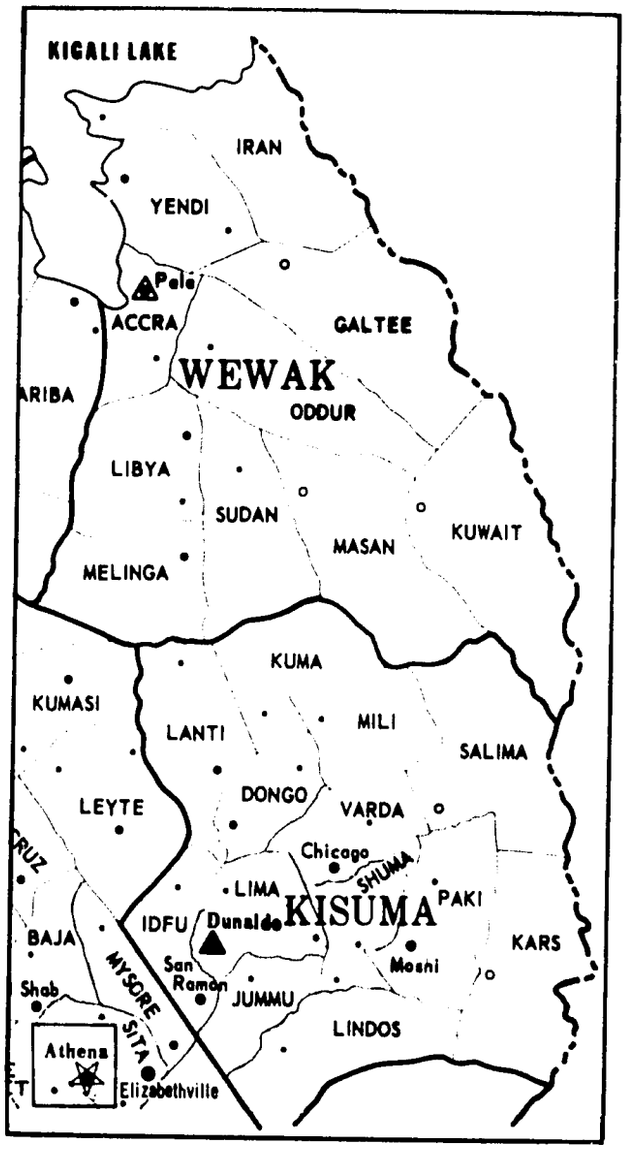
3. USES OF CENSUS MAPS

A census is a costly operation. It must be well planned and carefully carried out so that it produces reliable data at reasonable cost. As stated earlier in the chapter, adequate maps are essential in planning the census, collecting the data, and presenting and analyzing the statistical results.

3.1 *Planning stage*

As one of the first duties, the planning staff for the census usually looks for maps that show the location and boundaries of the administrative areas of government for which census data will be reported, such as major and minor administrative divisions, cities, towns, and villages. Before they can proceed further, however, the planners must have some knowledge of the physical geography of their country; that is, the location of mountains, hill country, plains, lowlands, valleys, and rivers. Physical geography also refers to the climate and vegetation, which are recognized in such different areas as desert, grassland, savannah, forest, and swamp. All of these features of the landscape may be very closely related to population distribution and agricultural activity.

Figure 1e. PORTION OF MAP SHOWING ADMINISTRATIVE DIVISIONS



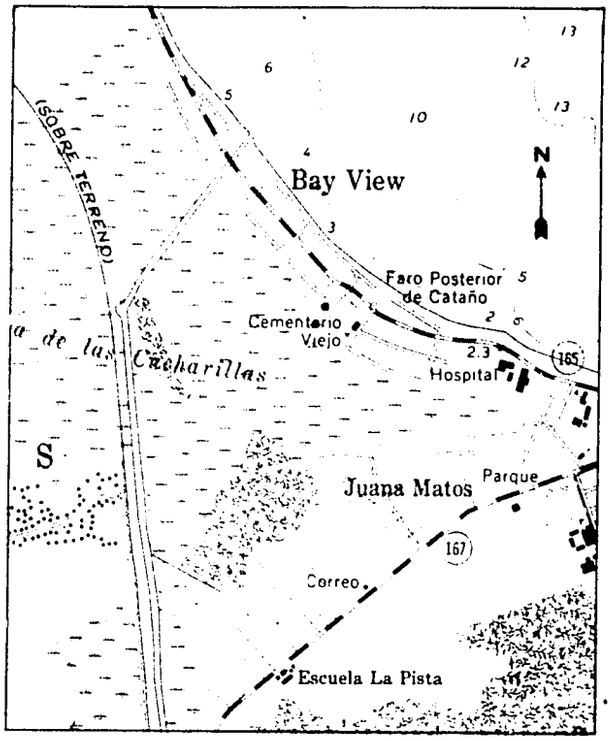
The planning staff needs to know even more about the human geography of the country. Where are the cities, towns, and villages, and what are their approximate populations? Where are the rural settlements and where are the sparsely settled areas? How are crops, livestock, mines, and forests distributed? What are the extent and quality of transportation and communication facilities?

Maps of several types (of which figures 1e and 1f are examples) provide this information. The staff uses the maps to carry out various planning activities that will contribute to a successful census.

3.11 Dividing the country into enumerator assignments.--This is probably one of the most important uses of maps. Each enumeration area (EA) must be of reasonable size (in population as well as land area), must have identifiable boundaries, and must lie entirely within an administrative or a statistical area. Maps supply information on population patterns, agricultural land use, and other ground features; such information permits suitable EA boundaries to be chosen (see figure 1g). Again, following the features on the map, the planning staff can group EA's into supervisory (crew leader) areas in such a way as to minimize travel and equalize workloads.

3.12 Estimating travel time costs.--By examining routes of travel and measuring distances on the maps, the staff can estimate the travel costs for the census. Canvassing hilly areas will require more time than flat lands, and canvassing sparsely settled rural areas

Figure 1f. PORTION OF TOPOGRAPHIC MAP SHOWING SWAMPS, FORESTS, ROADS, HOUSES, SCHOOLS, AND PUBLIC BUILDINGS



Source: U.S. Geological Survey, 1963.

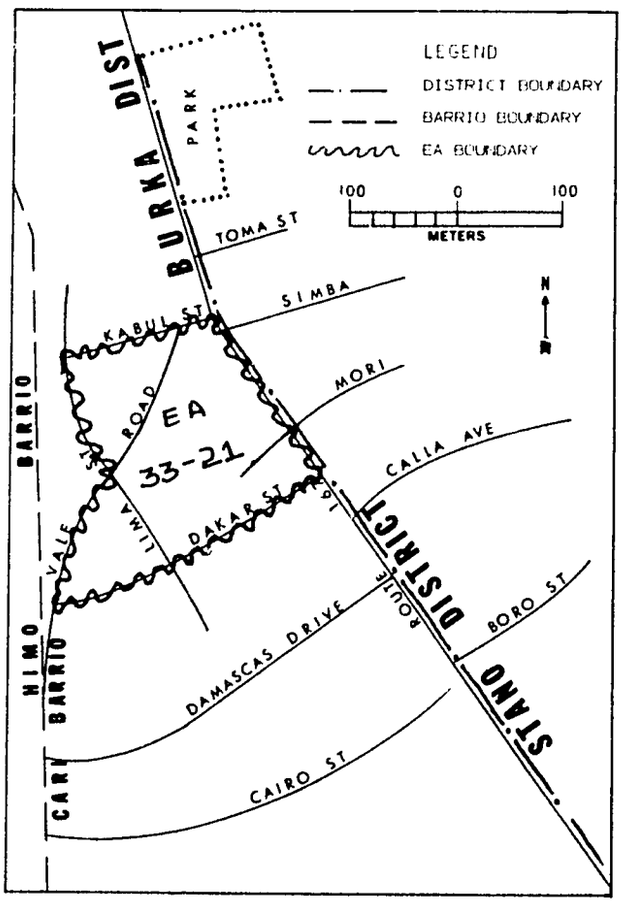
will require more time than densely populated sections of large urban areas.

3.13 Establishing field offices.--Knowledge of the physical geography and population distribution is important in setting up each field office, which is responsible for a number of crew leader areas. Where there are large urban places, often it is the population workload, rather than the natural features, that influences the location of field offices. In rural areas, more attention would be given to natural features. Wide rivers or high mountains cutting a supervisory area would present many difficult problems for the enumeration.

Additionally, each field office must be accessible in terms of transportation and communication. Materials and instructions should be transmitted promptly, problems that arise in the field should be resolved quickly, reports on the progress of the field enumeration must be up to date so that budget and work flow can be kept under control, and the data collection operation must be constantly reviewed to assure good quality results. Maps showing detailed communication and transportation networks can be studied to determine feasible locations for field offices. This is especially important in rural or remote areas where these networks are often inadequate and where the location of the field office may be limited more by its accessibility than workload.

3.14 Assigning geographic codes.--To assure that statistics for an administrative area cover each component piece of land once and only once, a unique geographic code must be assigned. The arrangement of EA's on a map makes it possible to assign the codes systematically so that there is no omission or

Figure 1g. MAP FOR EA 33-21, INCLUDING ADJACENT FEATURES



duplication. The procedure for assigning the codes[1] is discussed in chapters 2, 6, and 7.

3.2 *Data collection*

Without maps, crew leaders and enumerators would have to rely on verbal descriptions and directions or on local knowledge of the area boundaries. This leads to confusion and error. People tend to have mental images (or mental maps) of places, and these images may not coincide with the area as it really is. A native of Cairo may have a completely different version of the city from that of a villager living a few miles outside. For the same kinds of reasons, a crew leader's mental map of an EA may differ markedly from that of an enumerator. This may lead to disagreements as to the size of the area, distances between places, location of boundaries, and shortest routes to follow. Because census maps provide a realistic picture of an area, they are essential to the data collection operations for a number of reasons.

3.21 Assuring complete coverage of an area.--Even where local tribal chiefs believe they and their people know precisely how far their villages extend, the results of research indicate that their information is often inaccurate. Maps can show clearly whether EA boundaries overlap or whether they fail to touch; in the former instance there would be duplication, and in the latter instance there would be omission.

3.22 Determining best route of travel.--For the general public, the most common use of maps is for planning the best route of travel. Suppose a person wished to travel from a city on the eastern border to one on the western border of his country. All he needs to do is simply follow the sun and move in a westerly direction. There are many roads he could follow or he could ask directions from individuals along the way. In time he would reach his destination; he would not need a map.

Suppose this same person had a limited amount of time and money for the trip. He would want to select the most direct route and the best roads, and he may want to visit a few important places along the way. A road map is the answer.

Similarly, a map can be used to plan the best route for a census enumerator to follow when moving from his home to his EA. It can also help him canvass his EA properly so that no part is overlooked or duplicated.

3.23 Measuring distances.--Maps are used to measure distances between places or points. For example, the enumerator can measure how far it is between an imaginary boundary and some visible features, or he can measure how far it is from the intersection of two roads to a group of houses. Along with other information, such as the number and quality of roads, the census staff can estimate the time to travel to the EA's and to canvass the areas.

It should be noted here that precise measurements are not necessary for census maps that are used in the field. It is more important to show features in their proper relationship to each other. Whether a structure is 50 or 70 meters from the road is much less significant than whether it is located on the correct side of the road. There can be some savings in preparing maps for the enumeration since engineering accuracy is not required.

3.24 Locating a place or person.--Maps can help to locate persons, places, or things. An enumerator can determine his location by matching certain prominent features on the ground with the information on the map. He

[1] *Another coding system is the one that is incorporated in the Geographic Base File (GBF) System. For a discussion of the GBF System, refer to chapter 14.*

can find the boundaries of his EA, or determine the location of an imaginary boundary in relation to some other map feature. Maps can also be used to locate villages, houses, agricultural holdings, field offices, and many other natural and man-made features which are important to census taking.

The enumerator can mark on the map his daily starting and stopping points, dwellings where he must make callbacks, or the place where he must meet his supervisor. If for some reason an enumerator cannot finish his assignment, the stopping and starting points can be very important to the person who must complete the work. Additionally, if a return trip to a specific housing unit or agricultural holding is necessary, it is often impossible to retrace the enumerator's path of travel and locate the unit without a map.

3.25 Serving as a progress report form.-- A simple administrative area map that shows EA boundaries can be used to indicate the progress of the field work. As this work is completed, the EA can be colored or identified in some other way. Districts where the work is progressing slowly can be easily spotted so that remedial action can be taken promptly. Although records of progress can be kept on a standard report form, visual representation in the form of a map can be very effective.

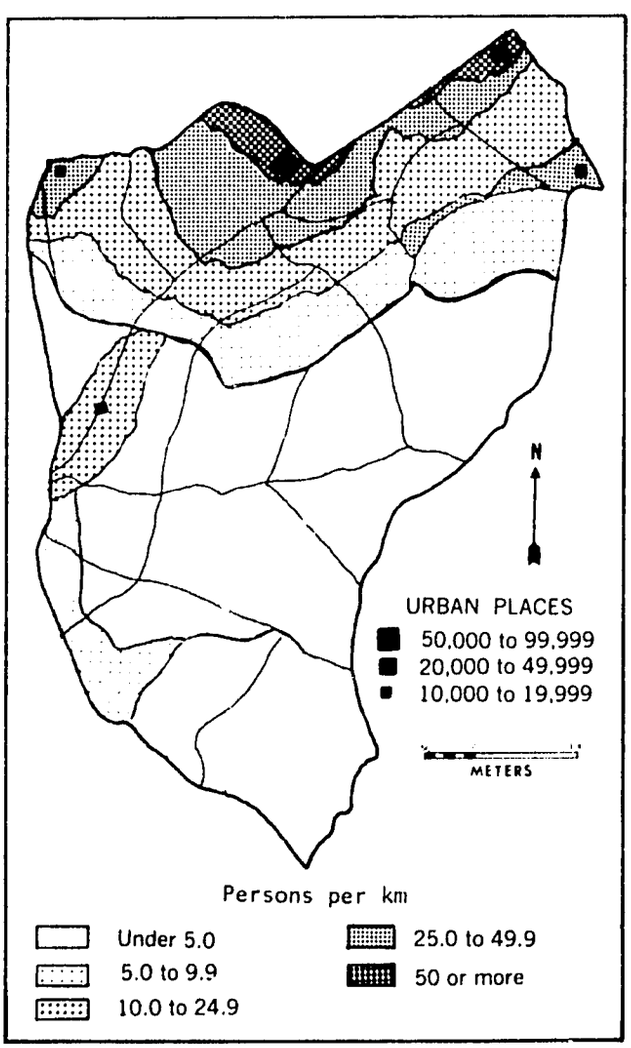
3.3 *Presentation and analysis of results*

When data are presented entirely in tabular form, it is difficult to visualize geographic distributions and patterns. Publication maps and charts present data in a way that can be readily understood.

Suppose the southern half of a province were sparsely settled, whereas the northern half of the province contained the bulk of the population. Also assume that a census was taken and that a table was published, showing the name and population of each of the 20 districts in the province. Since the information in the table is arranged alphabetically by district, the census user who is not familiar with that province would not be aware of the unbalanced population distribution. However, a map can quickly and effectively show the contrast. In this way, maps add a new dimension to the understanding and usefulness of data which tables do not readily reveal (see figure 1h).

Figure 1h. POPULATION DENSITY PER SQUARE KILOMETER, FOR DISTRICTS

(Calculated for subdivision of districts)



Census results can be indicated on maps in a variety of ways. For example, dots, circles, spheres, bars, or columns can be used to advantage to show relationships such as percentage of population change, percentage of the population that is urban, number of persons per square kilometer, incidence of literacy, types and quality of housing, agricultural holdings by size, and crop production per hectare.

Such maps can have a very substantial and favorable impact, if they are made available to government agencies, schools, various public and private institutions, and businesses. As a result of their widespread distribution and use, administrators, planners, businessmen, and the general public all are made aware that valuable and useful information about their country has been gathered and published. If the publications are favorably received, a sizable group of census users will have an interest in seeing that this important work is continued in the future.

4. KINDS OF MAPS NEEDED FOR A CENSUS

As noted earlier, many kinds of maps are used in the census. Since they serve different purposes, they differ in size and in the amount of detail with respect to natural and man-made features. Maps for planning purposes should show administrative area boundaries, location of cities and villages, mountains, deserts, swamps, transportation lines, and some indication of population density or extent of agricultural holdings. Maps for the enumerator should show streets, roads, and major buildings or other landmarks; these should be of relatively large scale. The crew leader's map may be simply a composite of the individual EA maps, probably at smaller scale. A field office, directing the work of several crew leaders, might use two types of maps of intermediate scale--one which would show the boundaries of each crew leader's area (as well as each EA within his area) and another which would show natural features, transportation routes, cities, and villages. For presenting statistical results, small-scale outline maps are used as the base.

Detailed description of the kinds of maps needed in a census is given in chapter 2 and later chapters. The chapters also discuss how to acquire the maps and how to prepare them for the purposes they are to serve.

5. CONCLUSION

A census administrator probably would not consider having the enumerators memorize the items on the questionnaire, then sending them into the field with blank pieces of paper in order to save printing costs. He would reason that, if his country is going to invest a large sum of money in collecting data for the census, then the planners should ensure that the data are as accurate as possible.

The same reasoning applies to the use of maps in taking the census; a census administrator should rely on maps as a necessary tool to ensure accuracy. When compared with the total census budget, including direct and indirect costs, the cost of producing adequate maps is small. Moreover, a mapping program should not be considered in terms of one census or survey. Once maps are produced, they are updated for use in intercensal sample surveys and future censuses. The initial costs, then, will be relatively insignificant when compared to the long-run benefits.

Some countries have compiled nationwide sets of fairly high quality maps; on the other hand, many countries have yet to establish a mapping program. Nevertheless, the situation is changing as more and more census organizations realize that adequate maps are a very important tool in increasing the accuracy, timeliness, and usefulness of census results.

Chapter 2. ORGANIZING A MAPPING PROGRAM

1. INTRODUCTION

A mapping program involves the systematic preparation, use, and publication of maps for census and survey purposes. A geographic staff is organized, and maps are gathered from many sources from which census maps are compiled. Field personnel are given training in the use of census maps and some of the statistical results are published in graphic form. All of these activities are essential ingredients in any successful mapping program.

The National Statistical Office (NSO) staff for carrying on these activities is generally known as the Geography Division. The Geography Division also provides the geographic identification for collecting the data, preparing the tabulations, and understanding the results--all in terms of their identification by area.

To achieve all the mapping tasks required for accurate and useful censuses and other statistical activities, a formal ongoing mapping program should be established as an integral part of the NSO. Failure to implement this important effort during early stages of census and survey preparation can endanger the final results. Mapping tasks undertaken too late or with insufficient planning almost surely will result in a lack of maps or maps that are inadequate for the enumeration of critical areas. For a major census, this lead time should be at least 2 or 3 years even with an ongoing mapping program. This should make available an experienced core of well-trained geographers and cartographers to handle not only mapping for intercensal surveys but also advance planning and training of the additional staff needed for the next major census. For purposes of this manual, the term "cartographer" applies specifically to a person who constructs maps; the term "geographer" describes a person who is concerned with land features, population distribution, and spatial or locational aspects. A geographer may perform some cartographic duties.

2. REQUIRED KNOWLEDGE AND CAPABILITIES

As mentioned in chapter 1, the NSO will need personnel with the proper skills in mapping to plan and take a census or survey. The personnel must have a detailed knowledge of the physical geography of the country--the location of the mountains, the hill country, the plains, the valleys, canyons, rivers, and lakes. Physical geography also deals with climate, vegetation, and drainage, which are recognized as desert, grassland, savannah, forest, and swamp. These natural features of the landscape usually are closely related to the distribution of the population and agricultural activity.

Those planning and preparing maps for a census or survey need also to know about the human geography of the country. For example, they should know the location of cities, towns, and villages and their approximate population; the location of densely populated and sparsely settled villages; the distribution of crops, livestock, and mining activities; the quality and availability of transportation networks and communication facilities. A broad general knowledge will not suffice; a highly specific understanding of the situation in terms of many small areas is required.

Knowledge of human geography also would include selected aspects of political geography. Staff should know the organization, location, and boundaries of the administrative areas of government for which census data must be reported, such as major and minor civil divisions, cities, towns, and villages.

An experience with maps and an understanding of the principles, techniques, and practices of cartography are also needed in the NSO. Abilities to evaluate maps, update the existing maps, and develop new maps all are required in a census mapping program.

Such knowledge of geography and cartography and accompanying technical abilities will be found in professionally trained geographers and in some cartographers who have received basic geographic training. Others with a good secondary school education can acquire necessary skills, through instruction and training, to carry out various parts of a census mapping program.

3. *BASIC DECISIONS*

Some basic decisions must be made before the preparation of census maps begins. Planners must decide on the (a) areas for which data are to be collected, whether official administrative areas or statistical areas designed to present data for specific statistical use; (b) typical size of an EA, determined partly on the basis of population or housing unit estimates that must be obtained; (c) criteria to be applied in defining urban and other statistical areas; and (d) the coding scheme that will provide a unique identification for each area. All these decisions must be made very early in the planning if the program is to be successful.

3.1 *Administrative areas for which census data are to be reported*

Early steps in the geographic preparatory work for a census are (a) making the decision as to which types or levels of administrative areas are to have data reported for them in the census, and (b) the compilation of as complete a list as possible of all administrative areas, including the relationships among the various types. Administrative areas include the following:

(1) Major administrative areas or first order divisions. These are known by different names in different countries, such as province, department, state, canton, etc. Sometimes there are two or more types of units at this level, such as department and territory, or state and territory. In any case, the 1st order divisions must include all of the land area of the country.

(2) Second order divisions. These also are known by various names, such as district, county, municipality, etc. These all are subdivisions of 1st order divisions.

(3) Third, fourth, and fifth order divisions. These may or may not exist within a specific country. They also may be known by various names, such as commune, canton, chiefdom, barrio, district, etc.

(4) Municipalities, including cities, towns, villages, and other places. In some countries, municipalities may be 2nd or 3rd order divisions, while in other countries they may be parts of divisions. In either case, they represent very important areas for reporting census data. Municipalities also may be subdivided into wards or other subareas.

3.2 *Statistical areas for which census data are to be reported*

While it is essential to provide statistics for the various administrative areas of government (including at least 1st, 2nd, and 3rd order divisions), statistics for these areas alone may not meet the needs of many data users. The administrative areas may fail to recognize the natural geographic regions or subregions within the country, or its metropolitan areas. They may be inadequate for classifying the population into its urban and rural parts. They may not distinguish between the settled fringe of cities and the surrounding agricultural area, or they may not identify the smaller settlements or villages. In the

larger places, statistical areas may be groups of blocks delimited to recognize common social and economic characteristics of communities or neighborhoods. To meet these kinds of geographic data needs, special statistical areas are defined in many countries and their limits are observed in the census (see chapter 15).

Statistical areas may be combinations of administrative areas, or they may be defined largely without relationship to such areas. In the latter case, the enumeration areas (EA's) must be delineated so as to observe the boundaries of the statistical areas. If the decision is made that statistical areas are needed for a census, professional personnel who are well trained in the field of geography should be assigned the task of defining them; and prospective data users should participate in reviewing the concepts and boundaries.

3.3 *Geographic identification code scheme*

To process and tabulate the census results by geographic areas, it is necessary to design a complete geographic identification code scheme. This requires developing a system of codes that will uniquely identify the enumeration areas (EA's) or the blocks within them. This is done so that the computer can correctly assign the tabulations for these small areas to all of the various administrative and statistical areas of which they are part. Development of a code scheme is not strictly a mapping task, but it requires complete knowledge of the various geographic areas for which maps and boundaries are being sought.

Numbers are preferred for these codes. The reason is that the use of numbers is less complex and is less likely to result in errors than is the use of alphabetic characters.

3.31 Design of code scheme.--The first step is to prepare lists of all administrative areas and their subdivisions. The hierarchy among the administrative levels and the sequence of areas within each level also must be established, whether the sequence is alphabetic (probably the most common), traditional, geographic, or other. The total numbers of such areas and the numbers within each higher order level must be determined, before a decision can be made on the number of digits that will be needed for each coding field; for example, if there are 25 provinces and the codes are to be assigned at intervals of 4 (02, 06, 10, 14, ..., 98), then two digit positions are sufficient. However, if there are more provinces, either the gaps between consecutive codes must be reduced or one or more additional digit positions must be reserved, as needed. The same procedure should be followed for the various orders of subdivisions, except that the limit should be determined by the largest number of subdivisions within any one group of the next highest order division; for example, if there are only four regions, and they contain 5, 22, 103, and 86 districts respectively, the district code field for all regions must contain at least three digit positions (see also chapter 6).

Statistical areas must be assigned their own unique positions among the various administrative orders and units; the census planners must decide where they belong, and of what kinds of units they will be composed, before assigning them to specific positions. The judgments made in this process must be based on a clear understanding of the role of these areas and of their composition within the hierarchy of areas to be recognized in the census. A statistical area may be a group of administrative areas or it may be a part of a single administrative area. For the larger statistical areas such as regions, subregions, and metropolitan areas, a 1- to 4-digit code may be assigned across the country; this becomes an additional identifier code for each

of the administrative areas assigned to each statistical area. For the smaller statistical areas, some of which include only parts of administrative divisions, the procedures may be somewhat different. Some of these may be treated as the equivalents of 3rd or 4th order divisions and coded along with these divisions. Others, such as census tracts or sectors, may be numbered consecutively within each higher order division. Again, each EA is tied to the statistical area, if any, of which it is a part, as well as to the various administrative divisions in which it is located.

3.32 Permanence and flexibility of scheme.--Once a geographic identification code scheme is established, it should be useful for many successive censuses unless there is a major reorganization of most of the administrative areas of the country. To assure that the code scheme is flexible to accommodate minor administrative area revisions (such as additions and deletions), the codes adopted should have numerical gaps. To illustrate, if there are no more than 19 subdivisions of an administrative area, the code numbers could be assigned beginning with 05, then 10, 15, 20, etc., to 95, with four unassigned numbers between each code number to be available for future assignment; in this way, alphabetical sequence of areas can be maintained without renumbering all subdivisions. If there are about 30 subdivisions, code numbers could be assigned with gaps of only two numbers, which would probably accommodate many revisions. This kind of flexibility in designing a code scheme should always be an objective to prevent major revisions for each census.

3.33 Uniformity of scheme.--A further concern in designing a geographic identification code scheme is the need for maintaining uniformity in the number of digits assigned to identify areas at any one administrative or statistical area level. Each administrative level of government should have the same number of digits for coding, whether they are needed or not. To illustrate, one 1st order division may have only nine 2nd order divisions while the largest one may have 150; therefore, at least three digits must be available for coding all 2nd order divisions. This kind of uniformity is necessary to maintain order in processing and tabulating the data.

To avoid errors in the data tabulation process, zeros should be used to fill in all blank positions in all geographic identification code fields. For example, a code for the 13th area would be 0013 if the code was designed to have four digit positions.

3.34 Authority for code development and revision.--Some one person or group must have complete responsibility for developing the geographic identification code scheme and revisions, and for assuring that the codes are complete and are correctly followed. Allowing differences to exist will result in a breakdown in the system of processing and tabulating and may result in a delay of months (or even years) in the publication of census results. However, it will always be desirable and necessary for the subject matter staff responsible for the publications and the computer staff responsible for the processing to participate in the development of the original code scheme and in the review of the appropriateness of code revisions.

3.4 *Population estimates*

Estimates of population or housing units[1] are needed for planning the individual EA's and for planning the total number of enumerators, number of supervisors, and quantities of materials that are needed for the entire census operation. Estimates are needed for

[1] *Estimates of population can be derived from the estimates of housing units by assuming an average number of persons per housing unit.*

each administrative area and for all the intermediate levels of areas. If a previous census has been taken, the results may form the basis for making current estimates.

Estimates of population or housing units may come from many sources, but ideally such estimates should be provided by provincial and local government officials who have some idea about where the population has been increasing or decreasing, and by how much. In some instances, a quick count of houses in an area will be needed. Where aerial photographs are available, estimates may be made from the photos. Although some of the estimates may be very rough, they will be useful. The process of defining EA's implies the making of estimates, even if there is no formal estimating procedures. Whenever the NSO staff must make field visits, they should be keenly aware of the need to obtain current population estimates. Whenever formal requests for maps are sent to regional and local officials, the requests should include obtaining current population (or housing unit) estimates.

3.5 *Determination of enumerator workload*

The enumerator workload is the average number of inhabitants that an enumerator will canvass during the enumeration period. This figure is needed for planning purposes. How large or small the figure will be depends on many considerations that are not geographical, such as the length of the enumeration period, the number of questions to be asked, the availability of enumerators, the cost, and other items. The average enumerator workload may differ between urban and rural areas and between centers of dense population and areas of sparse rural settlement. The field operations staff must be consulted and they must take an active part in determining the average enumerator workload.

4. *BASIC MAPPING AND RELATED TASKS*

An early start in the mapping operations is fundamental for developing the maps and obtaining the boundary information that is required for both censuses and surveys. Such work must be largely completed by the date of enumeration. The pre-enumeration mapping tasks include the acquisition and evaluation of maps, map revision, preparation of enumeration maps, and training of field staff in how to use the maps. During the enumeration, maps are received in the NSO, checked against the NSO Master List of EA's, and then filed. In some instances, corrections that are made during the census enumeration are reviewed and are carried through to publication. Of the major mapping tasks, only the preparation of the publication maps remains to be completed after the census field enumeration.

4.1 *Acquisition and evaluation of maps*

To develop the necessary cartographic knowledge to improve the taking of a census, several initial activities are required. They include examining earlier national censuses, making a list of all administrative and statistical areas, preparing an inventory of maps, determining the kinds of maps that are needed and where they can be obtained, and evaluating the maps and boundary information available.

4.11 Examination of previous census records.--The first step in preparing to take a census is to examine the publications and other records of the previous census so as to learn some of the requirements and problems that may arise in a new census. It is always desirable to build on the experience of the last census by searching for its successes and avoiding its mistakes. This applies to the geographic and mapping program as well as to other census operations. Examination of

the results will reveal what geographic areas were used in reporting data for the previous census and what kinds of maps appeared in census publications. Records may show how the census was taken and, of special interest, what maps were used in enumeration. If these census maps still exist, a detailed inventory of them should be made. An evaluation of such maps as to their coverage, quality, field notations, and sources will serve as an early guide in planning map acquisition for the current census.

4.12 Preparation of area listing and map inventory.--Another early task is to prepare a list of all administrative areas, statistical areas, and any other areas for which data will be tabulated in the census. Usually this list is developed by the geography staff and the subject matter staffs. Following this step, an inventory should be made of what maps are available for each of the areas on the list.

4.13 Kinds of maps needed.--Several different kinds of maps are needed for census planning, as briefly outlined below:

(1) National maps (maps of the entire country) showing major administrative divisions, major physical features, and the location of cities and towns. Ordinarily these will be single-sheet maps at a relatively small scale.

(2) Planimetric or topographic multiple-sheet maps at a relatively large scale. (The planimetric map has no elevation contours; the topographic map does.)

(3) Maps of major administrative divisions or regions showing levels of subdivisions and location of places.

(4) City and town maps or plans. Normally these will be large-scale maps showing all roads and streets.

(5) Special maps illustrating the distribution of physical features, population, transportation, and the like.

Not all of these types of maps may be available or up-to-date or accurate. Nevertheless, whatever maps are available will be useful.

The above is a list of the kinds of maps that are needed for planning and preparing base maps. For enumeration and publication purposes, the NSO will need to prepare the following kinds of maps:

(1) EA maps of relatively large scale for use of the field enumerators.

(2) Crew leader maps for persons who supervise the enumerators.

(3) District and province maps showing the crew leader areas that are under the supervision of a field office.

(4) Selected types of maps for statistical presentation of data.

4.14 Sources and acquisition of maps.--Whatever maps are not in hand must be acquired from various sources, mainly within the country. These sources include:

(1) National government departments, both civilian and military, such as the national mapping agency, military mapping agency, and other government departments which make or use maps for planning economic development, transportation and communication networks, etc.

(2) Provincial or regional governments

(3) Municipal, city, or local governments

(4) Private sources

(5) International sources

Acquisition of maps requires a coordinated effort on the part of those members of the NSO geography staff responsible for this activity. Such personnel must know or find the possible map sources and be persuasive in obtaining cooperation in furnishing map copies. Authority to pay the costs of reproducing maps may be required. Also, travel costs may be incurred to go to various places to inspect the maps that are available.

4.15 Evaluation of maps and boundary information.--The purpose of map evaluation is to determine whether the available maps are suitable for census use, or whether they must be modified, corrected, or even redrawn. It involves comparison of different maps of the same

areas to decide which are better. This evaluation includes the consideration of numerous map characteristics such as completeness of area coverage, suitability of map scale, date of preparation, clearness of print, ease of reproduction, and especially the usefulness and accuracy of the content.

Map accuracy may be difficult to judge, but some ideas about it may be obtained by comparing different maps of the same area. In most cases, dependence must be placed on knowledge of the integrity of the map maker or mapping agency or what they have to say about the accuracy of their maps. The best test is actual use of the maps in the field. Some field testing of the large-scale maps to be used in enumeration should be done on a sample basis by geography staff. This would involve taking detailed maps into the field and checking out specific features, such as roads, rivers, and boundaries, to determine if they are shown in their approximate positions on the maps. A field check should also determine whether a user, such as a trained enumerator or crew leader, could be expected to locate the map features and follow the map in canvassing the area to be enumerated.

Evaluation of the boundary information on the maps is also very important. Some maps show boundary information for major and minor administrative divisions; others do not. In some cases, the boundary information is drawn inaccurately; in other cases, it may represent a boundary that has been changed. Here, reliance must be placed on knowledgeable local officials to confirm boundary accuracy. A determination must be made as to which officials best know the legal or accepted boundaries, and an effort must be made to obtain their services in drawing or correcting boundaries. (Section 7 of chapter 3 discusses a number of specific characteristics that should be examined when maps are being evaluated for use in the census.)

4.2 *Revision and redrafting of maps*

Where maps and boundary information are not complete or some features are not shown accurately, it is necessary to introduce revisions. When maps require extensive revision or when poor quality linework will not reproduce well, redrafting is necessary. Where detailed maps do not exist, it is necessary to sketch or draft new maps. Vertical aerial photography is a valuable source of information in all of these situations. (Many of the points in this section are covered more extensively in chapter 6.)

4.21 Revise maps if possible.--It is almost always less costly to revise a map than to compile and draft a new map. Revision may include enlarging or reducing the scale of a map, which is an operation involving reproduction techniques and some photographic equipment. Or it may involve removing or adding features and names so as to clarify and correct the map, which is a drafting operation using information from various sources.

4.22 Redraft maps if necessary.--This operation involves taking information from several maps and, through reproduction and drafting, compiling a new map to more closely meet the needs of the census enumeration. This operation requires direction by personnel with considerable cartographic competence and good understanding of map characteristics and design.

4.23 Add boundary information if lacking.--Boundaries of different kinds of administrative areas are shown by different line symbols. Normally the sources of boundary information are other maps, usually those obtained from regional or local officials.

4.24 Update continuously.--If new and better maps become available or if boundaries are changed before the census is taken, the base maps should be replaced by the new ones or the earlier maps should be revised. For

changes that are found during the enumeration, instructions should be provided to the crew leaders and the enumerators to record changes in boundaries and major features (like new roads) for their own guidance in enumeration and future use by the NSO.

4.3 *Map field work*

As mentioned earlier, field work is required in a variety of activities performed by the geography staff. Some information may be provided on request by regional and local officials, but other investigations will need to be carried out by the personnel of the Geography Division with their special capabilities and training. These investigative activities usually are required as part of other geographic activities such as map acquisition, determination or evaluation of boundaries, etc. They are summarized below because the field mapping tasks are a distinct type of operation that requires a separate budget and a separate place in the calendar of operations.

4.31 Map acquisition.--Some maps that are adequate for enumeration may be available from regional or local governments or private sources, particularly if they are maps of cities or other urban areas. In some cases, maps may be obtained through correspondence. Whenever maps acquired from national sources are unsatisfactory and map requests by correspondence are unsuccessful, attempts should be made to obtain maps in the field by direct visit.

4.32 Boundary information acquisition.--Boundary information on maps for all administrative areas to be observed in census enumeration must be obtained from or verified by government officials. It is well if this can be accomplished by correspondence; if not, direct inquiry in the field is necessary. For the lower level administrative areas, such as villages, the boundaries may never have been recorded or even officially defined (except for a census) and disagreements may exist. If these can be solved before a census is taken, enumeration will be simplified and more accurate data can be published.

4.33 Map verification.--Maps can be compared and evaluated in ways that have already been noted. Where serious doubts on accuracy remain, there is need to go into the field and, by observation and measurement, determine what is correct. Census maps do not need to be perfect, but they do need to show the relative positions of areas and places well enough so that enumerators will not become greatly confused or lost when they are using them. For this kind of verification, trained personnel using automobiles (bicycles or boats in some cases) should visit the areas in question and resolve potential discrepancies if possible.

4.34 Map revision and map sketching.--Whenever all existing maps are clearly not adequate, then revision, redrafting, or map sketching are called for. Such work can only be done in the field by trained staff who have transportation available. Some techniques for developing maps where details are completely lacking are discussed in later chapters on aerial photography and map sketching (refer to chapters 4 and 5).

4.35 Gathering population estimates.--As mentioned earlier, the NSO field workers should at all times be keenly aware of the need for obtaining current population estimates. Population or housing counts in new areas and any local estimates will assist the geography staff in the planning of enumeration areas. All Geography Division staff in the field, whatever their particular mission, should seek this kind of information; for example, when formal requests for maps are sent to regional and local officials, they should be accompanied by a request for current population estimates.

4.4 Preparation of maps for enumeration

Maps with boundaries of administrative areas do not become census maps that are useful for enumeration until the boundaries and codes identifying enumeration areas (EA's) have been added to them. This operation involves a number of steps.

4.41 Delineate EA's.--Knowing the proposed enumerator workload (described in section 3.5), the geography personnel will divide the lowest level of tabulation areas (rural subdivisions or city subareas) into geographic areas that contain the approximate number of inhabitants or housing units proposed for the enumerator workload. This could be 100, 500, 1,000 or some other number of people; or it could be 20, 100, 200 or some other number of housing units. Depending on the accuracy of estimates of local population or housing units, this work may be done well or poorly. If the planned EA's are too large in population, they may have to be subdivided later in the field at the time of enumeration--a situation that may complicate the tabulation efforts. If the EA's are too small in population, census control and processing costs will increase. In delineating EA's, the boundaries that are selected should be visible features, such as roads, trails, streams, and shorelines. Administrative area limits may not follow such features but their boundaries never should be crossed in delineating EA's.

4.42 Locate Special EA's.--In a population census or survey, some population clusters require special enumeration procedures and, therefore, need to be identified and treated as Special EA's. These include such places as prisons, hospitals, transient hotels, convents, military installations, and similar institution-like places, including camps for nomads and refugee settlements. If a Special Dwelling Place occupies a large area, its boundaries may be drawn on the census map. If it occupies a single building or a small area, only the point of its location may be shown on the map by a symbol. In either case, these institutions or other Special Dwelling Places must be treated as Special EA's so that the field staff may assign specially trained persons to enumerate them.

4.43 Assign identification codes to all EA's.--The EA's are assigned consecutive numbers beginning with 1, normally within each 3rd order administrative division but in conformance with the geographic identification coding scheme that is adopted. This number together with the numerical codes of the 2nd and 1st order divisions will uniquely identify the EA.

4.44 Prepare EA listings.--EA listings contain the names and geographic identification codes of each administrative and statistical area and the EA numbers associated with them. The areas are arranged in logical sequence from the highest order division through each of the lower order divisions. Such listings are prepared in coordination with the preparation of the census enumeration maps. For a population census, the estimated population or housing unit count for each EA also is included. These listings serve a dual purpose: (a) provide the enumeration field staff and the central office staff with a control list of areas to be enumerated, as shown on the enumeration maps, and (b) provide the subject matter and computer staffs with a geographic tabulation list. These lists are customarily transferred to magnetic tape and form what may be called a master reference file of EA's.

4.45 Reproduce maps and EA lists.--Copies of the maps and EA control lists will need to be made for the NSO and the field census offices, with extra copies for the crew leaders

who are direct supervisors of the enumerators in the field. An individual map of the EA, preferably an enlarged copy, is required for each enumerator.

4.46 Define Crew Leader (CL) areas.--Areas assigned to individual crew leaders must be defined. In most census organizations, each crew leader supervises about 10 enumerators, although the number varies according to the difficulty of the data collection procedures, the transportation and communication facilities that are available, and length of time allotted to the enumeration activity. It is recommended that the crew leader areas be defined in the central office in order to maintain better control of the operation and to assure that there is no omission or duplication of coverage. The crew leader areas are usually delineated on the same maps that are used for EA delineation. The crew leader maps ordinarily are reproduced at a smaller scale to show an entire crew leader assignment on a single sheet. Lists of the crew leader assignments must be made to match the maps; the lists must be used for both central and field office control of field operations.

4.5 Training field staff in the use of maps

The best census maps will be of limited value unless the field staff responsible for enumeration is trained to use them properly. Training may involve direct instruction of the field supervisors and crew leaders by members of the geography staff; or it may involve the preparation of instructions on map reading and use of maps for inclusion in the manual for training enumerators.

4.51 Instructions on how to read census maps.--Many field personnel, crew leaders, and enumerators may not know how to read a map properly to obtain all the needed information from it. Special problems are presented by census enumeration maps which are at different scales or which show different types of boundaries and special symbols, geographic codes, and legends. With careful instructions this learning can be made relatively easy.

4.52 Instructions on how to use maps in enumeration.--The primary purpose of a census enumeration map is to indicate the area, and its boundaries, which must be covered by an enumerator during the canvass of his individual EA. It serves as a guide to prevent him from enumerating in the territory of some other enumerator and to insure that all parts of the country are covered. Yet, even though the enumerator reads the map correctly, it will not serve its full purpose unless the enumerator is told how to canvass the area most efficiently. It is necessary to plan the route of enumeration so that the enumerator will cover the EA with the least amount of travel and will not miss any part of the EA. Certain guidelines should be provided in the instructions (refer to chapter 8 for more details).

4.53 Instructions on how to correct census maps.--No matter what care is taken in the NSO to prepare census maps, there will always be some errors on them. These arise because of inadequacies in the base maps, incorrect information on boundaries, or simply because roads or other features have changed since the map was made. The crew leaders and the enumerators may recognize the errors and they should record the corrections on their copies, which should be returned to the central office after the enumeration. Specific instructions need to be provided on how to make these corrections (see chapter 8).

4.6 Check-in of maps after enumeration

When the maps are returned from the field after the enumeration, the NSO should check them against the Master List of EA's and attempt to recover maps for any missing EA's. The staff should review the returned maps for such things as changes or errors in administrative area

boundaries, and should record the changes on the official file copies for future use. In the case of annexations to a city, for example, the staff may need to use the EA maps (and the census questionnaires) to estimate the population in the annexed area.

Generally, the boundaries of administrative areas are set prior to the enumeration, and changes are not reflected until the next census or survey. Sometimes, however, major boundary changes which are discovered during enumeration may need to be made for the census that is being taken at the time. Such changes should be kept to a minimum; considerable error can be introduced into the processing of the results if changes are carried through after the enumeration takes place.

After the maps have been checked in, they should be filed systematically. Frequently, post-enumeration surveys or later statistical operations require that reference be made to the maps that were used in the census.

4.7 *Preparation of maps for census publications*

Maps, including charts and graphs, can serve two major purposes for users of census statistics:

(1) Identify, locate, and indicate the boundaries of areas for which statistics are provided.

(2) Portray the statistical values in cartographic form so that users may understand the geographic distribution of the census data.

These purposes result in two types of maps--administrative and statistical area maps and statistical data maps.

4.71 Administrative and statistical area maps.--Maps of this type are standard aids in all good census publications. They show in outline form the boundaries of all major and minor administrative areas and statistical areas for which data are published or tabulated. Not all levels of divisions can be shown on the same map. If the country is large in area, perhaps only the 1st and 2nd order divisions can be shown on small-scale maps of the entire country (or major portions of the country).

Maps of major administrative divisions may be needed to show lower-order divisions; maps of metropolitan areas or cities may be needed to show individual statistical areas such as census tracts or city blocks or to show municipal administrative areas such as wards. Ordinarily these maps will be printed in black and white; boundaries are indicated by line symbols and subdivisions or separate areas will be identified by names that are printed on the map.

4.72 Statistical data maps and charts.--Statistical data maps add considerably to the understanding of the geographical distribution of tabulated data. Indeed, they are essential for the presentation and analysis of data by areas. They usually take the form of dot maps or area-shaded (choropleth) maps and may be presented in black and white or in color. They represent a service to the data user, and their construction is one of the last operations in completing a census.

Statistical graphs or charts may be used to present data for some regional comparisons, but they primarily serve to highlight data characteristics of a non-geographic type, such as time series, proportional relationships, frequency distributions, and the like. Since their preparation requires many of the same materials and talents that are required in making statistical maps, the geography staff usually prepares charts and graphs as well as maps. (See chapter 9 for details on how to prepare statistical area and data maps and charts for use in the census publications.)

5. ADMINISTRATIVE CONCERNS

Some basic decisions that affect a mapping program were discussed earlier in this chapter (see section 3). Additional concerns of a planning or administrative nature are described below. They must be considered, and tentative answers must be supplied, before the NSO can assemble a staff sufficient to carry out the tasks of the mapping program.

5.1 Organization of the Geography Division

The staff for the mapping program will need to be recruited, organized, and trained to accomplish the various functions which have been discussed in section 4. It is suggested that this staff comprise the Geography Division of the NSO (see exhibits 2-1 and 2-2). The possible elements of this staff, the functions they will serve, and the personnel required are presented below.

5.11 Planning Branch.--In the very early planning stages for a census, attention should be focused on the geographic and cartographic requirements. Meeting these requirements takes a long period of preparation and, except for publication mapping, these operations all must be essentially complete before any enumeration can begin. For this reason, it is imperative that competent personnel be engaged in planning the mapping program at least 2 to 3 years before the census is taken.

The planning staff is responsible for making all of the technical decisions described in section 3 of this chapter, although some of these decisions will be made in collaboration with other staffs of the NSO. These technical decisions include the selection of the administrative and statistical areas for which census data are to be reported, the creation of the geographic identification code scheme, the collection and review of the population estimates that are needed, and the determination of the enumerator workload. The planning staff must lay out the overall work calendar for the mapping program; determine the workload requirements for each program element in terms of time, personnel, and cost; and determine how best to recruit and train personnel. They must estimate space and equipment needs for each program element, and finally they must calculate the budget requirements for achievement of the objectives of the mapping program.

The planning staff should include the very best people available with training and experience in geography and cartography; preferably, they will include persons with previous census experience and/or special training in geography and cartography. Ideally, the chief of the Geography Division will be chosen from the planning staff (if he has not already been named), and the others will form the nucleus of the supervisory mapping staff.

5.12 Cartographic Branch.--Ordinarily, the Cartographic Branch would have responsibility for three of the basic mapping tasks that were discussed earlier in the chapter:

(1) Base map compilation
(2) Drafting
(3) Reproduction

An experienced cartographer should supervise the Cartographic Branch with other professional assistance when necessary. This staff would be engaged in cartographic work throughout the census period. (Details on map compilation, drafting, and reproduction are discussed in later chapters.)

The compilation staff would have the responsibility for (a) acquiring and evaluating maps, aerial photos, and boundary information, (b) preparing the instructions for the drafting staff on how to revise and construct base maps, (c) doing map sketching and certain other field work, and (d) reviewing the final base maps

after they have been drafted. The staff should include geographers/cartographers and competent clerks. For the most part, the staff should be able to work on more than one task assigned to the Branch, or to other Branches. For example, when they finish map compilation, they should assist in the delineation of EA's.

The drafting staff would be responsible for the redrafting of revised maps and the construction of new maps based on the instructions of the compilation staff. The staff should comprise personnel with training or experience in drafting.

The reproduction staff would be in charge of map reproduction by photographic and/or other copying methods. This staff should be supervised by someone who has experience in photography; others would be competent clerks who could be trained on the job.

5.13 Statistical Areas Branch.--A staff competent in urban and economic geography is required to develop the criteria and procedures for defining statistical areas. The definition and delimitation of statistical areas should be performed as early as possible in the preparatory stages of the mapping program; later, the staff could assist in other mapping tasks such as the preparation of enumeration maps, training and supervision, and preparation of publication maps.

5.14 EA Delineation Branch.--This Branch is active only at the time of the census. It has the heaviest burden in the entire mapping program--delineating all the individual EA's on maps. This work must be done just before the enumeration and there always will be pressure to get the work done on time; however, it is a job that can be done by competent map clerks or technicians with professionally developed instructions and good supervision. The supervisor should be a professional person who has some training in geography.

5.2 *Place of Geography Division within the NSO*

Since the Geography Division is an integral part of the NSO, its activities must be coordinated with those of other divisions in the NSO. Close relations are required with the various subject matter divisions and with the Field Operations Division. Since the subject matter divisions have responsibility for determining the statistical data to be collected, tabulated, and published, they have a strong interest in the geographic areas for which the data are presented. Likewise, the Field Operations Division, which must conduct the enumeration using the maps prepared by the Geography Division, must be satisfied that the maps and the EA's do not cause problems in the field that could be avoided. The cooperation of these divisions through their participation in the development and approval of the geographic program is quite essential. On the other hand, this does not mean that these divisions should dominate the development of a geographic program which is outside their areas of expertise, but rather that their views and experiences should be considered so that accord may be reached on a geographic program most acceptable to all map and data users. One way of achieving such cooperation is through an intra-agency geographic areas committee in the NSO with representatives from all the divisions concerned.

5.3 *Space and equipment needs*

Space and equipment needs, like personnel, are difficult to prescribe except in terms of the known needs of a particular country. Here, an attempt is made to indicate some important considerations with regard to space and to list the major types of equipment and materials that will normally be needed.

5.31 Office space.--More building space per worker is needed for the geographic and

cartographic facility of the NSO than for most other statistical activities. The reason for this is that most maps are large in size, and often several must be spread out at one time when they are used by individual workers. In the course of the work, large maps must be compared one with another. Reference maps and all incoming maps must be stored while not in use, and many duplicate copies which are made in the preparatory stages also must be stored until they are sent to the field for enumeration. Every worker needs a large table or desk, and much additional space is required for map files and map reproduction equipment.

5.32 Equipment and materials.--The equipment and materials listed below are suggestive rather than complete. Later chapters will indicate additional items that may be essential.

(1) Furniture--tables, desks, chairs, bookcases, drafting tables, stools, and light tables.

(2) Files--map files, letter files, and card files (preferably of steel construction).

(3) Lighting--overhead and desk lights (preferably fluorescent tube lights).

(4) Office supplies--paper, pencils, pens, file folders, file cards, staplers, pencil sharpeners, colored pencils, etc.

(5) Drafting equipment--drafting pens of various types; drafting paper, cloth, and film; drafting ink, scribing tools, triangles, curves, lettering guides, pantograph, polar planimeter, etc.

(6) Photographic equipment--cameras, printers, enlargers, chemicals, films, paper, etc.

(7) Other copying equipment--xerographic, diazo, blue print, etc.

5.4 *Budgeting*

Good financial budgeting for the mapping program is a difficult and complicated problem, but is not unlike preparing budgets for any other type of government work. The availability of budget records and expenditures from previous census mapping programs can be most helpful in developing the current budget.

5.41 Steps in the budgeting process.--The various steps in the budgeting process are outlined as follows (some have been mentioned earlier in the chapter):

(1) List all the mapping jobs and activities, indicating in detail (so far as possible) all of the separate operations that are required to reach the objective. List the operations in sequence.

(2) Determine the time frame within which the jobs must be completed. Most of the mapping program must be completed 2 to 3 months before the date of the census. That date normally is set at the beginning of census planning or is required by law.

(3) Estimate the time required in man-years to complete each operation in step (1). Estimate the grade or salary level of employees needed.

(4) Determine the salaries that will be paid to each type of employee (professional, supervisor, and clerk).

(5) Determine the number of employees needed at each salary level and the total estimated personnel costs.

(6) List supplies and equipment that must be acquired and the total estimated cost.

(7) Estimate travel costs for field investigation work.

(8) Add (5), (6), and (7) and any overhead to arrive at the total estimated budget cost.

(9) Consider alternative methods and costs, balancing funds available with alternatives that would still meet the objectives. Arrive at a final budget.

5.42 Relationship to the total census budget.--The elements that affect the geography and mapping budget within the NSO, both in terms of its total size and as a percentage of the total NSO budget, vary widely among countries. It is impossible to give a single total cost figure or the proportion of the total NSO budget that is needed to carry out the mapping program. Salary levels and other local costs vary considerably, as does the value of space. The resources upon which the program can build also have a great impact on the budget. The country may have been entirely covered by topographic maps prepared within the last 5 or 10

years. There may be hundreds or thousands of square kilometers of territory which never have been mapped or photographed and for which there are only military sketch maps that are many years old.

Boundaries may be legally defined well-established and well-known lines; or they may be undefined lines whose location has been a matter of long-standing dispute. The budget would need to include the costs to settle the disagreements. Previous census materials may have been well prepared and kept in good order; or they may have been lost or may never have existed. In either case the budget is affected. The mapping program may be as little as 5 percent of the total estimated cost of the census or as high as 25 percent.

5.5 *Training of personnel*

In a census mapping program, most of the employees can be trained to do many of the required operations provided that they are literate, have an elementary understanding of mathematics, and have an interest in maps and a certain degree of intelligent initiative. They may be trained on the job or in small classes. The training will vary, depending on the work to which the employee is assigned; however, almost all except some professional staff will need instruction in how to read and evaluate maps for accuracy and completeness. Persons who are to be map draftsmen will need special training and experience in the use of drafting equipment and materials.

The training should not be left to chance or it will be of little value. It must be planned carefully, organized carefully, and carried out in a systematic manner. A brief outline of the topics to be covered include:

(1) Need for census maps
(2) How to read maps
(3) Evaluation of maps and boundaries
(4) Map correction and revision
(5) Map reproduction
(6) Preparation of area lists, enumeration maps, and other field-use maps

Training of this nature should be given to all employees working on maps in the Geography Division. Selected personnel will need training in air photographic interpretation, field work, and map sketching. Cartographic draftsmen will need instruction in the design, layout, and drafting of maps, including the redrafting of existing maps and the use of drafting tools. Special instructions will be required for the preparation of publication maps, graphs, and charts.

Those responsible for the training will be geographers and cartographers who have had professional university training or have had experience equivalent to university training. However, many geographers and cartographers lack practical census mapping experience; their capabilities could be greatly improved through regional or international workshops or through on-the-job training in a statistical office that has an active mapping program. It is most desirable that persons trained in mapping activities not be transferred to other census operations before all the mapping tasks are completed (at least the pre-enumeration tasks).

5.6 *Administrative controls*

Even a well-planned mapping program may fail to achieve the objectives of timeliness and accuracy if it is not pursued with vigor and efficiency. While there is no substitute for good management, there are a number of steps that can be taken to make the process of management more effective and help assure that adequate continuous progress is made.

5.61 Calendar of activities.--The census planning staff should prepare a calendar of activities that will indicate the starting and ending dates for each major operation that is needed to carry out the whole census program.

If the calendar is observed, it will assure that the earlier activities are completed so that they do not make it difficult to complete the final critical work on enumeration maps required by the enumeration date. Unforeseen difficulties may make it impossible to observe all of the calendar dates. If that occurs, it will be a warning that extra effort must be exerted to meet the future workload schedule.

A calendar of all key activities that are carried out in a census is usually prepared early in the planning stages. The one illustrated in exhibit 2-3 lists the activities under broad functional categories and indicates the beginning and ending dates. The amount of time allotted to each task depends on the number of persons that can and should be assigned to the job. Some activities can be completed faster if more persons are involved, while others can use only a limited number of people.

In exhibit 2-3, the scheduling centers around the census date, 1 July; plans for the census, including decisions on mapping, start 2½ years before the census date. Other census activities are scheduled to be completed 2 years after the census date; still others are continuing activities that extend beyond the dates shown in the calendar.

A separate calendar is prepared for each major census operation, as illustrated in exhibit 2-4 for the mapping program. It shows more detail than the overall calendar; however, the timing shown in the two exhibits must be consistent. For example, the beginning and ending dates for reproducing delineated maps, line 23 of exhibit 2-4, must be within the time period shown on line 22 of exhibit 2-3 for preparing and reproducing field-use maps.

5.62 Production and scheduling.--A production schedule shows how much of each activity is expected to be completed within specific time periods. For geographic work, it must be determined how much of each operation must be completed in each month to meet the dates that were established in the calendar of activities. Most operations are accomplished by gradually building up the number of people to do the work, so the production is gradually increased to a maximum level. The units of production that are reported ordinarily will be 2nd order divisions within which EA's are delineated, but they may be statistical areas or map sheets.

Production scheduling will assist in the preparation of detailed monthly budget allotments. It also provides goals against which progress reporting can be measured.

5.63 Progress reporting.--An organized written method for recording progress in the various operations of the mapping program is essential to management. It is desirable that this reporting be weekly and monthly in terms of numerical units of workload, when possible. The units may be measures such as maps requested; maps received; jobs done on maps; administrative areas, statistical areas, or EA's completed; etc. Progress can thus be evaluated with reference to the production scheduling--how much time is available to do the work and the percent of the work completed in relation to the time that is available. Progress reporting gives management a tool for measuring one aspect of success toward reaching its goals.

Progress reporting does not measure quality or accuracy of work. For this, there must be close and responsible supervision of the work while it is being done.

5.64 Records and files.--In the mapping program, it is important that accurate records and files be maintained. Records are complicated somewhat because there is usually more than one map for any particular area; on the other hand, a specific area may appear on more than one map. It may be desirable to make a card

record of each map and to know where the map is at all times. For other purposes, a list of areas or EA's may be more appropriate.

Many of the points mentioned here require elaboration and practical examples of the kinds of forms that will be helpful in implementing them. These are provided in later chapters, particularly in 6, 7, 10, and 11.

5.65 Communication.--To increase the efficiency of all employees and to maintain high morale, communication of the aims and policies of management is essential. Workers need to know the purpose of each activity and how management regards their contribution. If policies or procedures are changed, employees should be promptly informed of the changes and the reasons why they are necessary.

Each employee should have the opportunity to make suggestions for improving the work procedures and the quality of the work. Communication may be facilitated by notices and memoranda, but these are no substitutes for regular staff meetings for review of progress, discussion of problems, and announcement of decisions by the supervisor who is responsible.

6. QUALITY CONTROL

One of the primary purposes of a census is to produce reliable statistics for making decisions that will result in some action. To a large extent, uses to which statistics are to be put should determine how accurate they must be. Thus, the greater the precision that is required, then the higher the quality that is needed in the data. On the other hand, it is "dis-economy" to require of data a quality higher than needed for their intended use.

Quality control consists of the procedures used to measure the accuracy of performance and to limit the number of errors to an acceptable degree. Quality control applies to many census operations, including the preparation of maps.

The output of a mapping program is largely the product of human rather than machine effort, and human error is highly variable in both productivity and accuracy. In mapping operations, the desirable low level for some tasks is a zero error rate, while for others there is not a true requirement for perfect quality. For example, in EA delineation, each area should be divided into EA's with absolutely no duplication or omission; otherwise, there will be difficulty in later operations and considerable error may be introduced in the census results. On the other hand, when drafting features onto a base map, it is not serious if the distance between features is inaccurate as long as the relationship between features is correct.

Quality control applied to an operation attempts to limit, to pre-determined levels, the amount of error occurring in the operation. This is accomplished by reviewing the work and removing as many human errors as possible without the expenditure of excessive amounts of time or money.

Quality control applied to individual employees requires that their work be measured by verification and that records be maintained to evaluate their performance. Employees who have the best productivity with acceptable quality can be advanced to more responsible assignments. Those with poor performance should be retrained, encouraged to improve, or removed from the work.

Decisions on how quality control is to be carried out should be made early in the census planning and preparatory stages. Otherwise, an operation may be very costly (and perhaps even impossible) to carry out because there was inadequate control on the quality of the previous operation. For example, the enumerator may omit a portion of the province because EA boundaries were incorrectly drawn on his map. Or the tabulation of the census results for a city may be completely erroneous because wrong identification codes were entered on the

EA books (subsequently copied to the census questionnaires, then to punch cards). To aid in setting up quality control procedures, it may be helpful to make a list of materials and activities that should be checked and a brief description of how quality control should be carried out. Such a list may need to be updated or revised from time to time as progress is being reviewed; nevertheless, such a list will serve to remind the NSO staff of specific materials and operations to be checked.

6.1 *Controlling quality of mapping program*

Several methods or procedures can be used to control the quality of a program. The principal ones for the mapping activities are the (a) evaluation of maps for census purposes and (b) verification of the products of each step in the mapping operations. Evaluation is used in the inventory and acquisition of maps (discussed earlier in section 4.15 of this chapter). Each map is evaluated as to its possible usefulness for the census--the scale of the map, size of the map sheet, amount and kind of detail that is shown, date of construction of the map, line-work, lettering, reproducibility, etc. Quality of operational steps involves, for the most part, a review by the professional staff; decisions are based on intuition, experience, and established acceptance specifications. The procedures for establishing and maintaining quality of an operation involve the following:

(1) Selecting personnel who have an aptitude for, or experience in, mapping work.

(2) Establishing an effective and continuing training program.

(3) Identifying persons who produce work of poor quality, then retraining or removing them from the operation, as necessary.

(4) Identifying work of substandard quality, then re-doing or correcting, as necessary.

The points outlined above are not mutually exclusive. In fact, several of them need to be considered at the same time. For example, when work of substandard quality is detected, then persons responsible for that work are identified as unacceptable; moreover, they would be the persons in need of additional training.

6.2 *Verification procedures*

As mentioned earlier, the quality of maps affects the enumeration and the census results. The maps need to be reasonably accurate when they are given to the enumeration staff; maps that are inaccurate or deficient cannot be returned to the NSO and easily replaced by good maps during the enumeration. Similarly, inaccurate statistical maps in the census publications can possibly lead to wrong decisions by users of census data. Examples of steps to be verified include the following:

(1) Map compilation. Certain features on resource maps should be verified if the maps are used to prepare base maps for enumeration. Contents of map packages prepared for the drafting staff should be verified for completeness and clarity.

(2) Drafting. Base maps that are prepared by the drafting staff should be checked against the instructions and should be reviewed for accuracy and reproducibility.

(3) Reproduction. Copies of the reproduced maps should be checked for readability.

(4) Delineation. EA delineation should be checked for boundaries and desirable size. There must be no duplication or omission of area.

(5) Identification. Each map should have the proper identification codes and names, legend, north arrow, etc.

(6) Publication. Maps and charts prepared for publication must be verified for accuracy and conformance to technical and statistical standards.

The amount of verification of a mapping activity depends on how seriously an error can affect the census as a whole. Certain information must be reviewed on every map, whereas other items or features need not be verified completely. (See later chapters for details on quality control of specific mapping tasks.)

7. *OPERATIONAL CONTROL*

For purposes of this manual, operational control is distinguished from quality control. Operational control refers primarily to the control of the flow of materials to and from the field and through the various operations within the central office of the NSO. It is equally as important as quality control and, like quality control, decisions on how it is to be carried out should be made early in the planning and preparatory stages of the census.

The control system deals with the maintenance of records which show the location and movement of census materials at every stage of the program. The control functions are accomplished by using the records to (a) determine the location of materials, (b) oversee progress of the work, (c) make decisions relating to the priority and flow of materials through each activity, and (d) identify trouble spots where special attention may be required so that the operations meet the time schedules.

7.1 *Considerations in establishing a control system*

A census or survey of a country is a large and complex undertaking. A primary objective for the control of materials is to assure that assignments for each EA are sent to the field, that they are returned to the NSO, and that all questionnaires are processed and are included in the final results--without duplication or omission. Errors in keeping records can be costly. They can result in unnecessary trips to the field, for example, or wasteful duplication in drafting a map that already exists. Similarly, illegible handwriting or misfiling may have the same effect as losing a map.

It is important also that information be entered on the records promptly. If entries are delayed, the management staff cannot make precise judgments concerning the status of the work and the need for corrective action.

In setting up the operational control system, procedures should be kept as simple as possible. The essentials should be included, but the operation and control forms should not be cumbersome. There should be sufficient control but not "overcontrol" or "undercontrol."

7.11 Materials to be controlled.--The materials that are to be handled determine the control procedures and the kinds of control forms that are needed. Bulk supplies of questionnaires, for example, would be handled differently from individual EA maps. In a mapping program, the compilation of base maps may involve sections of maps of larger areas, various types of maps (topographic, aerial photographs, city maps), instructions to the draftsman, etc. Correspondence to and from local officials may be involved in specific operations and must be made part of the control record. Materials and equipment used in aerial photography, drafting, and reproducing maps may be important enough that there should be an accounting to assure adequate supplies when needed.

7.12 Unit of control.--When planning the control system, it is necessary to select the "unit of control" that is appropriate for the particular operation. This "unit of control" need not be the same for all operations. In making up a list of administrative and statistical areas for which census data are to be published, each such area must be listed. For purposes of map acquisition, the record would be kept by area; when base maps are being compiled, the maps for all areas within a district (2nd order division) might be used as the unit of control Progress on delineating EA's might be recorded both by individual EA's and by 2nd or 3rd order divisions when they are completed. The choice of the unit of control depends on the number of such units and the nature of the operation. For some purposes, such as reproducing individual EA maps, it is necessary to

make certain that maps are reproduced for each EA and that each EA is assigned to some crew leader; however, for purposes of distributing these maps, a larger unit of control probably would be more appropriate.

7.2 *Characteristics of control forms*

In designing control forms, attention must be given to identifying each form clearly and to presenting a clear picture of the purpose and use of each form. Consideration also should be given to such physical features as size, color and quality of paper, uniformity of style of printing, consistency in location of items that appear on several forms, etc. Basically, it is desirable for a control form to serve only one function. Transmittal forms should be used only for transmitting materials, progress report forms only for progress, etc. However, there are cases where a form can well serve more than one purpose; for example, it may serve as a transmittal, a report of completed work, and a record of EA's that make up a work assignment or administrative unit.

7.3 *Flow chart of control operations*

Control must take account of all the major operational steps in the census. As with the calendar of operations, a chart should be constructed to indicate the flow of all key operational steps in the census program. A separate flow chart would indicate more specific steps for the mapping program, as illustrated in exhibit 2-5. Note that the important control records are the responsibility of the Central Control staff of the Geography Division.

8. *PROCEDURAL HISTORY*

In order that future census or survey activities may benefit from the successes and the failures of the mapping program, a comprehensive procedural history of the operations is indispensable. It should cover all stages of the program--from preparing the inventory to publishing maps and charts. It should contain policy decisions, procedures, copies of forms, and evaluation memoranda. To be most effective, such materials should be gathered and filed as the program progresses.

Chapter 3. MAP INTERPRETATION

1. INTRODUCTION

Chapter 3 describes how to interpret the scale, symbols, and other information that may be shown on a map. Understanding a map and what it shows is preliminary to evaluating it, revising it, or using it for the various census operations of planning, data collection, and publication. Some of the discussion is technical; it is included for the convenience of those who are interested in understanding some of the details of map construction.

In this chapter, emphasis is placed on those characteristics of maps that must be understood by census staff who are responsible for evaluating and selecting maps and for using them as a base for the preparation of other maps for the census. Those characteristics of maps and procedures for their use that are important to the enumerator in the field are discussed in chapter 8.

2. MAP FUNDAMENTALS

Maps are widely available and they come in a number of forms from various sources. They are used by many individuals and many organizations, both public and private. But despite their wide availability and use, maps often are not well or fully used. To make the most effective use of maps, the user must be able to understand and interpret the various markings that appear on them. The user must be able to understand the map symbols, determine distances, and locate places.

2.1 Description of a map

A map shows part or all the Earth's surface. Also, a map can show the heavens, or it can show the surface of some heavenly body; but this kind of map does not concern census planners. Generally, a map is a representation of what would be seen from some point above the surface of the ground; it attempts to give the appearance of a flat (plane) view of a particular area.

Although it is similar to a picture, a map is not a photograph. It is a simplified representation of the real world; therefore, not everything that exists in the real world is shown on a single map. Certain things are selected and emphasized; others are ignored, eliminated, or de-emphasized.

A map shows the real world at a reduced scale; that is, the real world is compressed into a small area on the map. The extent of reduction influences the kind of features and amount of detail that can be shown.

Natural and man-made features found on the surface of the Earth are represented on a map by symbols. The choice of the features to be represented by symbols and the size of the area to be mapped depend on the purposes for which the map is prepared.

2.2 Map elements

There are two major elements that must be examined in order to understand a map: (a) horizontal scale and (b) symbols. Horizontal scale (hereafter referred to simply as "scale") is the relationship between distances on the map and actual distances on the Earth's surface. Map symbols represent both natural and man-made features such as rivers, swamps, parks, roads, houses, public buildings, and administrative area boundaries. The explanatory list of symbols used on a map is known as the map legend.

Some maps show a third element--elevation. It is defined as the height above sea level. Variations in elevation result in the recognition of landforms and in the development of drainage features on the Earth's surface. The difference in elevation within an area is known as relief.

2.21 Scale.--The scale enables the map user to translate distances between points on the map into corresponding distances on the ground. By using the scale, census staff can determine distances required for field checking the maps, for conducting the enumeration, etc. The scale always should be shown on a census map, although an exception may be made for maps of relatively small areas such as city blocks, where distances are usually short.

2.22 Map symbols.--The symbols used on maps may be in the form of figures, lines, colors, or patterns. They are used to indicate certain features on the ground such as structures and roads, characteristics of the landscape such as land cover or use, and administrative boundaries.

2.23 Elevation and relief.--For an area which has rugged and difficult terrain (physical features of the Earth's surface) the map user undoubtedly would like to know where the higher and lower parts of the local landscape are located, and what differences there are in elevation (relief). Knowledge of the terrain can be of great importance to the geography staff when crew leader and enumerator assignments are being set up.

2.24 Other map elements.--Other elements help the user to interpret the map: (a) grid coordinates describe all points on the Earth, (b) type of projection indicates the amount and kind of distortion of the features, (c) north arrow orients the map by compass directions, (d) date of the map reveals how current it is, (e) source of the original materials and the name of the map-making agency give some idea of the reliability and accuracy of the map, and (f) sheet number, or series number if the map is part of a series, helps in locating other maps for the same area. The geography staff should consider all these elements when they evaluate maps for their utility in a census.

3. SCALE

As defined above, scale is the relationship of the distance between any two points on the map to the horizontal distance between those same two points on the actual surface of the Earth. Without an expression of scale on a map, it is difficult to determine distance on that map.

3.1 Ways of expressing scales

Scales may be expressed in three ways: (a) word statement, (b) numerical fraction or ratio, and (c) graphic scale. Often only one type of scale is shown; it is usually found in a prominent place on the map.

3.11 Word statement.--A word statement indicates relationship of the distance between places on the map and actual distance between these same places on the Earth's surface. Word statements are not suggested for census work, partly because they are often difficult to use.

The following are some examples of scale expressed in terms of a word statement:

(1) Two centimeters represent 1 kilometer. A distance of 2 centimeters on the map represents a distance of 1 kilometer on the ground.

(2) One inch represents 1 mile. A distance of 1 inch on the map represents a distance of 1 mile on the ground.

(3) One inch represents approximately 16 miles. A distance of 1 inch on the map represents a distance of approximately 16 miles on the ground.

3.12 Ratio or representative fraction.-- A scale may be expressed as a ratio or as a fraction. Thus it may be shown as

$$1:x \quad \text{or} \quad \frac{1}{x}$$

for example,

$$1:25{,}000 \quad \text{or} \quad \frac{1}{25{,}000}$$

The ratio and the fraction have exactly the same meaning.

Although the ratio or fraction is usually found on good maps and is the most commonly used scale expression in air photo work, it has some disadvantages compared with other forms of scale on census maps. The major disadvantage is that it is difficult to visualize for people who have not had some training in its use. Also, if the map is enlarged or reduced, the ratio or fraction changes and it must be recalculated. On the other hand, expressions of scale, such as word statement or graphic, are almost self-explanatory and can be used with little experience. If a map is enlarged or reduced, the word statement also must be changed; when the size of the map is altered only the graphic scale changes automatically (see section 3.4).

The major advantage of a fraction is that it is independent of the type of measuring units used. It conveys the same meaning to some[illegible] who uses the English system of measurem[illegible] as it does to someone using the metric system. A ratio of 1:5,000 indicates that one inch on the map represents 5,000 inches on the ground. With metric measurement, one centimeter on the map represents 5,000 centimeters on the ground. It also has the advantage of giving a clear indication of the amount of reduction (and amount of detail) of the map. For example, a scale of $\frac{1}{50{,}000}$ means that a road is shown on the map as $\frac{1}{50{,}000}$ of its actual length. It should be noted that areas are reduced in two dimensions; in the example, an area would be reduced to

$$\frac{1}{50{,}000} \times \frac{1}{50{,}000} \quad \text{or} \quad \frac{1}{2{,}500{,}000{,}000}$$

of its original size. This serves to emphasize the fact that "scale" normally refers to linear relationships and not to area relationships unless specified.

When a ratio or fraction is used to identify scale, both the numerator and the denominator have the same measuring unit. Thus, if the measuring unit is a centimeter, then the ratio or fraction means that one centimeter of distance on the map represents x number of centimeters on the ground.

Section 3.11 presented three examples of the ways in which scale is expressed in terms of a statement. These same examples can be expressed in terms of ratios or fractions.

(1) Two centimeters represent 1 kilometer. Since the measuring unit on the map and the measuring unit on the surface must be the same in a ratio or fraction, the measuring unit on the surface (in this case, "one kilometer") must be converted to centimeters. The metric system permits a rather easy conversion in this example. Since one kilometer equals 100,000 centimeters, the statement "two centimeters represent 1 kilometer" as a fraction would be

$$\frac{2}{100{,}000} \quad \text{or} \quad \frac{1}{50{,}000} \quad \text{or} \quad 1:50{,}000$$

The numerator of the fraction (first term of ratio), which represents the distance on the map, is always expressed as 1.

(2) One inch represents 1 mile. Since there are 63,360 inches in a mile, the statement becomes

$$\frac{1}{63{,}360} \quad \text{or} \quad 1:63{,}360$$

Note that the use of miles as a linear measure results in some awkward fractions and ratios. Sometimes, maps using the scale of one inch represents one mile (or 63,360 inches) or one inch represents 2 miles (or 126,720 inches) will not use

a fraction to express the scale. On the other hand, if a scale of 1:62,500 or a scale of 1:125,000 is used, a statement may be added that "one inch represents approximately 1 mile" or "approximately 2 miles," respectively. These kinds of scales often are used because they are even divisions of the commonly used maps having 1:1,000,000 and 1:1,250,000 scales.

(3) One inch represents approximately 16 miles. This example is very similar to the preceding example. Sixteen miles equals 1,013,760 inches. By adding the word "approximately," the word statement then becomes approximately

$$\frac{1}{1,000,000} \text{ or } 1:1,000,000$$

These examples demonstrate that the metric system is easily adaptable to small as well as large distances and is easy to understand in statements, fractions, and ratios. Below are several examples:

10 centimeters represent 1 kilometer

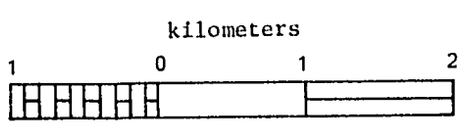
$$\frac{10}{100,000} = \frac{1}{10,000} \text{ or } 1:10,000$$

4 centimeters represent 1 kilometer

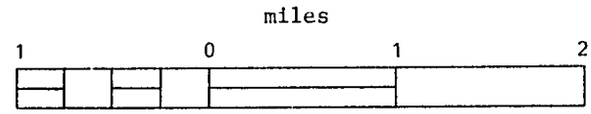
$$\frac{4}{100,000} = \frac{1}{25,000} \text{ or } 1:25,000$$

3.13 Graphic scale.--A graphic or bar scale shows the relationship between distances on the map and on the ground by means of a bar or line, with markings to indicate distances on the ground. Consider again the three examples that were shown in the preceding paragraphs. They can be expressed in graphic form as illustrated below.

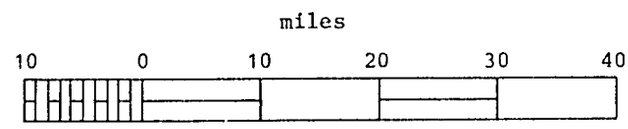
(1) Two centimeters represent 1 kilometer. The ground distance of 1 km actually measures 2 cm in length on the map. In the example used here, the portion of the bar to the left of the zero mark is divided into tenths to allow closer approximations of distance.



(2) One inch represents 1 mile. In this case, the ground distance of one mile actually measures one inch in length on the map. The portion of the bar to the left of the zero mark may be divided into halves, quarters, fifths, tenths, or some other convenient parts of a mile.



(3) One inch represents approximately 16 miles. In this example, one inch on the map indicates a real world distance of 16 miles. The portion of the bar to the left of the zero mark may be divided into units of 1 mile.



Generally, the representation of scale in graphic form is the most useful for census purposes. The graphic scale is the only satisfactory form for presenting scale on maps which are to be enlarged or reduced (and many census maps, or portions of maps, must be enlarged or reduced). The reason for this is that regardless of the degree to which the map is enlarged or reduced photographically the bar showing the graphic scale changes proportionately; whereas neither the reproduced word statement nor the ratio would continue to be accurate if the map is made larger or smaller. In other words, the word statement and ratio scales would have to be recalculated and rewritten on the map if the size of the map were changed through enlargement or reduction (see also section 3.4).

3.2 Use of scale to measure distances

Because the field and office staffs frequently need to measure distances, they need

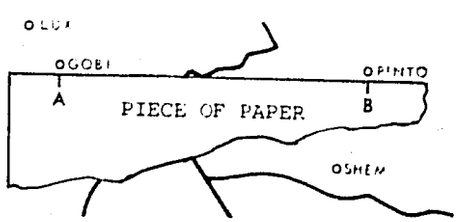
to understand how to use the map scale for this purpose. There are several fairly simple ways to measure distances with sufficient accuracy for use in most census operations. The procedures are best understood by several illustrations.

3.21 Ruler and fraction scale.--With a ruler, the distance between points A and B is measured on a map whose scale is 1:100,000. Assume that the distance measured on the map is 7.5 cm. Since 1 cm on the map represents 100,000 cm on the ground, then 7.5 cm on the map equals 750,000 cm on the ground. This is the equivalent of 7.5 km or about 4.7 miles.

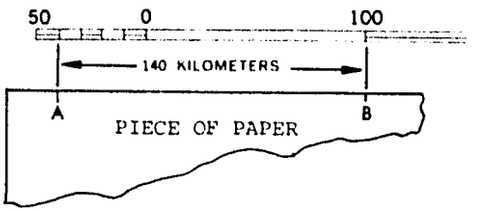
Note that this illustration uses a ruler that is marked off in centimeters. If a ruler that is marked off in inches is used, the distance between A and B would be slightly more than $2\frac{15}{16}$ inches. This converts to a ground distance of approximately 295,000 inches; at 63,360 inches to a mile, this converts to approximately 4.7 miles.

3.22 Paper strip and graphic scale method.--This is probably the easiest method to use to measure distances. The only equipment required is a piece of paper and a pencil or pen. The step-by-step procedure is as follows:

(1) Fold the paper you are using so that it makes a straight edge. Lay the paper on the map so that the straight edge joins point A and point B. Mark point A and point B on the paper.



(2) Place the paper just below the bar scale on the map. Read the distance from the bar. In this example, the distance from point A to point B is determined to be approximately 140 km.



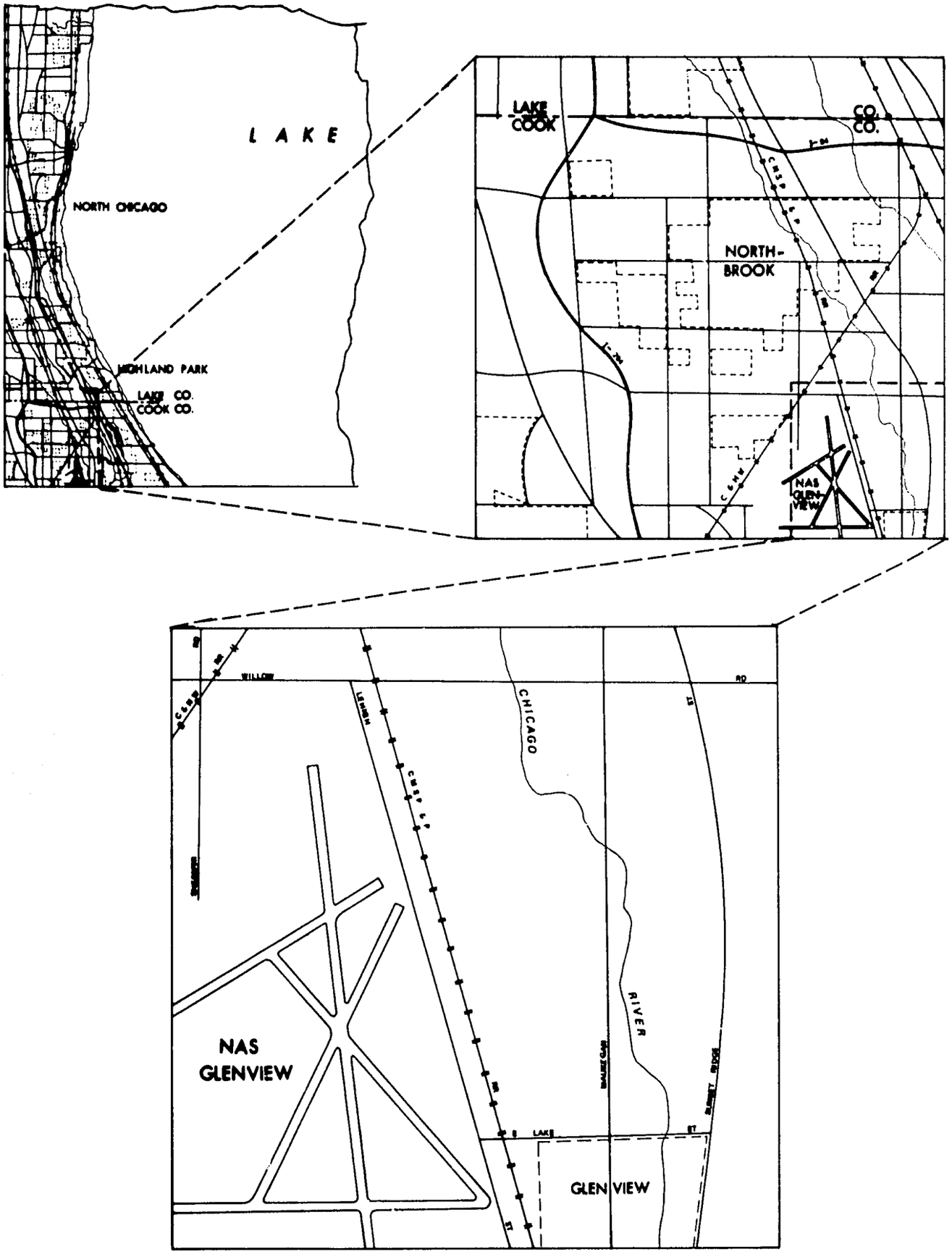
In actual practice, roads and streets are not always straight lines. For measuring distances on curved roads, the same procedure is followed. The distance between points on each straight section (leg) of the road is measured and added to get the total distance.

3.3 *Relative size of scale*

Maps are usually referred to as being large scale, medium scale, or small scale. The adjectives "large," "medium," and "small" do not refer to the physical size of the maps but to the amount of detail shown thereon. More accurately, they refer to the size of the representative fraction scale. Thus, $\frac{1}{500,000}$ is a small fraction (small scale) and $\frac{1}{2,000}$ is a large fraction (large scale). One expects to find many more details of a given area to be shown on a large-scale map than on a small-scale map. As a rule, large-scale maps show fairly small areas, and small-scale maps show fairly large areas. In figure 3a, the large-scale map covers only the portion enclosed in broken lines in the lower right corner of the medium-scale map which, in turn, covers only the portion enclosed in broken lines in the lower left corner of the small-scale map.

The concept of large-scale and small-scale maps can be illustrated in yet another way. Assume that there are three maps (A, B, and C), each of which is 50 cm wide. Assume further that the horizontal scale of Map A is 1:500,000; on Map B it is 1:100,000; and on

Figure 3a. SMALL-, MEDIUM-, AND LARGE-SCALE MAPS OF AN AREA



Map C it is 1:25,000. Map A covers an area that is 25,000,000 cm wide (250,000 meters), while Map C covers an area that is smaller--only 1,250,000 cm (12,500 meters) wide. Thus, one can readily see that details can be shown on Map C (the large-scale map) with greater clarity than those same details could be depicted on the small-scale Map A. The following table illustrates these facts numerically.

Map scale	Width of map	Horizontal scale	Width of ground area
Small	50 cm	1:500,000	250,000 meters
Medium	50 cm	1:100,000	50,000 meters
Large	50 cm	1:25,000	12,500 meters

3.31 Small scale.--Maps with scales having large numbers in the denominator (for example $\frac{1}{250,000}$ or $\frac{1}{500,000}$ or $\frac{1}{1,000,000}$) are generally considered to be small-scale maps for census purposes. Small-scale maps often are used to portray the whole country and its large 1st order administrative divisions; they are used as sources of information about generalized national patterns of distribution of landforms, transportation, agriculture, etc., and for planning the general distribution and boundaries of regional or district field offices. For census publications, small-scale maps can be used rather effectively to show the distribution of data for broad expanses of the country.

3.32 Medium scale.--Scales in the range of about 1:30,000 to about 1:200,000 are considered to be medium (intermediate) scale for census use. Medium scales are used for maps to show 2nd order administrative areas; for example, ampurs in Thailand or municipios in Honduras. Medium-scale maps may be used as a source of boundary information for all orders of administrative divisions (if the boundaries are not complex), or as a base on which to record the location of places. They also may be used as the basis for enumeration maps in areas of moderate to sparse rural population (for example, less than 50 persons per km^2).

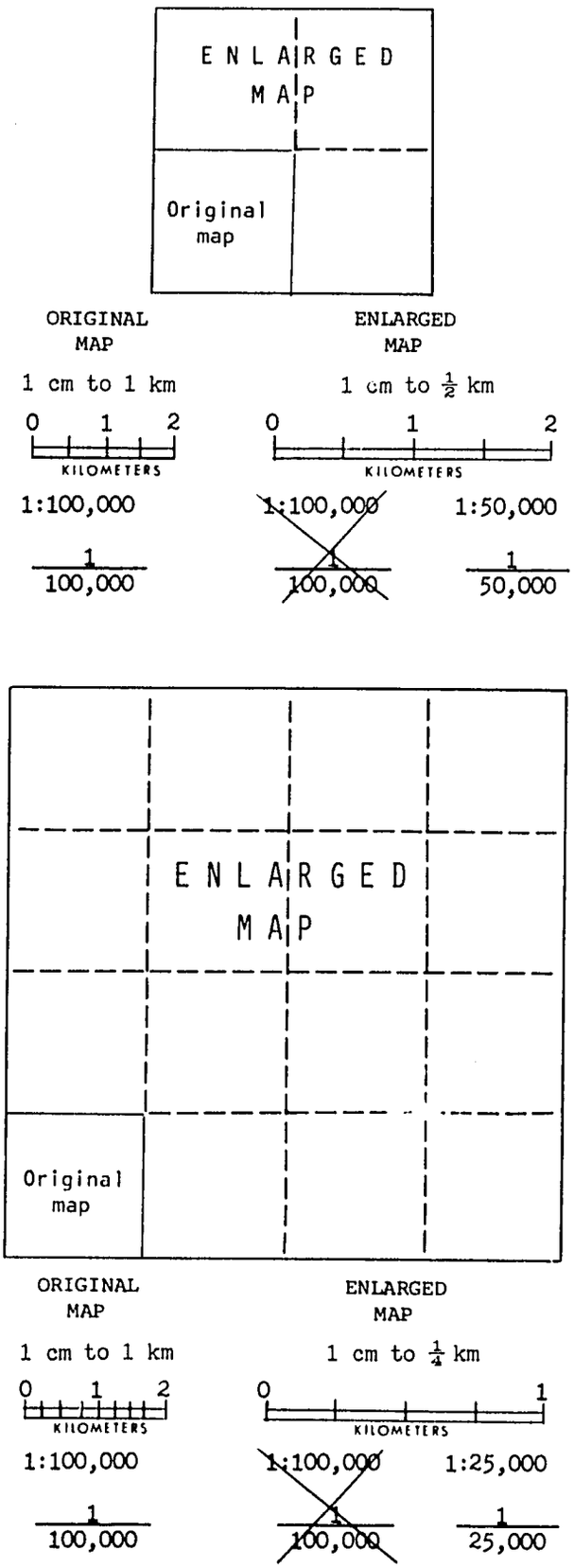
3.33 Large scale.--Maps in the large-scale category usually have scales larger than 1:30,000. Large scales are used by census organizations for maps showing 3rd or lower order divisions, including the urban and other more densely populated places in a country. Large-scale maps are needed to show complex boundaries of any order of divisions. They may be used as the basis for enumeration maps for the more densely populated parts of the country, and as the basis for publishing data for small areas such as city blocks in large urban areas.

3.4 *Scale reduction or enlargement*

Scale change can alter the size of a map so that it becomes too bulky to handle or too small to read easily. For example, if a scale of "1 centimeter represents 1 kilometer" is changed to "1 centimeter represents $\frac{1}{2}$ kilometer, the size of the resulting map is four times as large (see figure 3b). Similarly, if it is changed to "1 centimeter represents $\frac{1}{4}$ kilometer, then the map becomes 16 times as large. The opposite is true if the scale is changed in the other direction and the map is reduced. The map sheet may become too small for the user to interpret the features or read the names.

In a similar way when a map is enlarged or reduced, the scale changes. For example, if the word statement on a small map is "1 cm represents 1 km" and if the map is enlarged four times (that is, both length and width are doubled), the statement on the enlarged map must be converted to "1 cm represents $\frac{1}{2}$ km." If a fractional scale has been used in this same case (as in figure 3b), the original fraction of $\frac{1}{100,000}$ must be changed to $\frac{1}{50,000}$. On the other hand, if the scale on the small

Figure 3b. MAP ENLARGEMENT



map is graphic, it will automatically be enlarged when the map is enlarged.

4. MAP SYMBOLS

On every map, symbols are used to depict and locate natural and man-made features. On some census publication maps, symbols are used to show statistical data. The number and type of features and the kinds of symbols used will depend on the purposes for which the map is constructed and the scale at which it is to be reproduced. There is at least one symbol that appears on most census maps--a compass or north arrow which helps the user to locate his position and direction (see section 6.3).

A great variety of symbols can be found on maps. Although every map should have a legend (descriptive list of the symbols that are used), a good map symbol is one that can be recognized without a legend. A good symbol is drawn so that it is somewhat similar to the actual feature on the ground; for example, a line with small crossbars indicates a railroad, or a cross or crescent on a black square indicates a temple, mosque, or church. Quick and easy recognition of a symbol is an advantage; it decreases the chances of error and provides even the most inexperienced map reader with a guide he can readily understand.

4.1 Kinds of symbols

A variety of symbols will be found on maps. They generally can be placed in three categories--point, line, and area symbols. Occasionally a specific symbol may be difficult to classify. Each category is described briefly below along with illustrations of common examples. A display of symbols is provided in exhibit 3-1. However, no one list of symbols is complete; any map maker may devise symbols for features not included in a "standard" set, or he may create his own symbols.

4.11 Dot or point symbols.--These are symbols that are used to indicate the location of a feature that has no significant dimension relative to the scale of the map. The symbol could indicate a house on a large-scale map or an entire town on a small-scale map. Often point symbols are pictorial in nature. Examples of point symbols include ● for a place, for a school, ■ for a dwelling, and for a church.

4.12 Line symbols.--These are symbols which are used to indicate the presence of a feature that has only one significant dimension, which is length. These symbols include solid lines of different widths, broken lines, dotted lines, and mixed broken and dotted lines. They may represent physical features, such as rivers and roads, or imaginary features, such as administrative boundaries. Examples of line symbols include for a railroad, for a major highway, for a wide stream, for a power line, and for a boundary.

4.13 Area symbols or patterns.--These are symbols that are used to indicate the area covered by a given characteristic or phenomenon, such as a specific population density, swamp, sand dunes, urbanized area, park, etc. These symbols may include shading of different intensities, colors, or different patterns such as stippling , larger dot patterns , or crosshatching .

4.2 *Use of color*

Over the years, map makers have come to use different colors to emphasize important features or to symbolize different types of Earth features. For example, blue is usually used for bodies of water, and green is used for vegetation. The following indicate the colors that are most often used to represent various map features:

Blue - identify bodies of water, both fresh and salt water

Green - show vegetation

Black - designate man-made features, including boundaries, roads, streets

Red - show major roads or highways

Brown - indicate contours on topographic maps

The use of color may be limited by the facilities that are available for making maps. For consistency, it would be desirable to follow the above color scheme whenever color is used. For census purposes, color is generally not used for EA and publication maps because of printing costs (boundaries of EA's are drawn by hand on each map in a bright color).

4.3 *Information indicated by symbols*

Symbols may be used to show three different types of information.

(1) Location. Whether point, line, or area symbols are used, they show where a feature or phenomenon is located. In the case of area symbols, the extent of coverage is an aspect of location.

(2) Nature or quality of the feature. What kind of thing is it? Is it house or mill or village, road or railroad or river, sand or water or forest? In addition, the symbols may indicate whether the road is paved, unpaved (or passable only during the dry season), or whether the water is salty or fresh. Obviously, there are many variations in the aspect of quality or nature that can be symbolized.

(3) Quantity. How much of "it" is there? How much is the population of the town or the output of the mill? How much freight moves along the railroad? What is the population density of the province?

Maps normally will have symbols showing what the features are and where they are. Indeed, this is their primary function. Maps showing how much there is of various features are primarily statistical maps and are much rarer, but the information they portray may be of great value to the census planning staff.

4.4 Effect of scale on choice of symbols

Maps may be constructed at small, medium, and large scales. There should be a balance between what the scale of the map will allow to be shown with clarity, and what may be nice to show but does not significantly improve the map's usefulness. The scale not only affects the number and type of features that are shown but can cause variations in the way a symbol for the same feature is drawn. For example, on a small-scale map, roads or streets are usually depicted by a single line; whereas on a large-scale map a double line may be used. Other examples are depicted in exhibit 3-1.

4.5 Use of symbols on census maps

It is not quite correct to say that only certain parts of the map are symbols; in fact, the entire map is a symbol. From the point of view of census needs, symbols are of three kinds: (a) those which represent natural features of the landscape (including vegetation); (b) those which represent man-made features of the landscape (such as roads and towns); and (c) those which are added by the census office (such as EA boundaries). The final census publications may include a fourth category of symbols to assist the public in understanding and interpreting the published statistical data. Bar graphs and pie charts would be included in this category. (Refer to chapter 9 for discussion of publication maps.)

Maps from previous censuses already contain symbols added to the base map for census use in the field or for the publication of census data in map form. The symbols that were added to census maps in the past should have met certain standards. If they did, they were easier to interpret in the field and are easier to understand now. For example, it is advisable for a census office to be consistent in the symbols it uses on various maps. If a black square represents a certain type of structure on one census map, a black square should represent the same type of structure on another map. Such a procedure has the obvious advantage of facilitating the training of personnel on how to use census maps and lessens the chance of misinterpreting the meaning of a particular symbol. To make it easy to interpret a map, considerations should be given to symbols (a) that have general as well as census uses, (b) that can be easily recognized by persons having limited map training, (c) that are simple to understand, (d) that can be easily drawn and duplicated, and (e) that can be located and reproduced accurately, regardless of the method of reproduction used. At the same time, the number of special census-use symbols should be kept to a minimum; too many symbols clutter a map, obscure one another, and make the map more confusing to use.

Certain symbols may be added and others omitted or deleted as a map is adapted for a specific census use. The landscape features symbolized on maps prepared for a population census are not necessarily the same as those used on maps made for an agricultural census. Also, the importance of a feature can vary from one kind of census to another. For example, in a census of population, every school should be visited by the enumerator to inquire whether anyone lives in the building. In a census of agriculture, on the other hand, the school symbol serves largely as a reference point for the enumerator as he goes from one farm to the next. Furthermore, agricultural census maps should be small-scale maps without much detail in densely populated nonfarm areas; this would not be the case for population census maps.

Special items that should appear on the maps include (a) the names and geographic codes which identify 1st, 2nd, or 3rd order divisions of the country, crew leader areas, and individual EA's and (b) a variety of special symbols

which are used to identify major landmarks and to delineate the different types of administrative and statistical area boundaries (including EA boundaries on the individual EA maps). All the special symbols should be fully explained in the legends of both the office record maps and the map copies sent to the field.

4.51 For small-scale maps.--Since small-scale maps are used primarily for publishing statistical results for relatively large areas of the country, the amount of detail they show is limited. Few of the symbols illustrated in exhibit 3-1 are used. Generally, only boundaries for the major administrative divisions and possibly the location of large urban places are shown. Small-scale maps are the ones for which special symbols are designed and used, particularly for publication purposes.

4.52 For medium-scale maps.--Maps of medium scale generally have been used for enumeration in rural areas and small population clusters. They usually contain more symbols than small-scale maps. The 2nd order administrative divisions usually are mapped at a medium scale, and the cartographer must be sure that the boundary line around any administrative division agrees with the boundaries of adjacent administrative units. All places should be located and named on medium-scale maps. Names of capitals or other administrative centers may be underlined or the symbols starred. Sometimes enlarged insets may be included in the margins of the main map (see figure 3c), or a generalized street pattern symbol may be used for all urban places. However, the use of either of these methods does not eliminate the need for separate large-scale maps.

The same boundary symbols that are used on small-scale and large-scale maps are also recommended for medium-scale maps. For example, military installations, national parks, large institutional facilities such as university or hospital buildings, and other properties of significant size can be considered as special areas for purposes of administration and enumeration; they should be delineated with distinctive line symbols.

Important landmarks such as schools should be shown in addition to transportation systems and natural features. Roads and streams may be shown with single or double lines, depending on the actual map scale.

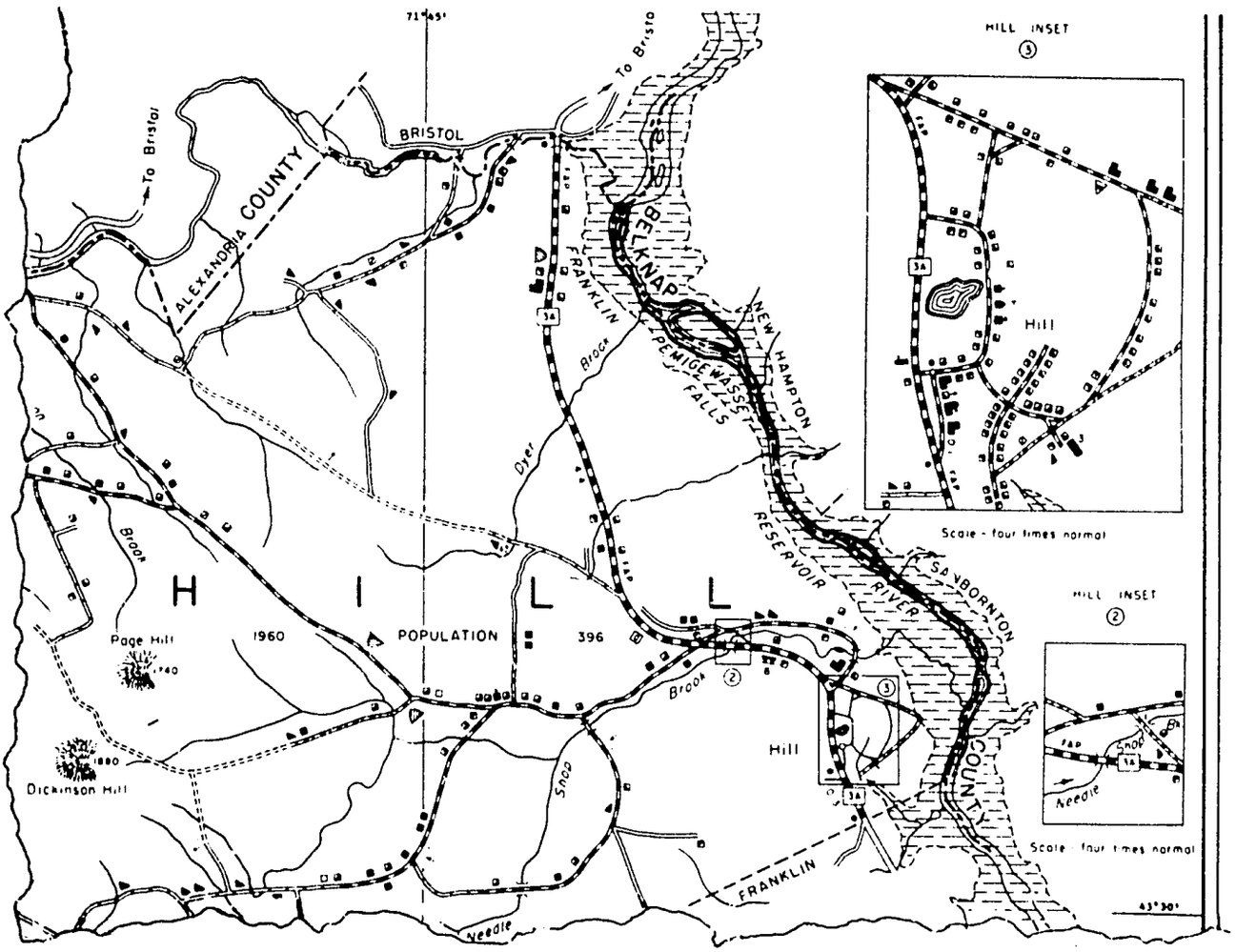
4.53 For large-scale maps.--Maps of large scale generally are used for enumeration in densely settled areas. Those natural and man-made features which can affect the enumeration should be included.

For consistency, the same symbols that are suggested for small- and medium-scale maps should be used for similar features on large-scale maps. For example, an administrative boundary in the area covered by a large-scale map should be represented on that map by the same administrative boundary symbol used on the small- or medium-scale maps. Because of the large scale, many line symbols for roads and streams are double lines and other features are depicted in more detail, depending on the use intended for the map.

5. ELEVATION AND RELIEF

A map has two dimensions--length and width. With these dimensions, it is fairly easy to represent horizontal distances in a geographic area. However, there is a third dimension--vertical distance or elevation--which can have significant interest to a map user. Although there are some maps (relief models) which are actually shaped or molded to represent that third dimension, most maps express vertical distance in other ways.

Figure 3c. USE OF INSETS TO SHOW MORE DETAIL



5.1 *Methods of showing elevation and relief*

There are three principal methods which are used to show vertical distance: (a) contouring, (b) layer tinting, and (c) hachuring and/or shading.

5.11 Contouring.--Showing elevation and relief by means of contour lines is a technique which probably was invented during the early 1700's. It is by far the most accurate method yet devised to show relief (differences in elevation).

A contour line is a line which joins points that have the same elevation. It is therefore possible to read exact elevations[1] of the terrain along contour lines and, by interpolation, to estimate elevations of points lying between contour lines. It is also possible to estimate steepness of slope by measuring the horizontal spacing of the contour lines. The vertical distance between adjacent contour lines is referred to as the contour interval, and usually is constant across entire

[1] *This statement would be true if all contours were located precisely. In practice, the contours are considered to be accurate if they are located within half of the contour interval, which is the vertical distance between adjacent contour lines.*

map sheets. From a single map having contour lines, information can be obtained concerning the three dimensions of the terrain--length, width, and height.

The census employee who has had neither training nor experience in using contour lines may have some difficulty at first in understanding contour maps. However, a contour map can provide much information that is useful in planning a census and only a brief training period is needed to teach the principles of interpreting contours.

Professional map companies and map-making agencies are producing contour maps more cheaply and more rapidly than ever before. Moreover, large areas now can be mapped directly from aerial photographs using techniques with relatively few known and measured points (control points) on the ground. As the availability of contour maps increases, it would appear that more and more of them will be available for census operations. It is essential that the census staff include qualified technicians who can convert contour maps into the simpler map forms that are most often used by census personnel (for example, planimetric maps).

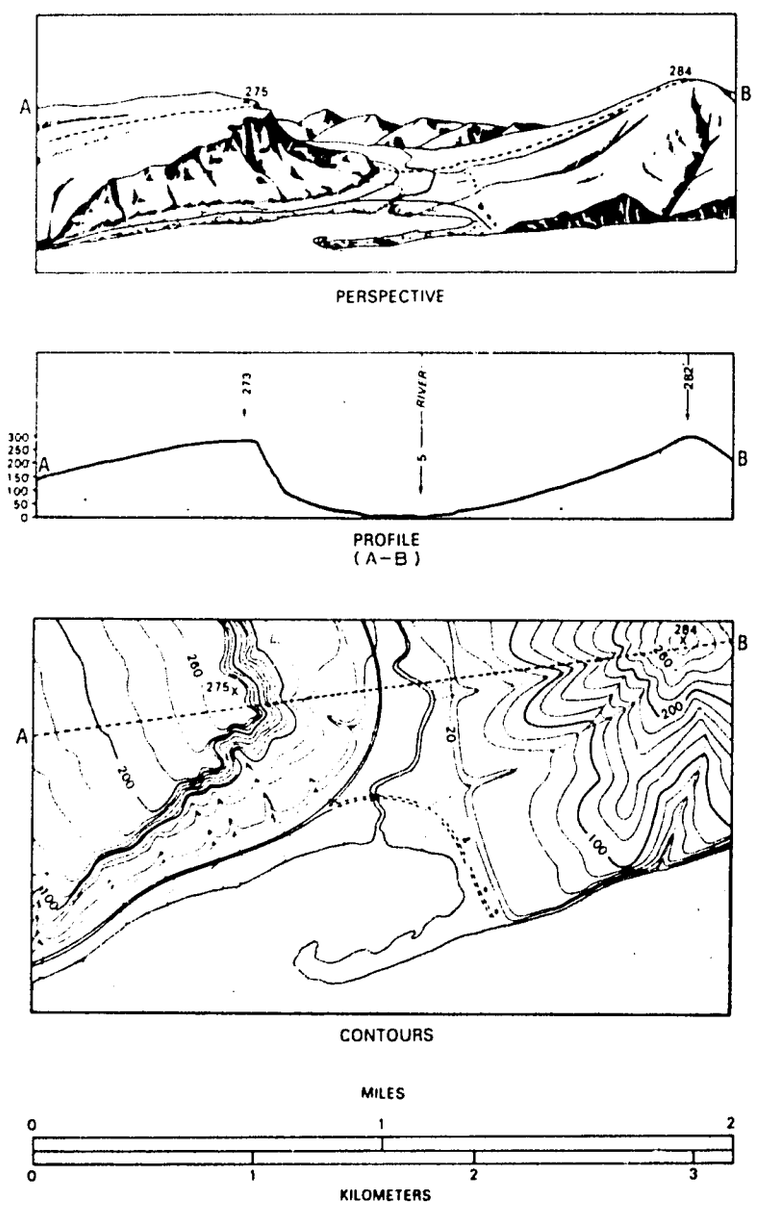
Figure 3d shows three views of the same area. The perspective view gives a good visual picture of the terrain; yet, because of the angle of the view, measurements of length, width, and height are distorted. The profile view gives a clear indication of the heights and horizontal distances, but there is no indication of the depth of the view. The contour presentation gives the clearest indication of all three dimensions involved--length, width, and height.

The characteristics of contour lines are described in the statements that follow:

(1) In general, contour lines are smooth curves.

(2) Contour lines have a tendency to parallel streams for some distance before they cross them, thus creating a V-shaped appearance in many cases. The V's always point upstream.

Figure 3d. PERSPECTIVE, PROFILE, AND CONTOUR VIEWS OF AN AREA



(3) Contour lines tend to parallel each other.

(4) Contour lines never fork or cross. They touch only at over-hanging or vertical cliffs or at waterfalls--situations which seldom occur in nature.

(5) Contour lines always close; that is, following a contour line shows that it will eventually return to the starting point (although it may close on another map sheet or in another country).

(6) Contour lines are close together when they represent steep slopes and farther apart when they represent gentler slopes.

(7) Generally every fourth or fifth contour line is drawn with a heavier line than the others and its elevation is noted on the map. This is done simply as an aid to make the contours easier to read.

5.12 Layer tinting.--A popular method of showing average elevation on small-scale maps is to use a solid color for selected elevation zones or bands. Each zone is shown in a different color. An example would be a map showing areas lying between sea level and 150 meters in dark green; from 150 to 300 meters in light green; from 300 to 600 meters in light brown; from 600 to 1,500 meters in darker brown; from 1,500 to 3,000 meters in darkest brown; and above 3,000 meters in red. In effect, then, each elevation zone is separated from the next by a contour line. Shading is sometimes added to make it easier to see the gross pattern of the landscape.

5.13 Hachuring and/or shading.--Hachures are short lines which are drawn perpendicular to a slope and which vary in width with the degree of slope. Shading is a representation of terrain by variation of one color from light to dark. In most cases, the color is darker where the slope is steeper. These techniques depict hills, mountains, and valleys; and in this way, they express relief. At one time, hachuring or shading was preferred by persons who wanted to make relief-like maps or to show topographic (surface) expressions of geological formations.

A portion of a carefully drawn map which illustrates the use of hachuring is reproduced in figure 3e. Such elaborate and carefully drawn maps normally are not used for census maps because considerable training, skill, extreme patience, and much time are required to produce a good hachure map. However, even the crudest attempt to show the location of high peaks, ridges, or areas of very difficult terrain can be a big help to supervisors and enumerators; in this case, hachures would depict only the most prominent landscape features.

Hachuring uses lines that are varied in width or spacing and drawn in the direction of slope. The steeper the slope, the closer and broader are the lines that represent it and the darker the representation of the sloping area. Very steep slopes may be represented in the system by lines so close together and so heavy that the areas appear to be almost a solid color. Level lands are shown by means of blank space or a few light lines.

The technique of shading has some advantages over hachuring. Maps can be produced faster with shading and there is less likelihood that other details shown on the map will be covered by dark hachure lines. Shading employs variations in light and dark tones (see figure 3f). With the use of black and white, it is possible to have a gradation from white to black with all intermediate shades of gray represented. This is called continuous tone.

The principle of shading is a simple one. It attempts to show an area as if the surface of the paper were 3-dimensional and as if light, coming from a specific direction, were illuminating the area.

The measurement of the exact amount of relief on maps drawn either by hachures or shading is not possible. Nevertheless, a good generalized notion of the shape of the landforms can be obtained.

A slope is an inclined surface. The amount of incline can be expressed in various ways: (a) by citing the amount of vertical change that occurs over a certain length or horizontal distance, (b) by describing the ratio between vertical and horizontal distance, (c) by expressing the amount of vertical change as a percentage of the horizontal distance, or (d) by expressing the slope as an angle from the horizontal. Thus a surface that changes elevation by 5 meters vertically over a horizontal distance of 100 meters may also be described as having a slope 5:100 or 1:20, as having a 5% slope, or as having a calculated slope of approximately 3°. When describing the slope of roads, trails, rivers, and railroads, it is common usage to refer to them as rising or falling X meters per kilometer, X feet per 100 feet, or X feet per mile.

Source: U.S. Geological Survey.

Census planners can use the information on slope when considering the establishment of field offices and when setting up crew leader and enumeration areas. Steep slopes hinder transportation and will affect such activities as supplying materials, supervision, and enumeration.

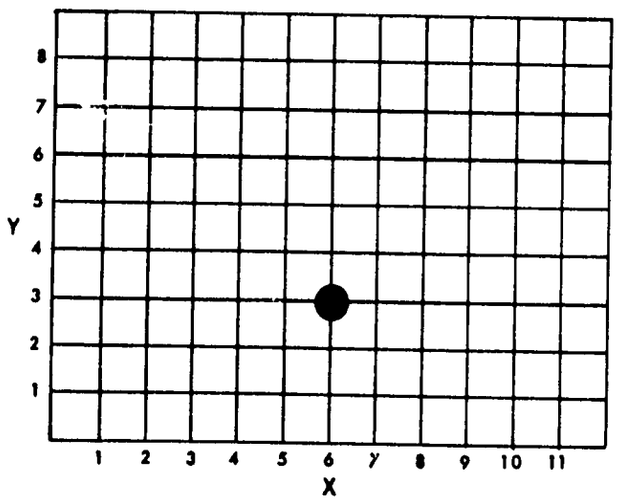
6. OTHER ELEMENTS OF INFORMATION AND INTERPRETATION

Scale, symbols, and elevation (where appropriate) are the three most important aspects of most maps. However, there are other characteristics of maps that affect their utility, and there are other general types of information that may be obtained from maps.

6.1 *Earth grids and coordinates*

The conventional method of describing the location of a point on the surface of the Earth is to use geographic coordinates. These are X and Y coordinates, just like the ones used in mathematical graphs. On these graphs, the location of various coordinates is shown by lines which collectively form a grid. In figure 3g, the point illustrated is at Y3 and X6; these are its coordinates.

Figure 3g. LOCATION BY COORDINATES



As mentioned earlier, the Earth is almost a sphere; it is not flat. The lines of the coordinate grid on a sphere are not always parallel, and the distances between them are not constant. Nonetheless, values of this spherical grid, in terms of degrees, minutes, and seconds, are used to express the location of points (towns, bridges, road intersections, etc.). This method of expression is specific; it is a universal worldwide system that can be used to express the location of any point on the surface of the Earth.

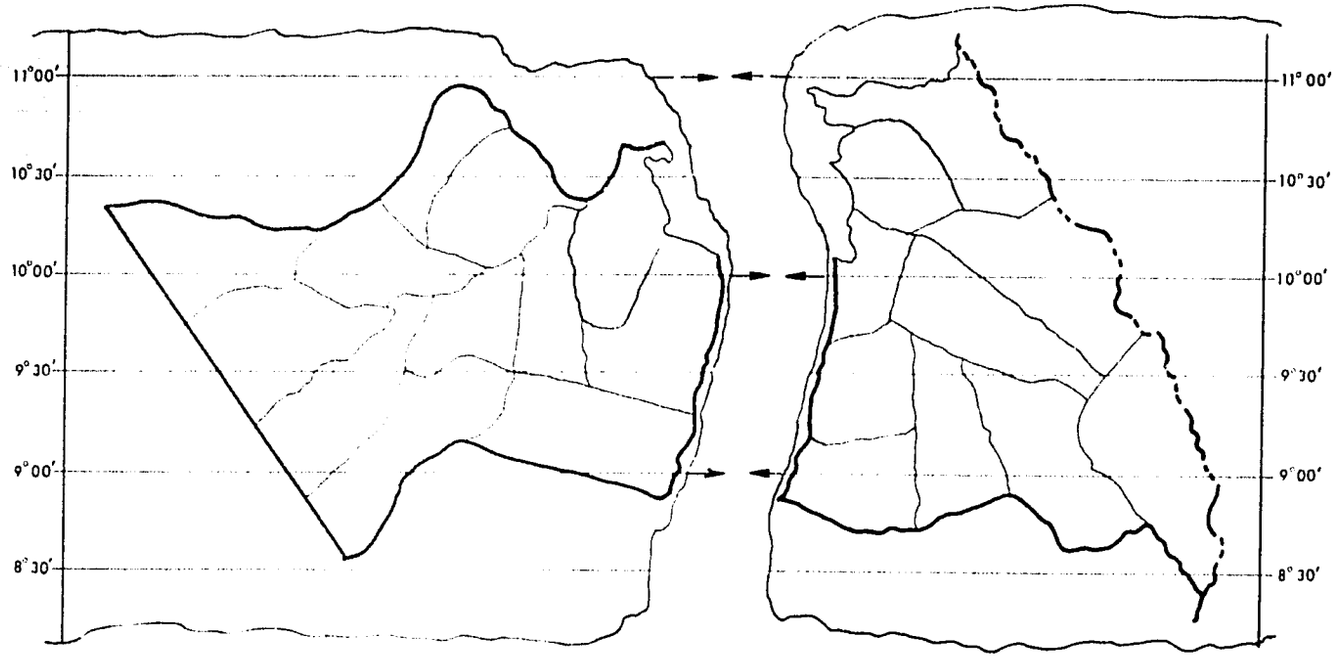
In practice, the lines of the Earth grid are called parallels and meridians, and they are used to measure angular distances called latitude (north-south distance) and longitude (east-west distance). They establish direction between points on a map; for example, city A is NNW (north northwest) of city B. They also can be used to measure linear distances; one degree of latitude is about 110.5 km, and one minute of latitude is about 1.85 km in length.[2]

Some maps that come to the attention of census geographers have grid lines (vertical and horizontal lines) identified by letters rather than degrees. In these cases, unlike in figure 3h, the grids often are arbitrary. These grids are usually found on maps of small areas, such as cities, and are intended to help the user locate specific features listed in the indexes that accompany the maps.

Earth grid lines are particularly useful when maps of adjacent areas are put together to produce a map for a large area. For example, if maps for districts are fitted together to produce a map for the province, the grid lines serve as guidepoints for matching the pieces. In figure 3h, the parallels shown on

[2] *Although the length of a degree of longitude varies drastically between the Equator and the poles, there is only a slight variation in the length of a degree of latitude.*

Figure 3h. FITTING TOGETHER MAP PIECES BY MATCHING PARALLEL LINES



each piece (11°, 10°, 9′) must coincide in order to make the pieces fit properly. Coordinates indicating the location of a specific place also are helpful in the matching process.

6.2 *Map projections*

The only way that the surface of the Earth can be shown correctly is on a globe. The Earth is a sphere; maps are flat. Showing the Earth's curved surface on a flat map introduces distortion, which causes problems for both map makers and map users. The cartographer may accept certain types of distortion in order to eliminate or minimize others; his choice depends on the particular use he intends for the map.

6.21 Description of projection.--A map projection is a systematic transformation of the spherical surface of the Earth to a flat (plane) surface. There are many different map projections, some of which are mathematical constructions, while there are others that could be derived by a geometric or physical process of projecting an image. There is no practical reason to distinguish between the two types.

The pattern formed by the parallels and meridians that are shown on a map help the potential user to understand the nature and the location of distortion on the map. Analysis of the spacing between lines, their parallelism, their tendency to intersect at right angles (be perpendicular to each other), and other characteristics of parallels and meridians on a sphere is the key to evaluating map projections. Comparison of grid characteristics found on a map with those known to exist on a sphere permits the cartographer to recognize and evaluate the kinds and amounts of distortion found on the map.

6.22 Map distortion.--The reason for map distortion can be illustrated simply. Imagine cutting in half a rubber ball which is hollow inside and which has a complex design on its surface. Probably the best way to flatten one of the halves would be to cut the hemisphere at various places and then to stretch some parts and contract others. If this were done at appropriate places, the hemisphere could be flattened. But what would happen to the complex design on the surface of the ball? Some

of it would be changed. Distortion, then, is unavoidable in showing the curved surface of the Earth on a flat piece of paper.

The only way to represent the Earth's surface without distortion is to use a globe or portion of a globe. A globe is the only representation of the Earth which does all of the following:

(1) Portrays the size of areas correctly
(2) Shows shape correctly
(3) Correctly indicates distances from any point on the Earth to any other point
(4) Correctly indicates directions from any point on the Earth to any other point

Globes are not convenient to use for most purposes because they are too heavy and bulky. Therefore, various methods have been developed to convert a curved surface to a flat surface. There is no one perfect method, however. Map projections can be designed to do some but not all of the things a globe can do simultaneously.

The cartographer (map designer) must select projections that minimize the kinds of distortion which would be most objectionable for the intended purpose of the map. For each type of map use, one projection may be much more suitable than another. For example, the Mercator projection is useful for navigation but is of little value for showing worldwide patterns because of its distortion of area at high latitudes--those nearest to the poles.

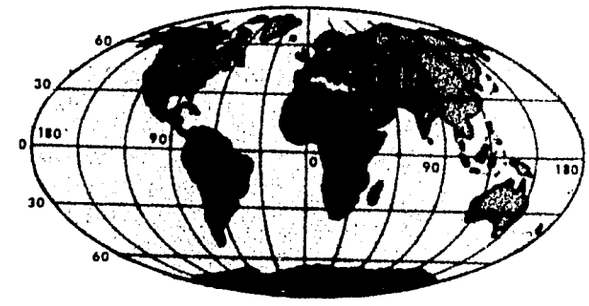
Most distortion problems arise when large areas are to be depicted, like the world, a continent, or a large country (see figure 3i). For smaller areas, distortion is not a major problem; for most census operational purposes, therefore, selection of the proper projection is not such an important factor.

6.23 Projections for census purposes.--It is beyond the scope of this manual to discuss the many different kinds of projections. As mentioned above, each has been made for a specific purpose; each distorts certain global features but shows other characteristics well.

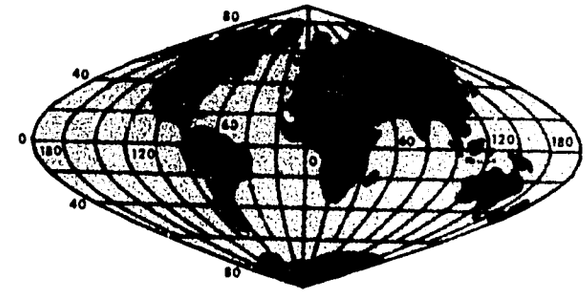
Only a few census employees need to be knowledgeable about projections. The geographic staff, however, should have some basic understanding of projections. They may be required to choose a projection (a) if they need to make one map by joining two or more maps of relatively large areas of the country or (b) if they must select or prepare maps of large areas for use in the published reports of the census.

An equal area (or equivalent) projection is one which shows the relative size of areas

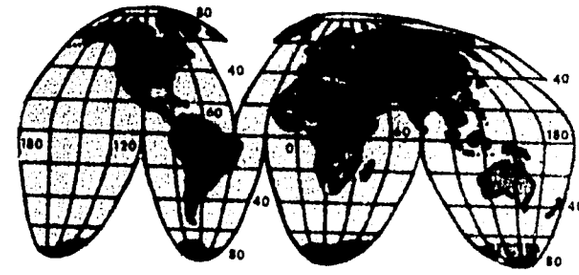
Figure 3i. EXAMPLES OF EQUAL AREA PROJECTIONS OF THE WORLD



MOLLWEIDE HOMOLOGRAPHIC



SINUSOIDAL



GOOD'S INTERRUPTED HOMOLOSINE

Source: Rand McNally & Company; R.L. 71-Y-43.

correctly. Figure 3i illustrates three different types of equal area projections. With a map made on an equal area projection, one can visually compare or precisely measure the sizes of two areas on the map to see which is bigger. Not all maps have this quality; for example, a Mercator projection shows Greenland and South America as about equal in size although the latter is eight times larger than Greenland. For census publications, the equal area projection is the type that is used most often (see chapter 9).

6.3 Map orientation

In using a map, it is important to know how to line up the map with the ground; that is, to locate on the ground certain features that are shown on the map and to locate on the map certain features found on the ground. The act of lining up a map is called "orientation." It is important in census work when (a) combining information from several maps into one map, (b) verifying maps in the field, and (c) conducting the field enumeration.

Orientation is the basic operation in determining direction on a map. To orient a map, the most important pieces of information are the north symbol (usually an arrow) and the symbols representing the ground features. A north symbol may represent true north (the direction of the geographic pole) or magnetic north (the direction of the magnetic pole). For most census purposes, the difference between true north and magnetic north is not significant. On small-scale maps, some of which are not intended to be used in the field, there may not be a north arrow. In these cases the lines of the Earth grid (described in section 6.1) can be used to determine direction.

When maps for several areas are to be combined into one map, the maps should be placed so that the north arrow on each map points in the same direction, or so that the parallels and meridians (see section 6.1) run in approximately the same respective directions on the various maps. Then symbols for any features that the areas have in common, such as roads, streams, parks, railroads, and large buildings, should be lined up so that their relationships are correct.

In the field, the map should be aligned with the ground. To do this, it is necessary to find objects on the ground which are represented by specific symbols on the map, such as a school or highway. The map should be held so that features on the map line up with their corresponding features on the ground. When the map is properly oriented, it is possible to identify any ground object and its relationship in direction and distance with any other object on the ground.

6.4 Area measurement

At various times, it may be necessary to measure areas on census maps. This does not happen very often because the areas of administrative units usually have been calculated by other agencies.

Area measurement may be needed for the purposes of an inventory of natural resources, population density calculation, or for other reasons. Area may be considered in planning census field operations, but it is not important during the actual carrying out of these operations. There are several ways of measuring areas from maps.

6.41 Polar planimeter.--If very accurate measurements must be obtained, a polar planimeter may be used. The outline of the area to be measured is traced with this instrument, and the enclosed area is calculated automatically. The results must be converted to ground surface area by applying a factor based on the scale of the map being measured. Polar planimeters are costly, however, and it may be difficult

Figure 3j. USE OF SQUARES FOR MEASURING AREA

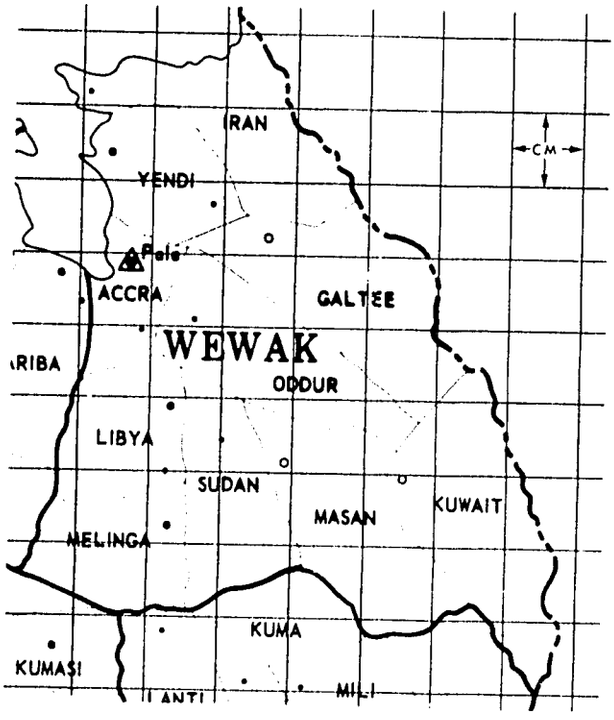
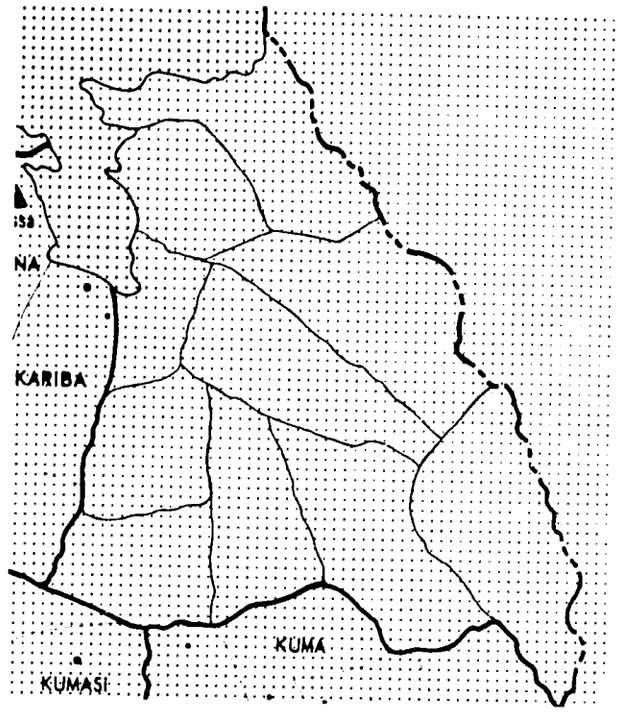


Figure 3k. USE OF DOTS FOR MEASURING AREA



to obtain a number of them for census use. If many areas are to be measured and only a few planimeters are available, the use of some other technique may be desirable. The instructions that accompany a planimeter usually are concise and clear, and no attempt will be made in this chapter to describe the way in which measurements are made. Chapter 10 has an illustration of a planimeter and instructions for its use. After a few hours of practice with a planimeter, the census staff should be fairly skillful in measuring areas with this tool, but results depend very much on the care used by people doing the measuring.

6.42 Squares.--Squares in a grid are counted to determine area. First, lines are drawn on transparent overlay material to form uniform squares. The overlay is then placed over the area to be measured and the squares within the area are counted. If the area includes more than half a square, the entire square is counted; if less than half, the entire square is excluded. The precision of this method varies with the scale of the map and the size of the squares being used; the larger the scale and the smaller the square, the more precise is the measurement (see figure 3j).

The area of the squares should bear a convenient relationship to the scale of the map. For example, the area of each square should be equal to 1 km^2, 1 hectare, $\frac{1}{4}$ square mile, etc.

6.43 Dots.--Figure 3k illustrates the use of a template (or overlay) which has dots spaced in proportion to the scale of the map being measured. The procedure is to count the number of dots that fall within the area to be measured, then to multiply the number of dots by the scale fraction. This technique often is used for estimating the area of agricultural lands. A variation of this technique is to use an overlay of squares (as described above in section 6.42 and illustrated in figure 3j), and to use the points at which the grid lines intersect as the dots.

6.44 Parallel lines.--One of the best ways to measure areas is by means of equal-spaced parallel lines. These lines are drawn on an overlay, which is then placed over the map area to be measured. The length of all of the parallel lines within the area boundaries, multiplied by the width of the space between lines, determines the size of the area (see figure 3ℓ). Generally, this technique is fairly accurate, fast, and cheap to use. A further advantage is that it is fairly easy to train clerks to carry out the process. The procedure is illustrated as follows:

(1) Draw parallel lines on an overlay. Make the parallel lines a selected distance apart--2 cm, 1 cm, or 5 mm, for example.

(2) Measure the length of each line within the area to be measured and obtain the sum of these lengths. (The length of each line segment is entered in italics in figure 3ℓ.)

(3) Convert the sum of the length of the lines and the distance between the lines using the scale on the map.

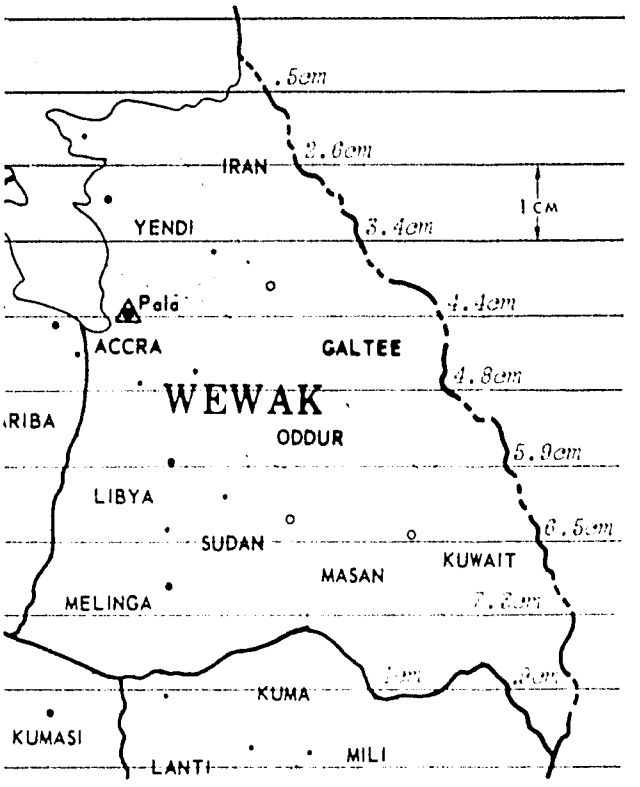
(4) Calculate the area by multiplying the sum of the lengths by the width of the space between the lines.

In figure 3ℓ, the lengths of the 10 line segments in Wewak Province add to 37.3 cm and the space between lines is 1 cm. The map scale is $\frac{1}{250,000}$, which means that 1 cm on the map = 2.5 km on the ground. Thus, the total length of the lines becomes 37.3 × 2.5 or 93.25 km; the space between the lines becomes 1 × 2.5 or 2.5 km. The area of the Province is 93.25 km × 2.5 km or 233.1 km^2.

6.45 Other techniques.--There are other techniques which may be used to measure area. Some depend on knowledge of geometry, and it might be difficult to find qualified clerks who can be trained easily to understand and apply these methods.

One technique involves cutting from the map the area to be measured, then weighing

Figure 3ℓ. USE OF PARALLEL LINES FOR MEASURING AREA



the paper. In this case, all maps must be made of the same paper. This, too, is not always practical. Another cut-out technique involves passing the pieces of paper through a "map area scanner" to determine the area; this method also requires conversion of the results using a factor related to the map scale.

Still another technique for measuring area is the use of certain high-speed machines that are called "digitizers." This technique can be fairly costly and therefore it is not widely used. However, the acquisition of digitizers for other purposes is becoming more and more common; this may make it possible to use them for census purposes also.

7. EVALUATION OF MAPS

The preceding sections of this chapter described many important elements of a map that must be taken into consideration when the staff

decides whether a particular map can be useful in the census operations, in what way it can be put to use, and whether it is better or worse than some alternative map. In the remainder of this chapter, these elements are reviewed and summarized from the viewpoint of the persons who evaluate and select maps for various census purposes.

7.1 *Intended use of map*

Maps may be used in several ways in a census. They may be small-scale national or major regional maps which provide a general overview about a large area. They may be medium-scale maps which provide information about boundaries, road patterns, distribution of housing units, and other features in rural areas that have a moderate to sparse population density. Such maps may be used by enumerators in the field or by supervisors. Or the maps may be large-scale plans of cities or other densely inhabited areas; these also may be used by enumerators and supervisors. The maps may record boundary information, with more complex boundaries requiring larger-scale maps. Maps may provide a base upon which statistical data can be plotted in preparation for its publication in cartographic form. In any case, the process of evaluation first must consider the use that is to be made of the map.

7.2 *Review of map elements*

When the evaluator has determined the purpose for which the map is needed, he should examine various map elements. Usually, more than one map is needed to satisfy all the needs.

7.21 Scale.--Is the scale appropriate for the intended use of the map? A large-scale map series requiring several hundred sheets to cover the country is not useful for understanding broad general patterns of distribution. Broad patterns are lost in the detail on such maps; a small-scale map is better. The reverse situation applies to maps needed to supply data for the individual enumerator who must have information about every road or trail; in some cases, he is required to mark the location of each housing unit on his map. Between these extremes are regional maps that are needed in district offices for the control of operations. The basic rule is that the scale of the map must be appropriate for the job that is to be done.

7.22 Symbols.--Do the symbols used on the map show the kind of information that is needed, or do they show information that is unnecessary for census purposes? Are the symbols legible; can they easily be read and understood? Are there too many (or too few) different kinds of symbols used? Like scales, there is a wide range of symbols that are appropriate for census work, but many symbols are more appropriate for some uses than for others. A map showing only the location of cities and towns is not appropriate for an enumerator who must work within such places and must know where the streets are and their names; he needs a map with more detail.

Another important aspect of symbols is the use of color in portraying them. The maps that are to be used in the field enumeration usually have to be reproduced and the printing process available to the NSO usually is a fast and inexpensive process such as diazo. This means that the maps are reproduced in a monochrome (black, blue, or sepia on a white background). If the maps must rely on color to distinguish among symbols, their usefulness for this purpose is low. For example, distinguishing between contour lines and roads will be difficult if only one color is used. Color is acceptable on maps for census purposes only if the maps are needed for reference or as base maps for the preparation of new maps.

Area symbols in the form of shadings, patterns, or colors are not acceptable for maps that must be reproduced. Such symbols usually cover large areas of the map and cause these areas to appear dark on the reproduced maps; thus, marks made in these areas or other symbols shown in these areas are difficult or impossible to read.

7.23 Elevation.--Is it necessary that the map show elevation? Maps that show elevation are called topographic maps; other maps are called planimetric maps. Topographic maps (such as Figure 3e) are useful in the planning stages of census operations in the hands of professional people who know how to interpret elevation symbols. They are not good for enumeration because (a) the elevation symbols tend to clutter the map and (b) topographic maps usually are printed in several colors, all of which reproduce the same on the equipment that is generally available to the census staff.

The best maps for most census purposes beyond the planning stage are planimetric maps. They are less cluttered, easier to read, and reproduce better. Major topographic features, such as mountain tops can be indicated by point symbols; the presence of valleys usually is indicated by the streams that flow along them.

7.24 Other elements.--Area measurements should be made on equal area (equivalent) map projections. However, on most large-scale maps, the distortion resulting from the use of other projections probably is too small to be detected with the naked eye. Area measurement is a specialized operation, and is not done on most census maps. The suitability of maps for area measurement normally is only a minor consideration in the general map selection process.

Orientation aids on maps occur so generally that they do not help in the process of selecting maps. Almost all maps have north arrows, a compass symbol, or Earth grid lines which one can use to orient the map with other maps or to determine directions on the ground. However, if a map lacks such features, care must be taken to assure that there are other features on the map which can be used to line the map up with other maps. City plans made by private sources are the most likely to be lacking north arrows or Earth grid lines.

Earth grid lines and coordinates are desirable because they permit the area on the map to be easily and quickly located in relation to any other area. They also can be used to determine directions on the map and as a basis for calculating the map scale or confirming the scale already printed on the map. On small-scale maps, grid lines and coordinates may permit the analysis of distortion due to the map projection on which the map has been made.

The name of the map projection on which the map has been made should be on the map. This permits the map user who has some basic knowledge of map projections to evaluate the suitability of the map for his particular purpose. Since all map projections have some type of distortion, the user can consider whether the kind, amount, and location of distortion due to the particular projection will have any significant effect upon the intended use of the map. However, map projections have significant effects only upon small-scale maps covering large areas.

Has the map been copyrighted? A government map normally can be reproduced or used without running into legal problems, but a map prepared and copyrighted by a private party or company normally requires permission for its use. Government or other uncopyrighted maps are preferable, as long as other considerations are favorable.

Additionally, such items as date of publication or preparation, date of the basic photography (if made from air photos), and map source are important items of information. Generally, recent maps are preferable to older maps.

A map evaluator has many elements to consider and balance. There is no one rule or procedure that can be given. Practice and experience are the only ways to develop the good sense for evaluating maps from various sources.

Chapter 4. AERIAL PHOTOGRAPHY

1. INTRODUCTION

Chapter 4 deals with the ways in which information obtained from aerial photography (air photos) can be used to produce, update, and supplement maps for census taking. It discusses also the interpretation of air photos and the technical skill that is needed to translate the photos into maps for census use. Aerial photography is a resource which the census staff should consider when existing maps for an area are not satisfactory.

Imagery is simply the visual representation of various characteristics of the Earth's surface as recorded by remote sensing instruments. These instruments are sensitive to certain types of electro-magnetic energy from the Earth. The most familiar form of remote sensing is aerial photography, which produces an image on sensitive film through the use of a camera/lens system. Newer and less familiar types are the various electronic sensors which record data as electrical impulses. Later, these impulses are reproduced in a visual form photographically or electronically.

Chapter 4 discusses aerial photography, which is imagery that is received from aircraft. Imagery from satellites is covered in chapter 14.

2. BACKGROUND

Aerial photographs differ from maps in that they do not show names of streets, roads, or boundaries; nor do they have symbols which are explained in a map legend. On the other hand, maps ordinarily do not show all of the natural and man-made features as they exist on the ground.

Aerial photographs are pictures of the natural and man-made features on the Earth. In this respect, air photos show what actually existed on the ground at the time the photograph was taken. Photographs have shadows, color, tone, and texture; the user must learn to interpret them in order to identify rivers, streams, hills, highways, railroads, schools, houses, and other features.

2.1 Brief history of aerial photography

The history of mapping covers several thousand years. However, the use of aerial photographs in the preparation of maps and sketches has developed only within the past century; progress in the use of aerial photographs for census purposes has come about only since the late 1940's.

By the middle and late 1800's, pictures of the Earth's surface were being taken from kites and balloons to examine the movement of enemy troops and to learn about the layout of cities. The development of the airplane in the early 1900's provided a more reliable and mobile platform for taking pictures. The first known air photos for mapping purposes were taken just before World War I.

Some experimental base maps and land use maps were made in the 1920's and 1930's, but it was not until World War II that photo interpretation techniques were developed, refined, and systematized. At the same time, the need for maps increased greatly and produced a rapid development in both the use of aerial photographs for mapping purposes, and the techniques for making maps from air photos. These techniques were further improved to

permit construction of contour or terrain maps from air photos, thus reducing the need for expensive and time-consuming ground surveys. Some modern maps are little more than composites of several aerial photographs which have been corrected for distortion and which have additional information superimposed on them (see figure 4a). They are called "orthophotomaps" (ortho-photo-maps) and are produced by advanced and expensive equipment (see section 4.21 for details on the procedure).

In recent years, rapid development has also occurred in the techniques for obtaining imagery from satellites. As yet, satellite imagery has not been used extensively, mostly because of the limited detail available at scales most used in census work. This is expected to change as more detailed imagery becomes available (see chapter 14). In the future, there will almost certainly be greater use of both aerial photography and satellite imagery, not only for censuses but also for other statistical programs.

2.2 *Sources of photos*

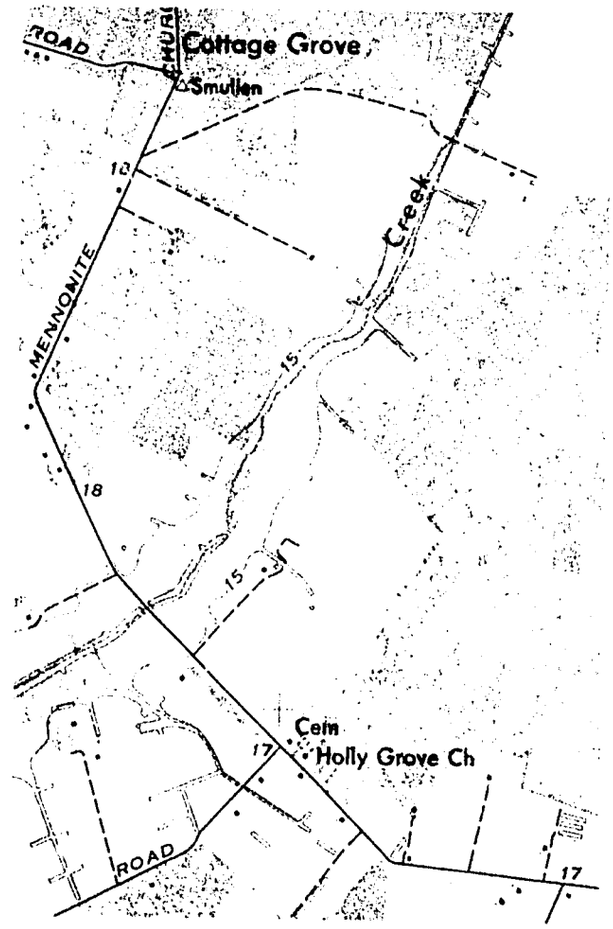
Almost all land areas of the world have now been photographed. Most of the photos are those taken by or for official agencies of the government. These include national mapping services; ministries of agriculture and forestry, mining and minerals, commerce, transportation, and trade; military organizations;

Figure 4a. AERIAL PHOTOGRAPH AND ORTHOPHOTOMAP OF SAME AREA

AERIAL PHOTOGRAPH

Source: U.S. Geological Survey.

ORTHOPHOTOMAP OF SAME AREA



Source: U.S. Geological Survey.

national and local planning agencies; conservation officials; river basin authorities; and city governments. As with maps, some photo series are of great value for census work, whereas others are not. A thorough search should be made in order to find all photography that is available and usable.

On occasion, existing maps or photographs for a specific area (for example, a locality undergoing rapid change) are not satisfactory for census use. In such cases, taking new photos of the area may be the solution. Useful photographs sometimes can be taken from a small plane.

3. CONSIDERATIONS FOR CENSUS USE

As with most techniques, aerial photography has advantages and disadvantages for purposes of a census. They should be carefully considered and evaluated by the census planners. Cost also should be given consideration.

3.1 Advantages

Compared with maps, aerial photographs have several advantages for census purposes. The principal advantages include the following:

(1) Air photos show great detail. Everything that can be seen from the air can be seen on the photos; therefore, they contain more detailed information than can be obtained from most maps.

(2) Air photos are reliable, in the sense that they show features as they actually exist, in correct relationship to each other. Although it may be difficult to interpret, the information is there.

(3) Air photos can be produced quickly. If necessary, photos can be available within 24 hours after the airplane takes off on a photo mission. Since air photos take less time to make than maps, they can produce a more up-to-date representation.

(4) Air photo information is concurrent; that is, air photos provide information on roads, drainage, vegetation, industrial buildings, houses, etc., as of the same instant in time.

3.2 Disadvantages

Aerial photography has some disadvantages compared with maps. As with any choice of procedure, the disadvantages should be examined and evaluated in terms of the final objectives to be met. The major disadvantages include the following:

(1) Air photos contain more detail than is needed in a census operation. The unnecessary detail may make it difficult to pick out features that are important to census operations. By way of contrast, a map maker can choose to eliminate certain details and to highlight others, thus making a map easier to read.

(2) Special training is required to interpret and use an air photo. Things are seen from an unusual position and color tones may be misleading if the photo is too dark or too light. Moreover, photos lack names; and features such as streets, roads, rivers, and buildings are not labeled as they are on a map. The geography staff must therefore obtain this information from other sources and match it to the correct features on the photo.

(3) On air photos, some features cannot be seen directly. For example, streets, houses, and streams may be hidden by trees; other features may be hidden by extensive cloud cover.

3.3 Cost

Cost of the mapping operations must be considered in relationship to the total cost of the census program and the cost of activities which are to be carried out as part of a continuing statistical program. Whether aerial photography is more costly or less costly than conventional map preparation depends on several factors. If no maps exist for an area, it may cost less to produce aerial photographs than to construct maps. The same may be true if existing maps are seriously out-of-date. On the other hand, if there is a shortage of resources for taking the photographs and interpreting them, drawing sketch maps of the area may be the best solution. The NSO should examine its resources

and consider both the short- and long-range benefits of using aerial photography.

3.4 *Other considerations*

In some countries, defense agencies have aerial photographs but, for security reasons, they may not release them to the statistical office that is responsible for the census. The same restriction may apply to certain types of maps.

Another consideration is the scale. Air photos often are taken at small scale and do not provide the detail required for census purposes; the same can be said for maps of small scale. On the other hand, enlargement of air photos may make more detail readily visible; but the same cannot be said of most maps.

4. USES OF AERIAL PHOTOS

Aerial photos can be used in several stages of the census--in planning, in data collection, and to a certain extent in connection with publication of the census results. This section describes some of the uses that can be made of aerial photographs and the considerations involved.

4.1 *Updating census maps*

Changes in man-made features, more than natural features, cause maps to be outdated--new roads are constructed, new settlements appear, and urban areas expand; on the other hand, some landmarks and streets disappear, boundaries are moved, and houses are torn down. For census use, maps that are as up-to-date as possible are needed to assure that EA's will be of approximately equal population size and that features used for boundaries still exist. Enumerators will have difficulty locating and identifying their EA's if the ground features have no relationship to those shown on their maps. The field staff should be warned, however, that some of their maps will not be completely up-to-date, particularly in rapidly growing areas, and that corrections may have to be made in the field.

Unless a census is being taken for the first time, maps from a previous census are likely to be available. These can often be used with little change. Even if much change is necessary, it is usually easier to revise an existing map than to construct a new one. Existing maps can be updated either by going to the field or by using air photos--or by a combination of the two. Some field checking is generally necessary in any case, but it can be kept to a minimum if aerial photography is available.

Updating existing census maps is one of the most important uses of air photos. If a census map of an area has already been made--even if it was made many years ago--much of the necessary work of producing usable maps for the present census will have been done. In areas of slow or moderate change, an old map may be usable without revision; but in an area of rapid change, it will be necessary to update it through the use of supplemental information such as local administrative records, other maps, and air photos. If recent air photos are available, the geography staff can update an old map in a fraction of the time and for a fraction of the cost that would be needed if other methods were used.

The procedure for updating is as follows:

(1) Orient the existing map with the photo for the area. It is helpful, but not necessary, if both are at the same scale.

(2) Review the features on the map to assure that they appear on the photo, either the same or changed. For example, new features may have been constructed or old features demolished; shape or location of some features may have changed.

(3) In the same way, compare the photo with the map.

(4) Carefully plot all changes on the map. If the map and the photo are at the same scale, trace the changes directly on the map by placing the map on top of the photo and using a light table.[1] (If marks are to be made on the photo, use a grease pencil or other substance that is rubbed off easily.)

If the photo and the map are at different scales, plot the changes by using a proportional divider or other scale-changing device. As an alternative, the photo can be reproduced in the photo laboratory at the same scale as the map. In some cases, there may be so many changes that it will be easier to sketch a totally new map, based on the photo.

(5) Add to the map the names of highways, streets, and important landmarks; a field check may be necessary for this step. The map copy with changes is a new manuscript map.

(6) Correct the original reproducible map (the map to be used as the original for reproducing copies) using the same symbols and markings that are used for other maps. Make all the changes indicated on the manuscript map.

Figure 4b illustrates a portion of a map that was updated from an air photo. The map at the top was the most recent map on file. Using the information on the aerial photo, it was updated and reprinted, as shown below the photo. To emphasize the changes, the area where features were added or deleted is outlined by broken lines on the map and the photo.

The most obvious advantage of using all available air photos to update maps is the saving of time and money. Expensive and time-consuming field checks can be reduced or even eliminated. Also, analysis of air photos is easier than field techniques to measure distances, to compute areas, or to estimate the number of housing units or fruit trees. On the other hand, if photos are not already available, the cost of flying the plane and producing them must be considered.

[1] *Refer to chapter 10 for a description of equipment and chapter 6 for map compilation.*

4.2 Preparing base maps

As their name suggests, base maps are used as the basis for EA maps, other field-use maps, and certain publication maps. Base maps can be made from aerial photographs if there are no maps for the area, or if existing maps are of poor quality or too old. Even small-scale photographs and satellite imagery can be used to make rough base maps if no other information is available; in such cases, additional information often is supplied through field work.

Air photos can be used by census offices to make base maps of small villages for which large-scale maps are lacking. Reasonably accurate maps can be prepared for small areas if not too many photographs are involved (for example, no more than five or six).

When a larger area needs to be mapped from aerial photos, a photo mosaic is required. The simplest mosaics are those where photographs are joined together visually with little or no attempt to match them with any ground control (technically, these groups of photos should not be called mosaics). They sometimes prove of great value in census work, since a base map can be traced from these uncontrolled mosaics, which are accurate enough in their relative proportions.

Sometimes more precision is needed in mapping large areas when their features must match those shown on maps of adjoining areas. In this case, a controlled mosaic, or other mapping procedure using aerial photographs, may be needed. This involves photogrammetric procedures, which are beyond the scope of this manual. The national mapping agency should be asked to assist the staff to prepare any maps requiring precision.

4.21 Orthophotomap.--One way to make a base map from a photo is to make an orthophotomap, which is illustrated in figure 4a.

EXISTING MAP OF AREA

AIR PHOTO OF SAME AREA

UPDATED MAP OF SAME AREA

As discussed above, orthophotomaps are made by correcting air photos for horizontal displacement, which results from variations in elevation and angle of view, and adding symbols or emphasizing certain features. Equipment for the process uses stereopairs of air photos to produce a planimetrically correct composite photographic image, called an orthophotograph. Selected features on this image (such as major roads, streams, important hills, or mountain tops) are emphasized by adding conventional cartographic symbols and names. Sometimes contour lines are added. The final product is an orthophotomap. As with any other map, it should be checked in the field and corrected, if necessary. A clean copy of the corrected map should be drafted before it is reproduced.

Because the specialized equipment that is used to produce these maps is expensive, census organizations do not usually invest in the equipment. Most orthophotomaps are made and distributed by national mapping agencies or geographic institutes.

4.22 Photo tracing.--Another way to make a base map is by tracing one or more aerial photographs or a photomosaic. Not all of the features need to be traced--only those that have some bearing on census activities. As a rule, only linear features such as streets, roads, railroad tracks, rivers, and power lines are marked on the tracing. By way of contrast, orthophotomaps contain all features, including vegetation.

Tracings may be made from small-scale photos (and satellite images), but the results may be inadequate for census purposes, such as EA delineation. On the other hand, the scale may be so large as to produce a bulky map. In either case, a more useful tracing can be produced if the scale of the photo is changed before it is traced.

Figure 4c illustrates a tracing made from a photo. For EA delineation, the scale is too small to show useful detail for the settlement. Therefore, the part of the photo containing the settlement had to be enlarged and a new tracing made as shown in figure 4d.

After a tracing has been made, it should be checked in the field and appropriate cartographic symbols and names of features should be added. A clean copy of the tracing should be drafted before reproducing it for distribution.

4.3 *Supplementing EA maps*

Even where reasonably good EA maps are available, air photos can be useful to supplement the information shown on the EA maps. In census evaluation surveys (which measure the completeness of the enumeration), aerial photographs may give clues to places that were missed in the original enumeration. The photos should be reasonably up-to-date.

4.4 *Substituting as EA maps*

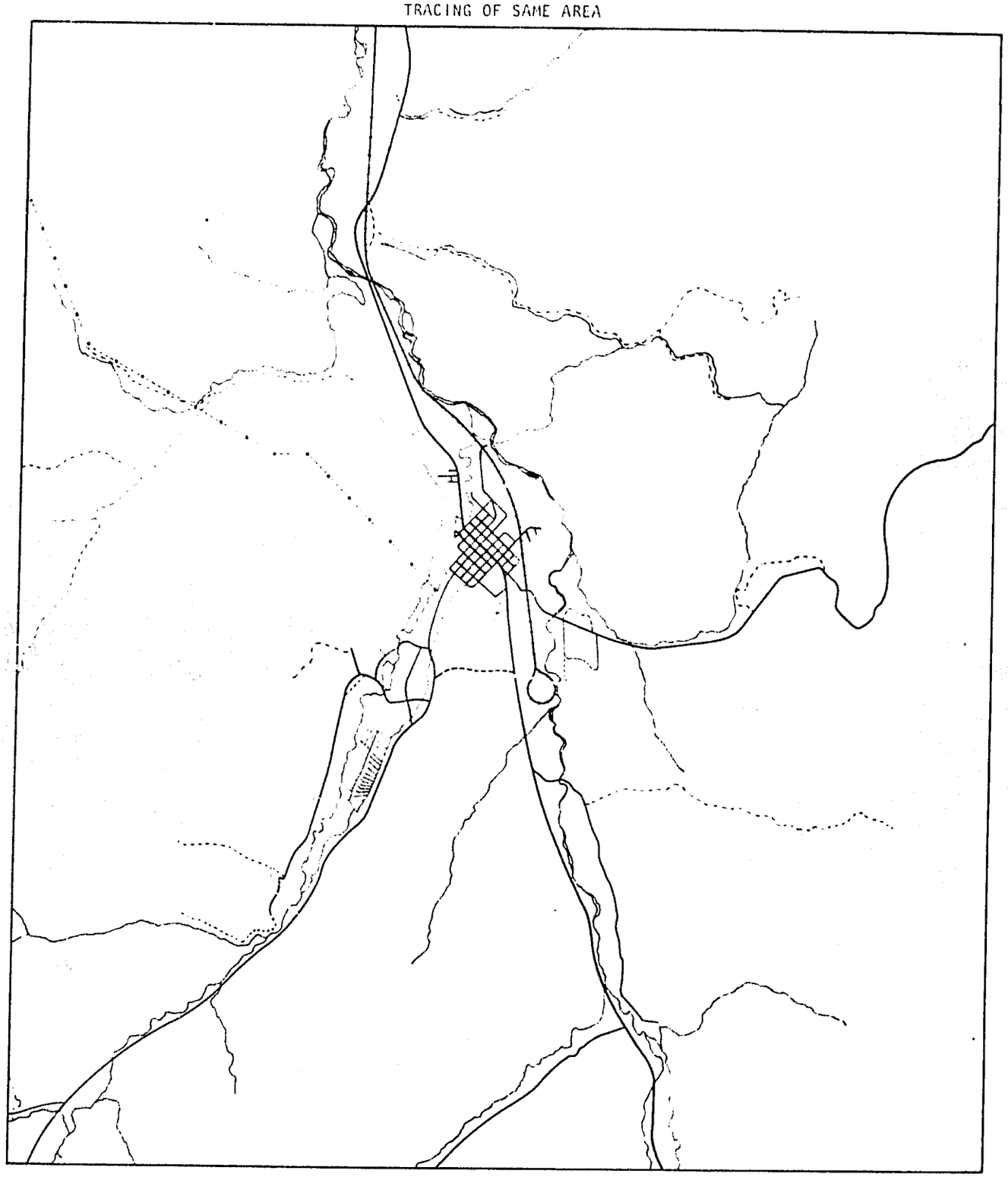
Aerial photos can be used directly as EA maps. When used for this purpose they should be as clear as possible, with little foliage or cloud cover. The photos must be prepared in the same way as maps. They should be annotated with north arrows, graphic scales, names, and boundaries. Important landmarks should be marked. A disadvantage in using photos as EA maps is the training that is usually required for the field staff. Some countries have had no problem with training; other countries have had little or only moderate success.

4.5 *Estimating population or agricultural holdings*

After the base maps are prepared, census planners must use estimates of population (if a population census) or estimates of agricultural holdings (if an agricultural census) to

AIR PHOTO

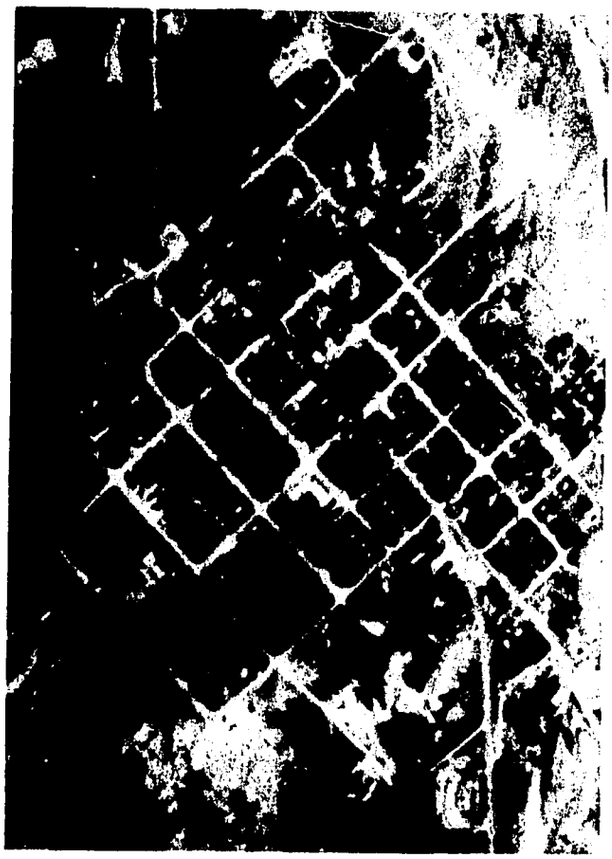
TRACING OF SAME AREA



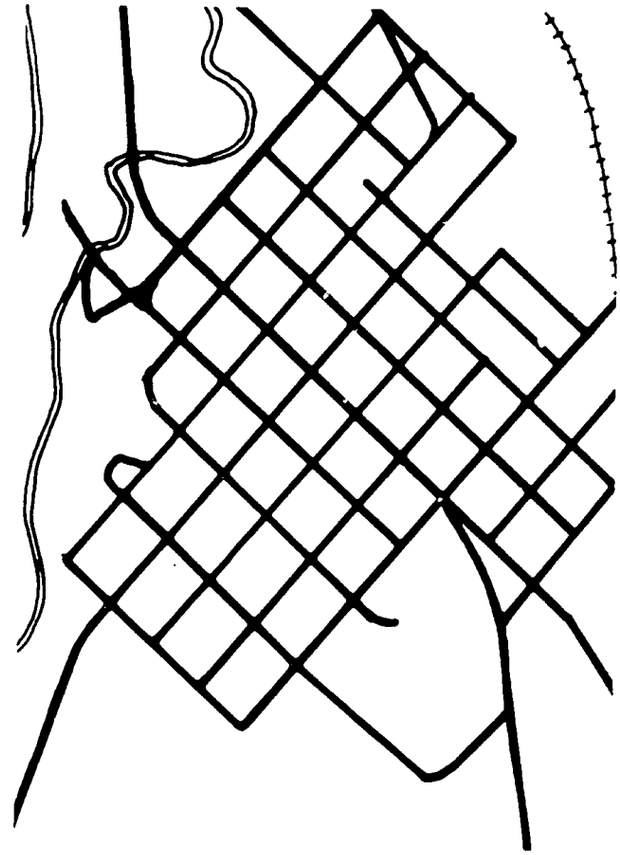
Source: Tracing from photo on preceding page.

Figure 4d. ENLARGED AIR PHOTO AND TRACING OF ENLARGEMENT

ENLARGED PORTION



TRACING OF ENLARGED PORTION



Source: Defense Mapping Agency, U.S. Department of Defense.

delineate EA's. This information usually is obtained in the field. However, if photos are available, these estimates can be approximated by counting the number of housing units (HU's). For purposes of the population census, an estimate of population can be made by assuming an average number of persons per HU.

To make good estimates, the photos should be current, they should be of proper scale for interpretation, and there should be little foliage or ground cover to hide dwellings. Moreover, it is sometimes difficult to tell whether a tall building is an apartment house or a commercial structure. For multiple dwellings, it is not always possible to estimate the count of HU's (and population) very accurately.

4.6 *Identifying isolated settlements*

For census purposes, one of the most important uses of aerial photography is to reveal the existence of settlements in remote areas. Settlements unknown to the census staff often appear on the photographs. Usually they are small in terms of the number of inhabitants. Larger settlements are more easily identified, frequently because of a more compact pattern of roads and streets. In some respects, this use of aerial photos is part of the process of "updating census maps."

4.7 *Delineating statistical areas*

Air photos can be helpful in outlining the boundaries of certain statistical areas.

These would be areas that are defined in terms of transportation patterns, types of housing, various land uses, or other characteristics that can be identified on an air photo. For example, the urban fringe of a city may be defined to include the built-up area with connecting highways to the center of the core city. On the other hand, if the concept of a statistical area specifies certain economic or social characteristics, examination of the features on an air photo may not be useful. Chapter 15 discusses in detail the criteria for establishing statistical areas.

4.8 *Setting up strata for sample surveys*

Survey designs for sample surveys often require that the universe be stratified and sample areas selected from each stratum. For agricultural surveys particularly, air photos provide a means for differentiating between forest, pasture, cropland, and other land use. Chapter 13 discusses the use of maps and air photos for conducting sample surveys.

5. *KINDS OF PHOTOGRAPHS*

Photographs may be taken with the camera pointed straight down (vertical) or at an angle (oblique). Vertical photographs are the most useful and most common. At present, high altitude photography, radar, and satellite imagery are also used for census work but only on a limited basis. Chapter 4 is concerned mostly with vertical air photos and their uses in a census. The other kinds are defined but not discussed in detail.

5.1 *Vertical photographs*

Vertical photos are taken by cameras that are pointed directly downward. Balloons or helicopters may be used, but most photos are taken from airplanes. Generally, the scale of the imagery depends on the height of the vehicle above the Earth. Photographs taken at a low altitude result in relatively large-scale imagery, and high altitude photography results in small-scale imagery. When similar cameras are used, a picture taken at a higher altitude will cover more ground area than a picture at a lower altitude.

Vertical photos are most accurate near the center of the picture. At the edges, objects are photographed at a slightly oblique angle. Roofs of buildings are seen in the center of the photo, and sides of buildings (as well as roofs) are seen at the edges of the picture (refer to figure 4x). This is not a critical factor in interpretation, but the photo user should be aware of this difference.

5.2 *Oblique photographs*

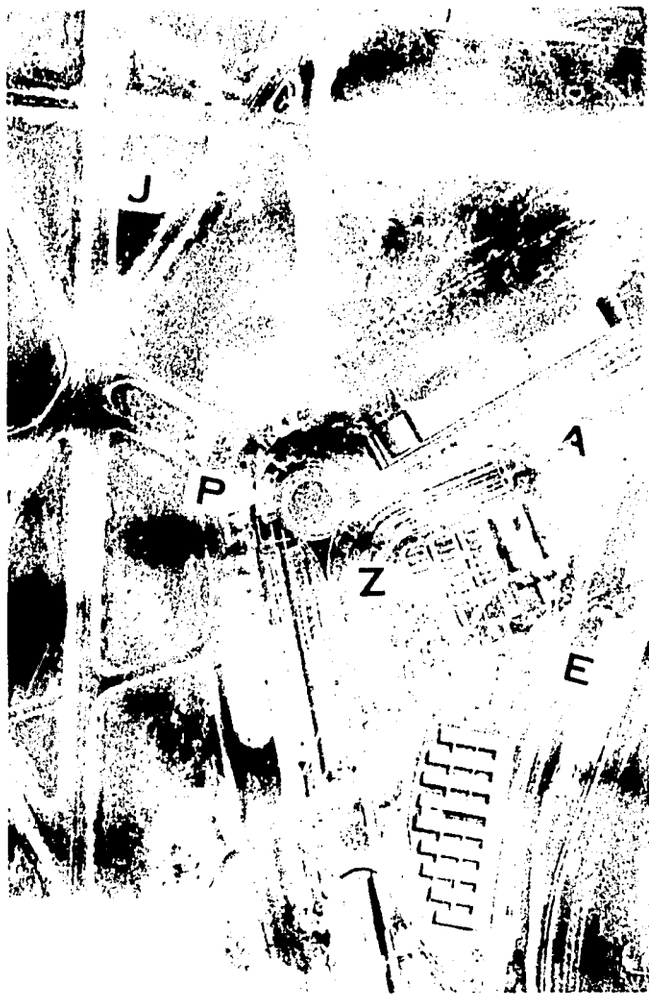
Oblique photographs are taken with the camera pointed downward at an angle which is not vertical. Figure 4e illustrates the difference between vertical and oblique aerial photographs. A low oblique photo has a relatively small deviation (about 30°) from the vertical; a higher oblique photo has a relatively large deviation (about 60°) from the vertical. For example, a passenger in an airplane who takes a picture of the ground that is immediately beneath the airplane is taking a low oblique photo; if he takes a picture of something on the far horizon, he is taking a high oblique photo.

It is difficult to make maps from oblique photos, because the scale varies. Accordingly, vertical photos are used if they are available and otherwise acceptable.

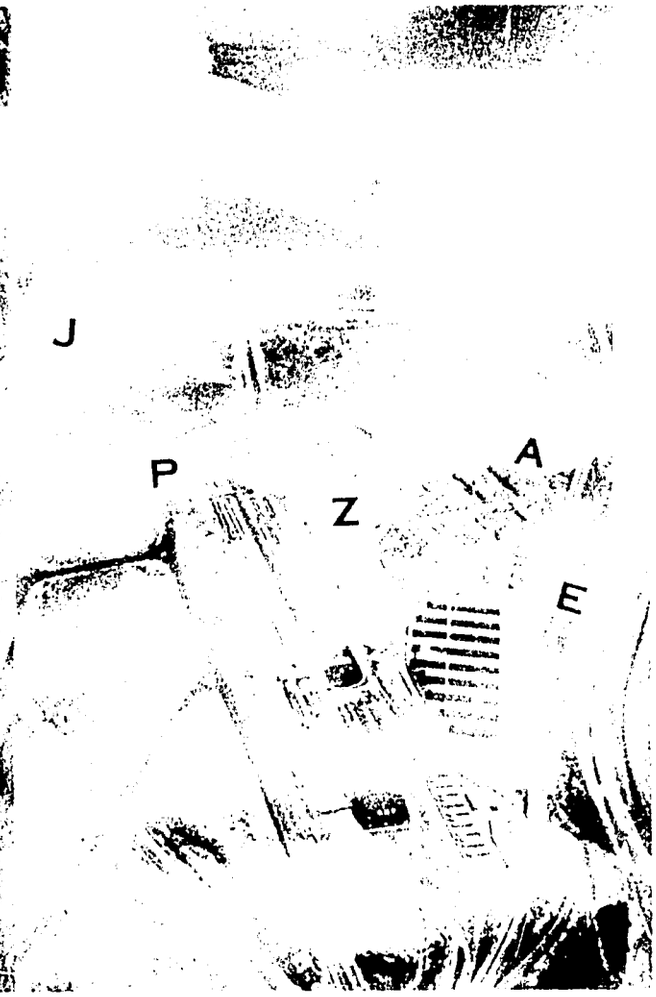
5.3 *High altitude photography*

Generally, flight altitudes for mapping operations range from 2 to 10 kilometers (or about 1 to 6 miles). Flight altitudes above 10 kilometers yield what is considered "high altitude" photography. Even though the operational costs increase rapidly as the flight

VERTICAL PHOTO



OBLIQUE PHOTO OF SAME AREA



altitude increases, the area that is covered by any single photograph is increased even more rapidly. Hence, high altitude photography usually results in good coverage at reduced unit-area cost.

During the last 10 or 15 years much progress has been made in photography. It is now possible to take high altitude photographs at scales of 1:60,000 to 1:120,000, which can cover several hundred square kilometers (100+ square miles) and which can be enlarged 5 to 10 times without significant loss of detail. Photographs or portions of photographs taken from high altitudes may be enlarged with little difficulty to scales of approximately 1:25,000 to 1:50,000 for census work in rural areas, and may be enlarged to scales such as 1:10,000 for census work in urban areas.

5.4 *Radar*

Another fairly recent technique for obtaining information similar to that contained in air photos is radar. Most commonly used is side-looking airborne radar (SLAR). Developed during World War II and modified for survey work, airborne radar has some advantages over

photography. It can function at night or in cloudy weather, it can cover a large area rapidly, and it can produce images which have no scale variation. The source of energy is the radar equipment itself rather than the sun. Under certain circumstances, radar is able to differentiate ground objects better than a photograph (see figure 4f). In areas with constant cloud cover, radar imagery has been used effectively. Continued improvement may result in increased use of radar for census work, particularly in areas where cloud cover is a problem.

5.5 *Satellite imagery*

Satellite images differ from aircraft images in several ways. They are smaller in scale and reveal less detail about any given area. On the other hand, they produce separate images in different parts of the spectrum and can provide repetitive coverage which may help to identify some features and monitor changes. These images are described in more detail in chapter 14.

6. *SCALE*

Vertical photos suitable for census work usually vary in scale from about 1:60,000 to 1:20,000 (from about 1 inch to 1 mile to about 3 inches to 1 mile or from about 1.7 cm to 1 km to about 5 cm to 1 km). Figure 4d illustrates the advantages of obtaining enlargements of critical areas. Clearer detail is available in the enlarged (or large-scale) version, making it possible for census photo interpreters to obtain information that could not be obtained from the small-scale photo. For example, the street patterns are clearer and buildings can be identified and classified more easily. Large-scale vertical photos of urban areas may be the most important form of air photos used because they can be converted into map form by simply tracing streets and other features. For censuses, the cost of obtaining large-scale photos can be relatively high. Ease of interpretation and use must therefore be balanced against cost in deciding whether to use this scale of photography.

6.1 *Calculating scale*

Since an aerial photograph is a perspective view, it is possible to determine only an average scale across the imagery. The scale varies according to the kind of terrain, the elevation of the surface, the altitude of the plane, the focal length of the camera, and the distance from the central part of the photo (part directly below the camera at the time the picture was taken), and the varying tilts of the plane in flight. Slight scale variations do not present a problem for most census uses.

The horizontal scale of a vertical photograph can be expressed as a ratio or fraction, in the same manner as scale is shown on a map. Usually, the fraction is printed on the photo index, but is sometimes stamped on the photo itself. Where the fraction is not available, it can be calculated from other information. Often it is possible to calculate scale from other marginal information on the photo or on the photo index.

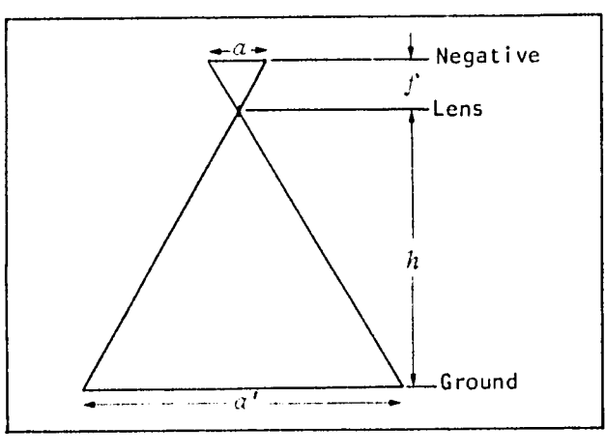
6.11 Using camera height and focal length.--To calculate the scale of a photo from these data requires the application of the geometry of similar triangles. Thus, in figure 4g,

$$a:f = a':h$$

where:

- a = width of the negative
- f = focal length of the camera
- a' = distance across the ground covered on the image
- h = height of the camera lens above the ground

Figure 4g. SCHEMATIC DRAWING FOR CALCULATION OF PHOTO SCALE



The scale of the photo can be determined directly if the focal length of the camera, the flying height of the airplane, and the average elevation of the terrain are known. The equation is as follows:

$$\text{Scale} = \frac{1}{\frac{H - h'}{f}}$$

where:

- f = focal length of the camera
- H = height (or altitude) of the airplane above sea level
- h' = average height of the terrain above sea level (average elevation)

Note that H - h' is equivalent to h (the height of the camera lens above the ground).

For example, if --

f = 0.15225 m (or 0.5 feet)

H = 3416 m (or 11,200 feet)

h' = 366 m (or 1,200 feet)

then:

$$\text{Scale} = \frac{1}{\frac{(3416 - 366)}{0.15225}}$$

$$= \frac{1}{20,000}$$

$$= 1:20,000$$

Calculation using the English system will yield the same final result. In the example, the average height of the terrain was estimated to be 1,200 feet above sea level. To achieve a desired scale of mapping photography, the average height of the terrain must always be estimated by the flight planners.

6.12 Comparing map or ground distance with photo distance.--Since scale is merely a way of relating distance in the real world to distance on a map or photo representing the same area, another method of determining the scale of a vertical photograph is to compare the photograph with an accurate map of known scale. With this method, two points on the photo are selected and the distance between the two points is measured on the photograph. Then it is compared with the measurement of the distance between the same two points on the map; the ratio between the measurements establishes the scale of the photograph. For example, if the distance between A and B is 4 cm on a map of scale $\frac{1}{50,000}$ and the distance between the same two points on the photo is 10 cm, then the scale of the photo is

$$4:10 = \frac{1}{50,000} : s$$

$$4s = \frac{10}{50,000} = \frac{1}{5,000}$$

$$s = \frac{1}{20,000}$$

The same procedure can be used with measurements on the ground instead of on a map. However, it can be used only if the straight line distance on the ground can be measured (that is, it must be possible to travel between the two points on the ground). For best results, the line between the two points on the photo should pass near the center of the photo.

6.13 Using oblique photographs.--Mapping from oblique photographs is somewhat difficult. To obtain even the crudest kind of sketch from oblique photographs requires rather complex geometry to determine the principal point, true horizon, and a perspective grid. The scale will vary from large scale at the near end of the imagery to an infinitely small scale at the true horizon end of imagery. Previously, there were areas of the world where oblique photography was the only available basic mapping information. By 1970, however, vertical photographs had been taken of most of the Earth's land surface. Now, with the use of high altitude photography and satellite imagery, the need for census cartographic personnel to use oblique photography to obtain census mapping information has been reduced considerably. But if the need should arise, the census cartographic staff is urged to seek help from specialists in photogrammetry, probably to be found in the country's national cartographic or geographic institute.

As noted, the occasion may arise when oblique photos of certain areas are taken for census purposes from small aircraft. In such cases, the maps constructed from the photos will probably be crude, but they still should be useful for census purposes. The use of this technique for censuses is limited by the cost and availability of aircraft; but in many cases it may prove to be the cheapest way to get needed information.

6.14 Estimating scale from photo features.--If no other information is available, an estimate of the size of certain objects can be made and a crude scale can be determined. For example, if it is known that most housing units in an area average 9 meters by 12 meters, the ground distance for 1 cm on this photo can be roughly calculated. Similarly, the size of an athletic field or standard railroad car, for example, may be used as an indicator. In this manner, a scale can be estimated. Generally, agencies from which imagery is obtainable know the scale of the photo. The individual who is ordering the pictures should always inquire about the scale.

6.2 *Using scale*

The most useful type of scale on census maps is the graphic scale. It allows the user to measure or relate map distances to real world distances. Although this type of scale is almost never found on air photos (some photo indexes have them), it is often useful to make one if there is need for much measurement of distance. A simple one (like those described in chapter 3) can be made of paper or heavier material. Transparent material is even better; it permits moving the scale across the photo.

Knowledge of the scale is needed for the measurement of area. Area is most easily measured by constructing a grid on tracing paper or on a transparent overlay. Techniques for calculating area are described in chapter 3.

7. *IDENTIFICATION OF PHOTOS*

In almost every case, a photograph has a unique identification. It may consist of numbers and letters or symbols. The identification is normally printed in the top margin of the photo. In figure 4h, for example, the flight code (TP-3V) and the photo number (101) appear in the upper right corner and the date

Figure 4h. AIR PHOTO IDENTIFICATION AND OTHER FEATURES

Note: Flight code and photo number--TP-3V-101; Date of flight--10-20-58; A--Highway; E--Dirt-road tracks; I--Stream hidden in wooded area.
Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

of the flight (October 20, 1958) appears in the left corner. Unfortunately, the identification is occasionally cut off when a photo is trimmed to a more convenient size.

The scale of the negative is not usually printed on the photo. There is normally no other written information included on a photograph, although identifying information may be added later, on the back of the photo, to facilitate its use. When identifying information is missing, the user must depend on other methods to pinpoint the location of the area shown on the photo.

To locate the area covered by the photo, reference must be made to an index--either an index map or a photo index. A photo index is made by fitting together and then photographing all of the air photos taken on a particular flight (or portion of a flight) so that the identifying information of each photo shows (see figure 4i). An index map includes some ground features, the area shown on each photograph, and the identification of each photo. Each type of index has some advantages and some disadvantages. Both usually include some additional information such as scale, date, and ordering information.

Photo indexes contain a wealth of usable information, and they can be produced quickly. If the photos are of small scale, a photo index may be more useful than the photographs themselves. Photo indexes, however, are bulky and cannot be folded easily to a manageable size; moreover, they display all the photos in such a way that it requires careful examination to select the one which best shows a particular area. The index map avoids some of these shortcomings by simplifying the base information (roads, rivers, etc.) and by clearly indicating the approximate area shown on each photograph.

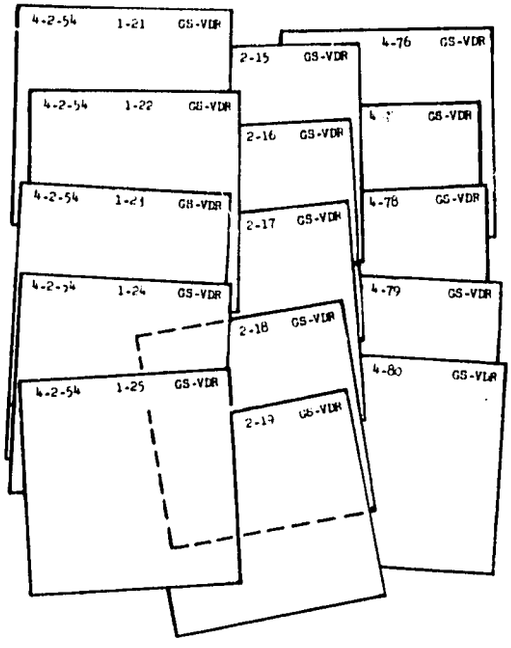
The problem of accurately showing the exact area covered by each photograph arises because all photos intentionally overlap. To provide continuity from one photo to the next, and to provide for stereo coverage, each photo overlaps the adjacent ones by 30% to 60%. Showing this overlap is impossible on a photo index, and difficult on an index map. A photo index generally shows only the upper right portion of each photograph. This portion represents approximately one-fourth of the total area contained in the photo.

Figure 4j shows a typical example of the overlap which results from standard air photo coverage of an area. Any point in the area will be shown on at least two photos, and may be shown on as many as five or six photos.

Figure 41. PORTION OF AIR PHOTO INDEX

Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Figure 4j. DIAGRAM OF AIR PHOTO INDEX, ILLUSTRATING OVERLAP

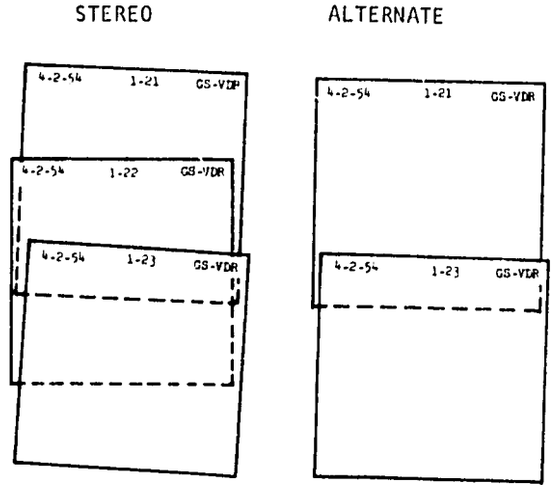


Source: U.S. Geological Survey.

If a user is ordering a single photo, he must keep in mind that a particular photo will show not just the area visible on the photo index, but also a considerable area below and to the left of the area visible on the photo index. Note the area covered by photo number 2-18 in figure 4j; note also that, in this case, the photo number is placed in the center at the top of the photo. If a user desires stereo coverage of an entire area, he would obtain the complete set of photos in order to have complete coverage of an area on at least two photos. If stereo coverage is not needed, it would be necessary to obtain only alternate photos as shown in figure 4k.

Most air photo coverage is shown so that the photograph can be used stereoscopically. However, ordering a complete set provides the interpreter with more photos than are normally needed for census work and will approximately double the costs. Ordering alternate photos will lower the costs.

Figure 4k. DIAGRAM CONTRASTING COMPLETE STEREO COVERAGE WITH ALTERNATE PHOTO COVERAGE



Source: U.S. Geological Survey.

8. TRAINING IN USE OF AIR PHOTOS[2]

Identifying the features shown on air photos and using the photos for census taking requires some training. There are some formal courses in air photo interpretation that are taught in universities and other training centers around the world. Such extensive formal training, however, is not necessary for census work. A brief introduction to a few fundamental principles plus some experience in working with photos should be sufficient.

It should be recognized that photo interpretation is largely a process of proceeding from the simple to the more complex. To identify particular features, the interpreter uses the characteristics of the features plus an association with other features and contrast with the surroundings. The successful interpreter brings to his work an understanding of

[2] *This section is based mainly on John E. Estes and David S. Simonett, "Fundamentals of Image Interpretation," in Manual of Remote Sensing, Vol. II, Ch. 14, published by The American Society of Photogrammetry (Falls Church, Virginia, U.S.A., 1975).*

the nature of many features (houses, factories, roads, rivers, etc.) and an ability to imagine what they must look like from a point of view he may not have experienced before. He should start with objects which are already very familiar to him--houses, other types of buildings, roads, rivers, etc.--and practice finding them. Then he can move on to other types of features and areas, such as fields of grain, forests, airports, railroad yards, and numerous other types of features with which he is less familiar. Many of these may be unrelated to census work, but a good interpreter recognizes most of the features on air photos and uses them to help understand other features. Until he knows what a feature is, at least in a general way, the interpreter will not know whether it is significant for census work or not.

The beginning interpreter should examine characteristics of features within a limited area in a systematic fashion. He should also study the various shapes of features, their sizes, and their tones. As he builds up a store of information about his limited area, various pieces will fall into place and he will find that he has developed a comprehensive understanding of the landscape.

The interpreter for census uses is interested primarily in linear and point features. Linear features, such as streets and trails, are the means of getting around, or they may be barriers, such as waterfalls and mountains. Linear features are usually used for EA boundaries. Point features may be buildings, parks, or other landmarks. In a population census, the map interpreter is concerned with point features (houses or other buildings) where data for the census are collected. In an agricultural census, he may be interested in interpreting areas for various crops. The photo interpreter for the census may be able to do his job well by recognizing mostly point and line features, but he will learn something about other features in the process.

The interpreter should have access to various types of reference material. Maps, especially topographic maps, will help him to establish the location of the photograph and will permit him to identify and name highways, rivers, and other familiar features. The use of photo-interpretation keys also can be useful. A key is like a map legend; it shows what a previous interpreter in this or a similar area identified in terms of the feature's characteristics. Frequently, keys are shown pictorially.

Field work should be carried out in conjunction with photo interpretation. Photo interpretation reduces the amount of field work that is necessary, but it does not eliminate it. The field work serves three purposes: (a) provides an opportunity to obtain names for features, such as roads; (b) permits the residue of features which have not been interpreted to be precisely identified; and (c) makes possible a quantitative evaluation of the accuracy of the interpretation. Field work is important to photo interpreters, especially during their period of training, so that they can see what kinds of features were hard to identify on the photo and why.

9. *IDENTIFICATION OF FEATURES*[3]

Like Sherlock Holmes, the fictional detective who could make judgments about people's lives by observing their clothing and their appearance, a highly skilled photo interpreter

[3] *This section draws heavily on Norman Carls, "How to Read Aerial Photographs for Census Work," U.S. Bureau of the Census (Washington, D.C., July 1947), pp. i-44. The pamphlet was prepared to assist census employees whose work involved the use of aerial photographs in census planning and in field work. Although the use of air photos in census work was in its infancy at that time, the pamphlet remains one of the best sources of information on this subject.*

can put together an amazing amount of data about the activities and characteristics of an area merely by observing details found on an air photo. Census personnel will find that some familiarity with obtaining information from air photos will be very useful in dealing with census mapping problems. For example, identification of dwellings, roads, streams, high mountains, bridges, and the like enables the mapping staff to delineate EA's of reasonable size and with identifiable boundaries. Identification of landmarks such as schools, monuments, parks, industrial buildings, etc., can help the field staff find the EA's.

Understanding the use of aerial photographs to the extent needed in census work should not be difficult. In the case of the vertical photograph, which is the type most frequently used, a major problem is that the picture is different from the kind most people see. The vertical photograph is a picture of the tops of things and not the sides. For example, a pointed monument set on a square base would appear as a square; but after recognizing and measuring the shadow it casts, it is possible to determine its height and understand its shape. Secondly, things look small because the usual vertical photograph is taken from a great height, and several square kilometers of area appear on one photo. This is much more than usually can be seen by the human eye at one time. However, it is possible, with good photography, to obtain sizable enlargements of the photos which will minimize this problem (refer to figure 4d).

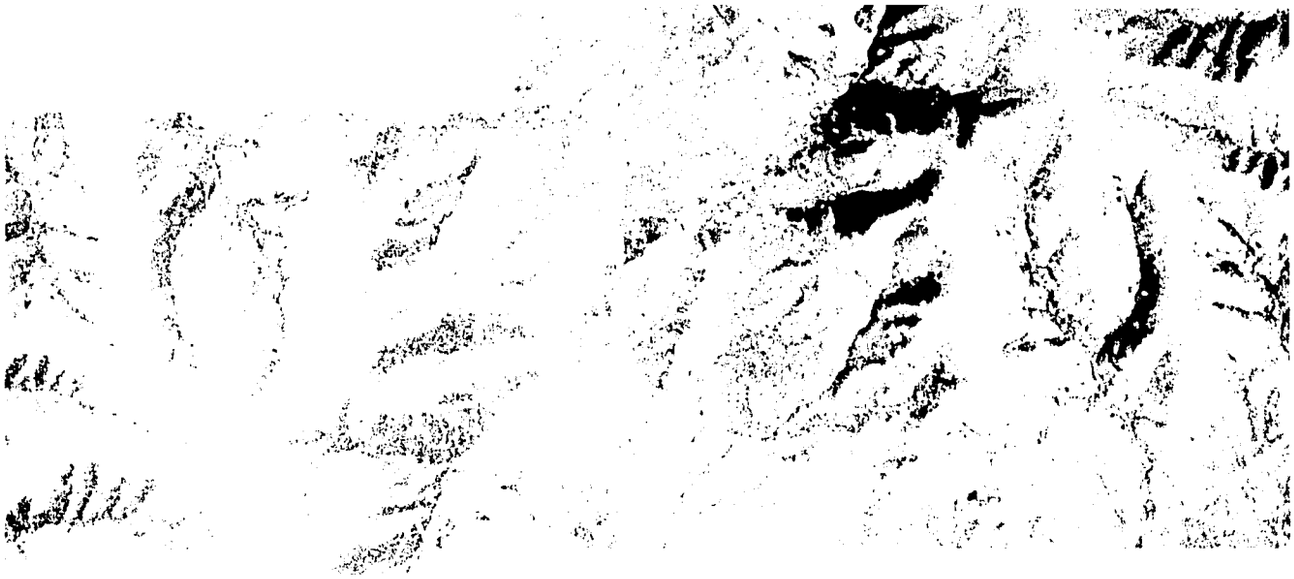
It is often necessary to compare imagery with the ground (a) when specific images cannot be interpreted or (b) when there is a need to obtain names of specific features either from name signs or by questioning persons in the field. This process is referred to as obtaining "ground truth." In general, the larger the scale the less is the need for ground truth, except that there is always the need for names of certain features when maps are to be used for census purposes.

9.1 *Orientation*

The direction of shadows on an air photo influences the way in which imagery is interpreted by the viewer. For ease of interpretation, the photograph should be positioned so that the shadows fall toward the viewer. This is to allow the image of the object to be above its shadow relative to the viewer. If, for example, the photograph is of a city in the northern hemisphere, the sun's rays most probably come from the south (depending on the time of day and latitude) and the shadows of the trees, buildings, ridges, etc., fall away to the north. Holding the photograph so that the shadows fall toward the viewer means that the top of the photograph is to the south of the city.[4] In this way, the ridges normally appear as ridges and the valleys as valleys. If the shadows fall away from the viewer on the photograph, ridges may look like valleys. The reader can try this by holding a photograph in various positions. As the photograph is rotated, ridge tops and valley bottoms seem to reverse their relative elevations. Figure 4ℓ shows two copies of the same picture. On the left photo, the shadows fall toward the viewer; on the other photo, the shadows fall away from the viewer.

If it is necessary to take an aerial photograph to the field to obtain names of places, roads, streams, etc., the photograph should be oriented with the features as observed on the ground. The technique is the same as that used for orienting a map. Note that in figure 4c the photograph and the tracing are oriented the same. In order to

[4] *It should be noted that this would be opposite to the position in which a map normally is held.*



have the shadows of this photo fall toward the viewer, the photo must be positioned with south at the top.

9.2 Use of stereoscopic photographs

The interpretation of imagery in the form of vertical aerial photographs frequently can be made easier by looking at stereoscopic (three dimensional) photography. Although not used frequently in census work, paired photographs are useful because they can be viewed in three dimensions and thus help in the job of photo interpretation. Because adjacent photographs have an approximate 30% to 60% overlap along the line of flight, any ground point within a given flight strip will be on at least two photographs (ignoring possible cloud cover). Stereoscopic viewing is possible by using two photographs of the same ground area taken from different camera stations; this constitutes a stereopair. See figure 4m for an example of a stereopair.

In using the simple-lens type stereoscope ordinarily available in a census cartographic office or the more expensive mirror type less frequently available (see figure 4n) an illusion may be created if the photographs are reversed. If the photograph which should be looked at with the left eye is placed in the right-hand position, the effect is similar to the situation created when a single photograph is viewed with the shadows falling away from the observer. In both cases, the topography and other features will appear reversed in elevation--hills look like valleys, etc.

The following steps are taken to view a stereopair:

(1) Place the stereoscope over the two photos which have overlapping coverage.

(2) Find a prominent object such as a large house or a cleared field on both photos. Put the right index finger just below the object on the right photo. Follow the same procedure with the left index finger and the left photo.

Figure 4m. STEREOPAIR

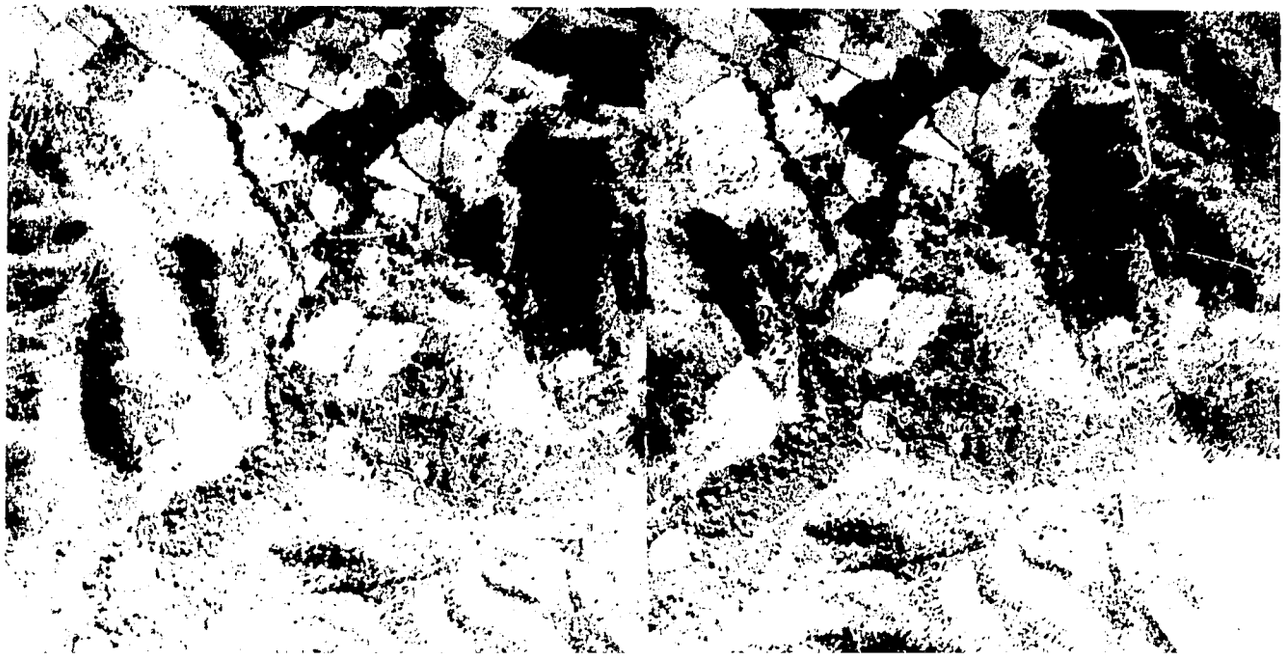
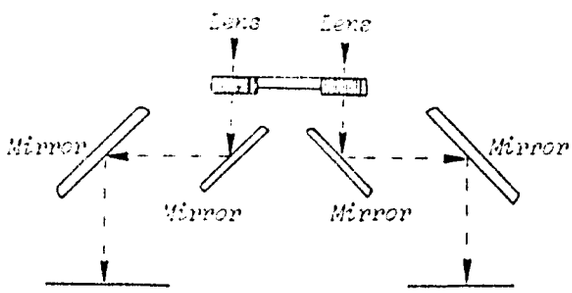


Figure 4n. TWO TYPES OF STEREOSCOPES

1. Single-lens stereoscope

2. Lens-mirror stereoscope

Lines of vision of a lens-mirror stereoscope:



Note: The top illustration is a single-lens type stereoscope that will fold and fit in a pocket. The second is an illustration of the lens-mirror stereoscope, and the third is a diagram of the line of vision. The lens-mirror stereoscope, which is less portable, permits a larger field of vision.

(3) Move the two photos slowly, bringing the two index fingers together. When they appear as one, the viewer should be able to see, in three dimensions, the objects within the area of overlap on the two photos. Patience is required for those persons who are unfamiliar with this technique and who find it hard to adjust to this kind of viewing. Eventually, skill will be developed and it will be possible to see the photos in three dimensions very quickly.

9.3 *Individual image qualities*

An aerial photograph is made up of varying shades of gray (or varying colors in a color photo). Interpreting these variations in shade or color is the job of a photo interpreter. The ability of the interpreter to identify ground features will, in part, depend on the image qualities described below. In the photos which appear in the remainder of this chapter, a particular feature is usually identified only once. For example, the key letter may point to one or two thatch roofs or it may point to one or two fence rows, although many more may be shown in the photo.

9.31 Shape.--The outline made by an object is a key in determining what the object is. It should be kept in mind that the viewer sees the tops of features and that the image on a single photo is two dimensional. When this is understood, and the ability to "see" or visualize objects from above is developed, the viewer will possess a powerful tool to help in understanding the structure, composition, and function of features. What kind of a building or structure would have such a shape when it is viewed from above? How would a house, office building, or factory look if it were viewed straight down from an altitude of about 10 kilometers? A view of an industrial plant from above could tell more about its function than if it were seen from the street; shapes recorded on the photo may reveal road

patterns, parking facilities, and some special relationships of one building to another.

9.32 Size.--Size is related to area and to volume. The scale of the photograph must be considered in estimating the true size of the object. If there is trouble in identifying an object, a magnifying glass should be used to obtain an enlarged view. If the interpretation is still in doubt, overlapping photos should be examined through a stereoscope. This will reveal the three-dimensional shape of the object, and its volume can be estimated by comparing it with other features.

9.33 Arrangement and location.--The identity of an object is often discovered by looking at the things around it. Arrangement refers to the pattern of things and how they are distributed. For instance, many Latin American cities have central parks or plazas and around the parks are churches, stores, and government buildings. Knowledge of such a local situation aids in photo interpretation. Location is also an important guide. For example, in arid or semi-arid areas where trees are found only along watercourses, it is possible to find a stream by spotting the winding ribbons of trees in an otherwise bare landscape (even though the stream itself might actually be hidden from the camera lens by overhanging vegetation). The ability to determine the identity of an object from its surroundings depends to a large degree on the interpreter's knowledge of an area and on his experience. For this reason, some interpreters will readily identify a barn, a garage, or a thatch hut, whereas others will not.

9.34 Shadow.--Objects which lie between the ground and the sun cast shadows upon the ground. This is useful to know because the shadow gives an idea of the profile view of the object which cuts off the light rays. Although some idea of the construction of a bridge over a river can be determined by observing the image of the bridge itself, the shadow of the bridge upon the water can be more revealing (refer to figure 4s). Shadows can indicate the size of a dwelling or can be used to distinguish between such features as piles of vegetation and huts with grass roofs. However, it should be kept in mind that shadows differ in length according to time of day, season, latitude, and location of the camera when the photo is taken.

9.35 Tone and color.--Tone is the relative darkness or lightness of an object recorded on a photo. It is a function of the ability of an object to reflect and to absorb light, and of the angle at which it reflects the light back to the camera. In figure 4o, the roofs of the farm buildings show different tones; in figure 4w, the grass and the dirt in the stadium cause different tones. If there were no difference in the capacity to reflect light between the object and its background, the image of the object could not be distinguished from its background. Hence, the photographic tone of an object is one of the best ways of determining what that object is; sometimes it is the only way by which it can be identified.

Color photographs have an advantage; it is sometimes possible to differentiate between objects which could not be distinguished on black and white photographs. This is possible because the objects may be of different colors even though they have the same black and white tone. Color film is more expensive. However, the use of color adds only a small percentage to the total cost of a photo project; therefore, it is being used more and more.

Color infrared (IR) photography is beginning to be used. Although infrared radiation cannot be detected by the human eye, it can be recorded with the use of special film. Care

must be taken when using IR images since many objects that appear to have the same color to the human eye have completely different colors on the IR image. Objects that reflect large amounts of IR are always shown in red on such images; for example, healthy growing vegetation appears as red no matter what color the individual plants appear to the human eye. (For more detailed discussion of IR see chapter 14.)

9.36 Texture.--Variation in tone, and the frequency of this variation, is known as texture. As the scale of the photography becomes smaller, the texture of a given image becomes finer and finer until the variation eventually disappears and the object appears smooth. In figure 4o, note that texture is an important factor in distinguishing the cultivated land from the wooded area; the cultivated land has smooth and velvety texture, while the wooded area is rough and lumpy. Figures 4q and 4s illustrate how texture can be used to identify water bodies; in both cases, the texture is very smooth. The texture of the water depends on the reflection of the sun, clarity of the water, and the ripples and waves produced by the winds and currents.

9.4 *Selected natural and man-made features*

Natural and man-made features all have distinguishing characteristics. They can be identified by means of shape, size, arrangement, shadow, tone, and texture, as described above.

9.41 Streams.--Small streams may be less obvious than large streams or rivers. However, they may be recognized by their winding courses, irregular widths, and frequently by the natural growth of trees and brush along their banks (see figure 4p). Streams always are found in valleys, which are most obvious in hilly or mountainous areas. The precise location of small streams in a wooded area may be difficult to determine on an aerial photograph; the visible evidence of such streams are breaks or variations in the density of the forest (see figure 4h).

Dry stream beds or streams along which no trees grow may resemble roads except that they are irregular in width and they generally have winding or irregular or even multiple courses. Dry stream beds are characteristic of dry areas, but they also occur in humid lands. A stream course may appear white or very dark, depending on the angle of reflection of light from the surface (see figures 4q and 4s).

Once streams have been identified, the direction of water flow may easily be determined by noting stream junctures and comparative sizes. In the vast majority of cases, tributary streams enter the more important streams at angles of something less than 90°. The major stream and its tributaries may develop into a system of large and small streams which resembles the veins in a leaf. The direction of water flow (refer to figure 4s) would be toward the larger veins or streams and then toward the central artery or main river. Divides or ridge lines are to be found above the headwaters of the smallest streams, especially between the major valleys.

9.42 Man-made watercourses.--Canals, irrigation ditches, and streams whose courses have been straightened by dredging may follow straight lines and be quite regular in width (see figure 4r). These man-made waterways may be difficult to distinguish from roads except by observing that they are connected with irregular natural stream courses and are not connected with roads, although they may be crossed by roads (as in figure 4t). An artificial lake or pond can be quickly spotted due to the presence of a dam across the stream.

9.43 Divides or ridge lines.--In census work, distinct ridge lines, or divides, are

Figure 4c. TONE AND TEXTURE IN A RURAL AREA

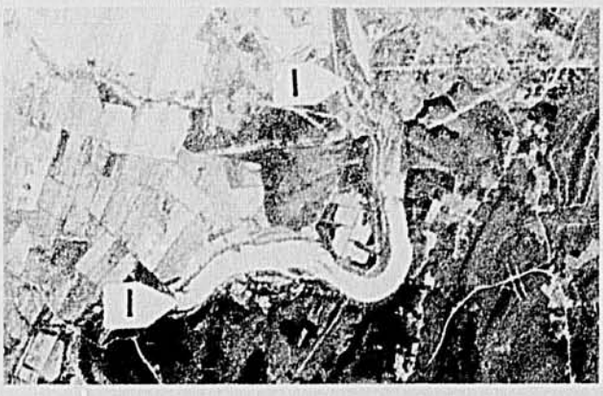
Note: B--Secondary paved road; C--Dirt road; R--Cultivated area (strip-cropped area with smooth velvety texture); S--Wooded area (with lumpy texture); T--Fruit orchard; V--Difference in tone on rough roofs of farm buildings.

Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Figure 4p. STREAM BORDERED BY LINES OF TREES

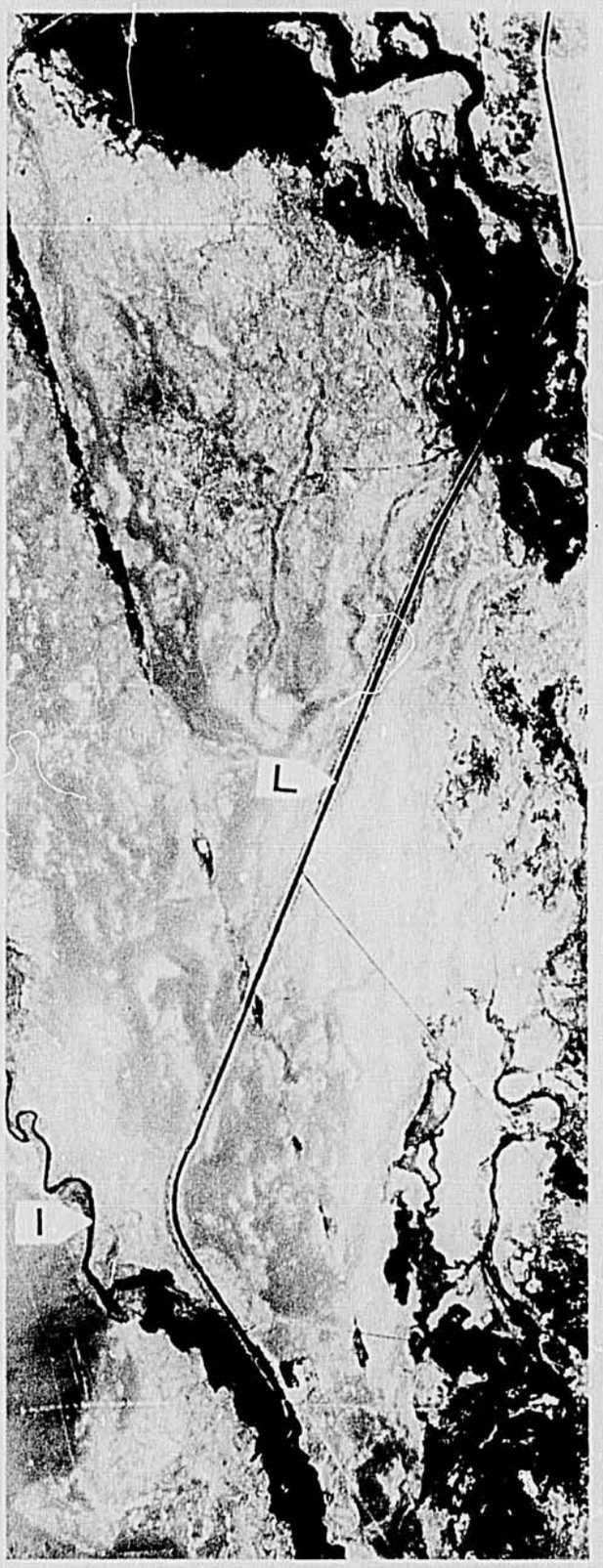
Note: I--Stream.
Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Figure 4q. VARIATIONS IN REFLECTION OF LIGHT ON WATER



Note: I--River.
Source: U.S. Geological Survey.

Figure 4r. NATURAL RIVER AND MAN-MADE CANAL



Note: I--River; L--Man-made canal.
Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Figure 4a. BRIDGES, RIVERS, RAILROADS, AND SHADOWS

Note: Bridges in this photo are built on piers which cause eddies to be created at the downstream end of each pier. D--Road bridge; F--Railroad bridge; G--Railroad yard; H--Shadow of bridge; I--River; M--Factory; Arrow--Direction of water flow.
Source: U.S. Department of Agriculture.

C
V
A
U
B
T
U

sometimes used as boundaries to define census work areas. Some members of the geography staff should develop skill in spotting these features. Divides are easily identifiable in terrain having moderate to high ranges of elevation (moderate to high relief). In terrain with only a small range in elevation (low relief), they may be identified as interstream divides; because they frequently are difficult to identify in the field, they make poor boundaries. Ridge lines in areas having moderate to high relief may make good census boundaries. A distinct pattern of streams and ridge lines may be seen in figures 4c and 4ℓ.

9.44 Roads.--Roads appear as narrow bands on aerial photos. Earth, gravel, and concrete roads usually are light in tone while asphalt, tarred, and oiled roads are dark gray. This means that an excellent blacktop highway can be less distinct on a photo than a highly reflective dirt road. A private road or lane may be distinguished from a public road because such roads usually end near a housing unit; however, this is not always the case. Paths and trails across fields and through forests have irregular curves, often wind in and out, and vary in width and distinctness. Modern highways can be recognized easily because of their width and the frequent use of "median" strips. Various types of roads are shown in figure 4t.

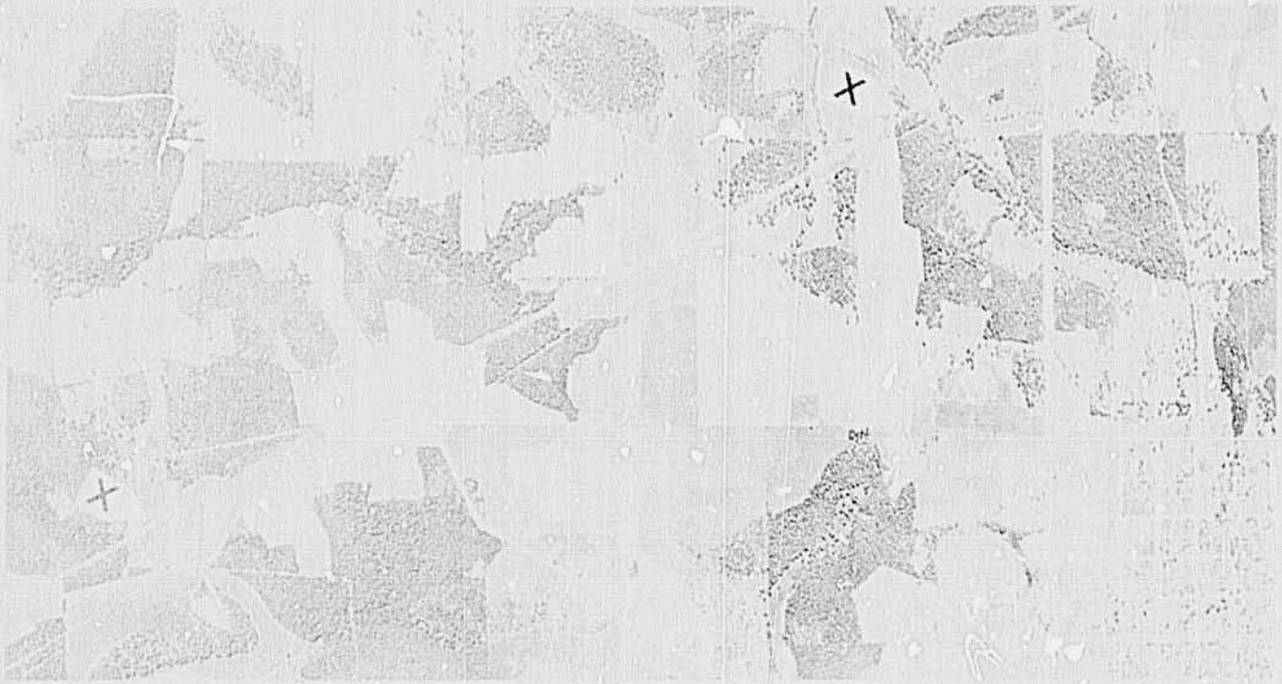
Foliage causes trouble by hiding roads and buildings. In the case of roads, the viewer must attempt to connect the visible portions. If a bridge is located but the road is hidden, common sense suggests that a road must cross the bridge. Roads are easier to find if photographs are taken when the leaves are off the trees (in the dry season in many low-latitude countries and the cold season in mid- and upper-latitude countries). However, because air photos are often used for agricultural purposes, they are likely to be taken during the growing season. Therefore, the interpreter may need to use indirect means to identify all the roads.

9.45 Railroads.--Railroads have large-radius curves or straight sections of track. They do not connect with roads (although roads may cross railroads) and there are no driveways or lanes leading from housing units which connect with the rail line. They are usually narrower than roads. On some relatively large-scale photographs the individual railroad ties can be distinguished. Railroad track spurs leave the main line at a gradual angle (not a right angle), and normally end at an industrial plant, warehouse, or collection point for materials. Railroad bridges are usually easy to spot, since a railroad will not lead into a bridge coming from a sharp curve, as frequently happens in the case of roads (see figure 4s).

9.46 Power lines.--High voltage electric lines may be used as boundary lines for EA's, especially where there are woods and forests. This is because the normal procedure is to clear the land for a given width on each side of the line; the cleared strip can be easily traced across the landscape even though the power lines themselves are not visible (see figure 4u). In urban areas, there is often a wide path, which otherwise might be occupied by housing units. The steel [illegible] towers which support the wires [illegible] on large photos, depending upon the scale; they can also be identified by their shadows.

9.47 Fence rows.--Property lines which have existed for a long time are frequently marked by stone walls, hedge rows, or bush or tree vegetation (see figure 4v). Where fence rows separate agricultural fields, they can be easily identified. In some areas, property lines might be used for agricultural census purposes or perhaps even to obtain an idea of

FLIGHT LINES



Source: Aerial photo courtesy of Soil Conservation Service, U.S. Department of Agriculture.

Figure 4.4 Flight Lines

Note: W=Water; K=Lake Kim.

Source: Aerial photo courtesy of Soil Conservation Service, U.S. Department of Agriculture.

the number of rural inhabitants in an area through an analysis of land use.

9.48 Airfields and airports.--Airfields and airports are excellent landmarks on both aerial photographs and maps. The airfield shown in figure 4e, for example, is the most distinctive feature of the photograph. Paved runways are even more distinctive than most roads because of their width, straightness, and abrupt ends. Many airfields, however, are nothing more than a cleared strip of land and may have few or no planes in the area. Unimproved airfields may be difficult or impossible to identify from an aerial photograph.

9.49 Buildings.--Buildings can usually be identified by their shapes and shadows. For example, they are regular in shape and consist of straight lines; in contrast, large trees or clumps of bushes have irregular lines. Also, buildings cast shadows which are straight-edged and angular (having corners or angles). Such patterns may be distinguished from garden plots, which will not cast shadows although they may have angular corners.

To help identify buildings, the viewer should look at surrounding objects and land cover. This information is of great value in interpretation. For example, a bus passenger station may be identified as such because of buses parked nearby. As noted, however, each country and culture may have different types of buildings and forms of land use. Accordingly, some photo interpreters may readily identify a building as a church because it is surrounded by a cemetery; in other cases, some persons can determine what type of crop is growing in a field if they are familiar with the area and its work patterns and custom

Some guides to identification of certain types of buildings are listed below.

(1) Schoolhouses. The size of school buildings may vary from area to area. They usually are larger than houses. One of the distinguishing features of a school is the play area around it (see figure 4w). One may be able to identify a soccer field, basketball court, track for running, or play yard for children. Many schools have a flag pole in the front of the building; it often can be identified by its shadow.

(2) Barns. A barn is often found close to a farmhouse. It may be larger or smaller than the house, depending on local customs. It usually can be distinguished by surrounding features such as chicken houses, animal pens, an enclosed feeding yard, piles of fertilizer, or haystacks.

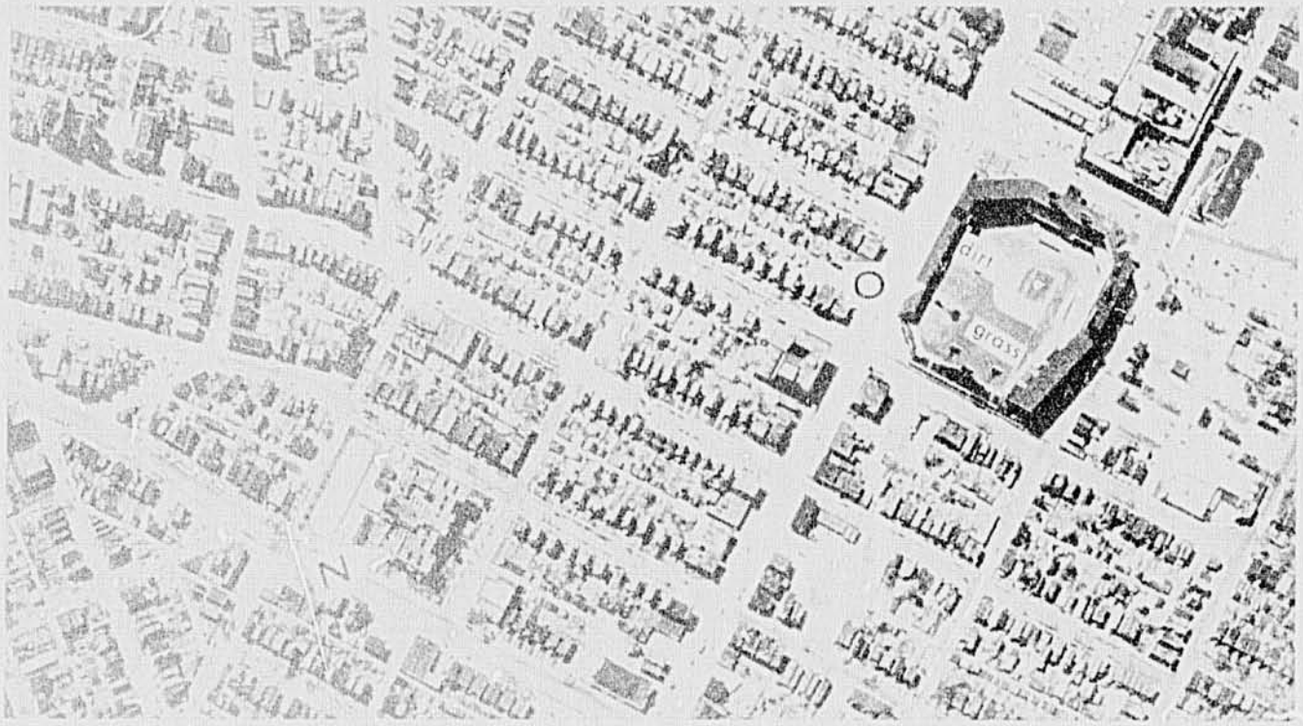
(3) Places of worship and cemeteries. A church, mosque, temple, or shrine may be found close to a cemetery. Cemeteries usually can be recognized because of the orderly arrangement of surface features such as stones, earth mounds, roadways, or small buildings. Shadows may be important aids in recognizing tall buildings such as churches with distinctive steeples or towers.

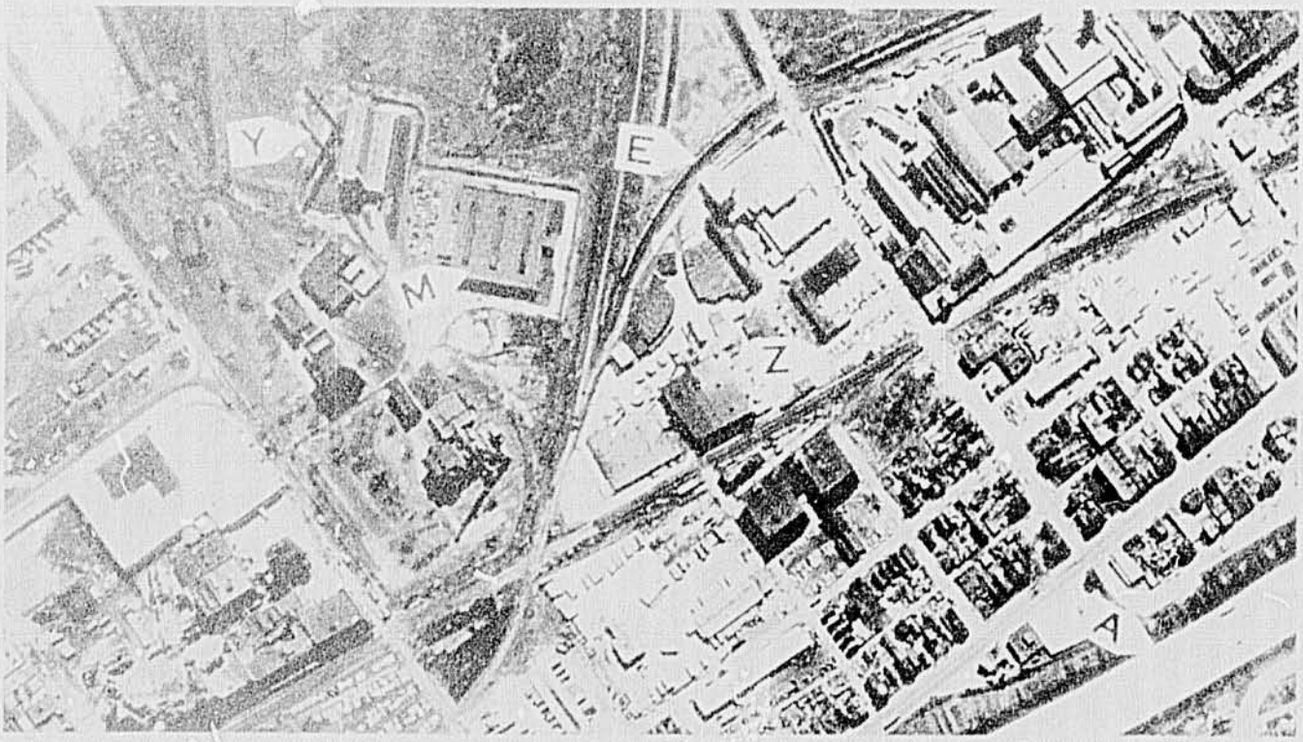
(4) Government buildings. These buildings frequently face an open plaza or park. They are usually fairly large. Parking lots and flag poles may be other guides to help in identification.

(5) Industrial buildings. An industrial plant may have a railroad track ending close to it and will usually be surrounded by open parking areas (see figure 4x). Industries are generally located in an urban area, but are occasionally found isolated from other developed areas. A steel plant, oil refinery, or other "heavy goods" industry will usually be located near or on a waterway. Such a location may provide a source of water or a means of transportation for incoming raw materials and outgoing products.

(6) Harbors. In large urban areas, harbors can be easily recognized by the railroad and highway lines coming to the water's edge, the straight-line breakwaters lying off-shore, warehouses and loading facilities, or the presence of a ship lying in a slip or off-shore.

(7) Retail stores and gas stations. Retail stores are usually clustered in urban areas: (a) in bazaars or market areas, (b) facing major streets, or (c) in shopping centers surrounded by parking lots. Isolated stores often can be recognized by their locations on main roads or at crossroads. A rural store on a


grass


Y
E
M
Z
A

dirt road frequently can be recognized by the amount of cleared land around it and the variety of heavily traveled and highly reflective dirt roads that are usually associated with it. Often there will be other buildings near it, probably a residence or two, and a beaten dirt or paved parking area usually between the retail unit or units and the main road. Gasoline stations may be recognized by the "islands" which contain the gasoline pumps. In some cases, they may have roofs which cover these islands, which then give the station or building a distinctive "L" or "T" shape. There generally will be at least one building associated with the station.

(8) Railroad stations. A railroad station can usually be identified on photographs at scales of about 1:40,000 and larger. Railroad spurs, automobile parking areas, and important connecting roads are associated with this type of building.

(9) Playing fields and stadiums. Football and soccer fields are rectangular and may have spectator stands. A sports stadium may be spotted quickly because of its distinctive rectangular, oval, or "U" shape and because of its relatively large size (figure 4w). Sometimes, the markings on the field can also be of assistance in identification.

7.5 Dwellings

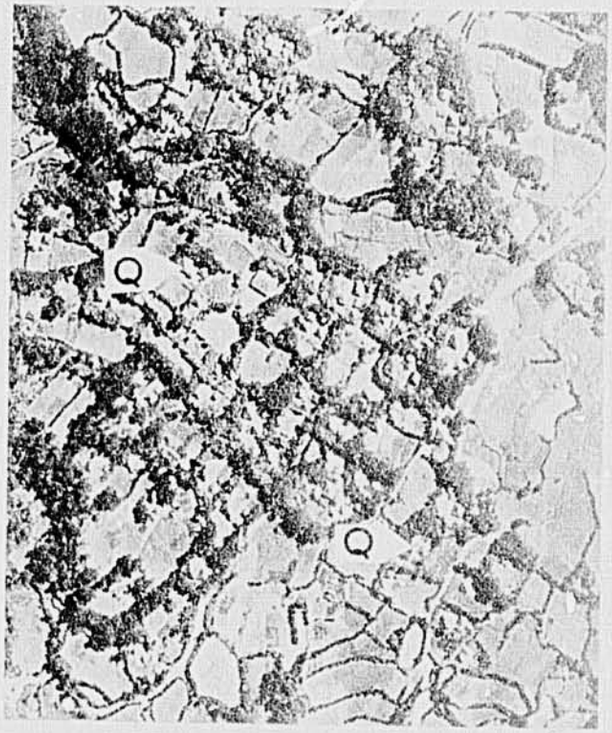
The identification of dwellings is important in most censuses. While buildings may be easy to spot on the photos, it is frequently difficult to identify them and to determine their function or use. Therefore, identification of buildings as residential can be difficult. The following examples may help to point up the problem:

(1) Although a building may be identified as an apartment house from its shape and surroundings, there still remains the question of how many housing units the apartment house contains and how many people live there.

(2) Foliage may hide many buildings of various types, sizes, and uses. Structures which have thatch roofs also may be difficult to separate and identify from surrounding vegetation or other buildings (see figure 4y). The same type of difficulty is encountered when the buildings themselves are covered with materials which reflect light in the same manner as the surrounding area. For example, buildings having roofs made of adobe may be hard to differentiate from the ground nearby, if there is no vegetation cover.

(3) Low structures containing multiple housing units or combinations of small shops and housing units also are hard to distinguish in terms of the number of units involved.

Figure 4y. HOUSES WITH THATCH ROOFS



Note: --Houses with thatch roofs, Yucatan.
Source: Photo courtesy Kodak, S.A., Mexico City, Mexico.

In these and other situations, it is necessary to look for clues. Perhaps there are agricultural fields close by which would indicate the presence of farms and population. When streets and roads become more closely spaced, there will probably be housing units associated with the pattern. Smoke can come from an industrial plant, village trash fires, a burning field, or any of a number of other man-made reasons. Irregular small dark patches on what seems to be an uninhabited sparsely vegetated landscape might be the tents of

nomadic herdsmen. Conversely, very small and very bright spots indicating objects of high reflectance (great reflecting power) might be the sun's rays reflecting off iron or tin roofs of dwellings.

9.51 Urban dwellings.--Dwellings in closely built-up urban areas commonly appear on aerial photography in rather neat, tightly packed rows along streets (see figure 4w). If there are trees, they usually grow in lines along the streets, or scattered in the yards. The angular shadows of the dwellings fall in clear outline. There may be no separate sheds or out-buildings, and every building in the block may be one housing unit or a combination of housing units. Multiple housing units generally are identifiable because of their large size and taller shadows. Objects around the buildings also may give some clues--large trash bins, play areas, and many cars parked along the streets.

Urban residential areas often contain many industrial and commercial establishments, especially in congested slum areas. In these cases it is desirable to use enlarged photographs in order to improve the accuracy in distinguishing between commercial establishments and housing units.

Wealthy suburban residential districts characteristically have large homes on large plots of land. The homes usually stand far apart and are set back from the street. In addition, there may be several smaller buildings which are used as living quarters for persons employed on the grounds, or as greenhouses, sheds, garages, etc. In such districts, the private driveways which might give clues to the number of dwellings may be completely hidden by overhanging vegetation. The housetops may form the only breaks in the foliage.

9.52 Dwellings in villages, towns, and compounds.--Dwellings in small agglomerations usually consist of farmers' houses, homes of non-farmers, commercial establishments, or mixtures of these and other types of buildings. Again, identification often depends on the land use around the structure in question. If a farmer's dwelling is located on land used for agricultural purposes, the photograph will help to determine this fact. Roofing material also can serve as a guide in identifying types of structures. Materials that are used may vary according to the type of structure. For example, housing units may have thatch roofs while commercial establishments may have tar and gravel roofs.

9.53 Rural area dwellings.--Dwellings in rural areas may vary in size; however, most are not very large. Other buildings such as sheds used for storage purposes may be so small that they are hard to spot on the photographs. In some countries the largest building in a rural cluster is often a barn, while a house is the next largest.

Commercial holdings, such as plantations, estates, or ranches, may have clusters of buildings of varying sizes. In most cases, smaller holdings consist of fewer buildings. Roofing materials in rural areas very often consist of vegetation or sod; therefore, the photo interpreter must look at an area closely in order to identify buildings.

9.6 *Land cover or land use*

Land cover is the entire collection of features that cover the surface of the Earth. Some of the features have been discussed separately in this chapter because they have special significance in census operations. The remaining elements are less important for most census operations; but some understanding

of them will aid the photo interpreter in doing his job. The term "land use" often is used for "land cover."

9.61 Types of land cover.--There are many ways of classifying (and coding) different kinds of land cover. One of the simplest, but most comprehensive, systems was developed by the U.S. Geological Survey, and has been designed to include the interpretation of features on images of all types and scales from satellites through low-flying aircraft. This system first recognizes several broad general categories of features, and then provides for subdividing each one through progressively more detailed levels until the level that meets the needs and abilities of the particular interpreter and his project is reached. To illustrate the system, the first two levels are shown below.

Level 1

01 Urban and built-up land
- 01 Residential
- 02 Commercial and services
- 03 Industrial
- 04 Extractive
- 05 Transportation, communications, and utilities
- 06 Institutional
- 07 Strip and clustered settlement
- 08 Mixed
- 09 Open and other

02 Agricultural land
- 01 Cropland and pasture
- 02 Orchards, groves, bush fruits, vineyards, and horticultural areas
- 03 Feeding operation
- 04 Other

03 Rangeland
- 01 Grass
- 02 Savannas (palmetto prairies)
- 03 Chaparral
- 04 Desert shrub

Level 2

04 Forest land
- 01 Deciduous
- 02 Evergreen (coniferous and other)
- 03 Mixed

05 Water
- 01 Streams and waterways
- 02 Lakes
- 03 Reservoirs
- 04 Bays and estuaries
- 05 Other

06 Non-forested wetland
- 01 Vegetated
- 02 Bare

07 Barren land
- 01 Salt flats
- 02 Beaches
- 03 Sand other than beaches
- 04 Bare exposed rock
- 05 Other

08 Tundra
- 01 Tundra

09 Permanent snow and icefields
- 01 Permanent snow and icefields

It is apparent that a very wide range of features can be seen on aerial photographs, depending on the area being studied and the photographs that are selected. Only a few examples are discussed below.[5]

9.62 Cropland and pasture land.--Cropland or pasture land will be recognized by its division into fields. Fields ordinarily are bounded by straight lines that are marked by bushes, trees, or perhaps only unplowed earth (which will not appear the same as plowed earth). The contrasts between different crops or crop combinations in different fields will create different tones; differences in the time of planting or harvesting will have the same effect. Field sizes vary widely throughout the world, but almost always they are larger than the farmhouse yard or the individual farmer's compound. In many parts of the world, the farmers live in villages, and there

[5] *For more information, refer to Manual of Remote Sensing, Vol. II, published by the American Society of Photogrammetry (Falls Church, Virginia, U.S.A., 1975); refer also to the various textbooks and manuals on photo interpretation.*

are no dwellings or other structures in the fields. Shadows are of minor or no importance, because the crops usually are not very tall. In terms of patterns, the fields form a mosaic of geometric shapes, although some of the pieces may be of other types of cover. Figures 4o and 4v illustrate characteristics of cropland.

9.63 Forests.--Forests are areas where trees cover most of the ground. Because the trees are unequal in height and irregular in spacing, the apparent texture of wooded areas is uneven and rough. Size and shape of areas are not dependable criteria; there may be vast expanses of forest in the tropics, or there may be only scattered patches of wooded areas as shown in figure 4o. Individual trees may vary from less than the height of a man to more than 100 meters in height, depending on the species, the maturity of the trees, and the physical environment. In many cases the trees are large enough to cast recognizable shadows on adjacent treeless ground.

Orchards are a special case. Here, man has established a regular geometric pattern of tree location that is quite distinct from the random natural pattern. Orchards also occupy area units like fields, and within any one unit the trees are rather uniform in size (refer to figure 4t).

9.64 Rangeland.--Rangeland is land that is extensively grazed; often it does not have fences or other artificial barriers. Normally it has few trees, and these are scattered. It differs from crop and pasture land in that it is not divided into a block pattern of fields; rather it is more nearly uniform in tone, with changes being in the form of gradual shadings over the area rather than sharp changes along fence lines. Texture may be as smooth as it is for cropland, or it may appear a little rougher if shrub growth is common; but it is not as rough as the texture of wooded areas.

9.65 Urban settlements.--Streets, houses, schools, factories, public buildings, and other features that were described earlier in this chapter form an urban or urban-like land cover when they are clustered. Figure 4w illustrates an urban landscape. The regularity and density of the street pattern, the many buildings close to one another, and the relatively small amount of empty land are the usual characteristics of an urban settlement.

9.66 Other types of land cover.--Other types of land cover will be mentioned only briefly.

(1) Barren lands include beaches, sand dunes or other sandy areas, and bare rock outcrops. Beaches are located along water bodies and frequently are used for recreation--as indicated by the presence of roads, bath houses, and other structures that serve the beach users. Other barren lands usually have only sparse signs of human or other use. Generally, barren areas are light in tone; sandy areas appear smooth, with even sand dunes having smooth surfaces; bare rock is rougher, often showing cracks, corners, and edges.

(2) Water areas often are glassy or mirror-like unless there has been a wind to ruffle the surface or there are rapids or falls. Its reflective ability and tone characteristics have been described earlier.

(3) Snow and ice are extremely light in color; where they exist, they usually are the lightest parts of a photo.

10. CONCLUSIONS

Although aerial photographs have limitations, a well trained interpreter can obtain a substantial amount of information that can be of great value in preparing or updating maps for census or survey work. The identification of structures, and particularly residential dwellings or houses, is not to show them on a map but rather to count them and thus provide a basis for estimating the number of inhabitants living in an area where other estimates are not available; counting houses on an aerial

photograph also serves as a check on the reliability of other estimates. In turn, the HU estimates from aerial photographs can serve as a guide to dividing a city, town, village, or rural area into EA's of relatively small and equal size, so that an enumerator can complete his assigned EA during the census period. The identification of other features enables the office staff to give more specific guidance to the field staff. For these reasons, the availability and usefulness of aerial photographs and their value for follow-up surveys should be given very careful consideration in the early planning stages of a census.

Chapter 5. MAP SKETCHING

1. INTRODUCTION

Ideally, suitable maps are acquired for all parts of the country before base maps are prepared and divided into EA's. In practice, however, it may not be possible to acquire suitable maps for some areas. A sketch map may be the solution.

A sketch map is a hand-drawn map of an area. It is usually constructed in a relatively short time and with the aid of simple tools. Sketch maps do not possess the high order of accuracy required of topographic maps, for example, and are not intended to do so. Sketch maps are needed in two types of situations:

(1) When there is no suitable map or air photo available for the area; that is, when there is no map of any kind, when the only map available is of too small a scale to show sufficient detail, and when existing maps are seriously out-of-date. The sketch map is used by the NSO to prepare the base map for delineating EA's.

(2) When the EA map sent to the field turns out to be so out-of-date that it would be easier to draw a crude sketch than to try to mark the changes on the available map. This may be the case when extensive construction creates new streets or new settlements in the area or when new highways eliminate streets and other landmarks that are on the existing map.

Chapter 5 describes how to make a sketch map for census purposes. Most of the discussion is directed to making a sketch when there is no suitable map available to use as a base map for delineating EA's, described in (1) above. Section 8 of this chapter deals with the situation described in (2) above.

2. NEED FOR SKETCHING

As indicated above there are several circumstances when sketch maps are needed. In a census the decision to prepare a sketch map should be considered carefully. The NSO staff should determine if a more practical alternative exists. For example, it may not be necessary to make a map of a desert or swamp if it is known that it is not habitable. In other cases, it may be easier to correct an old map than to make a sketch.

Although sketching is a more rapid process than conventional surveying and mapping, it is nevertheless time consuming and requires field visits. Moreover, personnel assigned to do the sketching will need some technical ability, a knowledge of basic geometry, and some training.

When it is necessary to prepare a sketch map, usually a team from the Geography Division of the NSO is sent to the area involved. Personnel from NSO field offices also may be used if they have better knowledge of the area, can be spared from their usual duties for a short time, and can be trained. Since the sketching needs to be done in advance of setting up EA's, crew leaders and enumerators would not need to be involved in pre-enumeration sketching; however, they should be familiar with the basic principles of sketching in order to apply them if they discover that the EA map is seriously out-of-date.

3. REQUIREMENTS FOR A SKETCH MAP

For census purposes, a sketch map should not include unnecessary features but it must be sufficiently detailed to permit the geography staff to prepare a base map for EA delineation. Moreover, it must include features and other information that will help the crew leaders and enumerators to locate and travel around their areas. Included are administrative boundaries,

major transportation and communication features, and major landmarks. The map sketch should be consistent in scale and direction, and features should be indicated by standard map symbols.

Natural features which should be shown include streams, rivers, and lakes. As on EA maps, contour lines and detailed features of the landscape are not shown. An exception is made for unusually prominent landforms which help the enumerator to locate other features. Such prominent features should be indicated on the sketch map in words written parallel to the trend of the feature; for example, "Blue Ridge" written parallel to the crest of the ridge would indicate its location.

Man-made features of the landscape normally are very important on a sketch map, since the enumerator depends heavily on the location of these features to plan his route of travel. A country should adopt a set of many symbols (similar to those illustrated in exhibit 3-1) and use them to show the location of highways, roads, railroads, bridges, parks, factories, schools, mosques, churches, administrative area boundaries, etc. Finally, a sketch map should show some peripheral area so that the features can be used to merge the sketch with maps of adjacent areas.

4. EQUIPMENT FOR SKETCHING

A sketch map of acceptable quality can be constructed with simple tools. The following basic equipment is recommended:

(1) Hard pencils and erasers
(2) Magnetic field compass with compass card
(3) Ruler
(4) Protractor
(5) Drawing paper and hard writing surface
(6) Form GEO-201, Information for Map Sketch

4.1 Pencils

Pencils of 4H hardness are usually recommended since they have less tendency to smear. It is advisable to carry a pencil sharpener to keep a sharp point on the pencil. A small piece of sandpaper can substitute for a conventional pencil sharpener.

4.2 Magnetic compass

Several types of magnetic field compasses are satisfactory for map sketching. A compass with a compass card, scaled in degrees from 0 to 360, is preferable since it can be read with greater precision than a compass showing direction and only the 90° points (see figure 5a). For sketching census maps, it is not necessary to use a compass which has a bubble for leveling the instrument; nor is it necessary to use a compass which adjusts for magnetic declination (deviation from true north).

4.3 Ruler

An ordinary 30 cm (12 inch) ruler is suitable for most sketching. However, if available, the triangular variety known as an "engineer's scale" has the added advantage of allowing the map sketcher to subdivide unit measurements in a number of ways (see figure 5a). An engineer's scale shows measurements in several units; for example, one side may show decimeters and centimeters, another may show centimeters and millimeters, and another may show inches subdivided into sixteenths.

4.4 Protractor

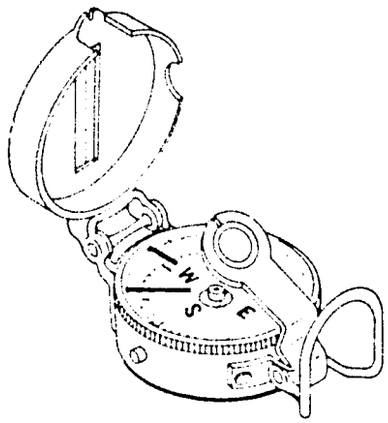
Another instrument that is needed is an ordinary protractor. This is an instrument with a graduated arc for plotting angles on paper. A simple inexpensive one will suffice (see figure 5a).

4.5 Paper

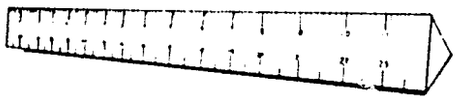
The map sketcher should use a good quality drawing paper. The surface should be smooth and tough so that it will not smear and will not be damaged by erasures. Most paper of this type will be high in rag content, of medium to

Figure 5g. MAGNETIC COMPASS, ENGINEER'S SCALE, AND PROTRACTOR

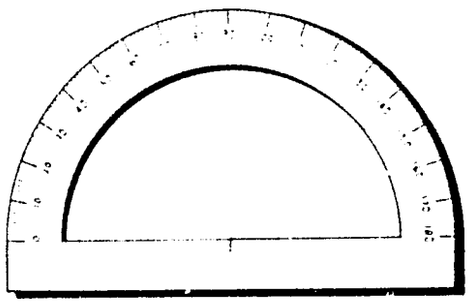
Magnetic compass



Engineer's scale



Protractor



heavy weight, and two ply. With the paper, the sketcher needs a stiff piece of cardboard, plywood, fiber board, or similar material, to use as a writing surface. What is known as a clipboard would be excellent. A clipboard is a small writing board with a spring clip at the top for holding papers.

4.6 *Form GEO-201, Information for Map Sketch*

Form GEO-201, provided by the NSO, should be used by the map sketcher to record all the information that the draftsman needs to construct the map of the area--distances between points, directions, location of features, etc. This information is the basis for drafting the base map and for delineating it into EA's. An illustration of a sketch and the accompanying form GEO-201 are shown in figures 5h and 5i.

5. *SKETCHING TECHNIQUES*

Map sketching involves the location of ground features in relation to each other and measurement of the distances between them. It consists of two principal tasks: (a) measuring angular direction and (b) measuring linear distance. Angular direction may be vertical or horizontal. Vertical measurement of height and elevation requires knowledge of trigonometry and surveying. Ordinarily this type of measurement is not needed for census map sketching. However, it is advisable to indicate on the sketch the location of mountains, valleys, and the like. The sketching operations described in this chapter refer to horizontal measurement of direction.

Persons who do map sketching ordinarily need not only training in the use of the tools that are listed above but also some training in certain basic skills. The training is not difficult, and the results of the training can be evaluated by checking the final sketch with the location of features on the ground. Below is a description of basic skills that the map sketcher needs.

5.1 *Using a compass to measure direction*

The operation of a magnetic compass is simple. The compass ordinarily is a round box with a free swinging needle, which will orient itself parallel to the Earth's magnetic field and therefore will point to the magnetic north pole. Note that magnetic compasses establish magnetic north rather than geographic north, which is the direction to the North Pole. In

detailed map work which requires a high degree of accuracy, correction of compass readings would be necessary; sketch maps for a census normally do not require such adjustment.

Every compass is sensitive to magnetic attraction. The needle may be disoriented by an iron object in the close vicinity, including bicycles or automobiles. There will be fewer errors if readings are taken at some distance from metallic objects.

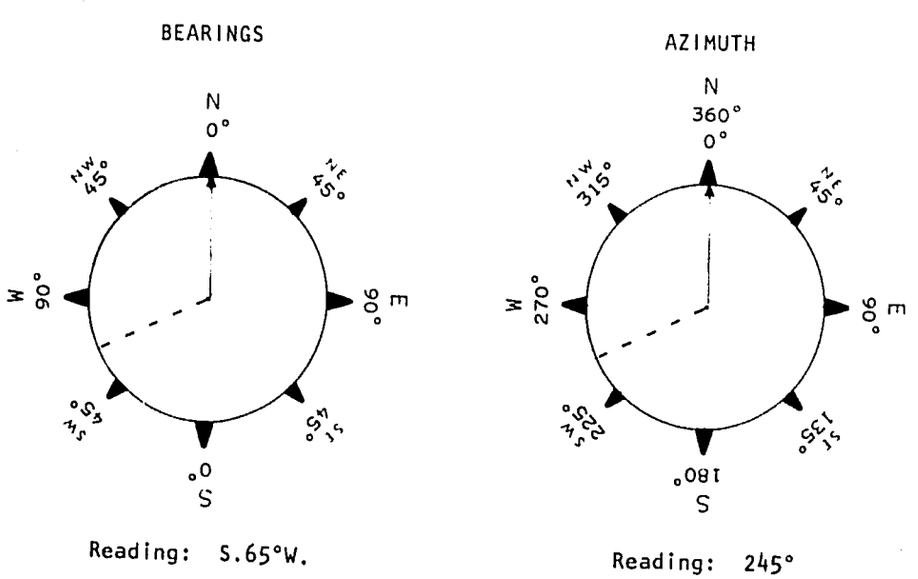
A magnetic compass is used to determine direction. The observer measures (or reads) the angle between magnetic north, as indicated by the needle of the compass, and the line of sight between himself and an object. A peep sight (small lens) is mounted on one side of the compass and a vertical wire can be seen on the opposite side. The observer sights through the small lens and lines up the vertical wire with a distant object. Then he levels the compass and reads the angle on the compass card.

5.11 Systems for determining direction.--There are two principal systems for designating direction--the compass bearing system and the azimuth system. In the compass bearing, the compass card shows the conventional North (N), East (E), South (S), and West (W) directions. All other directions are designated as the number of degrees of angle east or west of north (in the north half of the compass) and east or west of south (in the south half). Thus, the direction halfway between north and east is designated N.45°E. Another way is to describe the direction as 45° from north in an easterly direction. In the south half of the compass, the line S.65°W. in figure 5b is 65° west of south.

In the azimuth system, the compass is divided into 360 degrees beginning with 0° in the north position and proceeding clockwise. North is designated 0°, east is 90°, south is 180°, and west is 270°. A line halfway between south and east would be 135° in the azimuth system or S.45°E. in the compass bearing system. For most census sketching purposes, the azimuth system is preferable since directions can be read easily and with less chance of confusion. In figure 5b the direction in the azimuth system is 245° (or S.65°W.).

5.12 Backsighting.--The angular direction of each road, trail, street, etc., is measured from both ends of a straight-line portion of

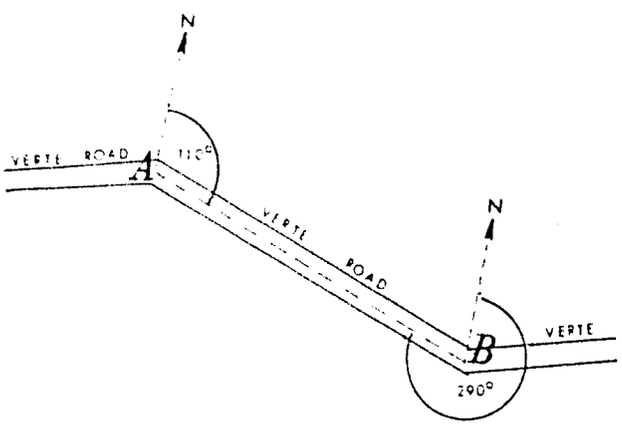
Figure 5b. COMPASS DIRECTIONAL SYSTEMS



Reading: S.65°W. Reading: 245°

the feature. The second reading serves as a check on the accuracy of the first. The two readings should differ by exactly 180°. For example, in figure 5c, the azimuth reading at point B is 290°. At point A, another compass sighting of 110° is taken along a straight part of Verte Road back to point B; this is often referred to as "backsight."

Figure 5c. AZIMUTH READINGS FROM OPPOSITE ENDS OF A LINE



Note: The difference between azimuths is 290°-110° = 180°.

Note that the difference in the two readings is 180°. The accuracy of the measurement depends on the quality of the compass, the experience of the sketcher, and the nature of the terrain. In practice, if the compass sightings are within approximately 5° of the ideal 180° value, they are adequate for census purposes. Larger differences suggest errors in readings, which may require that they be repeated.

5.13 Procedure in the field.--Assume that the map sketcher has a magnetic compass with 0° to 360°, and assume that he is sketching the area illustrated in figure 5d. He would follow the instructions given below.

(1) Set the magnetic needle (which points to magnetic north) at 0° azimuth. When the needle stops moving, tilt the compass slightly. This will keep the north arrow at 0° without fluctuating. In figure 5d, assume you are standing at point A.

(2) Bring the compass up to eye level and look at point B. Take an azimuth reading. Note that the reading is 332°.

(3) While standing at point A, look also at point X; the azimuth reading for X is 39°.

At each point of observation in figure 5d, note that readings were taken for two other points. Readings to points B and X were taken when the observer was at point A. At point B, readings to points A and C were taken. This procedure was repeated for the entire area.

5.2 *Measuring distances*

Another important task in map sketching is the measurement of distance. This can be done by pacing, striding, using a wheel, or reading an odometer.

5.21 Pacing.--If distances are measured on foot, a simple but careful pacing procedure is required. Distance is calculated by counting the number of steps between two points and multiplying by the average length of the pace. For example, if a person steps off 150 paces between two points, and the average length of his pace is 0.6 meter, the distance between the points is 150 X 0.6 or roughly 90 meters.

To determine average length of pace, proceed as follows:

(1) With a measuring tape, or similar device, measure the distance between two points--about 100 meters (or 100 yards) if the surface is level and 200 to 300 if hilly.

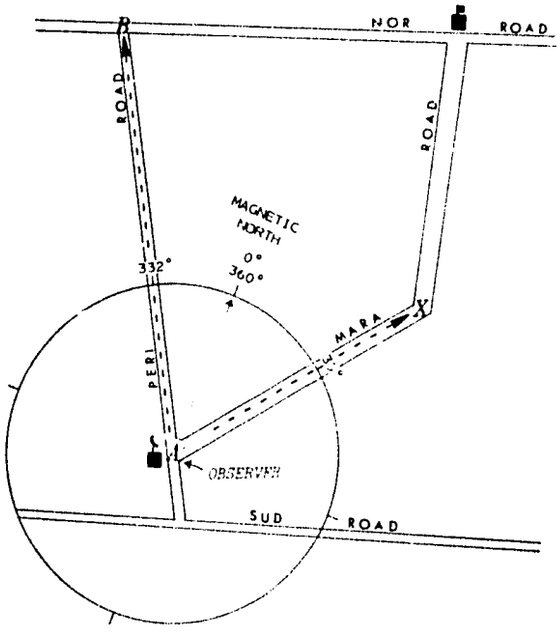
(2) Walk the distance at least three times in each direction (a total of six times). Walk normally; do not take unusually long or unusually short steps. Count the number of steps taken each time.

(3) Compute the average number of paces for the six trips. In computing this average, disregard any count that is unusual. For example, if the counts are 154, 157, 153, 141, 159, and 153, disregard 141. The average would be (154 + 157 + 153 + 159 + 153) ÷ 5 or 155.2 paces.

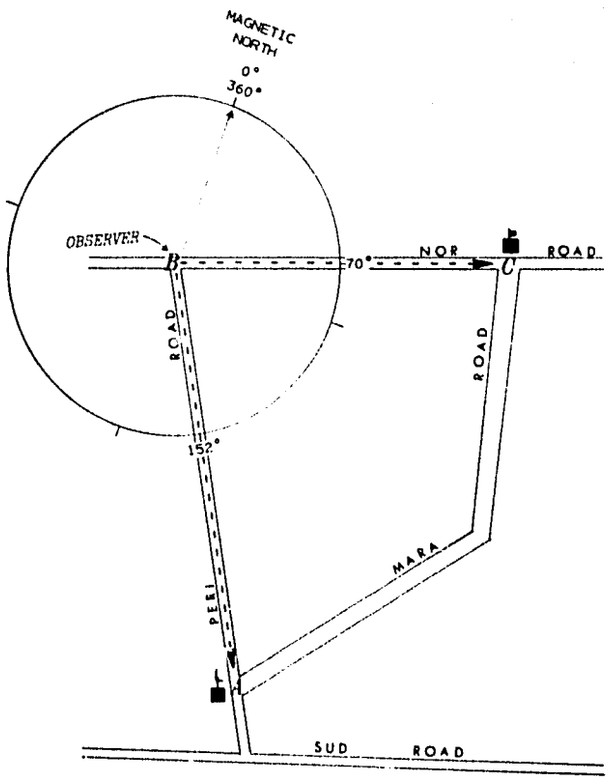
(4) Divide the average number of paces into the distance that was laid out to get the average length of pace. In the example, 155.2 is divided into 100 meters for an average of 0.644 meter per pace.

Figure 5d. USE OF A MAGNETIC COMPASS

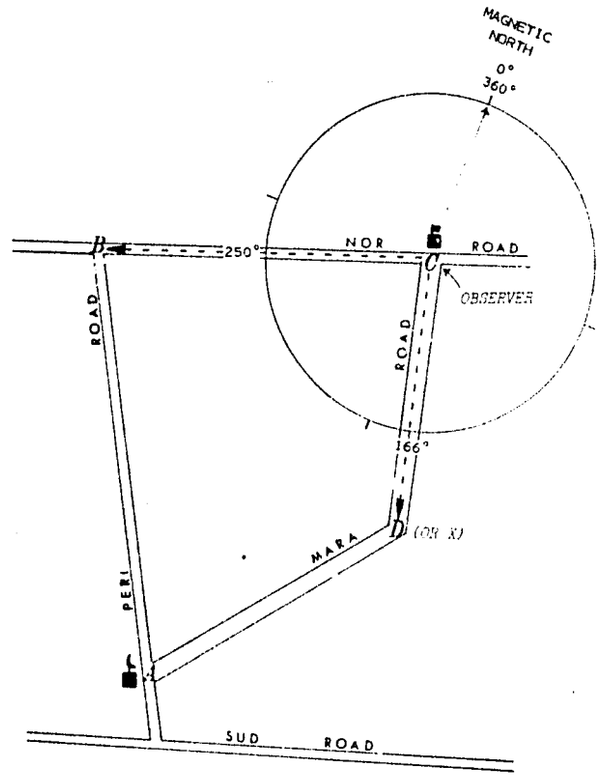
1. Observation AB and AX



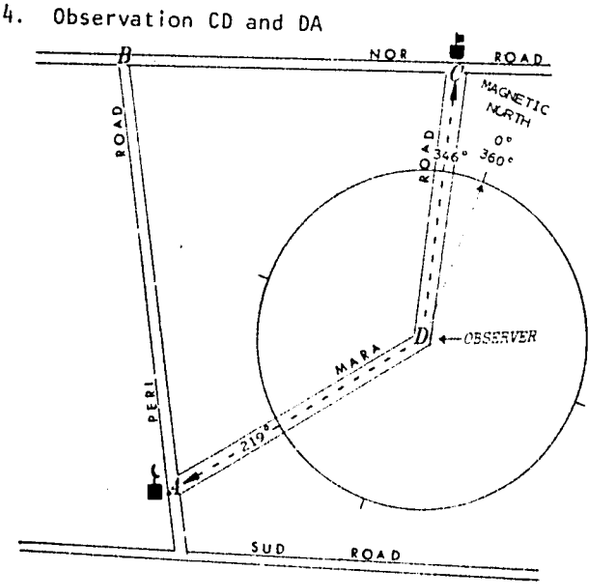
2. Observation BA and BC



3. Observation CB and CD



4. Observation CD and DA



Each person will have a different length of pace. Moreover, the length of pace varies on unusually steep land slopes, or when a person is very alert or very tired. Nevertheless, for each individual, an average pace length is satisfactory for most census purposes. Number of paces and average length of pace should be recorded on form GEO-201 and converted to distances by the NSO staff.

The same principle is applied to striding except that strides are twice as long as paces and are easier to count, particularly when the counting gets into hundreds of paces. Count as one stride each time the right foot (or the left foot) touches the ground.

5.22 Measuring with surveyor's chain or tape.--For short distances, the map sketcher may use a surveyor's chain or tape. The links of a surveyor's chain are usually in standard units of measure--a foot, $\frac{1}{2}$ of a meter, etc. Likewise, a tape could be marked in standard units. With chain or tape, the measurement of distance would be more accurate than by pacing. On the other hand, both require a team of at least two persons (unless the map sketcher can anchor the chain or tape to a stake or tree). The chain or tape also may be useful to guide the sketcher in sighting in a straight line.

5.23 Other methods.--When traveling by car, odometer readings can record distances. When traveling by bicycle, an odometer can be attached to one of the wheels. A simple wheel also can be revolved and distances measured by multiplying the circumference of the wheel by the number of revolutions. A counter attached to the wheel can record the number of times it turns. For short distances, the sketcher can make a distinct mark on the rim of the wheel and count the number of times it turns. Form GEO-201 can be used to record the results.

Using an automobile permits greater and faster coverage of areas. However, a satisfactory job of sketching usually requires frequent stops and a combination of driving and pacing.

5.3 *Traversing*

Traversing means walking or riding around and within the area to be sketched and noting distances and directions. A traverse may be long or short, depending on the number of "legs." (A leg is a straight part of a road from a point to where another road intersects or where some important feature is located; or it is an arc of a circle if the road is curved.) The number of traverses depends on the number and straightness of the roads in the area. Since an enumerator is expected to canvass his EA thoroughly, the map sketcher must traverse the area enough times to ensure that all the roads, streets, and trails in the area are included in the sketch.

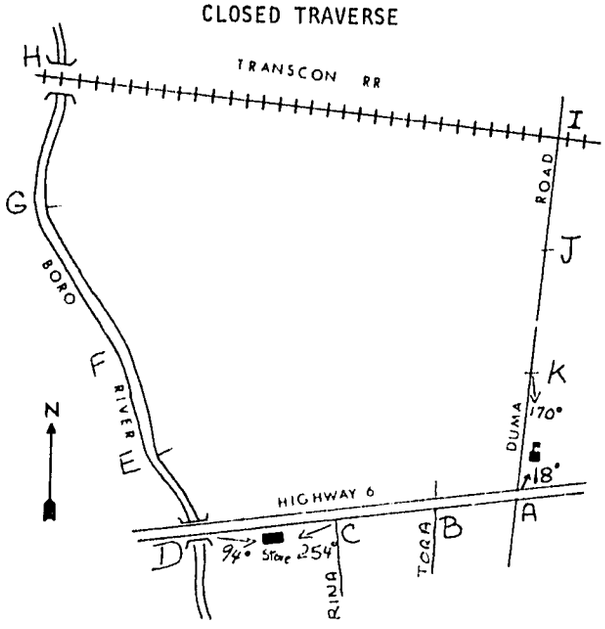
Two types of traverses are involved. A closed traverse is a walk or ride around the boundary until the observer returns to the point where he started. An open traverse is a walk or ride along a particular path or road; the observer need not return to his starting point. In both cases, observations of features are taken on both sides of the trails or roads that are to be shown on the map.

5.31 Closed traverse.--The person making the map sketch should first make a closed traverse of the area. He should produce a rough sketch that would show major landmarks on both sides of the traverse as well as the points of intersection and the directions of intersecting land features, such as roads, trails, streams, power lines, or boundary lines.

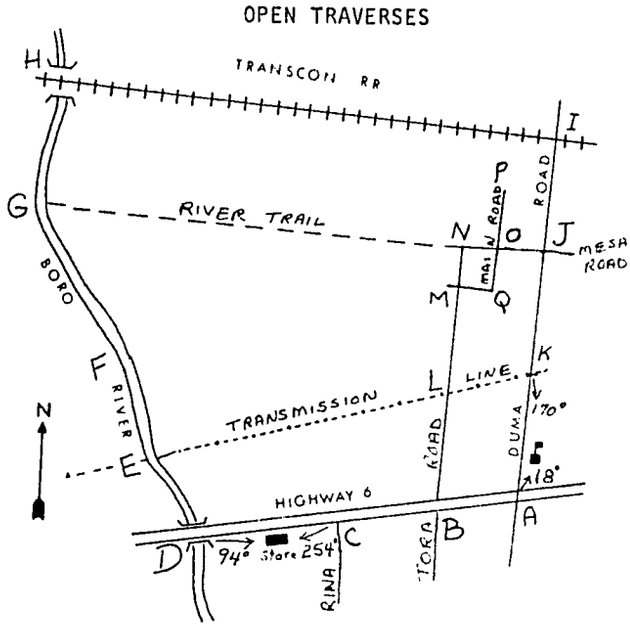
Figure 5e contains an example of a closed traverse. Note that the observer started at point A and proceeded clockwise until he came back to point A. Note also that he marked the points of intersection of roads and trails.

5.32 Open traverse.--After he completes the closed traverse, the map sketcher fills in

Figure 5e. CLOSED AND OPEN TRAVERSES



Note: The closed traverse follows the known boundaries of the area to be sketched; it consists of legs AB, BC, CD, DE, EF, FG, GH, HI, IJ, JK, and KA.



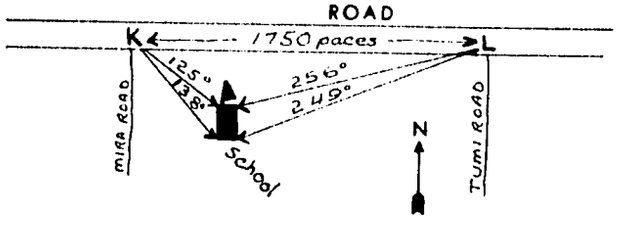
Note: Traverse B to N consists of legs BL, LM, and MN; traverse K to E consists of KL and LE; traverse J to G consists of JO, ON, and NG; etc.

the sketch by making open traverses through the area (see figure 5e). Techniques for measuring distances and angles are similar to those for closed traverses.

5.4 *Triangulation*

To be useful in the census enumeration, the EA map should indicate important landmarks as well as rivers, nighways, roads, and streets. A technique for determining the location of a landmark in relationship to other landmarks or features is called "triangulation." In figure 5f, if the location of points K and L is known, the location of the school may be established with a magnetic compass. At point K, a sighting is taken on the school and the azimuth reading is recorded to establish the line from K to the school. In a similar way, a reading is taken from point L to establish the line from point L to the school. The school will be located at the intersection of the two lines when plotted on the map. If the building is large and more precise measurements are required, the sighting can be made from points K and L to the front and back of the building, as illustrated in figure 5f.

Figure 5f. TRIANGULATION

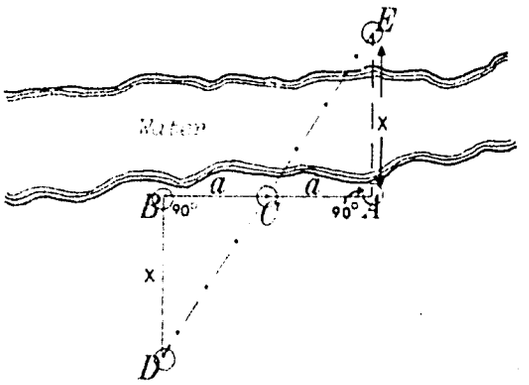


5.5 *Getting around obstacles*

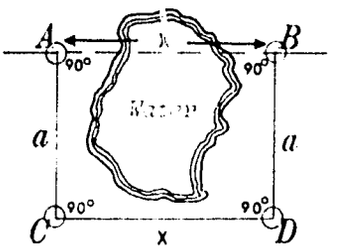
Measuring distance is simple as long as no physical obstacles are encountered. Where obstacles do occur, distances that cannot be paced can be measured in other ways. Several examples are given in figure 5g. You will note that they use basic principles of plane geometry. The selection of the method would depend on the contour of the land and accessibility to features or markers which can be

Figure 89. MEASURING ACROSS OBSTACLES

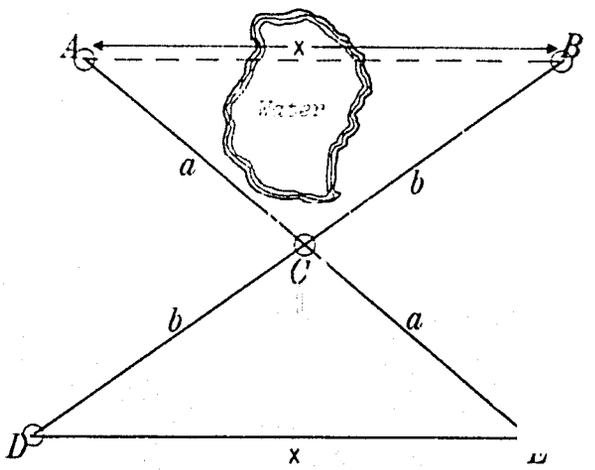
Example 1. Congruent triangles



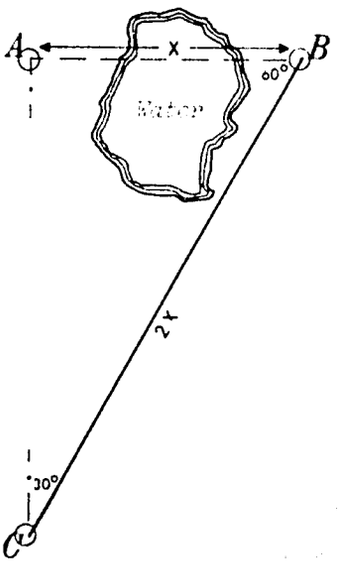
Example 3. Parallel lines



Example 2. Congruent triangles



Example 4. Sides of a 60°-30° triangle



LEGEND: ○ Stake or other marker ——— Paced line;
— — — Distance to be computed —·—·— Line connecting sighting points

used as sighting points. Tall pieces of wood, large stones or rocks, a tree, or some other distinct feature can be used as a marker.

5.51 Example 1.--In this example, the line to be measured crosses a wide stream. The following is one way to measure the distance by constructing congruent triangles (triangles of the same size and shape).

(1) From point A, sight across the stream to point E. If point E can be reached from the other side of the stream, a marker of some sort should be placed there; or a large tree or building could serve as a marker.

(2) Pace the distance from A to B, at a right angle to line AE. Place a stake or marker at A and at B.

(3) Divide line AB in half; place a stake or rock marker at C, which is the midpoint.

Note that the distance from A to C is "a" and the distance from C to B is "a."

(4) At a right angle to line BA, proceed to D, which is the point where you can sight in a straight line from D to C to E.

Triangles BCD and CAE are congruent (two angles and one side equal). Therefore, line DB (a distance of X paces) equals AE (also X paces). Note that the angles at A and B must be 90° angles. Note also that when two lines intersect, opposite angles are equal.

5.52 Example 2.--This example also uses the principle of congruent triangles to measure the distance across a pond. Although there are several ways to measure such distances, the following is one of the simplest procedures.

(1) Select point C where points A and B can be sighted. Use stakes or other markers.

(2) Pace the distance from C to A. Extend line AC so that CE is the same distance as AC.

(3) Pace the distance from C to B. Extend line BC so that CD is the same distance as BC.

Triangles ABC and CDE are congruent (two sides and one angle equal). Therefore, line DE (a distance of X paces) equals the distance represented by the distance AB (or X paces). Note that the angles need not be right angles.

5.53 Example 3.--This example uses the principle of parallel and equal lines to measure the distance across a pond. The procedure is fairly simple to follow.

(1) From point A, at a right angle to line AB, sight to a point beyond the limits of the pond. Mark point C and pace the distance from A to C.

(2) From point B, at a right angle to line AB, pace a distance equal to AC. Mark this point D.

The figure ACDB is a rectangle (two right angles and side AC equal to BD). Therefore, line CD equals the distance represented by the distance AB. In the example, angles CAB and ABD are right angles. Other angles can be used as long as they form a parallelogram.

5.54 Example 4.--In this example, it is necessary to construct a right triangle with angles of 60° and 30°. The 30° angle must be opposite the distance to be measured indirectly (to be computed). The procedure is based on the geometric principle that the hypotenuse of a 60°-30° triangle is twice the length of the shorter side.

(1) Walk in a line perpendicular to point A. Continue in a straight line to point C, where you can sight point B at an angle of 30°. (Note that the 30° is the conventional 30°--not an azimuth reading of 30°.)

(2) Pace the distance CB.

Triangle ABC is a 60°-30° triangle. Therefore, line CB (a distance of 2X) is twice the distance represented by AB (a distance of X).

5.55 Record of computations.--On form GEO-201 or on the sketch itself, show how you computed the distances. If you used the procedure in example 1, you could draw a sketch that would show, for example, that line AC is 80 paces, line CB is 80 paces, angle EAC is a right angle (90°), and the distance DB measured 95 paces. Therefore, line AE is 95 paces.

6. *STEPS IN SKETCHING*

Various techniques involved in map sketching were discussed in section 5. The map team in the field should produce a rough sketch in addition to recording all the measurements on form GEO-201. Since the sketches are used as the base maps for delineating EA's, the map sketcher should also provide estimates of HU's (housing units).

In most map sketching operations, some initial information in map form will be available to the person making the sketch. The nature of such information varies. In some cases, a crude sketch of a larger area will already have been made. In other situations, a small-scale map of a district or province may be the best information that is obtainable. Nevertheless, such maps normally provide some

control for the sketching operations, since major roads, highways, rivers, and railroads will be shown. Sometimes the sketching operation is an attempt to fill in the gaps between features or areas that were previously mapped on a smaller scale. Occasionally, only a word description of the area to be mapped is all that is available. As a general rule, the map sketcher should try to locate a major road or highway, or a major intersection as his starting point.

6.1 *Establish boundaries*

The personnel making the sketches should first establish the outer boundaries of the area to be sketched. This can be done by a closed traverse. If the area is large, the sketches can be done by segments--the outermost segments first and the internal segments last in order to link them to points already established in the outer segments.

At the same time, boundaries of administrative areas should be carefully located. The eventual value of the map sketch will depend very much on the accurate location of these boundaries, which are most important for census purposes. Since the NSO will delineate EA's within administrative divisions, all administrative area boundaries must be included in the map sketch.

6.2 *Measure direction and distance*

Figure 5h is a sketch map for the area described as the Highway 15 - Clear River area. Assume that sketching begins along Highway 15 just west of the bridge over Clear River. The starting point is designated A. A new road, called Amur Road, extends south of Highway 15.

6.21 Leg AB.--From A, a compass sighting is taken on Amur Road along the first straight leg ending at B. At B, Amur Road turns in a new direction. It also intersects School Road at this point. The compass sighting from A indicates that leg AB is along an azimuth of 195°. This measurement is recorded on form GEO-201.

The next step is to pace the length of leg AB. In this case, the count is 400. At point B, another compass sighting is taken back to A. The sight BA is along an azimuth of 15°. These readings are recorded on form GEO-201, as shown in figure 5i.

At intersection B then, the map sketcher has measured the azimuth of leg AB, paced the length of the leg, and taken a backsight reading from B to A. The backsight reading should be exactly 180° from the reading from A to B. In this case, it is correct (195°-15°).

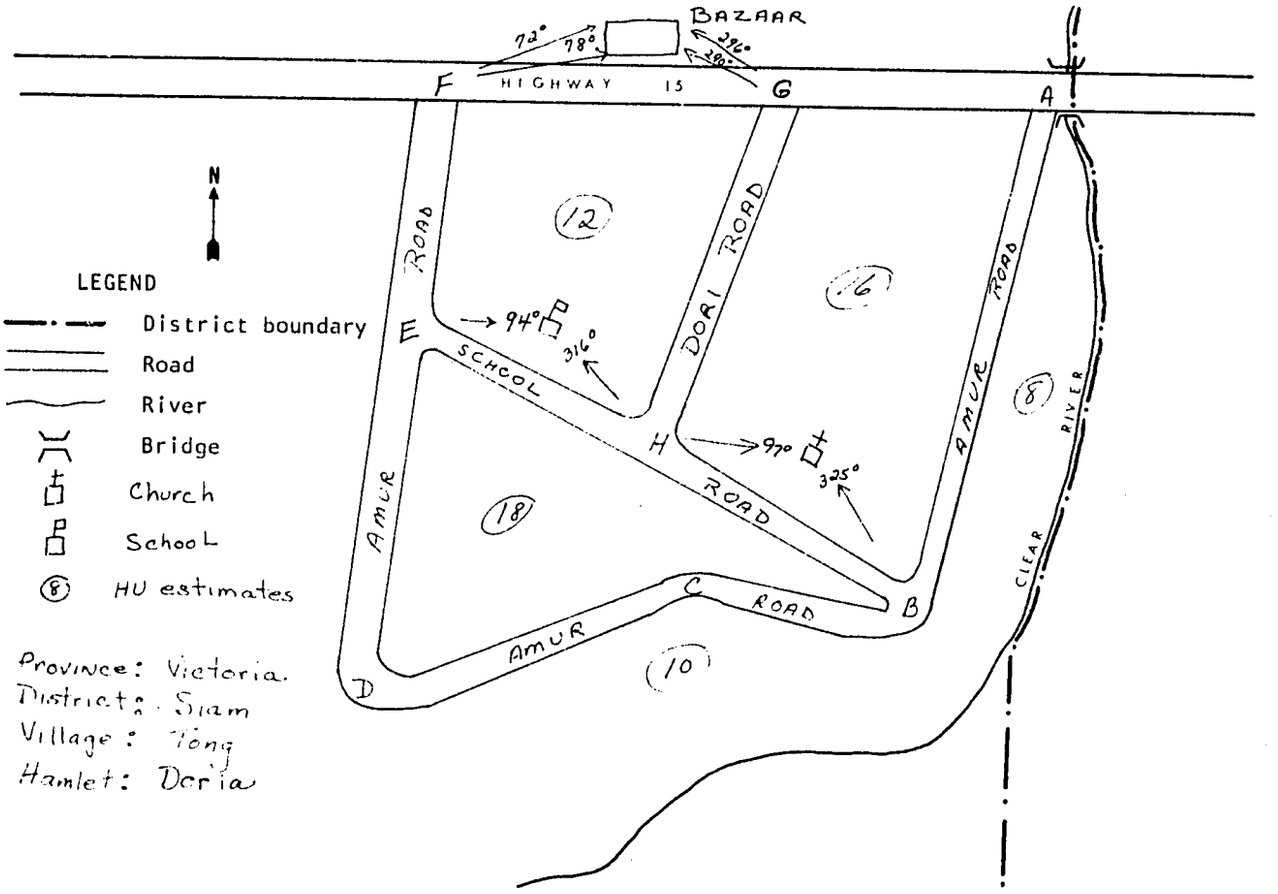
With a protractor and ruler, leg AB can be plotted on the map sketch. Since North is straight up on this sketch, a 195° angle is measured clockwise; thus the line is 15° west of south.

6.22 Remaining lines.--The remaining legs are systematically treated in the same way. Again, information is recorded on form GEO-201. Note that estimates of HU's are entered on the sketch and encircled.

6.23 Landmarks.--All important buildings are noted and standard map symbols are used to mark their locations. For the school located on the north side of leg EH, compass sightings are taken from points E and H. When the appropriate angles are plotted on the maps, their intersection point will fix the location of the school. An alternative approach to establishing the location of the school would be to count paces along EH to a point just opposite the school, then to pace a straight line at a right angle from that point on the road to the school.

The location of the church north of leg HB is indicated by sightings from point H and point B. The bazaar along leg FG, however, is a larger building than the others in the area. The map sketcher takes compass readings on both

Figure 5h. FIELD SKETCH OF A PORTION OF A VILLAGE



the front and back of the building. Pacing determines the frontage width of the store.

6.3 *Prepare the base map*

The crude map prepared in the field will be sketched in pencil and will have extraneous notes and markings. It is usually desirable to erase compass lines and unnecessary notes which may confuse the draftsman.

The draftsman will be guided by the rough drawing and the information on form GEO-201 to prepare the base map. Figures 5h and 5i illustrate a rough drawing and the accompanying form GEO-201. On the base map, the draftsman must include the identification, scale, legend, and date of preparation.

7. *ADJUSTMENT FOR ERROR*

As the sketch and the data on form GEO-201 are used to prepare the base map, it sometimes happens that there are gaps (openings) between the beginning and ending points of a closed traverse when it is plotted on paper. This is known as the "error of closure."

An error may be due to a variety of mistakes, such as an incorrect measurement of a distance or compass angle in the field. In a map sketching operation, normally it is not practical to retrace the entire traverse to correct the mistake. Unless the gap is quite large, the map maker may make an adjustment that will distribute the error throughout the

Figure 5f. FORM GEO-201, INFORMATION FOR MAP SKETCH
(Filled form for sketch in figure 5h)

Sheet 1 of 8

FORM GEO-201
May 1978

NATIONAL STATISTICAL OFFICE

INFORMATION FOR MAP SKETCH

a. Province: Victoria

b. District: Siam

c. Village/~~barrio~~: Tong

d. ~~Urban place~~/hamlet: Doria

e. Description of area to be sketched: Tong village - which begins West of the intersection of Clear River and Highway 15

f. Sketched by: J. Johnson

g. Date: 25 June 1978

h. Average length of pace: 100 paces = 80 Meters

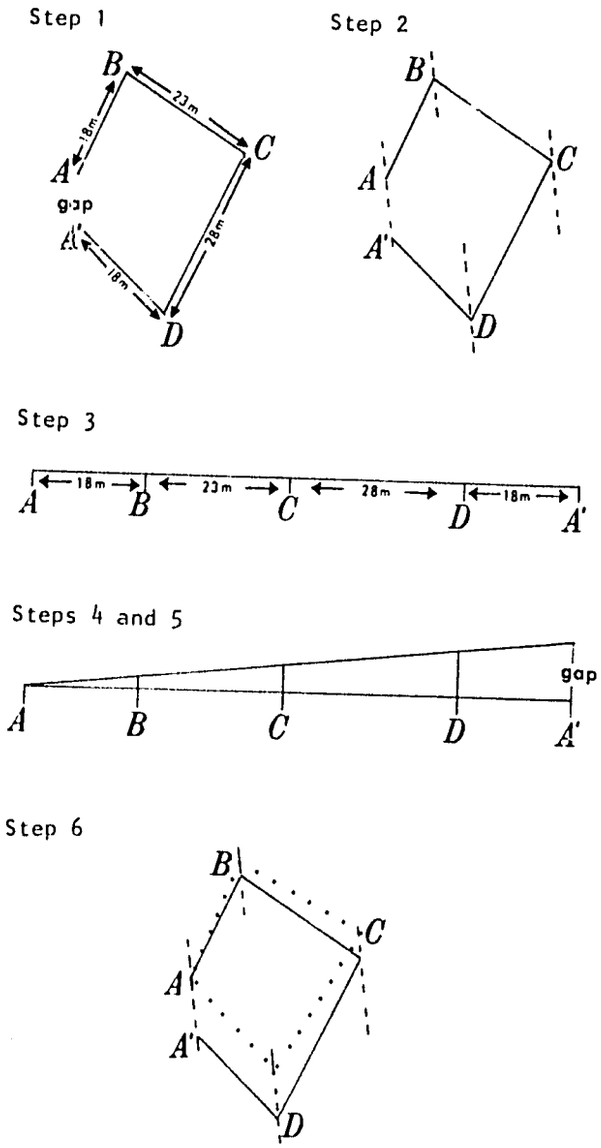
FOR NSO USE

i. Reviewed by: M. Adams

j. Date: 27 June 1978

Leg (1)	Azimuth (2)	Paces (3)	Odometer reading From (4)	Odometer reading To (5)	FOR NSO USE Length (6)	FOR NSO USE Unit of measure (7)	Comments (8)
AB BA	195° 15°	400					
BC CB	274° 94°	175					
CD DC	252° 72°	264					
DE ED	8° 188°	270					
EF FE	8° 188°	188					
FG GF	90° 270°	269					F to foodstand 78° G to food stand 290°
GA AG	90° 270°	213					
GH HG	201° 21°	288					
HB BH	120° 300°	238					H to Church 97° B to church 325°
HE EH	295° 115°	213					E to school 94° H to school 316°
----	----	etc.					
----	----						
----	----						
----	----						
----	----						

Figure 5j. ADJUSTMENT FOR ERROR OF CLOSURE



plot. One procedure for adjustment is best described by following the example illustrated in figure 5j.

(1) Assume that the original plotting produced the sketch shown in figure 5j. The lines did not meet; the plotting produced the gap AA'.

(2) Draw a line through A and A'. Also, draw lines through B, C, and D parallel to the AA' line.

(3) Draw a straight line equal to the sum of the distances of the four legs. In this case, the line would be 87 meters long (18 + 23 + 28 + 18). On this line, mark points A, B, C, D, and A'.

(4) Above A', erect a perpendicular line equal in length to the gap AA'. Connect the top of this line to A to create an elongated triangle.

(5) At points B, C, and D, erect perpendicular lines from the base line to the hypotenuse. These perpendicular lines represent the corrections needed in the plot.

(6) Return to the sketch in step (2). On the parallel line drawn through point B, mark the amount of adjustment. The adjustment is equal to the perpendicular line at point B in step (5). Do the same with points C and D.

Connecting the points of adjustment forms the adjusted sketch. Most plots will involve irregular shapes; nevertheless, the principles are the same.

8. MAP SKETCHING DURING ENUMERATION

As explained at the beginning of this chapter, the discussion is directed to making a sketch when there is no suitable map available to use as a base map for delineating EA's In such cases, a trained person or team is sent to the unmapped area. In other cases, it may not be possible to evaluate the suitability of a map until after the EA's are delineated.

Generally, the crew leader (or enumerator) will simply add new features to the EA map and cross out roads or other landmarks that do not exist. However, even though an effort is made to provide good maps, there will be times when he will need to make a rough drawing of the EA. When changes in the EA have been extensive (new streets have been constructed and others have disappeared), it may be simpler to sketch a new map. Since the crew leader or enumerator will not have a compass, protractor, or ruler, and he will not have had technical training in map sketching, he cannot be expected to produce an accurate drawing in proper scale. For census purposes, it will be sufficient to have the general direction of streets, roads, and other landmarks in proper relationship to each other.

9. ADMINISTRATIVE REQUIREMENTS

Administrative requirements for sketching will vary, depending upon the map coverage of the country, quality of existing maps and air photos, availability of trained or trainable personnel, amount of time before the maps are needed, cost, and special field problems. The priority areas should receive first attention, other field tasks relating to mapping should be handled at the same time, and the itinerary should be planned so as to make the best use of staff and time.

9.1 Time

The time which can be allotted for map sketching will often be determined by external factors such as the overall time schedule of the census mapping operation. If only a short time is available, more persons will need to be involved in the operation. They will need training, and allowance should be made for 2 or 3 full days of training.

The time required in the field will depend on the size and complexity of the areas involved and the experience of the personnel. Larger or more complex areas will require more mapping time. For example, in an open rural area, a map maker may be able to cover 1 kilometer in an hour or two. The same map maker in a complex urban area probably cannot cover as much area in the same time. Other factors being equal, it may be assumed that more area can be mapped in less time as field personnel gain experience; however, after a week or two, this increase will stop and a steady level of production should be expected. It is particularly important to provide closer supervision of field personnel during the first few days of field operations, to assure that the procedures are understood and are being carried out correctly.

9.2 Cost

Decisions will need to be made locally concerning the method of paying staff for map sketching. In some situations, payment is made on the basis of actual production of a sketch map for an area. In others, an hourly wage is recommended. The hourly scale is more difficult to control, especially with personnel who are new to the job. In either plan, the supervisory staff should make frequent spot checks to ensure that the sketching operation is of the required quality.

9.3 Personnel resources

Map sketching operations do not require large numbers of persons. Nor do they involve the team efforts required for making cadastral or topographic maps, for example. In most cases, map sketching can be done by individuals or by teams of two if the terrain is difficult or if there are other field problems.

Persons with field mapping experience, including employees of the NSO, might form the core staff. Persons in NSO field offices also should be considered. If the amount of sketching is extensive, it may be necessary to employ new persons. In any case, all will need to be trained and supervised. It may be helpful to construct a simple test before hiring or assigning persons to do the sketching. As a minimum, the individual should have a sense of direction and some basic mathematical ability.

9.4 Training

Depending on the background of the individuals, training may range from informal but specific instruction to formal class sessions. As part of their training, each person should have some practical experience before going to the field. He should be required to sketch an

area near the training site where his work can be checked by the staff.

Persons on the NSO geography staff can be trained in a relatively short time. They can be sent ahead of other NSO staff, or they can be assigned with an inexperienced person as one of a team. Persons who are recruited locally are likely to require more formal instruction. Their basic training should include instruction in how to use the compass and protractor, how to pace, and how to fill form GEO-201. Additionally, their training should show them how to get around obstacles and how to apply a few basic principles of geometry.

Chapter 6. PREPARATION OF BASE MAPS

1. INTRODUCTION

Ordinarily census offices do not construct original maps that require complex surveying and highly skilled surveyors and cartographers, but they do use information from a variety of sources to produce maps for enumeration and publication purposes. Enumeration maps consist of individual EA maps, crew leader maps, field office maps, and central office maps. Publication maps are generalized maps of relatively large areas, such as the entire country. Some identify 1st, 2nd, and 3rd order divisions and the location of important cities; others may show statistical data. The master maps from which enumeration and publication maps are made are called base maps.

This chapter is concerned with compiling base maps for use in preparing enumeration maps. It presents some detail on the operations that are involved--from making an inventory of map materials to preparing instructions for drafting final base maps. Techniques for drafting base maps, as well as publication maps, are discussed in chapter 10. Preparation of maps for publication is covered in chapter 9. It should be noted that base maps prepared for enumeration purposes can often be used as base maps for publication purposes.

1.1 Purpose of enumeration base maps

Base maps for the census enumeration are "special purpose" maps, designed with specific objectives in mind. These maps provide the means by which a country can be divided into EA's, without omission or duplication of area. Moreover, they should show all administrative area boundaries and major features--everything that the field staff needs in order to canvass the area completely and accurately.

1.2 Types of base maps needed

There should be base maps for every part of the country that is to be included in the census. For practically all nations this means a series of maps covering the entire country. The required maps are of two principal types:

(1) Maps of 2nd or 3rd order divisions showing places, transportation systems, water features, and important landmarks. These maps are used to delineate EA's in less densely settled areas.

(2) Maps of urban places and large settlements showing complete street patterns, water features, and important landmarks. These maps are used to delineate EA's in more densely settled areas.

Separate base maps need not be prepared for the crew leaders or the field offices. CL areas can be delineated at the same time as the EA's; therefore, the same base maps can be reproduced at a smaller scale for the crew leaders. Office control maps can be made by combining CL area maps; often they are large wall-size maps but at a smaller scale than individual EA maps.

1.3 General plan for preparing base maps

Maps to be used as enumeration base maps may be acquired from outside sources or they can be specially made by the geography staff. If the maps acquired from outside sources meet the criteria of good base maps, copies can be used as base maps without change; this is particularly true if the maps are to be used to delineate EA's in rural or sparsely populated areas. The maps for urban or densely settled areas in most cases have to be changed in order

to be usable in a census; these maps often contain much information that is not necessary for census purposes and may be too crowded and confusing after census information is added.

In constructing base maps, the geography staff may use map information from a number of sources; for areas for which no maps are available or for updating old maps, the staff may use air photos and sketches they have made. The assembled materials and the instructions for their use constitute a "base map package."

In general, enumeration base maps are compiled (or constructed) by 2nd order divisions. Base maps of densely populated areas are more complex and are made at a much larger scale than those of sparsely populated areas; therefore, an area such as a 2nd order division is normally covered on several base maps at different scales.

2. SUMMARY OF OPERATIONS

The steps to be followed in preparing base maps are summarized below:

(1) List and code all areas for which enumeration maps are required.

(2) Prepare an inventory of source materials (enumeration maps from previous censuses, published maps, air photos, map sketches, etc.) already available in the files for each area on the list; evaluate them for suitability as sources for base maps.

(3) Set up a priority list of areas for which base maps must be prepared.

(4) Acquire needed source materials for each area on the list, to the extent possible.

(5) Assemble materials for the base map and instructions for drafting (map package).

(6) As needed, obtain information from the field to correct and update maps and acquire any additional materials.

(7) Draft the final base maps.

(8) Review and verify the final base maps.

(9) Reproduce the maps.

Steps 7 and 9 are discussed in detail in chapters 10 and 11 respectively. Using base maps to delineate EA's and CL areas is covered in chapter 7.

3. LISTING AND CODING OF AREAS

In order to ensure complete map coverage of the country, a list should be prepared for all administrative areas and all statistical areas for which census data are to be tabulated. The list should be compiled by the NSO subject matter and geography staffs in consultation with various ministries that maintain official lists of administrative divisions of the country. (During the early planning stages of a census, a decision will have been made on the concept of urban place, rural hamlet, and rural balance.) After the list has been compiled and verified, each area to be tabulated separately should be assigned a unique identification (geographic) code.

3.1 Area List

The list of areas must include all administrative and all statistical areas down to the lowest level for which data are to be tabulated. Moreover the list should show the relationships among the levels. One of the simplest ways is to start with the 1st order divisions. Within each 1st order division, list each 2nd order division; within each 2nd order division, list each 3rd order division, etc., until all levels have been accounted for. Generally all levels are listed in alphabetical order. Figure 6a illustrates a listing and geographic codes for a country that has five levels of administrative divisions (see section 3.2).

After compiling the list from available sources, the NSO should send a copy of the list for an area (district, barrio/village, or other administrative division) to appropriate local officials for their review to ensure that the list is accurate and complete. The NSO should

Figure 6a. AREA LIST AND GEOGRAPHIC CODES

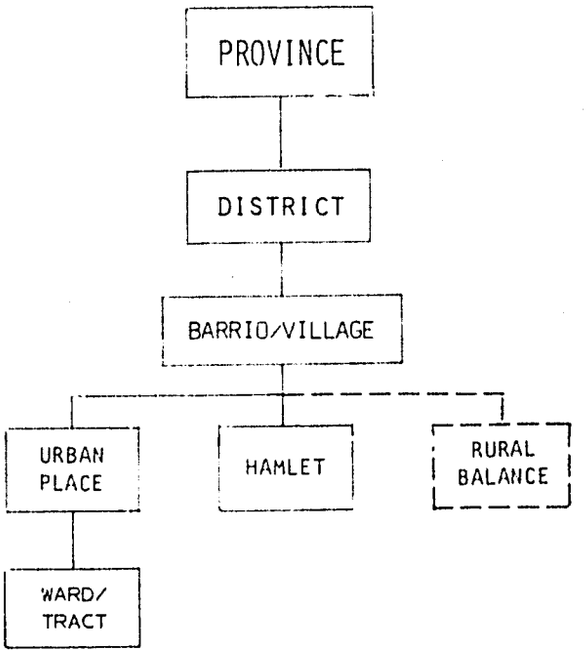
Administrative division	Province	District	Barrio/village	Place	Ward	Type of place
Alegro Province	03					
Antigua district	03	05				
Ariel barrio	03	05	03			
Rural balance	03	05	03	999	99	9
Cuta barrio	03	05	06			
Beri hamlet	03	05	06	059	99	4
Tori hamlet	03	05	06	522	99	3
Rural balance	03	05	06	999	99	9
Doreta barrio	03	05	09			
Casseta city	03	05	09	079	99	2
Hutta hamlet	03	05	09	220	99	4
Rural balance	03	05	09	999	99	9
Landia barrio	03	05	12			
Eddy city	03	05	12	127	99	2
Tangiers city (part)	03	05	12	511		
Ward 01	03	05	12	511	01	2
Ward 02	03	05	12	511	02	2
Zuni hamlet	03	05	12	672	99	4
Rural balance	03	05	12	999	99	9
Moro barrio	03	05	15			
Berria hamlet	03	05	15	067	99	3
Tangiers city (part)	03	05	15	511		
Ward 03	03	05	15	511	03	2
Rural balance	03	05	15	999	99	9
Borroloola district	03	10				
Caso village	03	10	03			
Derry hamlet	03	10	03	121	99	4
Fumi hamlet	03	10	03	165	99	3
Rural balance	03	10	03	999	99	9
Dummo barrio	03	10	06			
Kartoun city	03	10	06	281		
Ward 01	03	10	06	281	01	2
Ward 02	03	10	06	281	02	2
Mitta hamlet	03	10	06	341	99	4
Rural balance	03	10	06	999	99	9
(Continue with remaining districts in Alegro Province, then proceed to Cobo Province.)						
Cobo Province	06					
Attia district	06	05				
Cellar village	06	05	03			
Manga city	06	05	03	329	99	2
Nona hamlet	06	05	03	368	99	3
Rural balance	06	05	03	999	99	9
Lumba village	06	05	06			
Kuna city	06	05	06	296	99	2
(etc.)						

give them a date when all corrections and additions should be returned to the NSO. When all the lists have been returned, the NSO should prepare the final list of areas.

3.2 *Geographic coding*

After the list is completed, each area must be coded according to the geographic code scheme that was decided on in the early stages of planning. A unique number is assigned to each area for which separate census data are to be tabulated.

A geographic code scheme for a country is illustrated in figure 6a. It assumes that the country has five administrative or statistical levels for purposes of the census tabulations. A simple diagram of the country follows:



The code scheme for the country uses seven fields. The first is for province, the second for district, the third for barrio/village, the fourth for place (city or hamlet), the fifth for ward/tract, and the sixth for type of place (as explained below). The seventh field has been reserved for the EA number, which is discussed in chapter 7.

The country has 19 provinces and from 13 to 27 districts within a province. Therefore, two digits are assigned to provinces and two to districts. Note that the first province is assigned a code of 03 to allow for any future province with a name that precedes Alegro in alphabetical order; note also that the second province is coded 06 to allow for additions. The same applies to districts; the first one within the first province is coded 05 to allow for any district that might be added ahead of Antigua district, and the second is coded 10 to allow for additions.

Although barrios/villages are coded within a district, all districts must be examined to determine the highest number in any district. The highest number determines the number of digits that must be allowed; for example, if most districts have 9 or fewer and one has 13, then the code field must allow for two digits for barrios/villages in all districts. Figure 6a assumes 17 as the highest number. As with provinces and districts, the code scheme allows for barrios/villages to be added in the future.

The fourth field is for places (cities and hamlets). Places are generally coded in alphabetical order within provinces, since census publications present them in this form. In the example in figure 6a, three digits are assigned to allow for the largest number in any province. Note that the rural balance of each barrio/village is coded 999 in the "place" field to avoid having a blank field, which can confuse the persons who are processing the data. Note also that, although it is not an administrative level, the rural balance must be listed separately so that a code can be assigned to it, as in the case of Ariel barrio.

If standard coding for places is desired, without change from census to census, the numbering scheme will need to have some gaps to allow for addition of places in alphabetical order. Under such a plan, more digits would be required in this field.

In most countries, the large cities are subdivided into zones, wards, tracts, or other small areas; these may be administrative or purely statistical subdivisions. Even if the large city is not already subdivided, the NSO will likely divide the city in some manner so that the EA numbers (see chapter 7) will not exceed three digits, which is a manageable size The fifth field of the coding scheme shown in figure 6a has been reserved for wards. Code 99 is entered in this field if not applicable.

It is convenient for countries to code each place by type, which adds a sixth field to the code. In the example, a 1-digit code distinguishes the following:

Code	Description
1	Major or central city of a metropolitan area
2	Other urban place
3	Potential urban place, estimated to have a population within 20 percent of the minimum
4	Rural hamlet
9	Rural balance

The codes for type of place are useful in the data processing operation to tabulate total urban population in each of the categories and for extracting summary data by type of place. During the tabulation, the type code can be automatically changed if the census results indicate a change; for example, a rural hamlet that becomes an urban place other than a central city can be changed from code 4 to code 2.

As the example illustrates, the NSO would attempt to set up a code scheme that requires minimum change from census to census. Codes for at least the first three fields need not change; codes for places, type of place, and EA's will require change.

There are many variations in code schemes and each country should plan the one that best suits its needs. If large cities have several levels of subdivisions, such as blocks within wards, an additional code field would be needed. Similarly, if there are several metropolitan areas in the country, another field may be used to identify the parts that make up each of the areas.

3.3 Priority List

The list of all administrative areas for which census data are to be tabulated was discussed in section 3.1 above. To control the work of the compilation staff and to assure that the most important areas are completed first, the NSO should prepare a priority list. In general, the priority is as follows:

(1) Areas to be used in pretesting the census

(2) Urban places with large number of EA's and other areas of high population growth

(3) Rural areas in the vicinity of major urban areas

(4) Rural areas of normal population growth

(5) Remote areas with sparse population

Within each of these groups of areas, highest priority should be given to those for which no maps or resource materials are found in the files during the map inventory.

It should be noted that this list is not to be regarded as final; the priority of an area may change as the compilation operation proceeds. For example, it may be discovered that a rural area has become an area of high population growth.

4. INVENTORY AND EVALUATION

Using the area list as a guide, an inventory should be made of maps, air photos, and other resource materials in the NSO that could be used in preparing base maps. The materials should be evaluated in order to determine for which areas (a) maps of acceptable quality are available, (b) no maps, air photos, or other resource materials are available, and (c) newer and better maps are needed.

4.1 Preparing the inventory

All resource materials on hand should be organized and filed in a systematic way; moreover, the inventory should be kept up-to-date as materials are acquired. One of the better ways to account for and control the inventory is through the use of a catalog, inventory cards, and index maps. In using these forms, the first action is to decide how the materials are to be organized. One way is to number each map in any order, as long as it is identified and cross-referenced in the files. A second, and probably the preferred way, is to number each map within a 1st or 2nd order division, again with appropriate cross-references.

4.11 Map catalog card.--For each map, a card would be prepared for the catalog, giving the map title, scale, date, source, catalog number, and location of the map in the file. The purpose of the catalog is to provide easy reference. If a map covers several areas, a card is prepared for each area; for example, if map 52 covers both Mari and Rota districts, two cards would be prepared--one to be filed under Mari district, and the other under Rota district. The map itself could be filed under Mari district, and an appropriate reference sheet filed under Rota district.

4.12 Area inventory card.--The inventory card is the basic record which describes the materials that are available for an area, gives an evaluation of their major characteristics, and indicates the kind of field action that is needed, if any. A card should be prepared, and kept up-to-date, for each 2nd order division on the area list (refer to section 3.1).

A suggested design for the card is shown in exhibit 6-1. The identification of the

area to be mapped is entered in the upper right corner where it can be seen easily when searching the files. The rest of the card is divided into two parts.

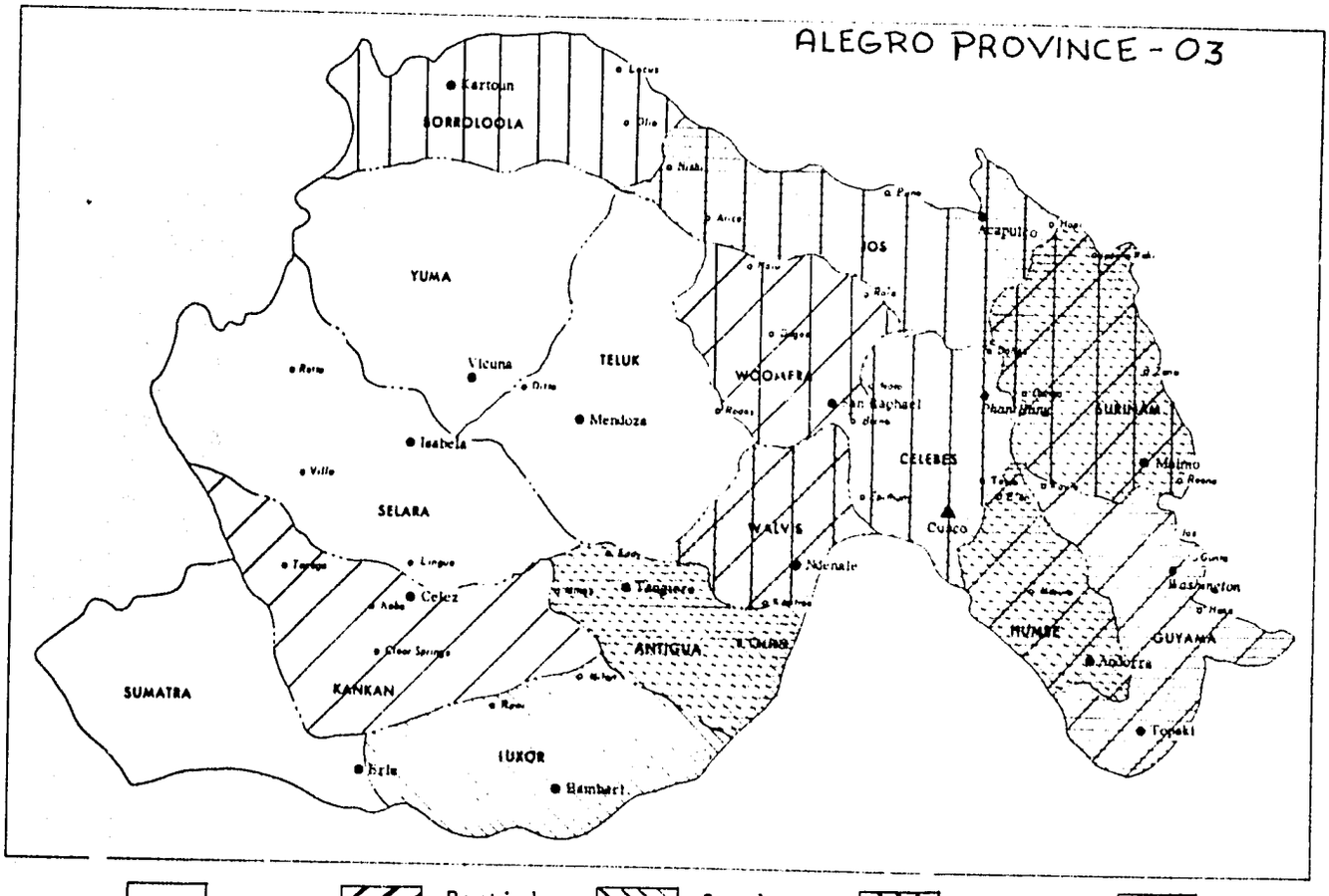
Part I is completed as the materials are examined for suitability as base maps or as resource documents. Note that aerial photographs are to be included, especially if good up-to-date map coverage does not exist.

Part II of the card is used when any NSO action is to be taken. It provides information on the specific action needed, the project or program, and the results of the action.

In a continuing mapping program, the card for each area should be kept up-to-date as new materials are received and NSO action is taken Additional cards may be attached to the first card, as needed.

4.13 Index maps.--When the inventory is evaluated, it may be useful to make an index map to show the areas for which acceptable map and air photos are available. The index map would show, in symbols drawn freehand, the status and progress in obtaining map coverage of the areas in each major administrative division Its value lies primarily in the fact that the viewer can determine very quickly the amount of work still to be done to obtain complete coverage. The index map should be kept up-to-date as more materials are acquired.

Figure 6b. INDEX MAP SHOWING AREA COVERAGE FOR A PROVINCE, BY DISTRICT



Key: None | Partial urban | Complete urban | Partial rural | Complete rural

Note: Using color instead of a variety of line patterns can be very effective--for example, yellow lines for partial urban, solid yellow for complete urban, blue lines for partial rural, and red lines for complete rural.

Figure 6b illustrates an index map for a province. The various line patterns indicate the status and progress in acquiring suitable maps for each district. Note that the use of color, instead of black and white, can be very effective.

4.2 Evaluation of source materials

Although the actual selection of materials to be used for the base maps is done during the compilation process, the possible use of each map or photo should be evaluated when the inventory is being prepared. Additionally, the person doing the inventory should note on the inventory card any special characteristics of the materials such as "this map shows the location of power lines and radio stations." If some of the evaluation is done at the time of the inventory, it will reduce the amount of work for the compiler.

The person doing the inventory must know the requirements of a good base map and the map specifications for each type of area, as agreed to by the NSO Geography and Field Divisions. He should be guided by such considerations as the following: Can the map be used as a primary source or should it be used as a supplementary source? Does the map contain all of the information needed for census enumeration? Is the map at an appropriate scale for the type of area covered? Is the information on the map shown in standard symbols? Is the information on the map up-to-date?

Characteristics required of good base maps include: appropriate scale, coverage of natural and man-made features, readability, timeliness, accuracy, standardized information, ease of reproduction, and ease of storage and handling. Not all of the maps available will meet all of the criteria, but they may have valuable information which can be used to compile a good base map. (For more detail on evaluation, see section 6 of this chapter and section 7 of chapter 3.)

5. SOURCES OF MATERIALS

Ideally, collecting maps between censuses should be undertaken on a continuing basis. If this is done, then the time and money needed for map preparation for any one census will be minimized and the quality of the maps will be improved. Unfortunately, many countries do not have a continuing program. Therefore, an attempt should be made to collect maps as one of the first projects of the census program. It is not necessary to wait for the findings of the inventory to discover which areas have poor map coverage; it can be assumed that almost all maps that are collected will be useful in developing base maps.

To develop a continuing source of maps, it should be possible to establish an arrangement whereby the NSO would receive two copies of every new map that is published or made for official use in the country; in turn, the NSO should be willing to collaborate with other agencies that have mapping programs. Such a program permits the NSO geographic staff to be aware, on a continuing basis, of at least some of the types of current maps that are available and some of the areas that have been covered by recent mapping. The coverage may not be complete, but it permits the NSO to begin a mapping program on a firm base with some maps on file and some personnel familiar with these maps, rather than to begin with no maps and no experienced personnel.

If a map is copyrighted, permission to use it, even in redrafted form, must be obtained from the copyright owner. This applies largely to maps from private sources, although some government agencies may copyright their maps. Often an agreement can be made that these maps will not be used for anything but census purposes. Without such assurance, the agencies may not be willing to cooperate, even in the matter of indicating that certain maps exist.

5.1 *NSO sources*

If the country has had previous censuses, it is assumed that the NSO would first examine the maps that were used in those censuses. The next step would be to contact various outside agencies; if there still are areas not covered by suitable maps, the NSO staff may need to obtain its own air photos or make map sketches.

Air photos may be obtained by contracting with private commercial aerial photographers to provide pictures to the NSO. In some cases the military may agree to fly training missions over areas specified by the NSO. Chapter 4 of this manual discusses the interpretation and uses of air photos for census purposes. Sketch mapping, described in chapter 5, also can provide some of the map materials that are needed for a census. However, because of the time and cost involved, sketching usually is limited to supplying additional details in selected areas.

5.2 *National Cartographic Service*

A major source of maps in many countries is the National Cartographic Service. It may be known as the "Geographic Institute" or by a similar name. It may be a civilian or military agency and may have, as part of its title, a word like "military," "geological," "defense," or "nautical." These organizations usually use engineering techniques to plot basic map information. They prepare topographic maps, which are often made available for large areas of many countries. The maps may range in scale from map sheets at 1:250,000 to map sheets at 1:12,000 or larger. Also, they may have aerial photographs available.

There usually are no restrictions on the use of the country's topographic map sheets because they are produced by the government and are available for public use. The newest editions of this type of sheet should be among the first maps to be collected. Topographic maps show the precise location of natural and man-made features and can be transformed into excellent bases for census maps by tracing or by photographic reproduction. The topographic mapping program is usually a continuing one, but progress is slow in many countries because of the precision work involved and because of lack of funds. Census base maps that involved less precise mapping in earlier years should be replaced by topographic sheets as they become available.

The acquisition of maps need not be a one-way flow from the cartographic office to the NSO. The NSO, especially after the census enumeration, can give the National Cartographic Service information it has received from local offices, such as names and correct spellings of surface features and places. It can give the cartographic agency the correct population and the location of administrative boundaries. Reciprocal relationships such as these can be arranged between the two offices at the time the census mapping program begins.

5.3 *Other government sources*

Many other government agencies may have special map information of value to the census operations. For example, highway agencies may have maps of the road network; ministries of natural resources, lands, or conservation may have maps of special areas such as forests or river basins; an agricultural ministry may have soil and land use maps; defense agencies, which are usually a good source for air photos, may have coverage of training sites and other installations of an unclassified nature, as well as seaports, coastal areas, and areas near the country's borders; housing agencies may have maps or street plans of new housing developments; and the postal service may have useful maps showing postal routes.

Still other possible sources include city and district planning departments, development

banks, government-owned public utilities, and health and education agencies. Local governments may be able to furnish maps from police, fire, health, sanitation, and highway departments.

The anti-malaria program offices in the ministries of public health in various tropical countries are sources that have been used to good advantage. In this program, the teams of workers need good identification of each HU in their areas. A common aspect of their work is the preparation of crude sketch maps showing the approximate numbers and locations of HU's for hundreds of small clustered settlements and for many areas of dispersed rural settlements. This may be excellent information for the geography staff of the NSO, even though the quality and reliability of these sketches may vary greatly from area to area.

5.4 *International and foreign sources*

International agencies such as the World Bank may have good maps and air photos that could be used in the census. Agencies of other governments may have map or air photo coverage of large parts of the world; they may be able to provide copies of these materials to the NSO. Such agencies include the U.S. Geological Survey, the Interamerican Geodetic Survey, the U.S. National Aeronautics and Space Administration (NASA), or the British Ordinance Survey and the British Department of Overseas Surveys.

5.5 *Private sources*

Under the heading of private sources are included land developers; commercial producers and processors of agricultural products; farm cooperatives; oil and gas companies; construction firms; telephone, telegraph, power, and water companies; air, rail, and trucking companies; engineering organizations; insurance companies; cartographic firms; commercial aerial photographers; and others.

Census planners in many countries have found useful map information in offices that might be considered very unlikely sources. Market researchers, road builders, investment firms, and land settlement and mining companies have been able to supply special maps at useful census map scales of areas not covered by government mapping agencies. Some examples of such maps include a plantation company's map of its railway lines or a utility company's map showing the plan and extent of its service and market area.

6. *CHARACTERISTICS OF GOOD BASE MAPS*

The compiler who selects materials and prepares instructions for constructing a base map needs to know what characteristics a good base map should have. It is expected that he will not find maps that have all the desired qualities. Experience and judgment must guide him in deciding whether to accept or reject a particular map, photo, or other resource document.

6.1 *Appropriate scale*

It is recommended that the number of different map scales used for base maps be held to a minimum. This will reduce confusion and possible errors among the enumerators, supervisors, and office staffs. For EA base maps, ordinarily larger-scale maps are needed for urban areas and smaller-scale maps are needed for rural areas; however, within each category, there should be as little variation as possible. (Maps for CL areas and for office control areas may be reproduced at a smaller scale.) Before they collect materials for base maps, the NSO Geography and Field Division staffs should agree on the range of scales that will be suitable for census use. Ideally, for EA base maps, there should be no more than two urban and two rural scales nationwide. In figure 6c are suggested map scales for various types of areas.

Figure 6c. SUGGESTED SCALES FOR MAPS OF VARIOUS TYPES OF AREAS

Type of area	Acceptable scale	1 km on ground equals--	1 mile on ground equals--
Large urban place	1:12,500 to 1:2,500	8 to 40 cm on map	5 to 25 inches on map
Small urban place or rural hamlet	1:25,000 to 1:5,000	4 to 20 cm on map	2.5 to 12.5 inches on map
Other rural area	1:50,000 to 1:25,000	2 to 4 cm on map	1.25 to 2.5 inches on map
Remote rural area	1:250,000 to 1:50,000	0.4 to 2 cm on map	0.25 to 1.25 inches on map

For rural areas of the same type in an administrative division, it is desirable to have the enumeration maps of the same scale, so as to avoid problems of matching different scales in the field. Likewise, all maps for a city or large settlement should be of one scale and, to the extent possible, that scale should be large enough that double lines are used for such features as streets, roads, and rivers. Since these features are used to delimit EA's, it is helpful to the field staff if EA boundaries are drawn down the middle of the feature.

Although consistent scales are desirable, it is not always practical to insist on such consistency. If maps at slightly different scales are otherwise quite usable, it may be uneconomical to change the scale.

In urban areas, streets, blocks, and such easily identifiable landmarks as churches and schools, should be shown on EA base maps. Thus, the map scale should be large enough to show these features clearly. According to figure 6c, the suggested scale is 1:12,500 to 1:2,500. At the other extreme, maps for deserts, mountainous areas, and remote grasslands with sparse population can use smaller scales, ranging from 1:250,000 to 1:50,000. For hamlets and small settlements, suggested scales would be between those for large urban places and remote rural areas. Whatever scale is used for rural areas, it should be large enough to show details that are needed by the enumerators without having to use numerous insets.

6.2 *Appropriate features*

The enumeration base maps need to show all features that could be useful to the staff when delineating EA's and helpful to enumerators and crew leaders when traveling in their assigned areas. Features which should be shown on base maps include the following:

(1) All administrative boundaries.

(2) Transportation and communication features such as rivers, canals, bridges, roads, trails, railroads, major telephone and power lines, and ridge lines.

(3) Landmarks such as schools; churches; parks; cemeteries; playgrounds; and large government, commercial, and industrial buildings.

(4) Place names and feature names spelled correctly and located so that there is no doubt as to which feature the name belongs.

Maps used for control in the NSO and for 1st order divisions need not show the same amount of detail. Administrative boundaries, location of places, and important transportation systems may be the only detail necessary.

6.3 *Readability and accuracy*

A good base map should be legible and easy to read. All lettering and symbols should be clearly seen and easily understood. They must be legible even when the map is reproduced at a smaller scale. Readability is very important; maps frequently must be used by persons who have had little or no experience in map reading.

The accuracy of distance from one feature symbol to another as shown on the map is less

important than the accurate placement of the symbols in relation to each other. For example, whether or not a feature is shown exactly 50 meters from a road is not as important as showing it on the correct side of the road.

6.4 *Timeliness*

It is essential for the enumerator that the information on base maps be as up-to-date as possible and that it include major features (particularly man-made ones). The date of the source materials is very important. Old source materials for areas of change should be revised before base maps are constructed.

6.5 *Standardization of information*

Information should be shown in standardized format; that is, certain items and symbols should be the same on all maps. Some of these items are:

(1) Complete title identifying the area that is covered and the purpose of the map (whether for the enumerator, crew leader, or office staff)

(2) Identification of each administrative area (or part of area) that is shown on the map

(3) Date when the map was constructed, drafted, or revised, and date of source materials

(4) North arrow for use as a directional guide

(5) Graphic scale in which the line is divided into standard units of length

(6) Consistent placement and format of legend

(7) Consistent symbols

In some cases, the difference in scale or lack of time and resources will prevent using the same symbol for a particular feature on all maps. For example, the use of double lines for streets and roads is preferred for census mapping; an EA boundary which goes down the middle of the street tells the enumerator that one side of the street is within his EA and the other is not. Double lines make it possible for him to mark each side of the street as he canvasses it. An additional advantage is that double lines make streets easier to recognize. On a black and white map, if a street is shown by a single line, it can be mistaken for other features similarly indicated, such as a stream, canal, administrative boundary, etc. Time and costs, nevertheless, often dictate that streets be shown as single lines; if some maps for an area have double lines and some have single lines, but are otherwise quite adequate, it may be too costly to redraft the maps for the sake of consistency.

6.6 *Ease of reproduction*

A number of copies usually are needed of all census maps. The original copy of the base map, therefore, must be on material from which it is possible to make suitable copies quickly, easily, and at low cost. Ordinarily, the original copy must be without color. (See chapter 11 for details on reproducing maps.)

6.7 *Ease of storage and handling*

Base maps should be made on paper sizes that will fit in map drawers with no more than one fold. Ideally, the base maps should not be larger than 1¼ meters by 1 meter (approximately 48 inches by 36 inches), which is the standard size of most map cabinet drawers.

Very large maps have some disadvantages. They are awkward for draftsmen to work on, and often they are too large for the map tables. Furthermore, few photographic laboratories and printing establishments have equipment that can photograph or print such maps; this is important if the scale is to be changed, or if redrafting and tracing are to be minimized.

7. *BASE MAP PACKAGE*

As mentioned earlier, compilation consists of (a) selecting source materials from which base maps are prepared and (b) writing instructions for the draftsman on how he is to use the

materials. The selected materials and instructions make up the base map package. Individual tasks are summarized below.

(1) Obtain file of materials and the Inventory Card. Verify that all materials listed on the Inventory Card are in the file, and that all materials in the file are listed on the Inventory Card.

(2) Review all the materials starting with the ones that are of possible use, as noted on the Inventory Card.

(3) Select primary and supplementary source materials (maps, air photos, or sketch maps) for each type of area. Make notes on the deletions to be made, scales to be changed, features to be added, etc.

(4) Prepare the specific instructions for the draftsman.

As a rule, the compiler should work with one area at a time--first all the rural, then each urban place or settlement. There should be a certain amount of checking back and forth to ensure that the boundaries for each administrative division are consistent on all of the maps. Whatever field work is required should be requested and done at one time for the area covered by the map package.

7.1 *Organizing the map package*

A package is assembled for each administrative division or place for which EA maps are needed. In most countries, the administrative level for which map packages may be assembled conveniently is the 2nd order division, which consists of units such as districts or municipalities. A map package often will contain the materials and instructions for two or more base maps, as when a district includes one or more cities or hamlets for which separate maps are needed.

7.11 Purpose of map package.--There is an advantage to keeping together all maps, air photos, other materials, and instructions for all parts of an administrative area, including urban places, rural hamlets, and rural balance. Thus, one administrative area or several contiguous areas can be assigned to one person or one group of persons to evaluate and compile. Otherwise, if the maps for all urban places throughout the country were to be handled by one group, rural hamlets by another, and other rural areas by a third group, it would be difficult to check all the boundaries for accuracy and consistency from map to map. As a result, errors in map coverage could occur more easily.

7.12 Description of map package cover.--It is suggested that a large envelope or folder (made of plain wrapping paper that is folded) be made for each administrative area for which the map package is being prepared. The folder can be used to hold all the materials that are to be used for that area. If the same source map is to be used for two different administrative areas and only one copy is available, that copy can be put in the folder for one area and a cross-reference made on both folders.

The folder should be slightly larger than the largest materials they will hold but not too large to fit the map drawers in which they will be filed. It is suggested that important control information be placed on the cover of the folder so that it will be easy to locate materials and determine when all materials for an area are ready for the draftsman. Suggested control items can be printed and pasted on the cover. As illustrated in exhibits 6-2 and 6-3, they may include the following:

(1) Name and code of the major administrative area--the area(s) covered in the package. For convenience, the name and code should be printed in large numbers and letters.

(2) Area list for the major administrative area. This is a portion of the area list referred to earlier in section 3.1 of this chapter. It is assumed that the total list of the country will be printed and the appropriate piece can be pasted on the cover of the map package.

(3) List of materials selected for preparing the base maps.

(4) Record of field work requests.

(5) List of operations needed and the name of the person carrying out the activity.

7.2 *Selecting source materials*

The compiler should review all available maps for an administrative area before he makes a decision as to which materials he would like the draftsman to use in preparing the base map. This includes a review of maps for each urban place within the area, all rural hamlets, and the rural balances of each administrative area. As he selects materials, the compiler should ask such questions as the following:

(1) What was the purpose in making this map? Would the map maker have been interested in the kinds of information that are important to the census?

(2) Are the producers of the map considered to be reliable sources of information?

(3) Is the information of recent date?

(4) Is it possible or desirable to check the original sources that the map maker used?

The answers to these questions give clues to the probable reliability of the type of information being considered on a particular map. For example, a map made by a city planner or a real estate developer may not be reliable in showing streets that no other map shows. They may be "planned" streets, drawn on the map but not existing on the ground (often referred to as "paper streets"); they may be intended to impress buyers and business men. The reliability of the information must be established early in the selection process. Air photos, if available, may be helpful in this respect.

In most cases, maps from previous censuses should be reviewed first. Before using them again or discarding them, however, the compiler should consider the following:

(1) Is there other map coverage that is more recent and more reliable?

(2) In the earlier census, crew leaders and other field staff may have added some features to the census maps. Do they appear on new maps that are available? If not, then is the new map more reliable than the census map?

If no new map coverage exists, then the old maps must be used. If there are new maps, but they do not show all the desirable information that the old maps show, the base map may need to be a composite of old and new maps.

If there is no adequate map coverage, the base maps can be made from air photos and, in some instances, from enlarged satellite images. For additional information on the use of photos and satellite imagery, refer to chapters 4 and 14. Sketch maps, described in chapter 5, are not normally used to prepare base maps for an entire administrative area because of the size of the area to be covered. Some kind of map or photo information which can be used as a base should be sought. Sketches are best used to fill in details in selected parts of the area for which a few main features already are plotted from other sources, and for which there are no published maps or air photos that show the required details.

7.21 Considerations in drafting completely new maps.--If the primary source is chosen carefully, a completely new map may not be needed; the primary source map may be used as a base. Unnecessary details can be deleted from this map, details from other maps can be added, and the scale can be changed (if needed) through photography. In many cases, an existing map may be photocopied at an enlarged scale and unwanted or incorrect features removed on the photo negative. On a print of the modified map, additional features may be drawn.

In some cases, the compiler will prefer to draft a new map, taking only those features he wants from a variety of materials. This practice eliminates unnecessary features that clutter most maps and confuse the enumerators. Also, drafting a new map permits the standardization of symbols.

Making a new map, however, is more costly and time consuming than using an existing map which may be usable but not necessarily ideal for census use. Moreover, making a new map may introduce some errors. Using an existing map or constructing a new one is a matter of judgment for the compiler, who must consider the cost involved in the two alternatives and the resources available for base map preparation--money, material, personnel, etc. He must be able to judge the amount of modification that needs to be made to an existing map, and must be able to evaluate and anticipate the effect of his choice on the work of the enumerator.

7.22 Primary and supplementary sources.--Usually a primary source is a map that provides a large part of the information to be shown on the base map. It is chosen because it has more of the information needed than does any other map, and has relatively little unwanted information. When the compiler selects the primary source, he should choose the material that will be the most important source of basic information for the enumeration map of a given area; that is, the source that has most of the characteristics of a good base map. In some cases, one suitable source may not exist. The compiler will have to select several maps or air photos which can be combined to make the base map. In other cases, he may have to choose maps that are of a much smaller scale than is desirable and which contain only generalized information about the area.

Many primary sources will not contain all the details that may be needed on the base map. Therefore, supplementary materials will have to be chosen. These may be air photos, which do not make ideal maps of large areas by themselves, or maps of local areas which emphasize one particular type of information such as boundaries. Any map or photo which shows additional detail or which may be newer than the primary source, even if it does not cover the entire area, can be used as a supplementary source.

If both older maps and recent air photos are available, it is wiser to choose the maps as the primary source. Detail can be added to the maps from the photos; if photos alone are used, entire maps may need to be drafted.

After selecting the primary source, the compiler should examine all of the other available materials to see if they contain information worth adding to the primary source.

7.23 Sources for rural areas.--Normally topographic map sheets make the best primary source maps for rural areas. Planimetric maps, which are topographic maps without elevation contours, are even better if they are made to the same standards of horizontal accuracy as topographic maps. The contour lines of a topographic map clutter the map and can be mistaken for roads or streams when the map is photocopied Unfortunately, planimetric maps are not nearly as common as topographic maps. For purposes of this manual, topographic maps are cited as the most common desirable base maps.

The great advantage of a topographic map (or a planimetric map) is that the features are more accurately plotted in relationship to each other than on any other map. If the map is out-of-date or at such small scale that detail is not shown (for example, a scale of 1:250,000), the scale can be enlarged and new information can be added with some confidence that the map is reasonably correct. Ordinarily, topographic maps should be used whenever available.

If topographic maps are not available, the compiler should look for other maps with extensive coverage--highway maps, transportation maps, and the like. If several types of coverage exist for a rural area, it is usually best to use the topographic sheet as the base

even though another map (for example, a highway map) may be more up-to-date. The topographic map gives accurate locational information; new roads and developments shown on highway maps can be transferred to the topographic sheet.

When possible, maps selected for rural areas should show administrative boundaries. Even if the administrative area lines are not up-to-date, it is easier and quicker to make additions and corrections to them than it is to plot an entire set of boundaries.

In a few countries, satellite images have been used successfully to make base maps of rural areas when no other maps were available or when existing maps were much out-of-date. As mentioned earlier, some countries have had good results in using air photos themselves as enumeration maps in rural areas (refer to chapter 4 for more detail).

7.24 Sources for large urban places.--Maps exist for most large urban places throughout the world. In some instances, they do not extend far enough to encompass all the urban area, but at least the existing maps can form the nuclei to which other information can be added. For many large urban places, several primary sources will be needed to cover the complete areas at a suitable scale (see figure 6c for suggested scales).

The source of the map, its relative accuracy, its scale, and the extent of the urban area covered should be used as the basis for evaluating the usefulness of a map as a primary source. Particular attention should be given to the date and source of the information on street patterns. As mentioned earlier, city planning maps might show streets that exist on paper only--as a housing development is planned to be, not as it currently exists. Such maps should be checked carefully because census maps should show only what really exists. If a map is made for tourist orientation or some other special purpose, it may not be true to scale and may be undesirable for a primary source. However, such maps may provide street names and the location of landmarks for an otherwise good primary source that does not have them.

As stated before, the problem with most existing urban maps is that they show too much detail. The compiler should choose the map (or maps) with the most reliability and with the least amount of unnecessary detail. It is easier to add the necessary detail to a relatively uncluttered map than to redraft a new map because there are too many deletions. The features on urban maps should be limited to boundaries, streets, parks, cemeteries, schools, churches, bridges, important commercial and industrial buildings, and similar landmarks. Names of major features should be shown. Also, it is preferable that the map show peripheral built-up areas outside the current city limits. The place may have grown since the map was made. Furthermore, if it grows in the future and the limits are extended, then the base map can be used again.

7.25 Sources for small urban places and hamlets.--In many cases, separate maps for small urban places do not exist. The compiler should check to see if there is a rural area map that shows the place in detail. Sometimes this type of place is shown in an inset on a rural map. Air photos also can be used and, if nothing else, the compiler may have to request map sketching. Satellite imagery may be used, not as a substitute for a map of the place, but to identify the existence of small or isolated settlements.

As with large urban areas, the compiler must use judgment in selecting the best sources. For example, both topographic and area planning maps may be available. Although the planning maps may be reliable, they may be of such large scale that the size and number of sheets means

reducing them in scale and combining them--a time-consuming and costly job. Therefore, it would be better to use the topographic map as the base, even though the scale would need to be changed and up-to-date detail added from the large-scale planning maps.

7.3 *Preparing drafting instructions*

After selecting the source materials, the compiler should prepare specific instructions for the draftsman to follow. The instructions can be given in several forms: (a) notes on a separate piece of paper that is attached to the materials, (b) overlays or tracings of source materials with instructions written on them, (c) notes or markings on copies of the original source materials, or (d) combination of notes and tracings. It is strongly suggested that copies or overlays of source materials be used; notes should not be made directly on the source materials (unless it is being updated as the official map of the area). A portion of a map package, with brief drafting instructions, is illustrated in exhibit 6-6.

7.31 Using the primary source.--The best way to make use of the primary source is to make a copy of it. The copy can be made at the desired scale (see section 7.4 below), then unwanted information can be deleted and information from supplementary sources can be added. If the additions and deletions are carefully done, the copy itself may serve as the manuscript base map from which subsequent copies can be made. However, if there are too many changes, or if they are not made neatly and clearly, a new map should be made by tracing a copy of the primary source after all the needed changes have been plotted or otherwise indicated on it.

7.32 Using supplementary sources.--As a rule, each supplementary source contains only a relatively few pieces of information for the base map. The most common way of indicating what features are to be taken from the supplementary source is to mark them on a copy of the supplementary source or to list them on a separate piece of paper. (See section 7.4 if the scale is to be changed.) Making complete tracings of supplementary sources is generally not necessary, since most of the information on the supplementary source will not be used.

The compiler must be careful to ensure that the features taken from supplementary sources will fit into the proper spaces on the primary map. Usually the primary and supplementary maps have features that appear on both, and these can be used to establish the proper location of those to be taken from the supplementary source. (See chapter 10 for details on establishing the location of features.)

7.33 Using air photos.--In using aerial photography, the compiler should first refer to the photo index to ensure that the air photo is properly identified and does indeed show the desired area. Then he should mark the photo to indicate which features are to be taken from it. He can use various colored grease pencils to trace the features on the photo itself before he sends it to the draftsman, being sure to provide a key; for example, he may have used red for roads, blue for rivers and streams, and green for dwellings, etc. Names of places and features should be written on the back of the photo; sometimes a field check is necessary to obtain some of the names. Refer to chapter 4 for details on the use of aerial photographs in the census.

7.4 *Changing scale*

The compiler must make a decision as to which scale will be the best for the base map. If the scale is to be changed, he may request photographic enlargement or reduction; or he may specify some other method involving drafting equipment and drafting procedure, depending on the type of equipment available, the skill

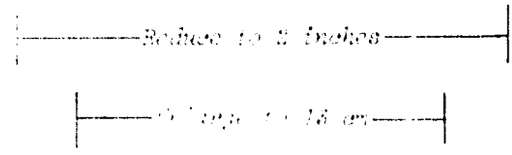
of the draftsman, and the amount of information to be taken from the sources. For example, most topographic sheets are published at a scale of 1:50,000 or smaller; rarely are they found to be at scales larger than 1:25,000. For most census purposes, only sparsely settled rural areas should be shown at a scale as small as 1:125,000 or 1:250,000. In many cases, maps traced from topographic map sheets would need to be enlarged; that part of the topographic sheet showing an urban place will need to be enlarged to a different scale from the rural portion. Air photos, if used as the primary source, also would need to be enlarged.

Often, maps from two or more sources must be used together to give complete coverage for any one administrative area. If their scales differ, one map must be brought to the scale of the other, or both must be changed to another more suitable scale. The maps would need to be recopied or traced so that they meet and match. Problems in the continuity of features shown on one map but not continued on the other map will need to be resolved, generally by contacting local officials.

Ordinarily, it is not necessary to change the scale of a supplementary source, since only a few selected features are to be taken from it. The compiler can prepare rough tracings or map overlays to indicate which features are to be transferred and whether to enlarge or reduce them.

7.41 Decision on changing scale.--The decision to change (or not change) scale is an important one; the compiler must consider cost and time. For example, suppose there is a map series for a large urban area available at a scale of 1:15,000 and suppose these maps are suitable as base maps. Even though the NSO has set 1:12,000 to 1:2,500 limits for large urban areas (refer to figure 6c), it would be impractical to change the scale of these maps just to be consistent with the maps of other large urban areas in the province or district. However, as stated above, if primary source maps of different scales must be put together to form a single base map, the various pieces must be standardized in scale.

7.42 Instructions for changing scale.--Once the decision to change scale is made, the compiler must then indicate how it is to be done. If it is to be done photographically, the instructions must be unmistakably clear. One of the best methods is to indicate in the margin below the map a certain length marked by vertical lines; between the vertical lines, indicate clearly in writing the length to which the distance should be reduced or enlarged, as the case may be. Two examples follow:



This method is clearly preferable to a written statement such as "Reduce 60%" or "Enlarge 30%" which can easily be misinterpreted by persons operating the photographic equipment. Several alternative methods for changing scales are described in chapter 10.

7.5 *Illustration of map package*

Exhibit 6-6 is an illustration of a base map package and the resulting preliminary and final base maps for an urban area. The source materials available include:

(1) A topographic map at a scale of 1:20,000

(2) A recent air photo at a scale of 1:20,000

(3) A planning map (consisting of seven sheets) at a scale of 1:2,000

The topographic map was selected as the primary source for the base map. The air photo was selected as the supplementary source for the street patterns. The planning map was selected as the source for street names and the

location of boundaries. Both the topographic map and air photo were of too small a scale to be used to make the base map; it was considered more efficient and less costly to enlarge them than to reduce all the planning map sheets and then construct a map mosaic.

As shown in the exhibit, only parts of the topographic map and air photo were needed to make the base map. The compiler indicated the portions of the materials to be used by blocking them out with tape. He then indicated the scale to which they were to be enlarged before the detail on the photo could be transferred to the map.

The compiler not only wrote instructions to the draftsman on the map and photo, but he also wrote explicit instructions on a separate piece of paper. He did not include instructions on the use of double lines for streets or the deletion of housing units; such instructions are part of the standard drafting instructions that are applicable to all maps of a particular type and scale. (See chapter 10 for discussion on setting up standard drafting instructions.)

After the preliminary base map was drafted, it was reviewed by local officials, who indicated that there had been further growth in the area. The base map was corrected accordingly, then sent to the EA delineation staff.

7.6 *Resolving boundary problems*

The determination of what administrative and statistical area boundaries are needed on EA base maps and the accurate plotting of the boundaries are important aspects of the census planning and pre-enumeration activities. The decisions about the areas for which statistics will be tabulated (see section 3.1) dictates which boundaries must be plotted on the map. In some countries, cities and hamlets have no officially designated boundaries; in such cases census officers need to recognize these units as statistical areas and to draw boundaries for them for census purposes (see chapters 12 and 15). All the subdivisions shown on the base maps must have accurate boundary lines.

Sometimes different sources show boundary lines in different locations, or they show ones that are known to be in dispute. These differences need to be resolved by consulting legal documents, tracing boundary changes since the original map was made, and contacting official government sources. In any case, the source of information must be reliable. The source, date, and signature of the verifying official should be shown on the map. It would be useful to have disputed boundaries resolved before EA maps are prepared.

A major problem in some countries is that official written boundary descriptions exist but they have never been made known to agencies that need to know about them. Instead of being in one place, the descriptions are scattered through several decrees and acts of government, perhaps covering a century or more. Because of the recurring need for such information, the NSO may become the general depository for boundary information.

8. *VERIFICATION OF MAP PACKAGE AND FINAL BASE MAPS*

It is most desirable that base maps be as accurate as feasible before they are used for delineating EA's and CL areas. Every map package should be reviewed before it is given to the draftsman, and every base map should be reviewed after it is drafted. The review can serve to check the quality of the maps being produced as well as the quality of the work of the compilers and draftsmen.

8.1 *Review of base map package*

As explained earlier, the materials and instructions for a particular administrative area should be in the map package and the materials should be listed on the outside of the

folder. An experienced staff member should review the map package for the following:

(1) Are all the materials that are listed on the folder actually in the package?

(2) Are all the parts (subdivisions) of the administrative area completely covered by the materials in the package? The materials should be checked using the portion of the area listing pasted on the folder.

(3) Are all the overlays and instructions for the draftsman complete and clear? Do they conform to established policies and requirements?

(4) Will the base maps produced from the instructions and materials cover the entire administrative division without omission or duplication? Will they meet all the criteria for good base maps (as described in section 5)?

When the reviewer is satisfied that the package is complete and ready to be sent to the drafting staff, he should sign the control form on the outside of the folder.

8.2 Review of drafted maps

After all the maps for an administrative division have been drafted, they should be reviewed by a member of the compilation staff, either a professional staff member or a clerk who has been specially trained. He should verify that all instructions have been carried out and that all the features which should be on the map have been placed there and have been located accurately.

The map should be reviewed for clarity and reproducibility. It is suggested that the reviewer ask himself these questions:

(1) Is the map suitable for EA delineation?

(2) Is it uncluttered in appearance?

(3) If double lines have been used for linear features (roads, streets, rivers, etc.), is there room for an EA boundary symbol down the middle?

(4) Are the linear features distinguishable? Can the difference between highways and rivers be easily recognized? This should be true whether single or double line symbols have been used.

(5) Are all the available names of features and subdivisions on the map?

(6) Are title, directional arrow, map scale, area codes, and legend complete and clear?

(7) Will all the information on the map (such as names, symbols, and numbers) be readable after the map has been reproduced?

Corrections should be requested and made until the reviewer is satisfied. At this point the maps should be ready for reproduction and EA delineation.

The drafting staff should have been in close communication with the compilation staff throughout the drafting operation. Any problems in drafting should have been worked out as they occurred. With this cooperation, corrections and redrafting are minimized.

9. FIELD WORK

In order to update or construct base maps and to estimate HU or population counts for EA delineation, it is necessary to obtain certain information from local sources (see also section 4 of chapter 7). Where there has been a significant growth or decline in population, new rural colonization projects, or some other dynamic development, the census will be handicapped if map information is not up-to-date. If local officials cannot supply the information, NSO personnel should carry out the field observations. In the long run, the expense of field operations will be less than the expense of resolving problems that result from the use of a bad map base and poor information for delineating EA's. Whether the information is collected directly by NSO staff or as a result of correspondence with local officials, the process is considered to be field work.

When contact is made with the field, it is desirable and efficient to collect all needed

information for an area at one time; repeated trips to the field or correspondence with local officials are time consuming and expensive. A time schedule should be established and progress reports maintained to assure that field work is accomplished in time to be useful for the census.

9.1 *Permission to contact field*

Whether collecting information through correspondence or through personal visit, the NSO should first obtain permission to contact local officials from ministries or provincial governments that the local officials represent. Ministries could provide names, titles, and addresses, which would be very helpful to the NSO. Additionally, to assure full cooperation, the local officials should be instructed by their superiors to assist the NSO.

9.2 *Field work by local officials*

Correspondence with local officials is one of the most desirable ways to carry out field work, since staff operations in the field are relatively costly. In most instances, local officials can collect the information requested themselves or can designate a qualified person to collect it. This procedure for doing field work must be carefully planned and administered if the end product is to be accurate and completed on schedule. The local people should be motivated to do a good job; it is necessary to develop in them some understanding of the need and usefulness of their work. They should be requested to supply only that information which does not take a great amount of skill or training to collect. They should be given specific instructions as to what information is needed and how to report it.

The NSO should review all information that is collected by local officials. Sometimes, the information is incorrect, incomplete, or unusable. This could be due to misinterpretation of instructions or inability of the local officials to provide the information. It is suggested that the compilation staff handle the requests to the field and review the information that is received from the field. Thus the compilers would control the use of all information that affects any of the maps.

9.21 Information requested from local officials.--In all areas, the officials may be asked to supply correct names of streets and roads; locate and identify large special dwelling places and large nonresidential buildings; locate administrative boundaries; add new roads or landmarks; and estimate population or housing unit counts. In urban areas, the officials may be asked to identify planning zones, areas of highly transient population, or subdivisions of administrative areas. In rural areas, they may be asked to identify and locate all settlements larger than a designated minimum size, locate tribal or village boundaries, and provide lists of tribal or village chiefs.

9.22 Materials sent to local officials.--The officials should be sent detailed instructions and a map of the area (if the NSO has a map) for which the NSO is requesting information. A letter should request the assistance of the officials, describe the importance of the work to be done, and instruct them on how it is to be reported.

The instructions should be as clear and as simple as possible. Exhibit 6-4 illustrates the type of instructions and forms to be sent. All the tasks should be explained and examples should be provided; it cannot be assumed that the officials have any experience in this type of work. Exhibit 6-5 illustrates the forms and map that were returned from the field.

At least two copies of the preliminary base map should be sent. The map should cover only the area concerned. Sending two copies of each map permits one to be corrected and sent

back to the NSO and the other to be retained by the local official for his own use. Many local officials do not have detailed maps of their areas.

9.3 *Field work by NSO staff*

Field work done by the NSO staff is costly and should be kept to a minimum. Field work by the NSO staff may be necessary when (a) information from local officials is not received or appears to be incorrect, (b) local officials are not able to do the field work, or (c) basic map sketching is required. Estimates of the amount of field work that has to be done by the staff should be made during the planning of the mapping program. In some instances, it may even be necessary to hire and train additional staff to do the field work; these costs must be included in the census budget.

The staff should be sent out in teams of at least two persons. An efficient itinerary should be established to minimize travel costs and time and to cover the priority areas first (see section 3.3). Several areas should be assigned for each trip and all the field work, including population or HU estimating, should be completed for an area in one visit. If the NSO has field offices, it may be possible to enlist the assistance of some of their employees for the field work.

The teams should be trained in correcting maps and in basic map sketching (see chapter 5). They should be well supervised to assure that the field work is done correctly and completed on schedule.

9.4 *Cut-off date for corrections*

In order that the drafting of base maps and EA delineation can proceed without delay, a date must be set after which no changes in names or boundaries are accepted for purposes of the census. The compilation staff usually is responsible for seeing that all corrections and changes in the base map have been made before the cut-off date. It is not advisable to accept boundary changes up to the date of enumeration; either the maps are corrected and the enumeration delayed, or the enumeration is completed without reflecting the boundary changes the NSO accepted.

10. *ADMINISTRATIVE REQUIREMENTS*

The preparation of base maps is a fundamental and time-consuming task that requires a knowledgeable professional and technical staff and proper equipment. The various tasks must be scheduled properly and controlled to ensure that (a) staff is hired in time to be trained for the job, (b) equipment and supplies are on hand when needed, (c) maps are prepared and reproduced in time, and (d) costs are kept at a reasonable level.

Controls, progress reports, training, and similar administrative matters were discussed in chapter 2. Those pertaining specifically to compilation of base maps are repeated here in more detail.

10.1 *Staffing requirements*

The size of the professional and technical staff needed for the preparation of base maps depends on the physical size of the country; population size and settlement patterns; and, more importantly, availability of existing maps suitable for census purposes. In the planning stage, estimates should be made of the staffing needs and decisions should be made regarding recruitment sources and training techniques. Often, the problem of trained human resources is far more serious than the problem of financial resources.

10.11 Types of personnel needed.--There are generally two types of personnel required for map compilation:

(1) Geographers. Professional geographers with some knowledge and experience in cartography are needed to inventory and evaluate available maps, acquire additional maps and other materials, sketch certain areas and carry out other field work, and compile map packages. Cartographers, under competent supervision and some on-the-job training in specialized census work, also should be able to do most of the required tasks.

(2) Clerks. Clerks are needed for filing and general office operations. If there is a shortage of professionally educated personnel then clerks who demonstrate an aptitude for mapping work can be trained to do some of the compilation work, map sketching, and other field work. Even though great dependence may be placed on competent clerical help, the work must be carefully supervised by a person with adequate training and experience in census mapping.

10.12 Recruitment and training.--Besides technical schools and universities, sources of qualified professional employees may include mapping organizations; surveying agencies; and construction, transportation, and mining companies. Orientation in geographic work for the census, which is a specialized activity and not generally known, will probably be sufficient training for most professional geographers. In addition, requests should be made to the other government agencies to temporarily assign some of their professional personnel to the NSO for the duration of the census work.

Since the demand for professional geographers probably exceeds the supply, it may be necessary to recruit non-professional persons with a secondary school background. In any case, they should have an aptitude for mapping work and they must be given some formal census training.

Clerical personnel may be recruited from secondary schools or through the media of newspaper advertising, radio, or television. Selection of the best qualified persons should be based on (a) results of a general clerical test, (b) educational background, (c) results of an interview conducted by a personnel specialist, and (d) expressed interest in the work. Since the applicants are to be trained for mapping work, they should be tested in map reading and aptitude for mapping tasks. Clerical personnel can normally be trained on the job for specific tasks they are to perform.

10.13 Specialization.--The map compilation operations will probably start with a small staff, whose respective duties will not be strictly defined; that is, the supervisor will assign jobs as they need to be done. However, specialists will begin to emerge as the work progresses into new areas and other sources of information are used. Early in the operation, the need may arise to have some of the staff trained in the interpretation of aerial photographs. Some staff members may be trained as specialists in solving boundary problems, in the review of field work, in map sketching, or in compiling maps for areas that are difficult to map, such as mountainous areas or the highly congested sections of urban areas. In addition to their regular duties these persons would assist other staff members when needed.

Some degree of specialization is desirable in order to accomplish the job efficiently and in a relatively short period of time. However, map collection and compilation, although permanent activities, may not require the full time of the compilation staff after the base maps are prepared. Most professional members of the staff may be expected to work on other mapping activities such as sketching, drafting, delineating EA's, defining statistical areas, or planning and designing publication maps.

10.2 Space and equipment requirements

The amount of space needed for the compilation staff depends on the number of persons assigned to the operation, type of equipment to be used, and amount of space needed for the map files. As a rule, there should be enough

room for the compilers to spread out several large maps at one time, and enough space for them to move around their work areas freely. The space should be well lighted; fluorescent overhead lights and desk lamps should be provided if at all possible. The average total space required per person ranges from 5 to 9 square meters (approximately 50 to 90 square feet).

The amount of equipment required also depends on the number of employees engaged in a specific task, but there are certain types of equipment and materials that are essential for map compilation. They include:

(1) Furniture--one table 2 meters by 1 meter (approximately 72 inches by 36 inches) and one high stool for each compiler, light tables, bookcases.

(2) Files--map files, letter files, and card files (preferably of steel, which is not subject to warping).

(3) Office supplies--tracing paper, colored pencils, grease pencils, file folders, file cards, staplers, pencil sharpeners, etc.

(4) General office equipment such as desks and chairs, typewriters, letter paper, envelopes, stamps, etc.

(5) Enlarging or reproduction equipment such as a camera, copier, reflecting projector, pantograph, or diazo-type printing machine in the compilation area (unless readily accessible elsewhere).

(6) Map sketching equipment such as magnetic compasses, measuring tapes, odometers, and clipboards (described in chapter 5).

In addition, magnifying glasses and stereoscopes are almost indispensable for interpreting aerial photographs (see chapter 4). These and the equipment and materials listed above can be shared with other Geography Division personnel. This is particularly true for the enlarging and reproduction equipment. (For more detailed description of equipment and uses, see chapters 10 and 11.)

Amounts of material needed will depend on the size of the country (more material for more maps), the kinds of maps that are needed, and the scales at which the maps are drafted. In any case, supplies should be ordered well in advance of the start of the compilation operation. When they are received, they should be checked carefully to ensure that they meet the standards necessary for the work. Careful control over the supply of material should be kept and materials reordered before the supply is exhausted; otherwise, the work may be seriously delayed.

As with materials, equipment should be ordered, received, and checked to see that it is working properly before the start of the compilation operation. Consideration should be given to the availability of parts and the amount of time needed to get them. In addition, a maintenance staff should be trained to ensure the upkeep of the more complicated and expensive equipment.

10.3 Controls and progress reports

The development of good base maps for the census enumeration is far from being a mechanical job. It demands individual initiative and research in finding the best source materials, and imaginative, thoughtful, and careful use of these resources to produce reliable usable maps. Establishing and maintaining controls over work flow and production in this type of work is not simple. Heavy reliance must be placed on regular recording of the progress of work for each administrative area and on individual assistance to each compiler to resolve problems.

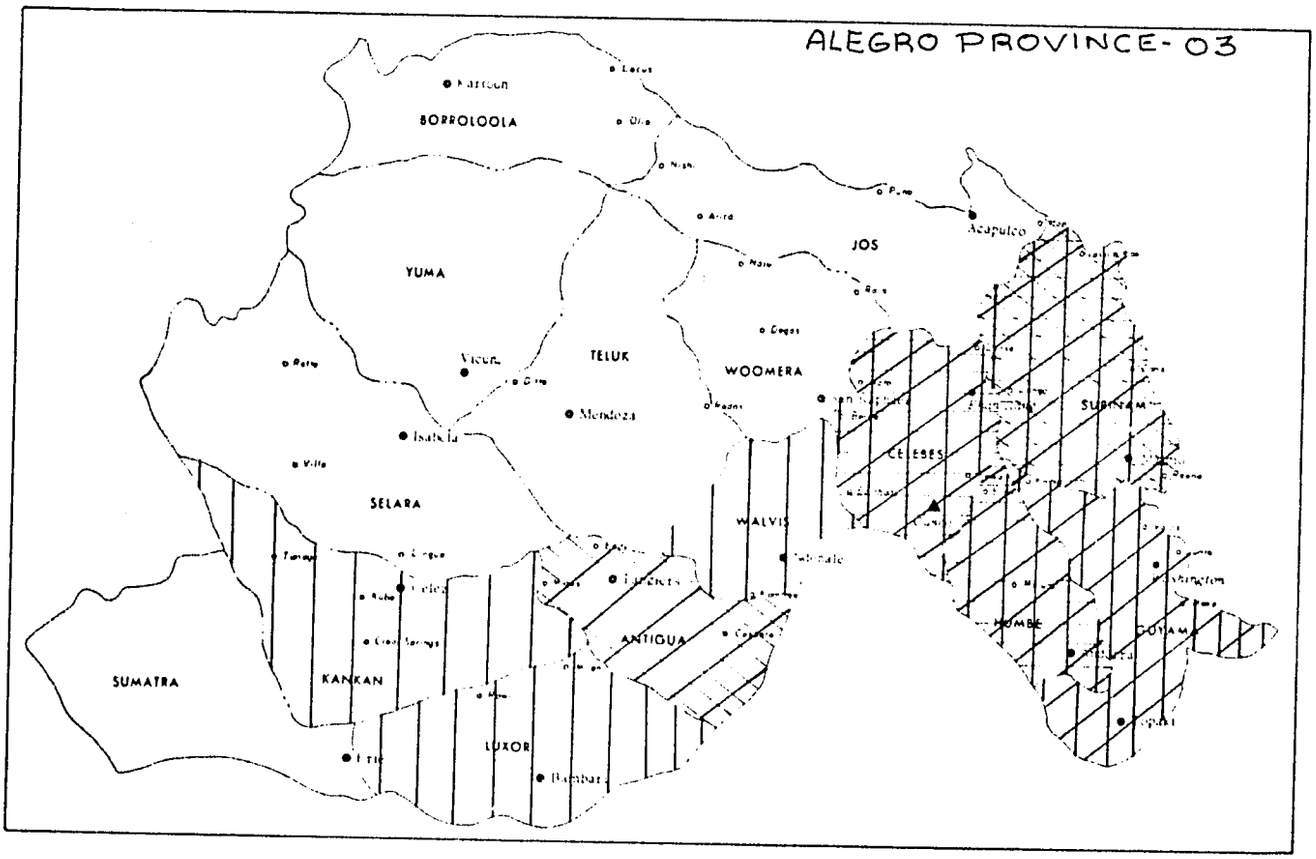
There must be a time for beginning of the mapping work and a date when all must be completed. (Refer to exhibit 2-4 for calendar of activities.) Within this schedule, priorities must be established. Ordinarily, highest priority should be given to those areas which will require the most time for setting up EA's--the heavily populated parts of the country and the most complex administratively. A close check

should be made frequently for adherence to the planned time schedule. Progress reports should be made weekly and perhaps daily as the final completion date approaches. The aim of the compilation staff is not only to complete work in priority order but also to keep a steady flow of work to the drafting staff. As for field work, such matters as availability of the staff and weather conditions may dictate when field work can be done.

As stated before, it is difficult to establish and maintain production control over work involving an unknown amount of research and a great amount of personal judgment and initiative. However, a record should be kept to show progress and indicate where the work is lagging. Exhibit 6-7 is one type of contro and work progress form. Figure 6d is another way of showing status and progress. In the latter case, the index map can be posted where the compilation staff can readily see it; this will likely motivate the staff and stimulate production.

Exhibit 6-7 is a control form that can be used for operations which do not have a rigid sequence of steps for each unit (or area). For example, it can be used for map compilation, EA delineation, or drafting. Exhibit 6-7 illustrates the use of the form for map compilation. Since the number of steps vary, an "X" can be entered in the first column so that one can easily see which units are completed. Exhibit

Figure 6d. INDEX MAP SHOWING COMPILATION PROGRESS



Key: Compilation started; Compilation completed; Field work requested; Field work completed

Note: Using color instead of a variety of line patterns can be very effective--for example, yellow lines for compilation started, solid yellow for compilation completed, blue lines for field work requested, and red lines for field work completed.

6-7 shows the individual steps within the Compilation Section. This differs from the central control shown in exhibit 2-5, which is a simple record of the work flow between major operations.

10.4 Preservation of original materials

All source maps should be handled carefully and stored safely. Because they are in many shapes and sizes, they can damage easily. The original maps should be handled as little as possible. The following are suggested:

(1) Use the original map primarily to make the "master" copy from which all tracings or copies can be made.

(2) "Edge" the master copy or tracing so that many copies can be made from it without harm. "Edging" can be accomplished by applying drafting or masking tape along the edges of the map on the under side so that the map will not tear easily. This can be done by hand or by machine.

(3) As a rule, do not allow original maps and original compilations to leave the compilation and drafting areas or the central files. (An exception may be the need to refer to the original maps in connection with defining statistical areas or other purpose.) Map copies should be used for EA delineation and later operations.

(4) Make no marks (other than inventory or catalog numbers) on the original maps, and do not permit other NSO personnel or anyone else to make marks on these maps. An exception to this rule is the matter of updating an official map. Additions or revisions are made on the original map if it is to become the official base map of the area.

(5) Exercise constant care in filing original maps to avoid accidental tearing or excessive creasing.

(6) Do not roll maps when storing them and do not store them in a standing position (will fray edges and will be difficult to flatten). Maps are basic work documents and they deserve at least as much care as data documents, punch cards, computer tapes, or other essential census records.

(7) Use steel map file cases to store original maps. These cases should have a dust protector cover in each drawer. Vertical files that are compartmentalized for area identification can also be used; however, they will occupy more space.

(8) Inspect files regularly for torn, worn, soiled, or deteriorating original maps; these should be reconditioned or replaced.

Chapter 7. DELINEATION AND CONTROL OF ENUMERATION AREAS

1. INTRODUCTION

After enumeration base maps have been compiled and drafted, the individual enumeration areas (EA's) must be established. This is done by making one or more EA's out of the smallest administrative divisions or statistical areas for which census data are to be tabulated. The process of selecting and marking EA boundaries on the base map is called delineation. This work is usually done by the EA Delineation Branch in the Geography Division of the NSO. The same staff also designates the crew leader (CL) areas.

Chapter 6 discussed the materials and the drafting instructions for preparing base maps for census enumeration. Techniques for drafting base maps (and publication maps) are described in chapter 10. Chapter 7 discusses the next step--dividing the country into EA's and marking their boundaries on the base map, and preparing copies of individual EA and CL area maps.

2. BASIC CONSIDERATIONS IN DELINEATING EA'S

Several considerations affect the decisions that are made about the numbers of EA's and CL areas that are to be delineated and the kinds of features that are chosen to be used as EA boundaries. One of the major considerations is size.

2.1 Ideal size of an EA

"Size" has two meanings in connection with EA's. It is used most often to mean population size; that is, the number of people in the EA. It may be used to mean area size, or the extent of territory included within the EA. Both are significant but, unless otherwise specified, "size" refers to population size when used in this manual.

The principal objective of EA delineation is to construct EA's so that each one contains a population that is approximately "ideal" in size. An ideal population size is the number of people that one enumerator can enumerate in the time period scheduled for data collection. There are different ideal population sizes, depending on the type of census, length of the questionnaire, educational level of the respondents and enumerators, area size of an EA, etc.

For an agricultural census, the size of an EA depends on the number of questions to be asked and the number of agricultural holdings the enumerator is expected to visit during the enumeration period. In some rural areas, he may visit many households that are not conducting agricultural operations.

Ideal population sizes are determined on the basis of pretests of the questionnaires and procedures that are to be used in the census. For example, if the field pretest shows that 16 HU's can be enumerated per day in urban areas but only 10 per day in rural areas, and if the enumeration period in both types of areas is to be 10 days, then the ideal urban EA would contain 160 HU's and the rural EA 100 HU's. If 5 persons live in the average HU, then the ideal population size would be 800 for an urban EA and 500 for a rural EA. The goal of the EA delineation work should be to create EA's of these two sizes. However, there are considerations that make it necessary to depart from the ideal size.

2.2 *Factors influencing size*

There may be several factors that require EA's to vary from the ideal in population size. They include the need to (a) observe administrative boundaries, (b) use well-defined visible features as EA boundaries, and (c) consider the amount and ease of travel for the enumerator (see also section 5 of this chapter).

2.21 Administrative area boundaries.--A small administrative division may contain fewer people than the ideal number for an EA; but if separate data must be tabulated for it, then that division must be delineated as a separate EA. If an administrative division contains more than the ideal number of people for one EA but less than the ideal number for two, the geography staff would not delimit one ideal EA and add the remainder onto an EA of another division; this should never be done. Rather, the staff would construct two EA's that are about equal in size, each of which is less than the ideal in size.

2.22 Visible EA boundary features.--If there is no adequate visible feature near the place where a line is needed to divide an area into approximately equal enumerator workloads, then some inequality in EA size may be tolerated. The use of a visible feature is of much greater importance to success in taking a census than is equality of workloads.

2.23 Mode and availability of transportation.--If travel within an administrative area is likely to be slow and difficult, if there are major barriers to movement (such as rivers with no bridges), or if the area of the EA is unusually large, EA's of less than ideal size should be created to compensate for the excess travel time. Means of transportation and density and quality of the road network also affect the amount of travel time needed to canvass the EA.

2.3 *Guidelines for variations in EA size*

If an EA must vary from the ideal size usually it should be smaller than the ideal. Small excesses over the ideal, perhaps no more than 10 to 15%, may be acceptable in certain situations. The NSO must balance the problem of extra time needed to canvass an oversized EA and difficulties that may result from using less desirable features as EA boundaries.

2.31 Small EA's.--There are times when it is necessary, and desirable, for the geography staff to delineate EA's that are smaller than average. For example, as mentioned above in section 2.21, the administrative boundaries of a small village may require that the EA be smaller than the ideal size.

There are times when the staff will want to delineate small EA's intentionally. This would be the case for (a) areas where the HU (or population) counts change very rapidly, (b) highly congested sections of large cities where the population density may be higher than expected, (c) areas where a high rate of callbacks is anticipated, and (d) areas where the natural features or transportation systems may make travel in the EA particularly difficult. In such instances, small EA's are delineated to avoid possible field splits or other problems which may delay the work. Field splits may involve a greater margin of error in making the separation and in recording the data than would occur if the NSO had divided the area into two EA's in the first place.

Small EA's have several distinct advantages. If the enumerator runs into difficulty as a result of illness, accident, high number of callbacks, unresolved boundary problems, or other unforeseen delays, he would still have time during the enumeration period to complete his EA. In addition, small EA's permit the field staff to contend with problems in a more

efficient manner. For example, an enumerator may quit in the middle of his job; it will be easier to get the work started again, or have the work redone, if the EA is small.

Small EA's increase the chances of early completion of field work so that processing of the census results can begin on schedule. Small size allows the crew leader to give more than one EA to a capable enumerator and permits the EA assignments to be balanced between easy and difficult areas.

On the other hand, small EA's have some disadvantages. A large number of small EA's will mean that more EA's must be delineated, more individual EA maps must be made, more EA books must be printed and handled, and more controls must be set up in all the census operations. Moreover, although a small EA permits the enumerator to finish his job quickly, it does not necessarily give him the opportunity to become experienced in his work; nor does it give the crew leader much time to observe the enumerator on the job. Unless there is tight control on the number of EA's, the costs may quickly exceed the budget.

2.32 Large EA's.--At times, EA's are delineated that are larger than average. This may occur when there are few natural features on the map which can be used to split an area. An EA might also be allowed to remain somewhat larger than average if it consists of one big housing development, or if a village consists of one tribe of people who live within a small land area. In such cases, travel time is not great; the enumerator can probably manage to see all the people in his assigned area within the time period allotted to him. As a rule, however, two smaller-than-average EA's should be delineated instead of one large one. As has been noted, small EA's can be given to the faster and more efficient enumerators as additional assignments.

2.33 Split EA's.--Occasionally, the crew leader finds that an EA is much larger than was expected. This may occur in areas of recent housing construction or areas of rapid population growth for which preliminary HU estimates were not available. Such EA's must be split in the field prior to the start of the enumeration. Refer to section 10.1 and figure 8e in chapter 8 for a discussion of split EA's.

2.4 *Special EA's*

Special EA's consist of large collective living quarters, which require special enumeration procedures. They include such places as orphanages, workers' camps, dormitories, army barracks, monasteries, convents, homes for the aged, hospitals, and penal institutions. Ships and houseboats may also be included. The large Special Dwelling Places are designated Special EA's. A Special EA is assigned the prefix letter "S" to distinguish it from other EA's.

Ordinarily, no special maps are made for Special Dwelling Places. A circle is simply drawn around such a place on the EA map. An example is shown in figure 8e in chapter 8. If the Special EA is small in land area, the map would be too small to show its boundaries; however, if it covers a large area, the boundaries should be shown.

The regular enumerator is instructed not to enumerate the Special Dwelling Place if it falls within his EA. A note to this effect is usually written on his map.

2.5 *Comparability of EA's with last census*

While it may be desirable to use the same EA's from census to census, it is usually not practical, except perhaps in rural areas with stable population and no change in features or administrative boundaries. Changes in streets and roads, expansion of population and construction of new housing, and the designation

of new statistical areas make it necessary to redefine EA's. Moreover, the complicated controls that would be needed to assure accurate geographic coding outweigh the benefits of retaining EA boundaries from census to census.

2.6 Annexation or deletion since last census

One responsibility of a census is to report statistical information for an area whose boundaries are defined legally. If the legal boundaries change, data users and analysts may want information for comparable areas as well as for the newly defined areas. In delineating EA's, therefore, it is desirable to make one or more separate EA's for the portion annexed or deleted since the previous census.

Occasionally, errors in legal boundaries are discovered by the crew leader after the EA's have been delineated. In this case, the crew leader should indicate the correct legal boundary, split the EA involved (using suffix letters with the EA number), have an enumerator enumerate the pieces as split EA's, and report the matter to the NSO by way of the district office, so that the correct geographic code can be assigned to the parts of the split EA's.

3. SUMMARY OF OPERATIONAL STEPS

There are six major steps in the preparation of EA's from base maps. The steps are summarized as follows:

(1) Obtain population and/or HU estimates for administrative areas and subareas.

(2) Obtain population counts and location of Large Special Dwelling Places.

(3) Divide base maps into EA's and CL areas; code the EA's and CL areas.

(4) Determine the number of copies of the base map to be reproduced for cutting out the individual EA and CL area maps; make the required number of copies.

(5) Cut up the reproduced copies into individual EA and CL area maps.

(6) Add the final map elements; transmit the copies to the NSO Field Division for distribution.

4. OBTAINING POPULATION AND HU ESTIMATES

In order to delineate EA's, estimates of population or HU's are needed for small land areas which the EA Delineation Branch can combine to form an EA. There are several ways to prepare or obtain such estimates. Whichever way is selected, the objective is to get the best estimate consistent with resources. As mentioned in chapter 6 (section 9), the census enumeration is hampered if current estimates are not available.

4.1 Cooperation of local officials

Obtaining estimates of population or HU's can usually be done at the same time that the field check is made for changes in boundaries or additions and deletions of major features. Care must be taken not to overburden the local officials with requests to the point that they become careless or refuse to respond.

Local officials are generally asked to review the map for corrections, provide population estimates of urban places and hamlets, make a list of Large Special Dwelling Places, and provide HU estimates for blocks or sectors (a sector being a small land area which is bounded by identifiable features).

Section 9 of chapter 6 describes the procedure for obtaining information from local officials. Exhibit 6-4 illustrates the type of instructions to be followed and the forms to be filled. Note that the HU counts are to be written clearly within the sector or block and circled. Also, the location of each Large Special Dwelling Place is to be indicated on the map, and the name, address, and population are to be recorded on a separate form. The estimates of HU's or population need not be precise but they should be based on first-hand

knowledge of local officials, who should be encouraged to consult with other knowledgeable local people. Note that HU estimates, instead of population estimates, are requested for the sectors (or blocks). Ordinarily, it is easier for local officials to make HU estimates for small land areas.

Exhibit 6-5 is an example of materials that local officials returned to the NSO. The officials updated the maps, provided a crude sketch of an unmapped hamlet, estimated the population of each city, hamlet, and Special Dwelling Place, and supplied HU estimates for sectors.

4.2 Field visits by NSO staff

As discussed in chapter 6, field work by the NSO staff may be necessary when the local officials are not able to do the job. The information they should obtain is the same as the information requested of local officials. An additional task for NSO personnel may be some map sketching, which ordinarily is not expected of local officials.

4.3 Use of existing information

If local officials do not respond to NSO requests and if the NSO does not have the resources to make field visits, the NSO may need to use existing information. A useful source would be air photos, highway maps, or planning maps. Another source may be postal zone population or addresses, utility company billings, population registers, and other administrative records. Still another source may be population, housing, or agricultural statistics from a preceding census and therefore will be 5, 10, or more years old. In any case, the NSO staff must estimate rates of growth or decline and must allocate the population or housing among the subareas (sectors or blocks) that appear on the EA base map. If estimates must be made without a visit to the field, it is suggested that they be entered on a work map similar to the one returned by local officials, as shown in exhibit 7-3. Prior to this step, it is recommended that a worksheet be prepared by the estimator, who may need to analyze aerial photographs and planning maps, or otherwise arrive at current population or HU estimates for sectors (see exhibit 7-1).

In those areas where the population is relatively stable, the use of earlier information may be satisfactory. However, a judgment that such a situation exists should not be made without some knowledge of current conditions in these areas. A decision to use earlier information is a risk. If EA's turn out to be too large, it will mean that the crew leaders will need to split more EA's and thereby add to the control operations and costs. If EA's turn out to be too small, more enumerators than needed will have been hired and costs will increase. (Refer also to sections 2.31 and 2.32 regarding small and large EA's.)

5. DELINEATING AND NUMBERING EA'S

After the map revision information that is returned by local officials is reviewed by the geography staff, it is incorporated onto the base map (see chapter 10 on drafting base maps). No further changes in administrative division boundaries or in place names can be accepted for inclusion on the maps. Notice of the cutoff date for boundary or name changes or other revisions must have been furnished to appropriate individuals, groups, ministries, and local and city authorities well in advance of that date.

Priority guidelines should be established (subject to revision as the work progresses) so that certain administrative divisions or cities will be worked on first. These priorities may be based on anticipated complexity, relative size, need to complete work in order to finish some larger area, etc.

5.1 *Guidelines in delineating EA's*

The major objective of EA delineation is to divide the country into EA's in such a way that there will be no omission or duplication of land area and no overlapping of administrative division lines. The job is not a difficult one, but it requires careful attention to detail.

5.11 Use special symbol for boundaries.--Before the delineation process starts, the Geography Division, in consultation with the Field Division, should decide on a symbol to be used for EA boundaries. The EA boundaries, like the administrative boundaries, should be shown with a unique line symbol. The symbol should stand out from all the other symbols used on the map. The symbol should be designated in such a way that it does not cover up other features. One of the most common symbols used is a "wiggly" line ( ). In most cases, the wiggly line is used when the EA's are delineated and then a solid line in a bright color is drawn over the line before the EA maps are used in the field.

5.12 Observe administrative and statistical area boundaries.--All boundaries of administrative and statistical areas for which data are to be tabulated separately (except for city blocks or other subdivisions which have a code within the EA) must be used as EA boundaries. If the legal boundaries have changed since the last census, and separate data are needed for both the old and new areas, EA's must be established accordingly (see section 2.6). When EA boundaries are drawn, they should not obscure the administrative boundaries.

For areas that do not have legally established boundaries, or for which boundaries are in dispute, the NSO must select boundaries to be used solely for statistical purposes. For such cases, the enumerator will need to know that the boundary lines shown on his map are not official; nevertheless, he must use them and not be influenced by ideas of local residents as to where the boundaries are located. Statistical areas, which may not have official boundaries, will have boundaries assigned to them by the NSO; these become EA boundaries.

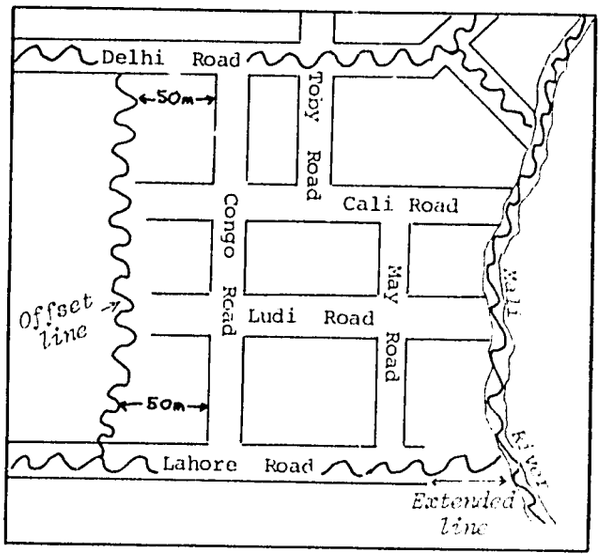
Rural settlements (such as hamlets) do not differ from other administrative or statistical areas in their need for boundaries. If there is need for separate data, one or more EA's must be drawn to coincide with each settlement. This means that the settlement must have some form of boundary, official or otherwise, before EA's are delineated for them or for the area in which they are located. These boundaries are often determined by local officials. If not, they must be set up by the NSO.

5.13 Follow visible features.--Insofar as possible, all EA boundaries that are not administrative division boundaries should observe natural features such as streams or lakes, and man-made features such as roads or railroads. The feature selected must be easily seen and clearly identified both on the ground and on the map.

Some visible features do not make good boundaries. For example, a ridge may not have a single summit that can be followed continuously and that can be recognized as being at one specific point along a road that crosses the ridge. A forest may not have a distinct edge; rather, there may be a gradual thinning of trees or an intermixture of trees and open areas. Such features should be chosen as EA boundaries only (a) when no better visible features are available and (b) when invisible features mentioned in the following paragraph are believed to be a poorer choice.

5.14 Use invisible lines only if necessary.--Occasionally, the use of invisible lines for EA boundaries cannot be avoided. Offset lines and extended lines are two types of invisible or imaginary lines. Examples of the

Figure 7a. OFFSET AND EXTENDED LINES



two types are shown in figure 7a. An offset line is a line that parallels a main road (in this case, it parallels Congo Road) at a specified distance. The purpose of the offset line may be to include, with the settlement, the HU's along the side of the road, as in figure 7a. Extended lines are imaginary boundaries which are used to connect one visible feature with another. For example, part of the southern boundary of the EA in figure 7a is Lahore Road extended a short distance in the same direction until it meets Mali River.

If offset lines are used, they should be consistent in being a fixed distance, such as 50 meters, from a given road. If extended lines are used, they should not extend more than roughly 100 meters. In both cases, the enumerator may have difficulty in sighting a greater distance and there may be obstacles to block his view. An extended line should end at a specific point or feature. In figure 7a, the extended line ends at Mali River.

An imaginary line should not be used if it will pass through an area where HU's are located in an irregular pattern close to the imaginary line on both sides. Imaginary lines should not cross each other; their point of intersection would be very difficult for the enumerator to locate on the ground. If using an imaginary line cannot be avoided, then it should be drawn with great care. If there is a visible feature nearby, the imaginary line should be drawn where it can be associated with that feature. Figure 7b illustrates a satisfactory and an unsatisfactory use of imaginary lines as EA boundaries.

A third type of imaginary line, known as a point-to-point line, may be useful in some cases. It is a line between two points where the line of sight is clearly visible and where no HU's are in the line of sight. (A point-to-point line may be from one road intersection to another or from a road intersection to a bridge or mouth of a stream.)

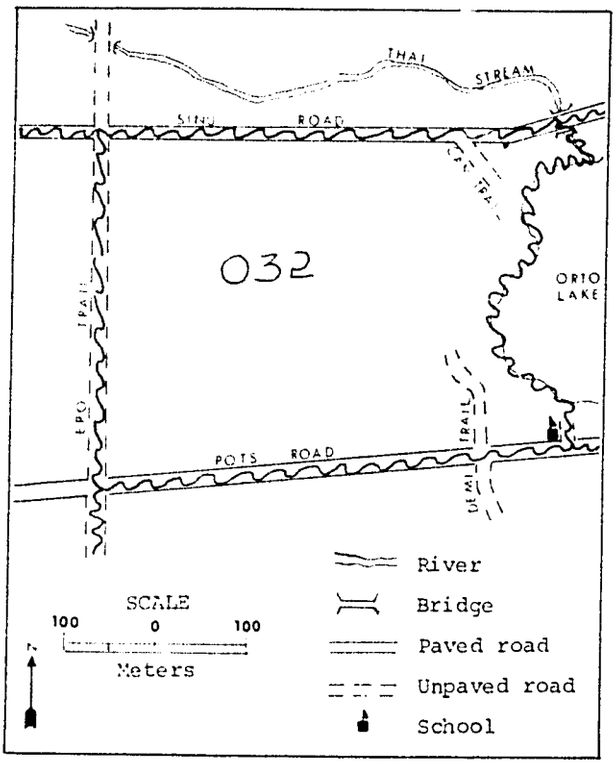
5.15 Indicate tie-in lines.--Base maps that are used for rural EA's show the location of urban places and rural settlements which usually have separate maps at larger scales. The person who is delineating the rural EA's should first draw, onto the rural base map, the boundaries of the urban place or settlement so that it can be excluded from the rural EA delineation. The boundaries of the urban place or settlement, which appear on the rural EA base map as well as on the separate map of the urban place or settlement, are called "tie-in" lines.

In figure 7c, the boundaries of the urban place (on the left) are drawn on the rural base map (on the right) before the rural map is delineated into EA's. It is important to show these tie-in lines for each place for which there is a separate map at a different scale.

5.16 Balance population size with land area and ease of travel.--The person who is delineating EA's within a given census tabulation area needs an estimate of population (or an estimate of HU's which he can convert to a population estimate). He needs to know also the ideal population size for that type of

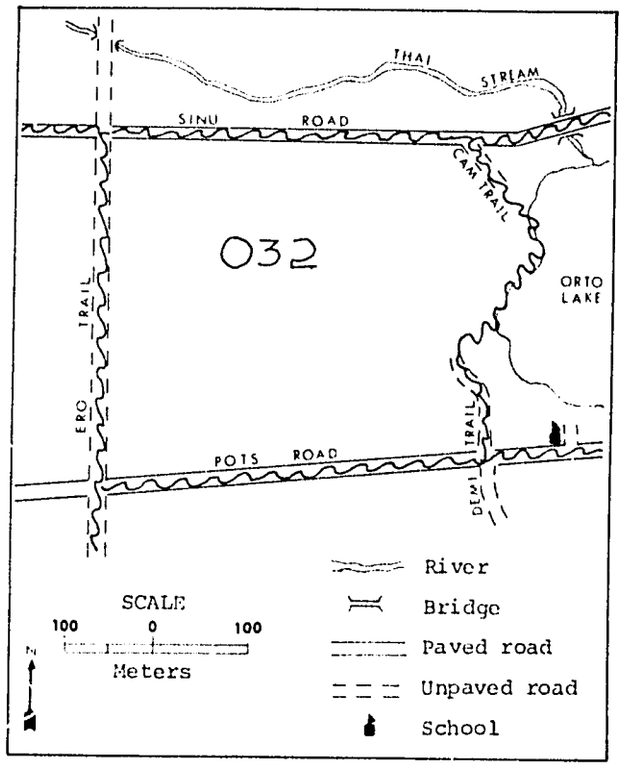
Figure 7b. IMAGINARY LINES AS EA BOUNDARIES

SATISFACTORY



Note: EA boundaries follow visible features except for a very small portion of the eastern boundary--that part from Orto Lake (southern boundary) to the unnamed trail off Pots Road. The trail does not have a name but it can be associated with a visible feature--the school.

NOT SATISFACTORY



Note: Two imaginary lines are used as part of the eastern boundary of the EA. An extension of Cam Trail was made a boundary line when Thai Stream could have been used. Secondly, the extension of Demi Trail to Orto Lake is curved and difficult to locate on the ground.

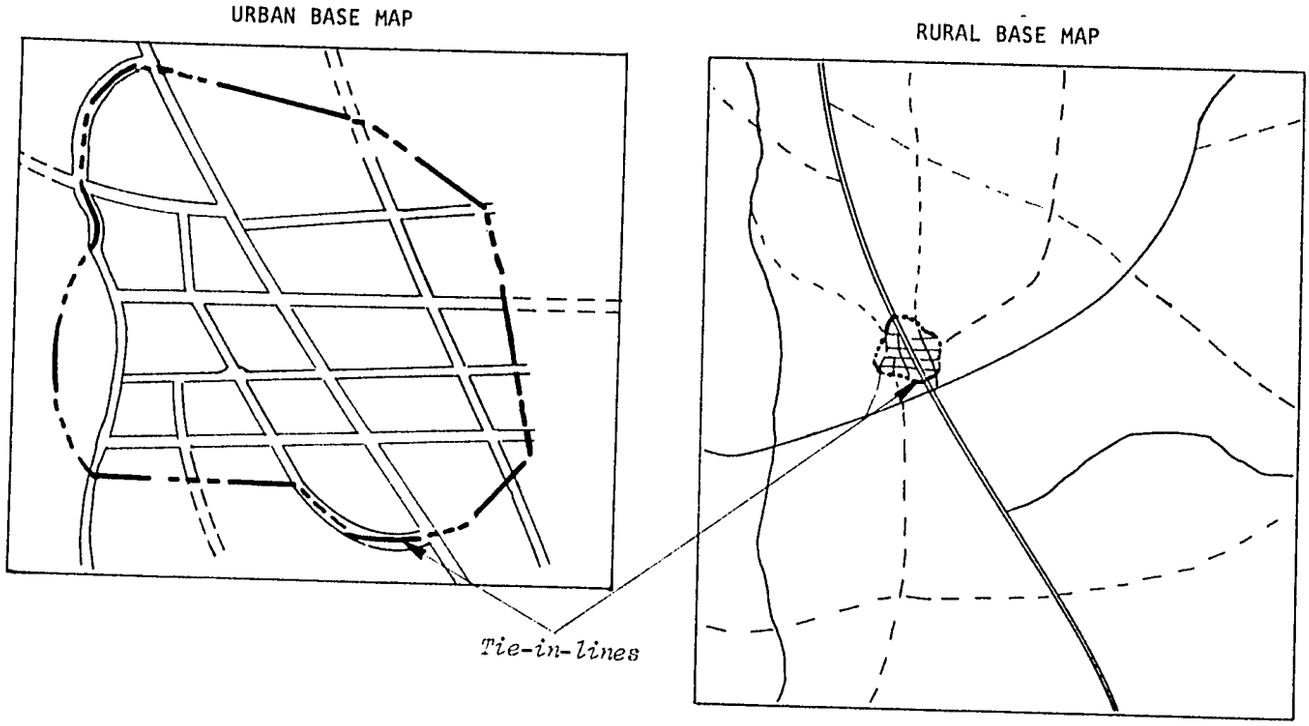
area (rural or urban, for example). Then he can calculate the number of EA's he should delineate within that area unless there are unusual conditions requiring departure from that number.

Current population and HU estimates may be provided by local officials or obtained by the NSO staff. If, for some reason, any adjustments are to be made in these estimates, they should be made before the EA delineation work starts. If out-of-date figures are used, an estimated change factor should be applied to them, again before the EA's are delineated. Changes are particularly critical in suburban and central city areas that have grown rapidly since the statistics were compiled.

If the only information available is for areas comprising several sectors or blocks, the assumption is usually made that the population is distributed rather evenly throughout each area unless there is evidence to the contrary. For example, there may be major travel routes, closely spaced roads, or apartment buildings where people are likely to concentrate; high hills, deserts, or swamps where people are less likely to live; or highly industrial sections where population density is likely to be less than average.

The delineation work involves calculating the ideal number of EA's, as described above, and then combining sectors or blocks into EA's until that number has been reached. A slightly

Figure 7c. TIE-IN LINES



larger number may be delineated, but a special effort should be made to avoid delineating a smaller number. The actual number of EA's that are created may vary from the ideal because of certain judgmental factors (such as those discussed in section 2 above).

If travel conditions exist within an area that will cause an enumerator to spend a disproportionate amount of time traveling between HU's, then the number of HU's per EA must be reduced; otherwise, the enumeration period will be prolonged and subsequent processing delayed. Travel conditions vary widely both in kind and in degree of effect; no specific criteria for adjustment to EA size can be provided.

The factors that increase the amount of time for travel may be either natural or man-made. Natural features may be barriers to travel--steep cliffs, wide rivers, lakes, or swamps. If possible, EA's should be drawn so that an enumerator does not have to cross such a feature while doing his work. Barriers of this sort within an EA may give the enumerator an excuse to disregard the part that is beyond the barrier. Where barriers exist, they can be used effectively as boundaries; they should not be contained within an EA. Other natural conditions that may hinder travel include very cold climate, rainy weather, dense woods, and rough terrain, particularly if the roads are poor or impassable.

Man-made conditions that have an impact on travel include settlement patterns, means of transportation, and road networks. If the population is dispersed (spread across a wide area), extra time is needed for travel between interviews. An incomplete or fragmented road system will mean that some roundabout routes must be followed during the canvass. Unpaved or poor quality roads cause slower travel, and may require the use of slower means of transportation such as walking instead of riding animals, or riding animals instead of driving jeeps or other vehicles.

5.2 *Delineation by local officials*

The suggestion is sometimes made that the local officials be asked to delineate EA's in

their areas. The reason is that they are more familiar with their barrios and villages and can readily estimate the population of an EA. Moreover, such involvement may stimulate local interest in the whole census program.

The general response to this suggestion, however, is a negative one. The difference between map updating and HU counting on the one hand, and EA delineation on the other, is a basic one. Many of the local officials may be unable to do the delineation and others may not have the time. More important, however, is the fact that the proposal leaves most of the production control and verification in the hands of a large number of local officials who have varying standards for map work.

In census and survey work it is generally not good policy to depend on local officials for complicated tasks. There are likely to be misunderstandings about what is to be done and inconsistencies in the results. Without some experience, training, and supervision, local officials cannot be expected to handle the job adequately; even if they could, the large number of persons that would be involved would make it virtually impossible for the NSO to exercise control over the quality and flow of work, and the accuracy of the census coverage would be in doubt.

If there is a desire on the part of local officials to participate in the EA delineation process, there must be a firm commitment to meet the dates set by the NSO. The work must be received earlier than the NSO's scheduled completion dates in order to permit review and change, and possibly redoing some of the work.

5.3 *Coding of EA's*

The geographic coding system has been described in chapters 2 and 6. All administrative divisions of every order for which data are to be tabulated have had unique numbers assigned to them. EA numbers simply represent another set of numbers assigned to the smallest areas that are identified in the census (except for block or sector numbers in certain cities). Three digits are usually assigned for EA's and, as noted before, EA's are generally numbered consecutively in serpentine fashion. Note that if EA's in large cities are not numbered by sub division, four digits may be needed; numbering in the thousands can lead to errors. If a city does not have administrative or statistical sub divisions, the NSO could divide it arbitrarily for purposes of the census enumeration. In any case, the EA numbering plan must be systematic and should be developed in cooperation with the data processing staff at the time the map inventory is prepared.

5.31 Numbering plans.--EA's can be numbered within any administrative divisions--1st, 2nd, 3rd, etc. What is important is that an EA number be assigned only once within each area for which data are to be tabulated. For example, if data for a 3rd order division are to be tabulated separately for each place and the rural portion of the division, then the EA numbers for each can start with 001. The geographic codes preceding the EA numbers must uniquely identify each place and the rural portion of the division.

However, it is generally understood that a systematic numbering plan should be developed and observed throughout the country. One of several plans may be used to code EA's.

In one system, the numbering sequence is unbroken, running from 001 to the final number in a 2nd or 3rd order administrative division. EA's in urban places, rural hamlets, and other designated places are generally numbered before EA's in the remaining rural area are assigned numbers. One problem is that the coding may have to be halted if delays are encountered in any of the areas. For example, if the total number of EA's in an urban place or hamlet is unknown because of some delay in preparing the

base map for that area, then no numbers can be assigned to the next area.

The second technique involves a separate numbering system for urban places, for rural hamlets, and for rural balances within each barrio (3rd order division). In this case, each of these groups would start with EA 001. This system makes it convenient to complete the numbering for each area as its EA's are delineated.

A third scheme involves assigning blocks of EA numbers to different groups of areas; for example, 001 to 499 for EA's in urban places, 500 to 699 for rural hamlets, and 799 to 999 for rural balances. In this case, care must be taken to ensure that sufficient numbers have been set aside for any one area; if this is not done, coding problems will result.

5.32 Numbering techniques.--In order to locate EA's quickly by number, they should be numbered in some fashion so that consecutive numbers fall next to each other. A preferred method is to begin at the northwest or northeast corner of an area and number in serpentine fashion; that is, go back and forth across the area (see exhibit 7-3). Thus, the lower numbers will be at the northern edge of the area, and the higher numbers at the southern edge. A second method that is more applicable to large cities is to start with the central ward (or other subdivision of the city) and number in spiral fashion. Whatever method is used, it is desirable to adopt only one system for the entire country. EA numbers would not be assigned at random; this would make it very difficult to locate a particular EA.

5.33 Master List of EA's.--Throughout the census operations, each EA must be accounted for once and only once; otherwise, the census results will not be reliable. As the EA's are delineated and numbered, a record should be made of pertinent information for each EA--at least geographic name and code and population estimate. The EA Delineation Worksheet, Form GEO-122, shown in exhibit 7-1, is an example of the type of form that can be used to record such information. When the delineation for an administrative division is completed, and the EA worksheet is filled, the information on the worksheet is transferred to the computer and becomes the master reference file of EA's. As required, additions and corrections are made, then the Master List of EA's is printed. An example of a computerized Master List of EA's is shown in exhibit 7-2. Note that the output is designed as a form and that columns 1 to 8 are the same as on the EA Delineation Worksheet. For convenience, a form GEO-501 should be used for each district (or other 2nd order division); that is, the computer should be programmed to start a new page for each district. The list should be printed double space to allow space for handwritten additions.

Multiple copies of form GEO-501 should be printed and used as the control forms for the various census operations--receipt of materials from the field, editing and coding, data entry, and computer processing. Columns 1 through 8 are used as controls for all census operations; the remaining columns can be changed to reflect the important steps in the operations. For example, if the form is used in the editing-coding operation, the additional columns can be used for the name of the editor-coder, date assigned, date completed, name of verifier, date sent to data entry, etc.

The Master List of EA's usually has to be revised before it is printed as a control form for the various census operations. Revisions are necessary when EA's are split in the field (see section 2.33 of this chapter). If field splits are necessary, the crew leaders should be instructed to send a copy of the map of the split EA to the NSO immediately (see exhibit 8-4) so that the codes and the EA list can be revised. The NSO should verify that the split is satisfactory and make the necessary changes

on the Master List of EA's. The final Master List of EA's should be printed and ready for use as a control list before any census forms are returned from the field.

5.4 Examples of EA delineation

Exhibits 7-3 and 7-4 are examples of EA delineation. Exhibit 7-3 shows the delineation of the rural portion of a barrio, based on information reported by a local official; exhibit 7-4 shows the delineation of a portion of an urban place (Levittown), based on information from an aerial photograph.

5.41 EA delineation based on information from local officials.--The first map in exhibit 7-3 is a map returned by a local official of Antigua district. It shows the location of a Large Special Dwelling Place (Antigua Prison Camp), location of a new hamlet (Feri), and HU estimates by sectors. The official corrected various features. He added New Casseta Road, Bridge Trail, an extension of Lento Trail, and a bridge where Hutta Trail crosses Jona River; he corrected the southern part of Hutta Trail and provided names for five previously unnamed trails and the name of the northern extension of Hutta Trail.

The local official provided HU estimates for small areas for which there were natural or man-made boundary features. He used "fishhooks" (☿) to indicate that the estimates included both sides of a trail or road. He indicated HU estimates for Casseta city, and for Feri and Hutta hamlets on form GEO-202 (see exhibit 6-5). Also, he appropriately added Feri hamlet and gave estimated population counts for Casseta, Feri, and Hutta; made a sketch map of Feri; and gave HU estimates, by sector, for each of the three places. (Maps for Casseta and Hutta are not included in the exhibits.)

The second map in exhibit 7-3 shows the final base map, which was corrected and delineated into EA's, based on information provided by the local official. For a rural area, the ideal EA size was set at about 100 HU's, but in order to use natural and man-made features as boundaries, the actual sizes of EA's ranged from 85 HU's to 120 HU's, as shown below.

EA No.	HU estimate
001	90
002	105
003	110
004	100
005	85
006	100
S-007	-
008	95
009	105
010	115
011	120

Note that the Special Dwelling Place was designated EA S-007; note also that EA's were numbered in serpentine fashion starting at the northwest corner. Separate base maps were used for Casseta, Hutta, and Feri but, as shown, an EA line was drawn around each place.

5.42 EA delineation based on information from an aerial photograph.--In exhibit 7-4, the first map shows a portion of the base map of a section of a city called Levittown. The base map was drafted according to the materials and instructions in the map package, exhibit 6-6. The heavy solid lines represent paved roads and the broken lines represent unpaved footpaths.

Since the air photo was of recent origin, the NSO did not feel that it was necessary to ask local officials for HU estimates, and there were recent planning maps which gave the names of streets and the location of boundaries and landmarks. The enlargement of the air photo was used to estimate HU's by block. The person making the estimates had to be trained to interpret the photo in order to distinguish between HU's and other buildings, and between streets that defined the blocks and footpaths that ran down the middle of the block.

The second map in exhibit 7-4 is a portion of the final base map which was delineated into

EA's. Note that, in order to delineate them clearly, the base map had to be enlarged.

6. DELINEATING AND NUMBERING CL AREAS

Crew leader areas consist of groups of EA's, and therefore do not have the boundary and delineation problems which were resolved at the EA level. However, CL areas have some problems of their own.

CL areas must observe the boundaries of field district offices. Boundaries of these offices are usually determined by grouping administrative areas to form a workload for each office. These areas must be determined early in the census planning.

CL areas normally contain from 8 to 12 EA's each. This number varies with the length of time for enumeration, the size of enumerator workloads, anticipated travel time within and between EA's, and the intensity of supervision desired. In practice, about 10 EA's usually make a good crew leader assignment.

CL assignments should be reasonably equal in size. Again, this depends on the variation in the EA's that make up the assignment.

If possible, CL areas should be confined to EA's under supervision of one field office. If it is necessary for the CL area to cross an administrative boundary line (a district line for example), the person delineating CL areas must be sure that the parts are adjacent to each other, that they form a compact area with no major travel obstacle between the parts, and that they lie within the boundaries of only one of the field offices. CL areas should be designed to minimize travel and they should not, except under unusual circumstances, consist of disconnected pieces of territory At the same time, every EA must be assigned to one, and only one, CL area.

The numbering of CL areas follows the same general principles as numbering of EA's. However, since CL areas may cross lower-order administrative boundaries, it is recommended that they be numbered within district field offices. A serpentine numbering system, like that suggested for EA's, may be used. Because of the difficulty of maintaining an orderly sequence of areas in preparing base maps and delineating EA's, great care must be taken to ensure that no CL area number is used twice within the area covered by one field office.

CL area numbers are used only for control purposes. They are not used in the tabulating geographic code scheme. CL area boundaries and numbers need appear only on copies of the maps prepared for crew leaders and field offices.

As CL areas are delineated and numbered, the numbers should be entered in column 7 of the EA Delineation Worksheet, Form GEO-122, as shown in exhibit 7-1. Each field office should receive a copy of the worksheet containing the CL areas and EA's for which the office is responsible. The field office, in turn, should give each crew leader a list of the EA's in his area.

As stated earlier, CL area maps and field office maps may be simply copies of base maps on which EA's have been delineated (referred to as EA base maps), but reproduced at a smaller scale. Each crew leader needs a copy of a map showing the individual EA's and boundaries of his area. The field office needs a copy of a map showing all the CL areas that it supervises. Individual EA maps would be too bulky to handle and the large number of copies too costly and hard to control.

7. PREPARING COPIES

After the base map is divided into EA's, it is necessary to cut a copy into individual EA maps. Since it is important to include some peripheral area on each individual EA map, it is not possible to obtain all the EA maps for an administrative area from one copy of the EA base map for that area.

7.1 *Reproduction of EA maps*

Map reproduction is a process that has its own unique problems. Size and number of copies needed and quality of paper all affect the cost of the operation. It should be stressed that at this stage of the work, time is a very important factor; any delay in sending EA maps to the field will seriously affect the progress of the census. Therefore, high-speed equipment for making copies of the size, quantities, and quality required is not only desirable but also necessary. (See chapter 11 for description of types of equipment.)

7.11 Size of copy.--An individual EA map should not be too large or too small. If it is large, the enumerator may fold it carelessly or roll it up tightly, and thus increase the possibility of mishandling and tearing. Large maps also are very clumsy to use in the field. By way of contrast, small maps are often difficult to read and can be easily lost. The size will depend on the settlement pattern in the area, which must be shown at a scale that is large enough for the enumerator to locate the EA and its features; at the same time, the EA map should be small enough to handle easily. Sometimes it is impossible to meet both of these requirements. In any event, legible maps must be available, even though the sizes of the maps may be awkward to handle.

7.12 Number of copies of EA maps.--The cost to produce several copies of individual EA maps and to control their distribution can be a problem. In the interest of economy, only one copy of the individual EA map is needed and that copy must be given to the enumerator. The crew leaders and field offices need copies of maps showing CL areas and EA's. The NSO should retain the original copy on which EA's and CL areas were delineated, rather than individual EA maps. It is recognized that an EA map may be lost, and the enumerator would be delayed unless the crew leader has an extra copy. An extra copy is useful also when the crew leader needs to split a large EA. However, the NSO must consider whether it is efficient to provide enough copies to ensure that every crew leader has an extra copy for the relatively few times he needs it. If an extra copy is needed in the field, the crew leader can make a tracing of the EA from his CL area map.

7.13 Quality of paper.--The paper used for maps should be of reasonably good quality. The maps may be used under conditions of high or low temperatures and in the rain. They may be folded, rolled, or crumpled. They will receive rough treatment. However, the actual enumeration period for any EA is normally not more than several weeks. Accordingly, the map paper need not be of such excellent quality that its use becomes prohibitive because of high costs. Use of coated diazo-type paper for EA and CL area maps reduces costs and provides enough additional strength in the paper to be satisfactory for field operations. This paper may be purchased already coated, although standard paper sprayed with a protective coating may serve the purpose in some cases.

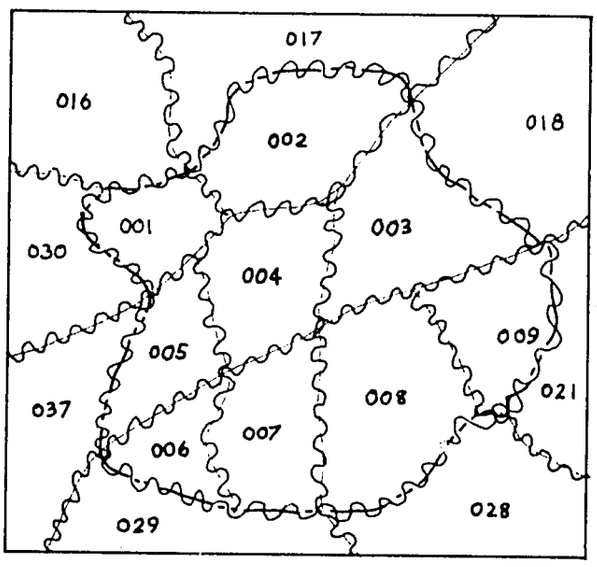
7.2 *Calculation of copies of EA base maps*

As mentioned earlier, individual EA maps may be cut from EA base maps. Furthermore, each individual map must show some peripheral area so that the enumerator can locate EA boundaries accurately. The number of copies needed depends on how many EA's appear on one sheet, how they are arranged, and which cut-out procedure is used. Enough copies should be made to do the job; at the same time, too many copies are wasteful. There are several ways to calculate the number of copies needed.

Since CL areas may also be delineated on EA base maps, additional copies of the EA base maps are needed. The calculation should provide one copy for the field office and enough copies to cut out individual CL areas.

7.21 Example A.--One procedure is to prepare a worksheet listing the EA's that can be cut from each copy. In figure 7d, assume that each EA around the margins of the map will be matched with the rest of the EA that appears on another sheet. The example requires four copies of the map sheet if individual EA's are to have some peripheral area. One way is to consider each EA in sequential order. Cut EA 1 from copy 1; since EA 2 cannot also be taken from copy 1, copy 2 is needed. EA 3 can be cut from copy 1, but EA 4 requires copy 3. EA 5 cannot be taken from copy 1 but can be cut from copy 2. EA 6 can come from copy 1; but EA 7 requires copy 4; etc. For this example, four copies of the EA base map are needed for the individual EA maps. When the copies are reproduced, the cutter should follow the worksheet.

Figure 7d. WORK MAP AND SIMPLE WORKSHEET FOR CUT-OUT PROCEDURE



Sheet 3 of

FORM GEO-121	Province: Doria	Code: 22
WORKSHEET	District: Bega	Code: 03
CUT-OUT PROCEDURE	Calculated by- J. Alvar	Date: 3/1/80
	Cut out by-	Date

Area Name	Area Code	Copy No	EA No
Toto barrio (rural)	09-999	1	1, 3, 6, 28
		2	2, 5, 8, 21
		3	4, 9, 17, 29, 30
		4	7, 16, 18, 37
Suma City	09-465	1	12, 15, 39,

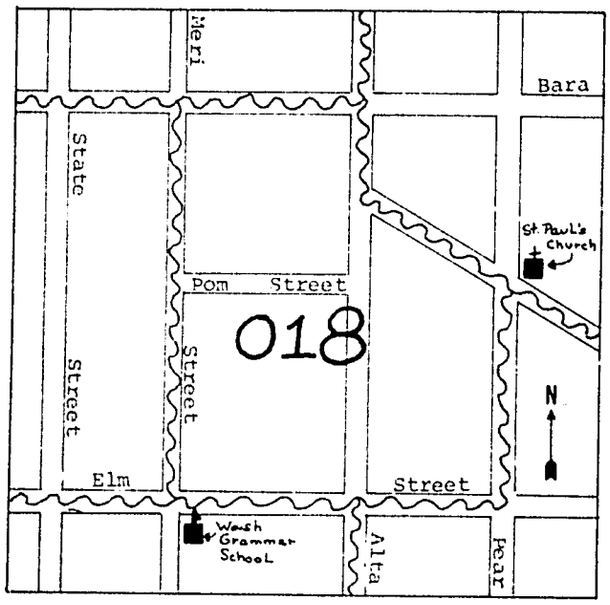
A similar way to calculate the number of copies needed is to start with one EA and list all the other EA's that can be cut from that one copy. For example, start with EA 16; place a pencil check mark beside the number on the map. Then look for other EA's that can be cut from the same copy--in this case, EA's 18, 4, 28, and 37. EA 17 would be cut from copy 2, as would EA's 5, 8, and 21. Do the same for copy 3, and as many more copies as needed. For this example, four copies are needed.

7.22 Example B.--Another procedure is to simply reproduce some copies of the base map and start cutting, without preparing a worksheet. It would save the time of calculating number of copies needed but may result in too many copies having been made or too few, in which case there would be a delay until more copies are available; in either case, the cost would be greater.

7.23 Example C.--A third procedure is to photograph each EA (with peripheral area) from the original copy of the EA base map, then enlarge and print one copy for the enumerator. Microfilm or larger film may be used to make the negative of the EA map. This is an efficient method, although it could be more costly than the diazo and cut-out method.

7.24 Example D.--A fourth procedure is to eliminate the peripheral area on the individual EA map and use only one copy of the EA base map to cut each EA along its boundaries. While this reduces the number of copies of the EA base map, the lack of peripheral area introduces possible error in identifying EA boundaries.

Figure 7e. EA MAP SHOWING PERIPHERAL AREA



7.3 *Map cut-out procedure*

Individual EA maps need not be rectangular or square although a regular frame of straight lines is usually more convenient to plan and cut. The procedure should be to cut the base map so that each EA plus some peripheral area, as shown in figure 7e, is on a single piece of paper.

A device that is often used when cutting the EA maps is a template. This is a form that is placed over the EA to be cut out. It can be rectangular or square. The cutter draws a line, in pencil, around the inner perimeter of the template. Before cutting any map, he should draw the pencil lines for all other EA's to be cut from that same map copy. Some adjustment may need to be made when the EA's on the sheet vary greatly in land area; there is risk of including too little peripheral area for some of them. If an EA is large in land area or if it has an odd shape, the template may have to be placed at an angle or moved to form a larger or smaller rectangle.

As the individual maps are cut from the base map, the cutter should keep a record of which EA maps he has cut. He could use the worksheet that was prepared by the person who calculated the number of copies of the base map that were needed (see figure 7d).

8. *ADDING IDENTIFICATION, COLORED BOUNDARY LINES, AND OTHER MAP ELEMENTS*

Final steps in preparing EA maps include coloring the EA boundary lines, supplying an appropriate legend, and adding identification codes. As with other mapping tasks, these final steps should be verified before the EA maps leave the EA Delineation Branch.

8.1 *Coloring EA and CL area lines*

On the copy of the EA map that is given to the enumerator, a colored line should be drawn over the EA boundary line. Color choice is optional, but a bright color (such as orange or red) is recommended, so that it can be seen easily. Colored lines serve to ensure that EA boundaries are clearly marked for the enumerator; they are used only on the EA for which the specific map has been prepared; boundary lines of adjoining EA's that appear on the map must not be colored. The colored lines should be verified, but their placement is one of the least time-consuming tasks in the EA delineation activity.

On the crew leader and field office maps, boundaries of the CL area(s) should be colored but in a different color. Bright green is suggested.

8.2 *Adding legend, scale, and identification*

The individual EA maps normally must have a legend, graphic scale, and north arrow added to them. These map elements already are on the base map, but they appear there only once and may be lost in the cut-out process. These elements can be added by means of rubber stamps which have been made for the specific purpose. Special care should be taken to ensure that the correct scale is added, since EA and crew leader maps may be of different scales.

The names of the 2nd, 3rd, and 4th order administrative divisions should be written on each EA map, in addition to the EA number. It is recommended that these names and codes be put on the map at the time that the EA maps are cut from the base map. If there is no room on the map itself, it may be necessary to place the items outside the map.

On the crew leader and field office maps, the code for CL areas should be indicated, in addition to the other identification.

8.3 *Mounting individual EA maps*

In some census offices, the EA maps are pasted or taped directly on the inside cover of the EA book, which contains materials that the enumerator uses for the enumeration. If this procedure is followed, the identification of the EA should be entered on the EA book at the same time.

Another procedure is to mount the EA map on a piece of lightweight cardboard about the size of the EA book. If the map is too large, it can be folded to fit the cardboard. This procedure has the advantage that EA maps can be recovered easily after the census enumeration and kept for later reference; on the other hand, they may be more easily lost than if they were attached directly to the EA book.

9. *ADMINISTRATIVE REQUIREMENTS*

The administrative requirements of the geography staff for delineating and controlling EA's are very similar to those involved in the compilation of base maps, including the types of personnel needed and recruited. Controls and progress reports also are similar.

9.1 *Personnel needs and training*

Although the EA Delineation Branch of the NSO is active only at the time of the census, it probably has the heaviest burden of the entire mapping program. Much of the work can be done by competent clerks or technicians with professionally developed instructions and good supervision. The clerks should be trained on-the-job to make boundary choices, judge the effects of terrain on the enumerator's travel in an area, and effectively combine groups of sectors (or blocks) into EA's and EA's into CL areas. The supervisors of the various EA delineation functions should be professional persons with census geography experience.

Some specialization of tasks may be introduced into the operations. Some tasks may even be accomplished by setting up an "assembly line" arrangement. For example, one clerk may simply outline the EA's; another may calculate the number of map copies needed; a third may cut the individual EA maps from the base map copies; a fourth may color the EA boundaries; etc. Such arrangement usually results in better production and better quality work. Even if one person did several tasks, it would be efficient for him to do one task at a time for each unit of work.

9.2 *Space and equipment requirements*

The space and equipment needed by the EA Delineation Branch parallel those of the map compilation staff. Of particular importance is the need to order supplies well in advance to avoid delays.

9.3 *Controls and progress reports*

Because of the importance and size of the job, it is essential that the EA Delineation Branch keep records on the flow of work in the Branch. As indicated in chapter 6, the control record, form GEO-102, can be used for compilation, EA delineation, or drafting (see exhibit 6-7). The form would reflect the various steps in EA delineation and control. An index map, similar to the one for map compilation (refer to figure 6d) could be constructed to reflect pictorially the progress of EA delineation.

Chapter 8. USE OF MAPS IN THE ENUMERATION

1. INTRODUCTION

Previous chapters in this manual discussed the interpretation of maps and the steps involved in preparing maps for census use. It is the purpose of this chapter to discuss the transfer of essential elements of this background to field office staff, crew leaders, and enumerators.

Chapter 8 is intended to provide the NSO staff with the needed information on the use of maps in the census enumeration. It does not substitute as a training manual; rather, it attempts to highlight information and procedures which may be included in such a manual.

2. PURPOSE OF ENUMERATION MAPS

Personnel who will be involved in field operations use three types of maps: (a) EA maps, (b) crew leader maps, and (c) field office maps. Although their uses have been discussed in earlier chapters, they are reviewed and summarized below.

2.1 Uses of EA maps

The primary purpose of delineating EA's is to divide the country so that each part is enumerated once and only once. With his individual EA map, the enumerator can accomplish the following:

(1) Locate his EA.

(2) Determine precisely what area he is to cover (boundaries are indicated in a bright color).

(3) Plan the best route of travel in order to cover every piece of his EA systematically. In this connection, he can indicate his starting point and direction of travel so that his supervisor can check his work more easily.

(4) Mark the location of houses (for possible return visits).

(5) Estimate the amount of travel from point to point.

(6) Add new streets and names, cross out features that no longer exist, and otherwise update the map for future use.

The individual EA maps can be used by the crew leader also. The crew leader can use them to estimate workloads, split EA's that are too large for one enumerator, help the enumerator to plan the best route of travel, and resolve boundary problems. However, for crew leader and field office control purposes, they are too bulky; smaller-scale maps showing the entire CL area on a single sheet are more practical.

2.2 Uses of crew leader (CL) area maps

As discussed earlier, maps for the crew leaders may be simply copies of the EA base maps (base maps with EA's delineated on them) at smaller scale and with CL area boundaries added. With this map, the crew leader has a visual representation of the relative location of each of the EA's in his area. He can also plan his travel to observe the enumerators and review their work, identify places that may be hard to reach, and verify the boundaries so as to assure that there is no omission and no duplication of area.

2.3 Uses of field office maps

Field office maps that show EA and CL area boundaries serve as a visual aid to monitor the progress of the census enumeration. They assist the management staff in estimating workloads and travel costs, arranging for distribution and receipt of materials, identifying trouble

spots, and arranging visits of office personnel to field locations.

3. BASIC SKILLS FOR PROPER USE OF MAPS

In order for the field staff to use the maps effectively, they will need certain skills. The skills are of two types: (a) pre-training skills, or basic skills personnel should possess prior to being employed, and (b) post-training skills, or special skills that will be acquired through special training for the census.

3.1 Pre-training in basic skills

Enumerators and crew leaders should have certain basic skills. These include not only a sense of direction (North, East, South, West) but also the ability to--

(1) Read a map and follow map features
(2) Understand written instructions
(3) Perform basic arithmetic computations relative to estimating distances
(4) Write legibly

When hiring enumerators and crew leaders, a test can be given to find out whether they have the required qualifications. Exhibit 8-1 is an example of part of a test which could be used.

3.2 Post-training skills

Both crew leaders and enumerators need to be trained in specific census matters relative to the use of maps. They should be trained in the following:

(1) Interpreting map symbols and relating them to natural ground features
(2) Identifying the EA boundaries
(3) Orienting the map to ground features
(4) Measuring distances on the map and on the ground by use of the scale
(5) Canvassing the EA systematically
(6) Updating and correcting maps
(7) Using aerial photographs (as appropriate)
(8) Caring for the maps

As stated earlier, maps are useful tools for taking a census. However, unless the enumeration staff is trained in how to use them, not only will the map preparation effort have been wasted but the census results will suffer.

This chapter is concerned primarily with the post-training skills that are needed. Further, it concentrates on the use of EA maps, whether by enumerators, crew leaders, or other field personnel. Topics that should be covered in the training have already been discussed in some detail in earlier chapters; only the more important points are mentioned here to call attention to those matters that need emphasis in the training.

4. INTERPRETING SYMBOLS, LEGEND, AND SCALE

EA maps for rural areas usually will have symbols, legend, and scale. EA maps for large urban areas, since they represent relatively dense but small areas, may have symbols only for major landmarks; further, the map may or may not indicate the map scale. It is expected that the enumerator will be familiar with the area and may not need symbols and scale.

4.1 Symbols and legend

If symbols are shown on the EA map, the enumerator should know how to interpret them using the legend. Understanding the map symbols is essential for identifying boundaries, planning travel, recognizing multiple dwellings, and locating landmarks so as to keep within the EA. In a population census, it should also be emphasized that the enumerator must visit every structure or place where people might live in the EA, whether or not the structure is shown on the EA map.

4.2 Use of map scale

On EA maps, the scale is generally of the graphic or bar type, which is the simplest to use. Examples of graphic scales and their uses

are given in chapter 3 (sections 3.13 and 3.22). In the examples in chapter 3, the part to the left of the "zero" position is used to measure short distances and to measure distances more closely; note that the subdivisions are shown in smaller units of measure.

Occasionally, an EA map shows the scale as a ratio, a fraction, or a word statement. More training normally is required when ratios or fractions are used. When possible, the map scale should be converted to graphic form before the map is given to the enumerator.

4.3 Measuring distances

Field personnel are often required to measure distances so that they can estimate travel time and, more importantly, determine how far EA boundaries extend. Several of the preceding chapters, particularly chapter 3, describe some methods of measuring distances--by pacing, by automobile, and by bicycle. The "paper strip" method, described in chapter 3, is a fairly simple technique to measure the distance according to the map. If the distance is not a straight line, the enumerator should measure the road in sections, then add to get the total.

Ordinarily, the enumerator can follow the direction and names of roads and intersecting streets; he need not be concerned with distance. However, he will need to estimate distances when EA boundaries are imaginary lines or when features have been added or have disappeared since the map was made. In all cases, the enumerator must cover the land within the EA lines as drawn on the EA map.

5. IDENTIFICATION OF THE EA

One of the most important features on EA maps is the EA boundary. It serves as a "fence" around the enumerator's assignment and helps to assure complete coverage. The enumerator must be able to recognize the boundaries and locate them accurately. Further, he should be cautioned to enumerate within the boundaries. The boundary is actually the middle of a street or road; the enumerator should not include the houses or land on the side that is beyond the boundary.

As indicated earlier, EA boundaries that are also boundaries of an administrative division often are imaginary lines. Using the map scale and measuring the distance of the imaginary boundary from some recognizable landmark should be encouraged. Sometimes there is a marker of some sort that indicates the limits of an administrative division. If the location of the boundary is still in doubt, the enumerator should check with a knowledgeable local official.

If the EA map does not show peripheral area (area immediately outside the EA), the enumerator may need a small-scale map of the larger area of which his EA is a part. This can help him reach his EA and assure that he has identified the boundaries accurately.

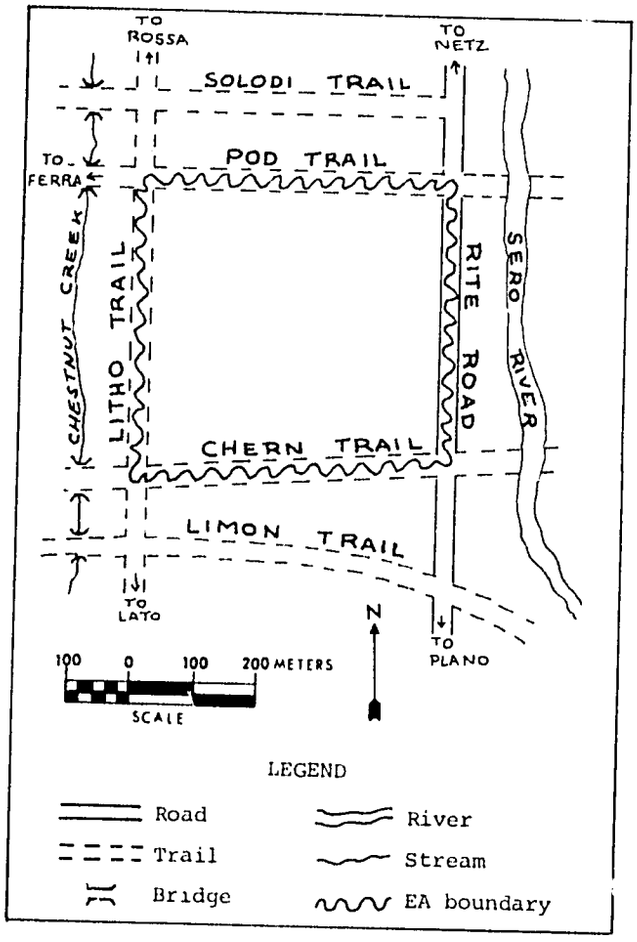
6. CANVASSING TECHNIQUES

Canvassing involves a systematic search of the EA one section at a time. However, before he starts, the enumerator must be certain that he has located his EA.

6.1 Locating the EA

In order to locate his EA, the enumerator must often rely on the peripheral area. In the example in figure 8a, assume that the enumerator starts out from the hamlet of Ferra (just west of the map area). He will know that he must first cross a bridge over Chestnut Creek and that, about 100 meters from that point, he will come to a road intersection (Pod Trail and Litho Trail), which is the northwest corner of the EA. This procedure contrasts with that of an enumerator who does not use the information about the peripheral area. When he approaches

Figure 8a. PERIPHERY INFORMATION



the EA from Plano (southeast of the map area), he might easily mistake Limon Trail for Chern Trail and start enumerating in the wrong place, outside the EA.

On the other hand, if he used his map and looked at the peripheral area, he would find two crossroads along Rite Road and he would know that the border of his EA was the second intersection, located about 150 meters north of the first intersection he encountered. To prove that these two crossroads are the ones on the map, the enumerator might continue north along Rite Road for about 400 meters and then come to another intersection. At this point, the Sero River would be closer to him (about 80 meters) than it was at the intersection of Chern Trail and Rite Road (about 120 meters). These indications of agreement between map and ground features should be sufficient to indicate to the enumerator that he has located the eastern boundary of his EA.

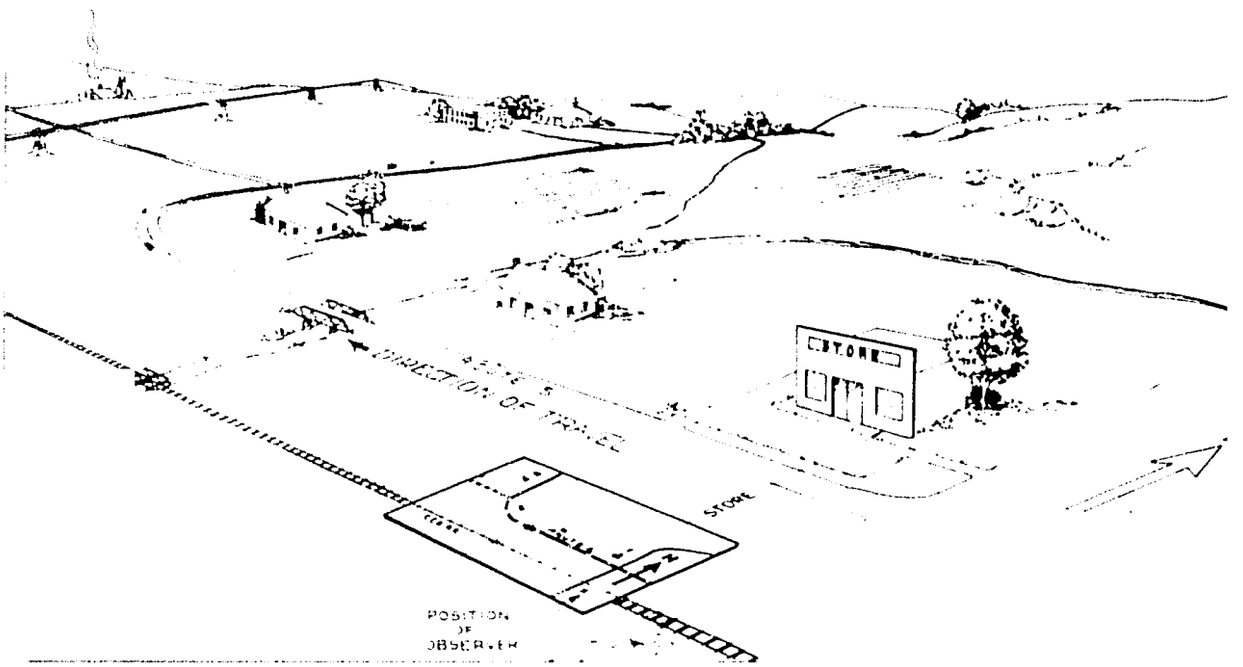
6.2 *Orienting the map*

Upon arrival in the field, the enumerator must orient himself with respect to his EA map. The first step is to lay the map flat so that the whole map and legend are clearly visible. It is usually preferable to begin orientation at a major street or road intersection, since this can often be readily located both on the map and on the ground. Other nearby features such as houses, churches, railroads, and rivers should be checked against the symbols shown on the map. The enumerator must be aware of the fact that certain man-made features, especially buildings, may be newly constructed and others may no longer exist. Accordingly, training should stress the fact that he still must use his map despite changes that have taken place on the ground but have not been reflected on the map.

The map should be held in such a way that major map features are lined up (or oriented) parallel with the ground features. In figure 8b for example, the enumerator has lined up Route 5 as shown on the map in the direction of travel. Then, the other map and ground features are in their correct relative positions; the store and the two houses are on the right, and the school and church will be on the left, both on the map and on the ground (after turning on Route 5).

If there is no named road to help him to establish his location, the enumerator should watch for other landmarks and check them with the map. Sometimes he can find a sequence of landmarks. For example, he might observe a store and two houses on the right, and a stream and a railroad on the left. With these, he is fairly certain he has located his EA. Checking distances to other landmarks shown on the map and observed on the ground help to confirm the location of the EA.

Figure 8b. ORIENTING THE MAP WITH THE GROUND



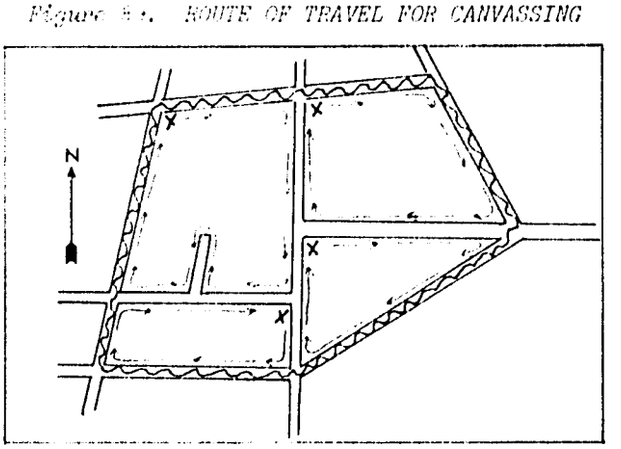
6.3 *Route of travel*

Before starting his work, the enumerator should examine the EA map carefully so that he can develop a clear and efficient plan for canvassing. The crew leader may help him plan the best route of travel. Insofar as possible, the enumerator should plan his travel to minimize "backtracking" (going back over the same roads or streets).

The initial step is to divide the EA into sections, if possible. In urban areas, the EA might be divided into blocks or sectors. In rural areas, the sections would follow roads, streams, etc. The starting point for the EA may be any convenient recognizable point. For the benefit of the crew leader, as well as the enumerator, the starting point should be marked with a large X or other symbol. In figure 8c the crew leader has indicated various corners as starting points for the respective sections or blocks. For each section or block, the starting point is also the finishing point canvassing (unless there is an obstacle).

At the end of each day, the enumerator could indicate on the map the point where he stopped; for example, he could draw two short lines at right angles to the road on which he was traveling and enter the date.

Figure 8c. ROUTE OF TRAVEL FOR CANVASSING



An important rule is: "Keep to the right." This means proceeding clockwise from the starting point so that the houses being enumerated are always on the enumerator's right. The EA map should always be oriented so that it points in the direction of travel. As each corner is turned, the map should be re-oriented so that the features on the map are lined up with the same features on the ground.

In general, the enumerator should complete one section or block before starting the next. However, if a road is very difficult to travel, the enumerator may need to canvass both sides of the road at the same time (if the EA indeed includes the area on both sides). Care must be taken in doing this, so as not to miss or duplicate any houses.

6.4 *Identification of housing units*

In some censuses, the enumerator is asked to plot housing units on the EA map, especially in rural areas. He is instructed to place a small square or other symbol at the spot where the HU is located. He will need to identify each symbol by serial number or similar identification of the particular HU. Although the enumerator may have difficulty pinpointing the exact location of the HU, even the approximate location is useful for checking or for finding the HU when a return visit is necessary. The enumerator should be able at least to indicate on which side of the road or street the HU is located. In urban areas, it is ordinarily not possible to plot the location of each HU on the EA map because of the large number of HU's in a city block and the relatively small size of the map.

6.5 *Moving around obstacles*

In rural EA's in particular, the enumerator may encounter obstacles to his planned route of travel. These obstacles might include natural features such as swamps, rivers, deep valleys, or mountains. Most obstacles of this type are essentially permanent and may be shown on the EA map. The enumerator should take such difficulties into account in planning the canvass. It is rare that such obstacles are completely impassable, but it is true that a lengthy side trip may be required to travel around them. A good canvass plan must make allowance for this. For example, if an EA contains a large stream with one bridge, the plan of canvass should provide for separating the area into sections which would minimize the number of times the stream must be crossed.

Temporary obstacles to travel also could develop. Examples include a bridge or street under repair, or a river in flood. In situations such as these, the EA map may show some alternative routes. Questioning residents in the area can also be helpful, particularly if the enumerator is not familiar with the area. If the obstacle is a temporary one, it may be possible to continue with another part of the canvass and return later.

7. *MAP CORRECTIONS*

Maps of EA's may sometimes be out-of-date, or they may contain incorrect information about specific ground features. The enumerator is responsible for making corrections on his EA map. Map correction should be considered an important and basic part of his census job.

7.1 *Changes in names*

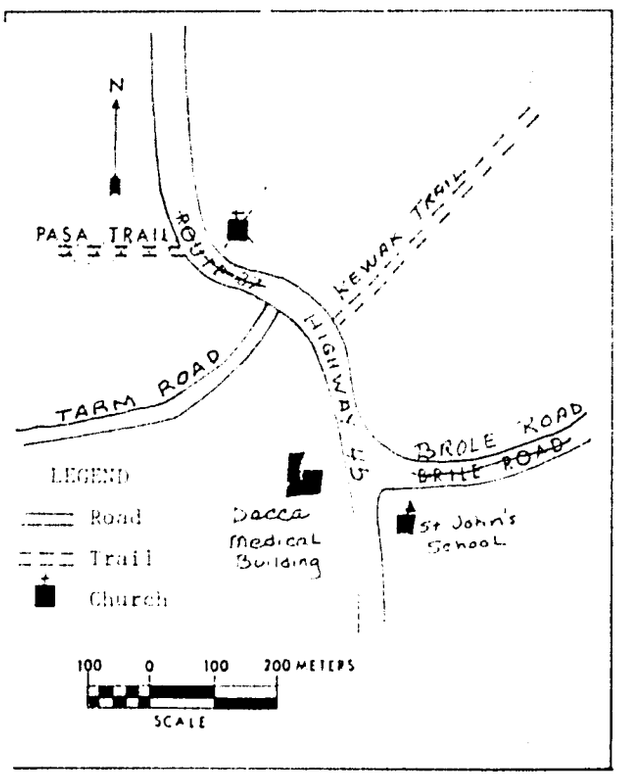
Streets and roads are important since they represent lines of travel and canvass. They are also important in determining locations of features. Streets and roads are the primary references within an EA.

The name of a road or street serves to separate that particular feature from other similar ones; for example, a church located at the intersection of Rondo Road and Cook Trail is different from the church at the intersection of Rondo Road and Wang Street. The names

of streets, roads, etc., therefore, should be correct. Names change occasionally. If an error is found, including spelling, the enumerator should simply draw a line through the original name on the map and write the correct one. In figure 8d, the major road formerly was called Route 47. It is now called Highway 45 and the new name has been entered on the map. In addition, the spelling for Brole Road has been corrected. Corrections for spelling and placement of names should not be limited to roads and streets. Names and locations of all natural and man-made features on the map should be examined and corrected, if necessary.

7.2 *Adding or deleting features*

It is important to add to the EA map any new features in the area. This includes new roads, important buildings, bridges, etc. When adding such features, the enumerator should try to locate them as accurately as possible and enter them on the map with standard symbols.



In figure 8d, several new features are shown. A new road (Tarm Road) is drawn in, leading southwest of Highway 45; a new trail (Kewak Trail) has been added northeast of the highway. Also, a large office building and a school have been added along Highway 45 near the intersection of the highway and Brole Road. All these have been drawn on the map by the enumerator, who also supplied the names.

Ground features that have been demolished or otherwise removed from the area should be crossed out on the map. An X can be used to cross out buildings and eliminate roads. Two such changes have been made in figure 8d; a church has been crossed out and a trail west of Highway 45 (Pasa Trail) has been replaced by cropland and therefore was deleted.

8. *USE OF AERIAL PHOTOGRAPHS*

Although it is not recommended, there may be times when an aerial photograph must substitute for an EA map; for example, maps may not be available for an area and there may not be time to make a sketch. If the enumerator must use an aerial photograph, he will need special training. Some of the training for using maps may be carried over to aerial photographs; for example, the same principles concerning the use of a graphic scale for measuring distances and the same rules for canvassing will prevail. The main difference that is likely to occur is in the identification of individual objects, which are normally shown by symbols on EA maps. Most enumerators will not have seen an aerial photograph before; even an overhead view of their own neighborhoods may be puzzling.

A simple approach to air photo interpretation might begin with identifying the usual features that are known to the enumerator, such as roads, streams, trails, and large buildings. It will be helpful also to train the enumerator to recognize woodlands, cultivated land, and

other types of land use, since these may be of value in establishing boundaries.

As soon as the enumerator can recognize the usual ground features on the photograph, he should be required to practice making distance measurements. An exercise in boundary identification likewise will be helpful.

Another likely difference between an air photo and an EA map is that of scale. Usually the photo has a smaller scale. Accordingly, it will show a larger area than the EA map. Thus the photo may contain more peripheral information than is needed by the enumerator and may confuse him. In addition, it may be found that many photos are too dark or too light. Some also may have too much cloud cover. Others may show dense foliage which can hide many of the features.

9. CARE OF MAPS

The enumerator should be made responsible for the care of his EA map. He must return it to the NSO along with his questionnaires and other census forms. The map is an important part of the record of the census; it may also be put to use at a later time.

Maps are best preserved if they are not folded or rolled. An EA map is normally small enough that the enumerator can keep it flat at all times. If it must be folded, however, it should be folded and refolded in exactly the same way each time so that it remains a neat compact package. Since folding will develop lines of weakness in the paper, it is best to limit the number of folds.

In the field, the enumerator should take care to protect his map during bad weather. Water in particular causes rapid deterioration of the paper. Because of moisture problems, the enumerator should be instructed to do all writing on the map in pencil rather than pen. If the map should get wet, the ink might run and destroy valuable information.

If the map is torn, it should be repaired as soon as possible, so that the problem does not worsen. A strong transparent tape can be applied to the back of the map. If the torn edges are carefully matched, the tear may be virtually unnoticed on the face of the map.

10. ADDITIONAL TRAINING FOR CREW LEADERS

Crew leaders should be trained in the same census tasks as enumerators. However, since they have some additional tasks that involve maps, they need additional training.

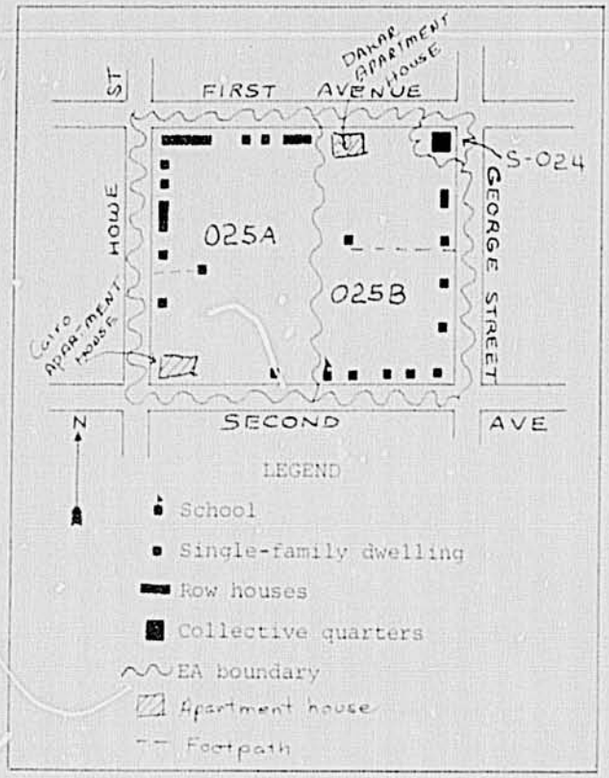
10.1 Split EA's

One of the duties of the crew leader is to make a preliminary visit to each EA to see if there are any boundary or canvassing problems. In cases where he finds that the EA is unusually large, in terms of population, he will need to split the EA into assignments of more reasonable size. In making the split, he should follow recognizable features so that the enumerator will know exactly what area his EA covers.

The need to split EA's occurs most often in areas of rapid population growth. A single city block may be so densely populated that it must be assigned to several enumerators. It may not be possible to use a natural feature as a boundary; but it is important that the split be made so that there is no doubt which part belongs to each EA.

Figure 8e shows an urban EA that had to be split. The boundary separating the two parts is an imaginary line. The enumerators should be instructed that the dividing line is next to the school on Second Avenue and between the apartment building and the row of houses on First Avenue. They should sight through the

Figure 8e. SPLIT EA AND SPECIAL EA



block from Second Avenue to First Avenue and enumerate every dwelling east of that line for EA 025B, and every dwelling west of that line for EA 025A.

On the EA map for Enumerator A, the crew leader must cross out the part represented by EA 025B. For Enumerator B, he would need to make a copy of the portion of the original EA 025 which became 025B.

10.2 *Special EA's*

Large collective quarters (places where people live collectively) will be designated by the NSO before the start of the enumeration. These places include prisons, convents, mental institutions, workers' dormitories, homes for orphaned children, and similar places. Special enumeration procedures are called for in these EA's, because the enumerator normally will not be able to interview the residents. Special EA's are usually designated by a prefix letter, which precedes the EA number. In figure 8e, the building at the northeast corner is a home for orphaned children; it is designated EA S-024.

11. *TRAINING PROGRAM*

To be successful, the training program on the use of maps needs to include both classroom instruction and field exercises. The written instructions ensure that no important points are overlooked, and the field work gives the practical application. As a minimum, the field staff should be trained in how to interpret map symbols and map scale, identify EA boundaries, orient the map, measure distances, canvass the EA, update and correct the maps, use aerial photographs, and properly care for maps.

11.1 *Training schedule*

It is suggested that $\frac{1}{2}$ day be devoted to training in canvassing and following the EA map and another $\frac{1}{2}$ day to actual practice in the field. In practice, training in the use of maps is integrated with training in other census operations.

11.2 *Training techniques and materials*

For a large operation such as a census, training techniques must be efficient. A considerable number of enumerators are involved and, consequently, a good share of the resources available for the census. Experience indicates that the method of presentation must be varied, the trainees need to be actively involved in the learning process, and they should have the opportunity to do what they are taught.

Materials that are needed for training include training guides, reference manuals, and classroom and field exercises. As mentioned earlier, training in the use of maps normally is incorporated in the training program for all aspects of the census.

11.21 Training guides.--A training guide may be in the form of an outline or it may be a verbatim guide. An outline shows the principal

topics that the trainer should cover. It has the advantage of permitting the trainer to use his own words. However, there is the problem that a trainer may not express his ideas well, and that the enumerators will miss an important point. Furthermore, there is the danger that important ideas or procedures will not be given the proper emphasis. Another disadvantage is the failure of some trainers to control their speed. Some will go too rapidly and not cover the material adequately; others will proceed too slowly and will not cover certain points at all because there is no time left.

A "verbatim" (word for word) guide is intended to eliminate most of the problems; on the other hand, it may introduce some new ones. Since a verbatim guide is to be followed as it is written, and since it is difficult for some people to read with expression, a class session which lasts for several hours could become very dull. To offset this tendency, the verbatim guide should have generous amounts of trainee participation--questions and answers, practical exercises, and the like. Verbatim guides can assure that the trainers present the materials properly and accurately; additionally, they can assure that all enumerators receive the same training and that the information is consistent. Selected portions of training guides for crew leaders and enumerators respectively are illustrated in exhibits 8-2 and 8-3.

11.22 Reference manuals.--Although the training attempts to cover the instructions adequately, it is impossible to explore every situation fully. Furthermore, it is expected that the enumerators will not remember everything. The reference manuals should contain explanations of concepts and procedures that the enumerators normally will be using. The manuals also should cover most of the unusual situations they may encounter. Enumerators should be trained in how to use the manuals. Exhibits 8-4 and 8-5 contain small portions of the crew leader's and the enumerator's manuals.

11.23 Filmstrips and other visual aids.--For a census, which requires a large number of employees, it is efficient to prepare visual aids to reduce the amount of time needed for training. Filmstrips are particularly effective and can decrease the training time to a considerable degree. They require very little equipment--a simple projector and a screen (or even white paper or a white wall). The script can be read or played on a record. Exhibit 8-6 shows a few pictures and an accompanying script related to canvassing procedures. Note that the pictures are illustrative only. There are gaps in the sequence and therefore they do not present a coordinated set of instructions; they were selected from a set of 50 pictures which make up the complete training filmstrip on how the enumerator should canvass his EA.

Chapter 9. PUBLICATION MAPS AND GRAPHS

1. PURPOSE OF GRAPHICS IN PUBLICATIONS

Publication graphics are tools which make the census statistics more understandable and easier to use. As enumeration maps help in taking a census, so publication maps and graphs help in using the census results. Sometimes, the base maps used in preparing enumeration maps can be used as base maps for preparing publication maps.

Publication graphics serve two purposes. The first, and the more essential purpose, is to provide maps which locate and show the boundaries of all administrative areas for which data are reported in census publications. These maps are known as census area identification maps. The second purpose is to present significant results of the census in the form of statistical maps and graphs (or charts), thus making it easier for the general user to understand the geographic distributions and patterns inherent in the data in the statistical tables. If these graphics are attractively designed, they can arouse curiosity and stimulate the use of the results of the census.

2. CENSUS AREA IDENTIFICATION MAPS

Census area identification maps, often called outline base maps, always include the boundaries and the names or numbers of the areas being identified. Sometimes, the names of boundary features, such as roads, rivers, and lakes, are included. In addition to serving in census publications as an aid to users, by locating and showing the areas for which statistics are published, these maps may also serve as base maps for the preparation of statistical maps. When used as base maps, they may be printed with or without the names.

There should be a requirement that census area identification maps accompany census publications to locate and identify accurately every area, administrative or statistical, for which any data are provided. Otherwise, many users will not be able to interpret the data in the proper geographic distribution.

2.1 *Types of maps published*

There are three major types of area identification maps that are used in most census publications--national maps, 1st order division maps, and urban or metropolitan area maps. Additional types of maps may be desired in some countries.

2.11 National maps.--A national outline map of page size showing the boundaries of the 1st order divisions (provinces, states, etc.) and their names are required for all censuses, as illustrated in figure 9a. A larger national map, showing 1st, 2nd, and possibly 3rd order divisions and cities with names, is also needed if data are provided for all of these areas (figure 9c). Other useful maps might show the major regions[1] of the country defined in terms of 1st or 2nd order divisions, or the locations and names of major cities or metropolitan areas either by symbols, outline, or shading of the areas.

2.12 First order division maps.--Outline maps of each 1st order division showing 2nd or 3rd order divisions also are usually published. Figure 9b is an illustration of a province map of a country showing districts (2nd order

[1] *As used in this chapter, the term region is applied to broad geographic divisions within a country--not to the broad regions of the world, which comprise groups of countries.*

Figure 9a. NATIONAL MAP SHOWING 1st ORDER DIVISIONS

(Provinces of Popstan)

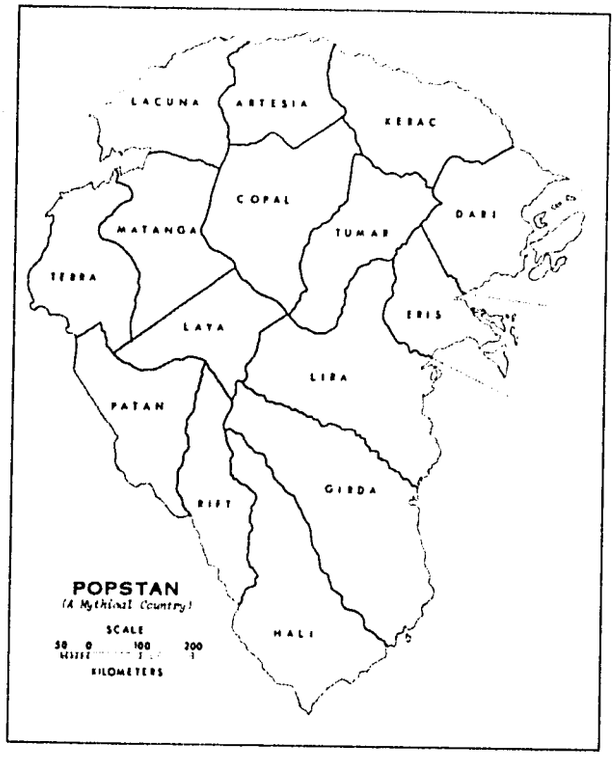
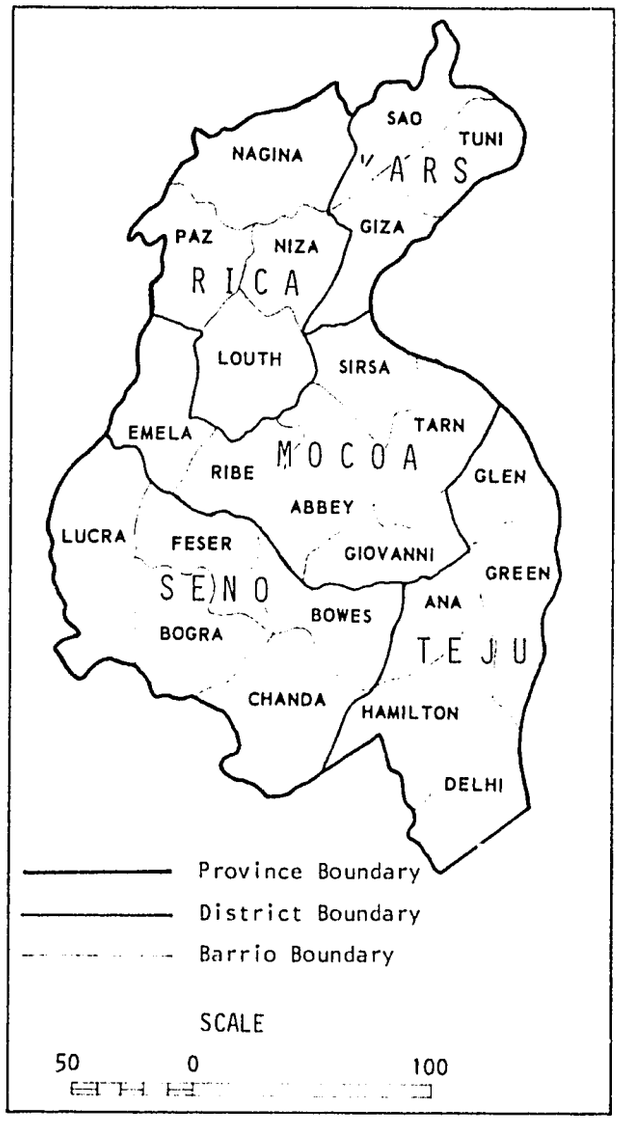


Figure 9b. MAP OF 1st ORDER DIVISION SHOWING 2nd AND 3rd ORDER DIVISIONS

(Districts and barrios in a province of a mythical country)



divisions) and barrios (3rd order divisions). These maps should accompany the census reports containing statistical tables related to the various divisions. If the 1st and 2nd order divisions are large in area and many small areas need to be identified, it may be necessary to present the map in sections with each section on one page.

2.13 Urban or metropolitan maps.--Where cities or metropolitan areas are divided into small areas (subareas) for statistical purposes, these small areas must be identified and boundaries shown for the user of the statistics. These small areas are generally specially defined statistical areas such as community areas, neighborhoods, sectors, or census tracts. The subareas also could be administrative divisions or planning areas. All should have names or numbers to identify them. These maps must be of large enough scale so that most of the boundary lines, generally streets, roads, or rivers, may be named on the map. Figure 9d illustrates census tracts of a city.

In some countries even greater geographic detail is published for cities and urban areas, such as housing and population statistics for individual city blocks. These blocks are the smallest areas which are bounded by streets, roads, and other physical features. The identification maps for blocks must be very large in scale so that all streets, roads, and natural

Figure 9.1. NATIONAL MAP SHOWING 1st AND 2nd ORDER DIVISIONS AND PLACES (Provinces, districts, and urban places of New Florencia)

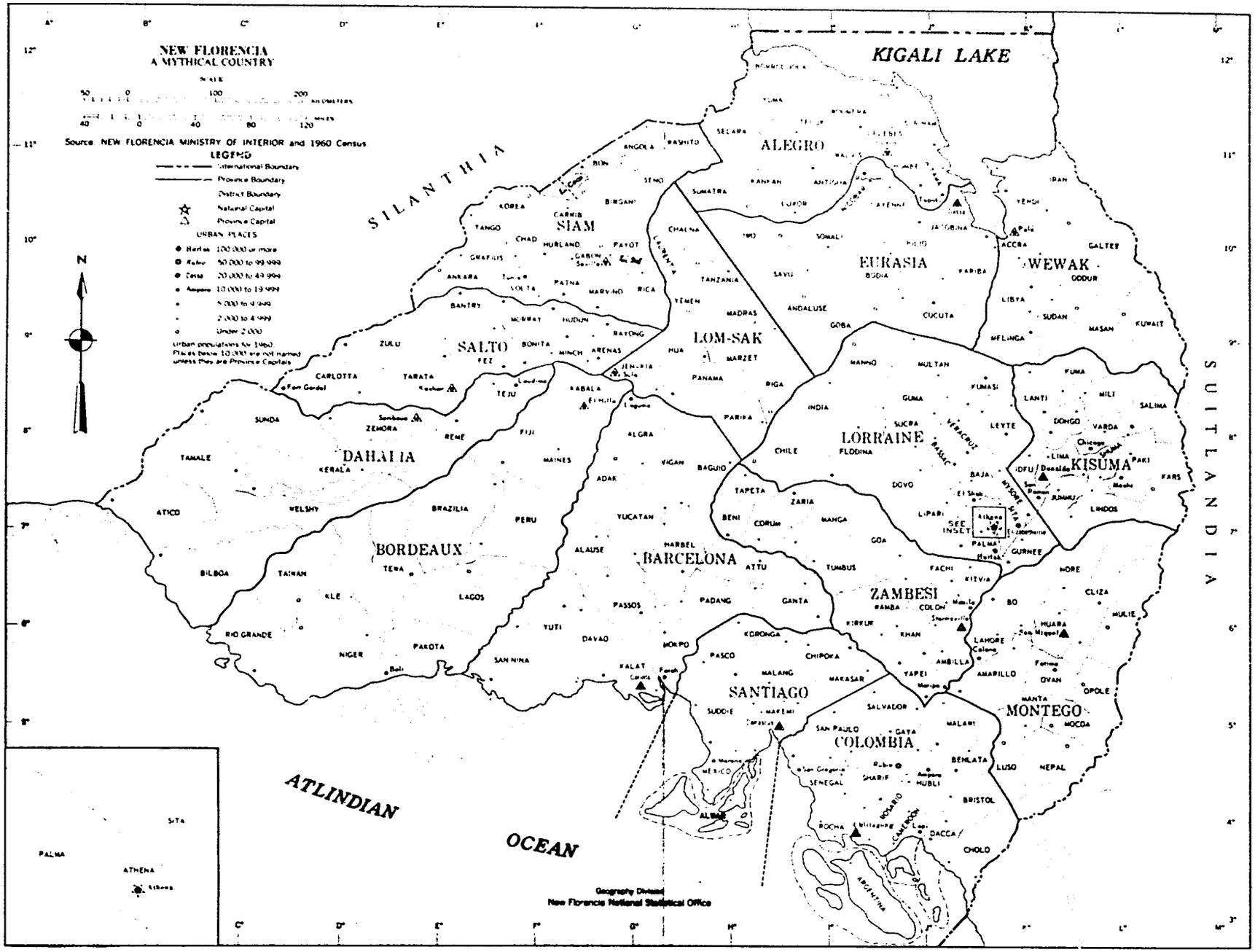
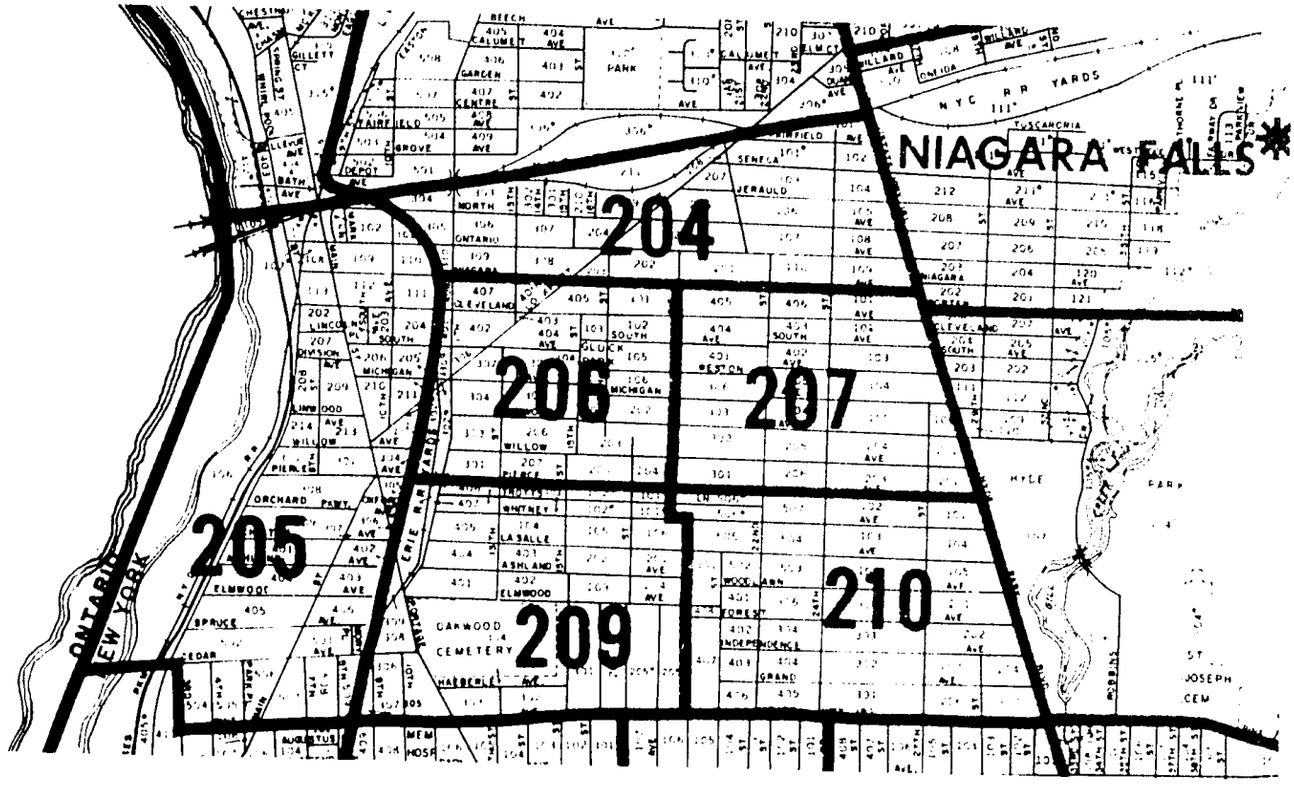


Figure 9d. CITY MAP SHOWING CENSUS TRACTS AND BLOCKS
(Census tracts and blocks for part of Niagara Falls city, New York)



features and their names can be shown, as in figure 9d. Since the maps are so large in scale, they must always be divided into sections.

2.14 Other types.--Other types of census area identification maps include the individual EA maps and the base maps on which EA's were delineated. Such maps are rarely published, because they are large and too voluminous; nevertheless, they are census area identification maps and are frequently used by those who work with tabulated but unpublished statistical data. For such users these maps are copied by non-printing[2] techniques. These maps are also important because they are the source maps from which all the published census area identification maps are made.

[2]*Non-printing techniques are described in chapter 11.*

2.2 *Planning the area identification maps*

After it has been determined which census area identification maps are to be published, attention must be focused on the design of each particular series. Map design is a process which begins with the initial planning of a map and continues through the preparatory steps until the map is ready for publication. Even in publication, the arrangement or placing of maps is a design problem that affects the usefulness of the map or maps. The requirements vary depending on the type of area identification map needed.

2.21 Selecting basic reference maps.--In preparing census area identification maps, it is necessary to select reference maps that show the boundaries of the subdivisions. Such maps should meet certain requirements of map projection and map accuracy.

For a national map showing 1st and 2nd order divisions, the projection of the map is important. It should be a map projection that possesses the characteristics of equivalence and conformality. Equivalence requires an equal area projection, where each area of the same size on the map represents an equivalent area on the Earth's surface. Conformality means that the shape of an area (but not the size) is closely preserved on the map. Equivalence and conformality are especially important if the area identification map is later to be used as a base for statistical maps. Some of the more widely used equal area projections are those invented by Albers, Lambert, and Bonne.

The construction of national maps on these projections is not discussed here, because national maps are normally constructed on an equal area projection and should be available in accurate form from the national mapping agency. If not, a competent cartographer may be employed to construct such maps. However, it may be noted that the use of equal area projections with good conformality for countries that are large in surface area is much more important than for small countries. For maps of small countries, the errors in area and shape are not significant. Maps based on the national topographic series which use projections that are not strictly equivalent or conformal may be quite satisfactory for small areas.

For a 1st order division identification map showing lower order administrative or statistical subdivisions, the base map can be an enlargement of the area from a national map, or from a regional map if available. The source of information for the boundaries of the lower order subdivisions and their names will be found on the EA maps and can be added to the base map.

For urban or metropolitan area identification maps, the base map as well as the source of boundary information and names or numbers will almost always be the EA maps. These are large-scale maps and were chosen because they were the most accurate and up-to-date maps available. Map projections used for these maps are normally of little importance; the type of projection employed is rarely indicated on a city map. The accuracy and completeness with which streets, roads, and other features are plotted are of major concern, because poor work will be easily observed by users who are familiar with local areas.

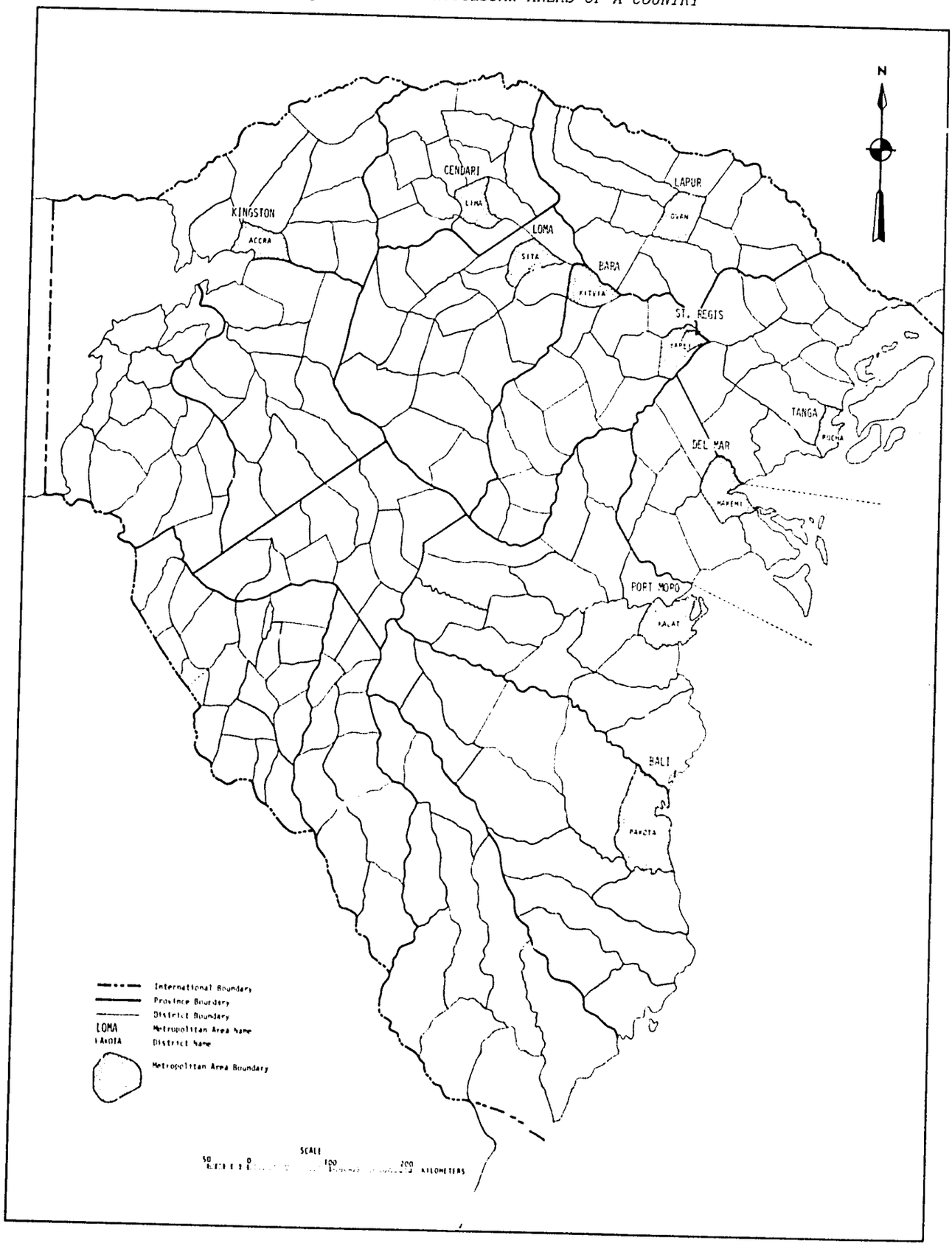
2.22 Determining publication map size and scale.--Before any map is made, the approximate size of the publication page should be determined. The page size of the census publication should be known because it is desirable to prepare maps to occupy space no larger than page size. Larger maps must be folded.

National maps showing 1st order divisions or major regions should almost always be constructed to fit on one page or less and should be included with the appropriate publications. If possible, each 1st order division map showing 2nd order subdivisions should be confined to a single page and should accompany the part of the census reports related to the 1st order division and its subdivisions. It is desirable to construct all the 1st order division maps at the same scale; however, this is not always possible if each map is to be confined to a single page and if the 1st order divisions vary greatly in land area.

In many cases, 1st order division maps showing both 2nd, 3rd, and smaller order subdivisions for which data tabulations are published will be too large to publish on a single page. This is especially true if the necessary boundary and name detail are to be clearly shown. Such maps may be drawn at larger scales and then divided into sections that will fit single pages for publication.

Urban and metropolitan areas may be indicated on national maps when the national summary

Figure 9e. METROPOLITAN AREAS OF A COUNTRY



shows data for these areas. It is necessary to show their location by symbolization or by general outlines with shading (as in figure 9e). Names also should be shown on the map. On the 1st order division maps, these areas may be shown in somewhat greater detail.

In reports which give detailed statistics by small areas within the urban or metropolitan areas, separate maps of each area are needed to show the boundaries of the small areas and their identifying names or numbers. Such maps will vary greatly in scale, depending on the total land area and the size and number of the small subdivisions. If only the major subdivisions (such as wards or school districts) are to be shown, most urban or metropolitan area maps can be confined to a single page. If much smaller areas (such as census tracts or blocks) are to be shown, then the maps will normally be much larger than can be clearly reproduced on a single page. As with detailed 1st order division maps, these maps may be drawn at larger scales and divided into sections for publication. The scale should be no larger than is required to show all the detail clearly. At the same time, it is desirable that a limited number of scales be used for all maps in a series.

2.23 Designing and placing the map.--If the area to be included in a map is large and the details are numerous and complex, there are several design possibilities:

(1) Draw the map at a large enough scale to show the boundaries and identification of most of the subdivisions and prepare inset maps for the more complex parts. Figure 9f illustrates an inset for an urban area.

(2) If the map is too large to fit on a single or double page, prepare it as a fold-in map which is bound into the report. This may not be satisfactory if several folds are required and the map may be torn easily. Also, this increases both the difficulties and costs of publication.

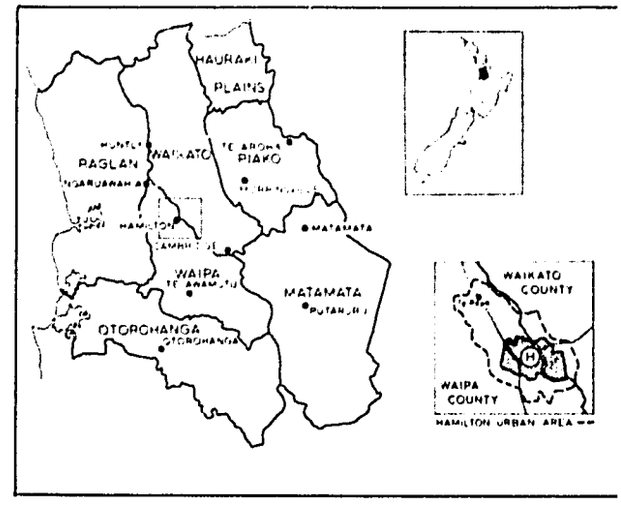
(3) If the map is much larger than page size, it can be prepared as a folded map and slipped into the report as a loose map, or preferably inserted in a pocket inside the back cover. Unfortunately, a loose map is easily lost.

(4) If the map is for a very large metropolitan area or 1st order division, it can be drawn on multiple sheets, using major subdivision boundaries to divide it into sections. These sheets can be folded and inserted in a pocket in the back cover.

(5) Still another possibility is to draw the map in sections or quadrangles, fold the sheets, and insert them in a pocket.

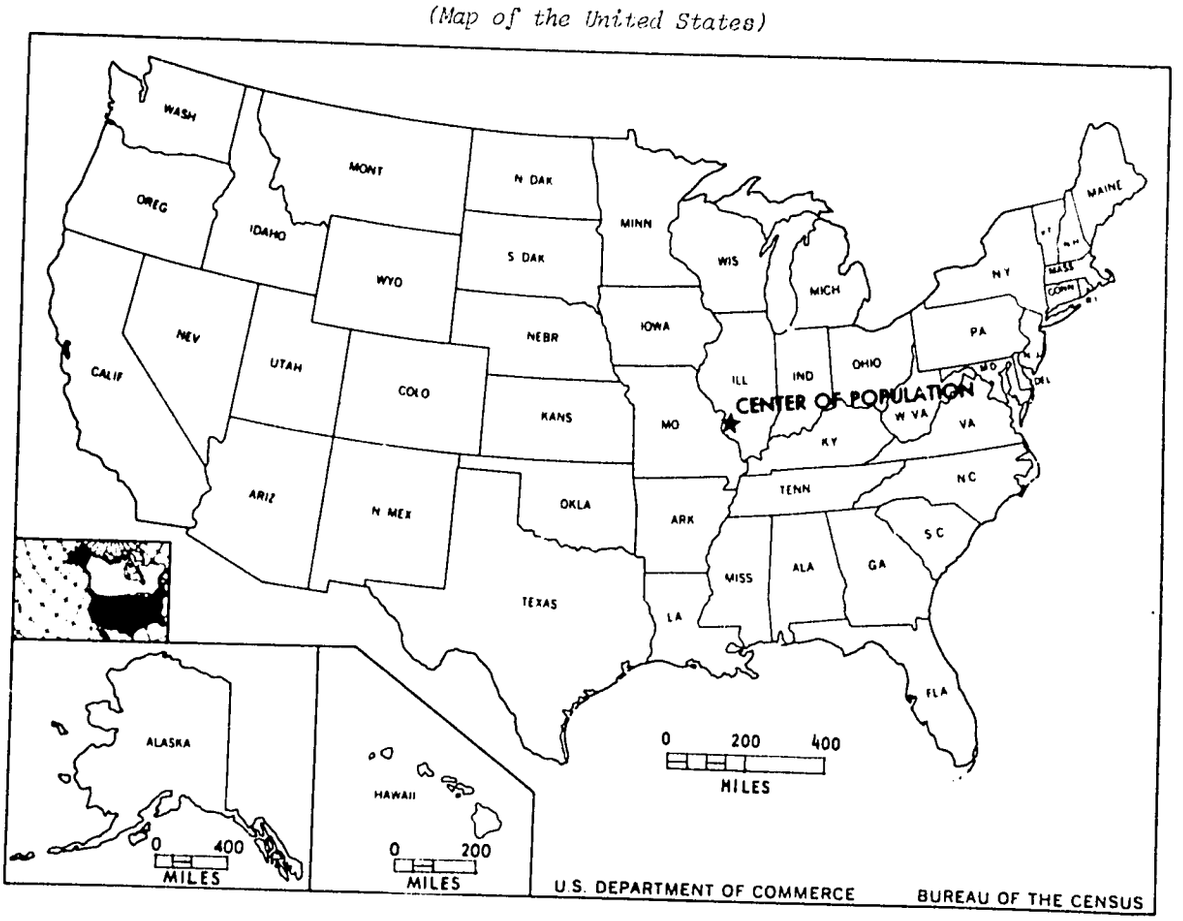
One further consideration is how to place the map on the page or sheet; this applies to all kinds of area identification maps. Ordinarily publication maps are placed with north at the top of the page or sheet. This is suitable if the area to be shown is longer in a north-south direction than in an east-west direction. If it is the reverse, then the map should be placed on its side (broadside) on a page. If the area has a diagonal orientation, it should be rotated to use the page or sheet more efficiently and permit the area to be drawn at a larger scale. In such a case, a compass arrow pointing to the north should be shown unless the map has latitude and longitude markings.

Figure 9f. INSET MAP OF AN URBAN AREA (Hamilton urban area in the Waikato Region, New Zealand)



Source: "A Survey of New Zealand Population. An Analysis of Past Trends and an Estimate of Future Growth," 1960. Courtesy of Ministry of Works, New Zealand.

Figure 9g. INSET MAPS OF NONCONTIGUOUS AREAS OF A COUNTRY
(Map of the United States)



2.24 Planning inset maps.--An inset map is a portion of the main map for which separate presentation is useful in the following cases:

(1) Where a part of a nation or an administrative area is not joined to the main area of the country. It may be necessary to show the part on an inset map, so that it can be placed on the same page or sheet. Figure 9g is an example of an island or group of islands located so far off the coast of a nation that it cannot be shown in its true position without seriously reducing the scale of the principal area.

(2) Where a nation or an administrative area comprises a group of widely separated islands. Inset maps for the larger individual islands are necessary so as to show clearly the details of the subarea.

(3) Where a 1st order division or lower order subdivision contains subareas so small that they cannot be clearly identified on a map. Inset maps may be prepared for selected parts. If the major part or all of the area is densely settled and most of the subareas are small, the map must be prepared at a larger scale and divided into sections so that a subarea will fit on a page or sheet. Even so, inset maps may still be needed for parts of the area.

(4) Where there are great differences in the land area size of subareas being identified within an inset map and further enlargement of the scale of the inset map does not appear feasible. In this case, it may be necessary to provide an inset of a portion of the inset map; however, this should be avoided when possible.

2.25 Planning separate maps.--Some separate maps that are not parts of the bound publications are needed for most countries. Such maps, covering a nation, are printed on single sheets (up to 90 cm by 120 cm or 3 feet by 4 feet for large countries) and at larger scales than the maps bound in the publications. They are used by the NSO in preparing statistical maps or by data users for plotting and analyzing the geographic patterns and distributions

for various data items. Such a map should show 1st and 2nd order divisions and in some cases divisions at a lower level. In many instances it would be the same national map printed with the statistical reports, but at a scale large enough to print the names of all subdivisions. This map normally would have no inset maps, except in cases of noncontiguous parts or islands.

Additionally, for countries with very large or very densely populated areas, 1st order division maps showing many lower level areas should be available on separate sheets for data users.

The planning of these maps is not too different from the planning of maps for publication in reports. Generally they will be larger in scale, show the configuration of coastline and boundaries in greater detail, use clearly distinguishable symbolization of lines for the different boundaries, and use different sizes of letters for names at different area levels.

2.26 Making a preliminary design.--Before undertaking the actual preparation of any area identification map, a preliminary drawing should be made to see how the final map would look. It may be a rough outline of the area to be mapped, with the boundaries of a few subareas. The location and approximate size of the identifying names or numbers should be indicated. The need for inset maps should be considered and their scale, size, and placement should be indicated. Also, attention should be given to the title and legend of the map and the manner in which they would be placed in order to create a well balanced and attractive map.

In the case of a series of maps it is advisable to try out the design plan by preparing one map or one section in final form. This will serve to bring early attention to problems that will be faced and the best solutions for achieving a series of well designed maps.

2.3 *Preparing area identification maps*

The preparation of maps will be easier if full attention has been given to the planning aspects, and if the elements of good design are observed and applied throughout the map preparation process.

2.31 Preparing base maps.--The first step is to examine the source map for the boundary information. Determine whether the boundaries have been changed based on information ascertained for the census and that these changes are accurately portrayed. The base maps on which the EA's were delineated for the census enumeration (see chapter 6) may be useful.

Next, map scale must be considered--the scale of the source map, the scale of the drafted map, and the scale of the published map. The scale of the source map may be larger than the scale at which it is desired to draw the area identification map. If so, it must be reduced either by photography or by using a pantograph (described in chapter 10).

The scale of the drafted map ordinarily should be larger (never smaller) than the scale of the final published map. A map of larger scale is easier to draft and reduction obscures minor imperfections. There is no precise rule as to how much larger the drafted map should be, but they often are drafted at twice or 1½ times the scale of the published map. Also, the linework may be drafted at a larger scale and then reduced photographically before lettering is applied. If a series of comparable maps is being drafted, it is desirable to draft all of them the same scale so that the width of the line work will not be noticeably different on the published maps. Moreover a common scale makes it easier for the users to compare one map with another in a series.

2.32 Drafting or scribing area boundary lines.--Boundary lines can be indicated on the

map in one of two ways: (a) by tracing the source map on a light table, draw the boundary lines with drafting pen and ink on tracing paper, cloth, or drafting film; or (b) with a scriber, trace the lines on a specially prepared scribecoat base. Scribing generally produces a much higher quality product than drafting. (See chapter 10 for detailed drafting and scribing instructions.) Before drafting or scribing the following must be considered:

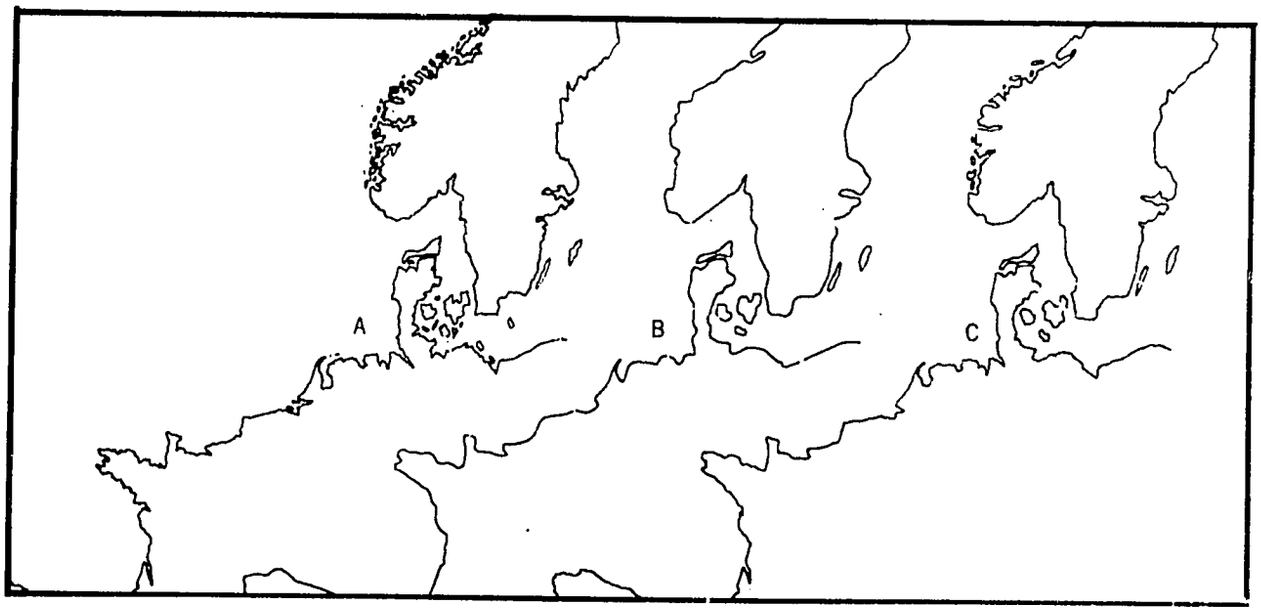
(1) Width of lines. A decision must be made as to the width of the line (lineweight) for coastlines and for each type of boundary. Generally, the boundaries on area identification and statistical maps are solid lines distinguished from one another by successively narrower line widths from the most important--the international boundaries--to 1st order division boundaries, 2nd order division boundaries, and lower-level division boundaries.

Normally not more than three or four lineweights can be distinguished by the eye unless excessively heavy lines are used for the major boundaries. Accordingly, if more need to be shown, it is necessary to adopt some symbolization other than lineweight. This situation may call for the use of dashes or dots (refer to exhibit 3-1). Even if a broken line symbol is adopted, variation in line width should be maintained to emphasize the more important type boundaries. Shorelines should be indicated always with solid lines of intermediate or narrower width, because they are in many cases so intricate that heavy lines would obscure their irregular windings.

(2) Generalization. Another consideration involves generalization or smoothing of shorelines and boundary lines. On a large-scale map, such as a topographic quadrangle, shorelines and boundary lines are shown in great detail with all the minor turns, twistings, and jogs. On smaller-scale maps these lines must be generalized; the smaller the scale, the greater the smoothing required (see figure 9h). On a national map the generalization would be greatest; on a city or metropolitan map it would be least. This generalization will be done by the draftsman when he is drawing the lines of the area identification map. It requires practice and the development of skill in following the general trend of the lines, not omitting important turns or identifications while showing all the detail that can be presented, considering the scale of the planned map.

(3) Use of color. Different colors can be used to present in a distinctive manner the different types of boundaries on area identification maps; color is sometimes used on various types of statistical maps,

Figure 9h. GENERALIZATION OF COASTLINES



Note: A and C are least generalized; B the most. All are greatly simplified from reality.
Source: A. H. Robinson and R. D. Sale, "Elements of Cartography," 3rd ed. (New York, John Wiley & Sons, Inc., 1969). Reprinted with permission.

but ordinarily this is not done. It would cost more to print such maps, but a more important objection is that area identification maps frequently serve as base maps for superimposing shadings to represent data values (statistical maps) and colors would present a handicap for such use. Furthermore, good cartographic practice can usually solve most problems of this type without the use of color.

There is one recommended use of color on area identification maps. If these maps are to be used as base maps for statistical dot maps, it is essential that the boundaries of the subdivisions are visible so that dots can be located properly. In order to help the cartographer or draftsman, the boundaries of the subdivisions and their names should be printed in nonphotographic blue on copies of the area identification map. These names and lines will disappear when the map is photographed for publication.

2.33 Preparing inset maps.--The use of inset maps was discussed earlier. Their preparation is similar to the main map. The same lineweight or symbolization should be employed as on the main map so that a common legend can be used.

The placement of an inset map is a special design problem. Where a single inset map or a few small inset maps are required, they may be placed at the margins of the map page or sheet. Where the inset maps are large or numerous, they may need to be arranged on a separate page or sheet. If there are many insets, they should be arranged in some logical order, either alphabetically by name or geographically according to their relative locations on the main map. Differences in the size and shape of inset areas may make it difficult to follow a completely logical plan.

When an inset map is used, the area covered by the inset map should be indicated on the main map if possible. This may be done in different ways. The area on the main map may be left blank with only the outline or the shape of the inset map showing; the area may be shaded with a parallel line or dot pattern or the major boundaries may be shown (as in figure 9c). For most large maps a reference to the inset map is needed, such as "See inset map." If there is more than one index map, each must be identified by name or by letter; for example, "See inset map A."

2.34 Lettering.--A name is placed within each area shown on the map in order to identify the area. For some smaller areas, numbers may be used for identification, such as division 1, 2, etc. Accordingly, the scale of the map must be large enough to accommodate these names and numbers. Different sizes or styles of lettering are used for different orders of areas, with greater prominence given to the large and more important areas. For very small areas, it may not be possible to position the name within the area, so instead it may be placed close to it on the outside. In some cases where the area boundaries are very complex, an arrow may need to be drawn from the name to the area.

The names may be lettered by pen and ink using a lettering guide, but there is a limit to the smallest size letters that can be drawn in this manner. It is preferable to have the names or numbers printed on thin clear plastic film with adhesive backing. To place this name in proper position on the map, cut around it and press it down so that the name adheres firmly to the map. It is also preferable to place the names or numbers on a separate sheet of drafting film which is in exact registration with the copy containing the area lines, so that the map may be printed without names for certain purposes. (See chapter 10 for further details.)

2.35 Preparing titles and legends.--Area identification maps are titled by the name of the administrative or statistical area represented by the map. Simple block-style lettering is preferred. Ordinarily, the title will be placed at the top of the map. If the map has a marginal frame, the title may be placed inside

or outside the frame. If the map is to be a page in the report, the title will usually be placed outside the frame with the figure number. In that case, the title will normally be set in type by the printer who will use the same size and type style for all figures in the report. Inset maps are titled in a similar way; but the title may be less precise, such as "city name and adjacent area."

Legends are required to interpret line symbolization, as in figure 9c. Legends should also include:

(1) All the sizes or styles of type used for the names of different order areas.

(2) All shadings that identify different areas.

(3) Any symbols that represent cities, villages, or hamlets, where map scale or lack of information prevents showing actual boundaries.

Placement of legends depends on the availability of space outside the mapped area. If several spaces are available, the choice is made on the basis of what is called map balance. For example, if an inset map is on one side, the legend probably should be placed on another side provided there is space. Good overall balance is achieved by proper placement of the inset maps, title, legend, and marginalia to achieve a pleasing appearance.

2.36 Preparing indexes.--Map indexes are needed for some area identification maps. They may be of two types: (a) quadrangle map indexes and (b) administrative area map indexes.

When the detailed map sheets are drawn as matching quadrangles (see figure 9i), a quadrangle index is needed. The quadrangle index map normally contains the simplified outline of the area being mapped, showing shorelines and major boundaries. On the simplified outlines, the frames of each separate quadrangle map are superimposed and identified by letter or by number. The map index is usually placed on a separate sheet or page and inserted in the publication before the detailed sheets or pages. It is also convenient to place the title, legend, scale, and other notes on this sheet or page. In some cases, the map index is reproduced at smaller scale on each sheet or page; the area that is covered on the sheet is indicated by shading. The purpose of the index is to inform the reader how the sheets fit together. This index also enables him to identify quickly the detailed map on which an area or point is located.

The administrative area map index has a similar purpose; but here the detailed map sheets are drawn for separate administrative areas (or groups of administrative areas) rather than for quadrangles. The index map is reproduced on each detailed map sheet with the area covered by that sheet being shaded (as in figure 9i). Only major boundaries are shown on the map index.

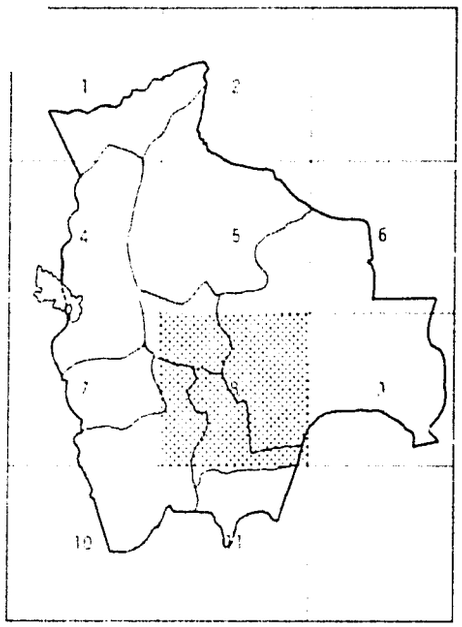
Another type of index is the name-finder index. This is simply an alphabetical list of areas with an indication of where an area may be found in terms of page number and location on the page. To permit locating the names on the map, it is necessary to construct an alphanumeric code in the frame of the map page, as illustrated in figure 9i. This type of index is extremely helpful to users of the maps where dozens or even hundreds of areas are identified on a single map or set of maps. It is especially needed for complex 1st order division maps.

2.37 Preparing marginalia.--As used in this manual, marginalia refers to all elements which usually appear along the margins of a map. These include scale, grid, border, source, date, etc.

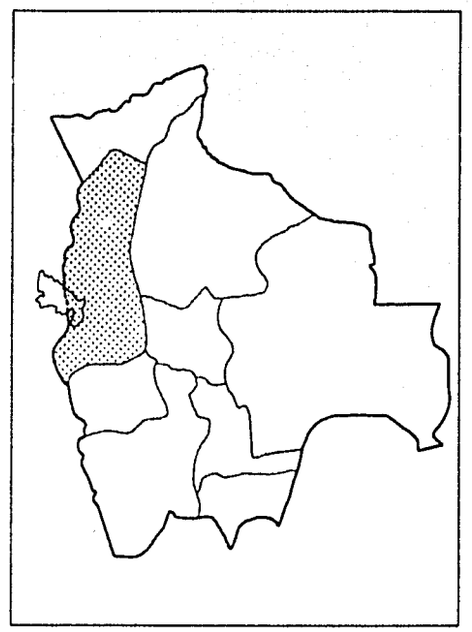
(1) Scale. A graphic scale is very important and should appear on every map so distances can be measured, usually in terms of kilometers or miles. In addition to the scale for the main map, every inset map should have its own scale. Scales can also be

Figure 94. MAP INDEXES

QUADRANGLE INDEX

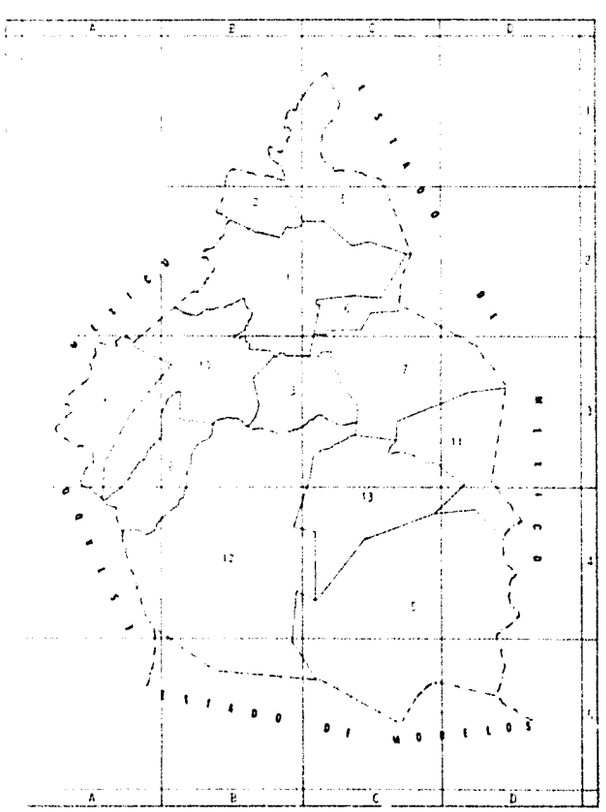


ADMINISTRATIVE AREA INDEX



Source: "Resultados Provisionales," 1977. Courtesy of Departamento de La Paz, Censo Nacional de Población y Vivienda, Bolivia.

NAME-FINDER INDEX



	MUNICIPIO	LOCALI-ZACION
1.	Ciudad de México	2-B
2.	Azcapotzalco	2-B
3.	Coyoacán	3-B
4.	Cuajimalpa	3-A
5.	Gustavo A. Madero	2-C
6.	Ixtacalco	2-C
7.	Ixtapalapa	3-C
8.	Magdalena Contreras, La	3-B
9.	Milpa Alta	4-C
10.	Obregón	3-B
11.	Tláhuac	3-D
12.	Tlalpan	4-B
13.	Xochimilco	4-C

Source: "IX Censo General de Población, 1970," 1971. Courtesy of Dirección General de Estadística, México.

expressed in terms of a representative fraction (1:1,000,000 for example) or as kilometers per centimeter; such scales are not ordinarily placed on area identification maps because they will be in error if the map is reduced or enlarged or because the map reader may not understand them.

(2) Grid. A latitude and longitude grid is usually placed on large-scale national or provincial maps but rarely on smaller scale, city, or metropolitan area maps; the additional lines introduce too much clutter, thus detracting from the emphasis on area identification boundaries. When a grid is used, except on very large scale maps, ticks (short lines) for the latitude and longitude are shown in the frame of the map without extending the parallels and meridians across the map. In the absence of latitude and longitude lines, it is generally necessary to have a north arrow suggesting to the reader how he should orient the map.

(3) Projection. For those few large maps that show latitude and longitude lines, it is desirable to indicate the type of map projection. The name of the projection is usually placed near the graphic scale.

(4) Border. A frame or rectangular line border is desirable for almost all maps. All page-size maps should have frames; also all continuous sheet quadrangles should have borders. The frame is normally a single line for page-size maps and a double line (with the outer line heavier) for sheet-size maps or maps with latitude-longitude grids. Exceptions are area identification maps for 2nd order divisions, cities, or metropolitan areas where there may be many inset maps, so that fitting them together within frames would be difficult and may not improve their usefulness or appearance.

(5) Agency name. The name of the NSO should appear on each map so that the map maker is always identified even when copies of the map may become separated from the published report. This name may be placed inside or outside the frame but normally is placed inside for page-size maps.

(6) Source. A source note may appear on the map indicating that the statistical areas were defined by the NSO or by another agency. Generally, the source is given only for special statistical areas that were defined outside the NSO.

(7) Date. A date should always appear on these maps. Often it is included in the title or in the name of the census; for example, 1980 Censuses of Population and Housing.

(8) Name of report. Finally, any separate map should always bear the name of the report with which it was issued or, if issued separately, it should be identified in a numbered series.

2.4 *Preparing the maps for printing*

Area identification maps may be published in two forms as was earlier indicated. First, they may be published as separate base maps for users who wish to plot statistical data on the maps and also for use of the NSO in preparing statistical maps. These maps vary in size but are almost always larger than page size. The maps may include:

(1) A national map with 1st order division boundaries

(2) A larger national map with 1st and 2nd order division boundaries

(3) 1st order division maps with 2nd order division boundaries

(4) Larger 1st order division maps with 2nd and lower order division boundaries

(5) Other maps, such as metropolitan area maps

The amount of photographic reduction of each map must be marked on the drawings so that the printer will make no mistake in preparing the printing plates.

Second, these maps serve to identify the geographic areas for which statistics are presented in the census reports; therefore, they should be published as a part of these reports, preferably bound into the report so that they will not be separated from them. Since some of the maps may be too large to be reduced and still remain readable at page size, it is necessary to divide them into sections along administrative boundaries; even then, it is necessary in some cases to reduce them photographically to fit on individual pages. It is more efficient to prepare the individual pages photographically than to redraft the map in page sections. The photographs may be mounted

on stiff cardboard and page-size frames may be prepared for each section, which may include a name-finder index, title, and other necessary marginalia.

2.5 *Verification*

While verification of the accuracy of each step in the preparation of the maps is needed, a final verification of each map should be conducted by someone other than the person who prepared the map. This verification and review should include an overall review of the appearance of the map; accuracy of the lines; spelling of names; and placement of inset maps, legend, scale, and other marginalia. This review should also be especially concerned with the quality of the line work and the size of the lettering in relation to any further photographic reduction required for printing.

3. *STATISTICAL MAPS*

Statistical maps show the geographic distribution of statistical data. It is possible to make a statistical map for any country or part thereof for which statistical data are available for subareas. For census reporting it is neither practical nor desirable to make maps of all geographic statistics. Rather, the purpose is to present the statistical highlights or the more significant results in terms of their geographic distribution. There is interest in the current pattern of the distribution and also in changes in the patterns that have occurred over time, particularly since the last census.

Statistical maps provide an immediate recognition of the geographic distribution of data which may not be apparent from statistical tables and certainly not in terms of the intricate patterns revealed by the maps. If statistical maps are well designed and attractive, they will interest the users of census reports and cause them to raise questions which may send them to the statistical tables for further detail.

Most statistical maps prepared for census reports are for the country as a whole, using data for 1st and 2nd order divisions, and 3rd order divisions in some cases. Statistical maps for 1st order divisions or urban areas may be provided, but the costs of this more detailed cartographic information may be prohibitive. Hence, the following discussion will largely be in terms of national statistical maps, although the suggested guidelines have equal application for maps of subareas.

3.1 *Types of statistical maps*

Generally most statistical maps contain point symbols or area shading. However a few other types of statistical maps have also been developed and are used occasionally.

3.11 Point symbol maps.--Point symbol maps are statistical maps on which dots or circles, each representing a certain value, are distributed to show as closely as possible the actual location of the numerical data they represent. Usually these are called dot or circle maps (see figure 9j). The use of dots and circles may be combined on the same map. In some cases different size dots may be used for different values. Circles are always graduated to represent smaller and larger values. Other graduated symbols may be used such as squares or vertical bars. Sometimes three-dimensional symbols, including globes or cubes, are used; but they are somewhat more difficult to construct and generally have proved less effective because the values represented are subject to misinterpretation.

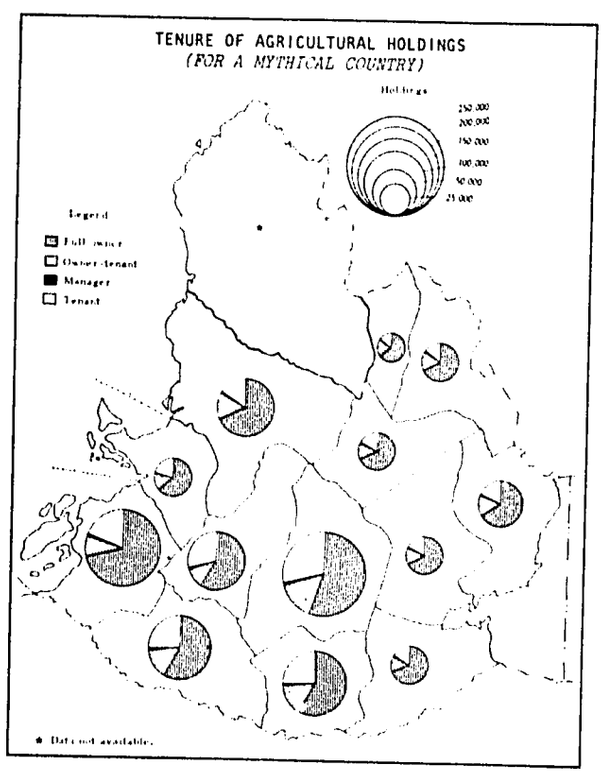
Point symbol maps are particularly valuable for showing location of numerical values. The actual values may be obtained from the map by counting the dots except in areas where there are such high values that the dots have become consolidated; likewise, the actual value

Figure 9j. POINT SYMBOL MAPS

DOTS

Source: "Atlas Estadístico de Costa Rica," 1953. Courtesy of Dirección General de Estadística y Censos, Costa Rica.

GRADUATED CIRCLES



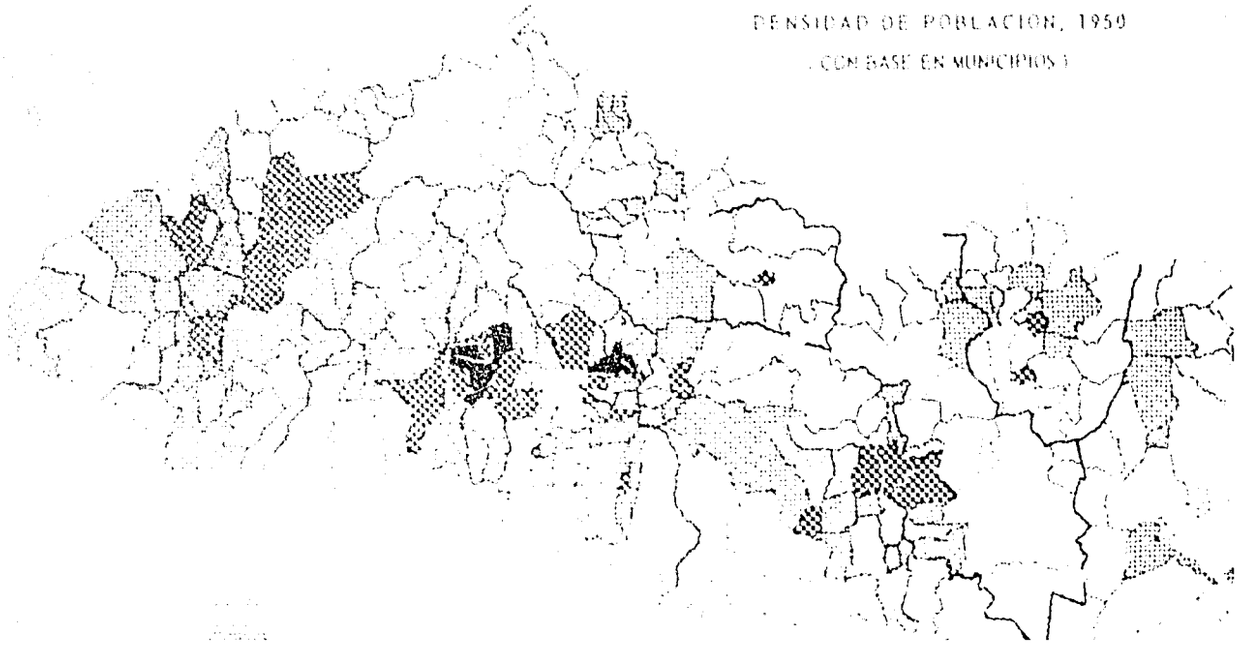
of graduated circles may be obtained by relating their diameters to the legend. However, this is not the way these maps are ordinarily used; their major purpose is to give a detailed picture of the distribution of the phenomenon being mapped so that the users will quickly understand the locations of the concentrations and the dispersions as well as their general magnitude. If exact figures are required, the statistical tables should be consulted.

Dot maps are never used to show ratios or percentages. Graduated symbol maps are occasionally used for ratios or percentages but only when it is a secondary element of their presentation. In such cases, the size of the circles always represents a numerical value, while related ratios or percentages may be indicated as a shading or color on the symbols. Graduated circles may be divided into sectors (as in pie charts) with each sector representing an element in the total numerical value. This makes it possible to present more detailed information on the map, but this technique can detract from the overall effectiveness of the map by making it difficult for the user to read. This is especially true if more than three sectors are used, if many of the circles overlap each other, or if many circles are very small.

3.12 Choropleth or shaded maps.--Choropleth maps are statistical maps where administrative or statistical areas are shaded in black and white or in color to present several classes of statistical data. The statistical data are almost always ratios or percentages--population density, percent of total, ratio of one characteristic to another, per capita, percent change, and others (see figure 9k). Very rarely should absolute totals be represented on a choropleth map, and then only when the geographic sizes of the areas for which data are available are roughly equivalent. Otherwise, very large

DENSIDAD DE POBLACION, 1950

(CON BASE EN MUNICIPIOS)



A

areas which fall into the same class as very small areas lead to serious misrepresentations of the total distribution. When data are in the form of densities, ratios, or percentages for areas, the distortions caused by great variations in area size are far less critical.

The statistical data shown on these maps represent value ranges by class intervals from high to low. The number of classes and the upper and lower limits for each class present major problems in the planning and development of these maps in terms of presenting the data realistically. (Class intervals are discussed in section 3.26).

3.13 Isopleth maps.--An isopleth map is a type of isoline map. Isoline maps present distributions of statistical data by a series of lines each connecting points at which a given variable has a specific value. Among the most common are topographic contour maps with lines connecting points of equal elevation and climatic or weather maps showing data such as precipitation or air pressure. At all points where data are not available, they are interpolated from nearby known points. Statistical data in terms of ratios and percentages can be mapped in a similar way by assuming the values to be at the centers of the areas and drawing lines of equal value between them (figure 9ℓ). Although there is not universal agreement on the term, this type of map is usually referred to as an isopleth map.

Isopleth maps are not used very much in census statistical mapping for several reasons. They are difficult to construct in a consistent manner and many users would have difficulty in understanding them because the resulting patterns may be highly intricate. Also, many users want to know the value for individual areas which can be determined rather adequately from a choropleth map when individual areas with many boundaries are shown. They are less inclined to be satisfied with an isopleth map, because smaller administrative area boundaries cannot be clearly shown under the isopleth.

3.14 Flow maps.--Flow maps show movements of people, commodities, and other measured items by graduated lines with arrows showing the direction of movement between areas. The widths of the lines are scaled to indicate the amount of flow in terms of persons or commodities or some other definite measure (as shown in figure 9m). Very few flow maps are made for census reports, inasmuch as relatively little census data are collected on movements. Flow maps are applicable to mapping migration and commuting information; more and more data of this kind are now being collected. Such maps are very difficult to construct in a clear manner for any area which has more than a few subareas; they are not manageable when the number of possible flows is in the scores or hundreds.

3.15 Other types.--Some maps may use line or bar graphs in each subarea to represent statistical trends or other conditions which can be represented by such symbolic means. There are point symbol maps, or pictomaps, which use pictures or symbols to represent men, buildings, animals, etc., to show distributions. Rarely do these symbols represent quantitative data; rather they show in a general manner a very simplified view of distribution. Pictomaps are seldom used in census publications.

3.2 *Planning statistical maps*

Considerable planning is involved to achieve a well balanced statistical mapping presentation for a census. Decisions need to be made on a number of matters before actual preparation is undertaken. Early in the planning, the geography staff of the NSO must work closely with the subject matter staffs, particularly in the selection of subjects, symbol values, and class intervals.

3.21 Selecting subject matter.--In the initial planning of the statistical maps, there

must be consideration of the various subjects that were covered in the census. Several questions should be asked. What are the more important elements under each subject in terms of what the general user will want to know about the results of the census? What data can be adapted to statistical mapping? They may be total numbers, ratios, and percentages by geographic areas; in some cases, ratios or percentages not appearing in the tables may need to be calculated. For which data are statistical maps likely to show significant regional differences?

Some of the subjects covered in a census are listed below to indicate the wide variety of statistical detail from which data may be prepared. This substantiates the point made above, to the effect that the subject matter staff and the geography staff should examine the census data to determine which subjects are to be presented in the form of statistical maps or graphs.

(1) Population. For a population census the single most important piece of information collected is the total population and its distribution by subareas. A new map is always needed after any census. Other closely related subjects are population density, urban and rural population or metropolitan and non-metropolitan population, and changes in these population totals since the last census. In terms of population characteristics, there is a much wider variety of subjects that may be covered. They include such characteristics as age, sex, tribal group, place of birth, language, fertility, educational attainment, migration, employment, occupation, industry, income, place of work, etc.

(2) Housing. For a housing census, an important measure is the number of housing units. However, this item would rarely be mapped (as a dot and circle map), because its nationwide distribution would very closely resemble a total population map. Important subjects which could be mapped include type of structure, material of construction, tenure (owner or renter), number of rooms, sanitary facilities, lighting and heating equipment, value of home, rental, etc.

(3) Agriculture. In an agricultural census, data are collected on number and size (land area of holdings) and such subjects as amount of land in crops by type of crop, crop production, livestock and poultry, irrigation, income and sales, etc.

(4) Manufactures. In a census of manufactures, the basic collection unit is the individual establishment. Other important measures include number of employees, value added, value of shipments, payrolls, man-hours, cost of materials, new capital expenditures, inventories, etc. The reporting of manufactures is usually subdivided by kind of industry.

(5) Business. A census of business is also conducted for individual establishments, subdivided by retail, wholesale, and service industries. Total annual sales are an important measure; other subjects include payroll, employment, and further subdivisions by kind of business.

3.22 Determining map type.--At the time the subject matter is reviewed for selection of significant data to be mapped, the choice of map types is easily made on the basis of whether numerical totals, ratios, percentages, or averages are available. Generally, point symbol and choropleth maps are used.

3.23 Selecting base maps.--The census area identification maps, usually without names, can often be used as base maps for preparing statistical maps. Two types of national or country base maps are used commonly. The first shows only 1st order division boundaries and is used where statistical data are to be displayed by 1st order divisions only. The second type is a larger map; it shows 1st order division boundaries in black without names and shows 2nd order division boundaries and names in blue. This second type of map is used where the data for 2nd order divisions are to be displayed. The blue boundaries and names aid in drawing the statistical map but disappear when the map is photographed for reproduction. In both cases the selection of these base maps permits compilation of a final map at page size, or in some cases less than page size.

Statistical maps of 1st order divisions and metropolitan or urban areas are not often made for census publications because of cost and time involved. If they are made, the area identification maps may serve as base maps.

3.24 Choosing color or black and white.--During the planning stage it is necessary to decide whether the statistical maps will be prepared for printing in color or in black and white. The use of color is preferable for showing greater detail and usually results in a more attractive map. However, black and white maps can be very effective. The color printing cost is higher depending on the number of colors used; the preparation cost may also be a little higher. If color maps are used, they should be printed together in one section of the report, if feasible, or in a separate graphic summary report to save on printing costs. Also, all maps should use combinations of the same primary colors to produce many different colors.

3.25 Choosing symbol values.--A critical decision in the planning of statistical point symbol maps is the selection of the values that will be assigned to the point symbols (dots, circles, etc.). Insufficient attention to this problem may sharply reduce the effectiveness of the maps.

For a dot map, if the unit value of a dot is too high, there will be very few dots and it will not be possible to show much detail in the distribution. If the unit value is too low, there will be so many dots in areas with high values that the dots will overlap and may become a solid mass so that individual dots cannot be discerned. A balance between the two extremes should be achieved so that detail is shown, yet relatively few areas will have a consolidation of dots (see figure 9j). Achieving this balance also depends on the scale of the map and the size of the dots in the final publication. The larger the map scale, the more it is possible to show many dots. The smaller the map scale, the fewer dots there should be.

Most dot maps use one size of dot to represent a designated number of units. On large maps (larger than page size), several point symbols may be used to represent different size values. For example, a population distribution map might use a small dot to represent 500 rural inhabitants, a small square to represent rural places, and a series of graduated symbols to represent urban places of different size categories.

For a circle map, the circles are graduated; generally the size of a circle, in terms of area covered, has the same proportion to the value of the unit being mapped as all other circles. On some circle maps, the circle sizes are not individually computed; rather, a graduated series of circles is used, with each size representing a class interval of values, as under 10, 10-24, 25-49, etc. Circles and dots may also be used together on the same map. Squares and upright bars are sometimes used as point symbols but are more difficult to prepare and interpret in small areas. Symbols of three dimensions (spheres, cubes, etc.) have been tried but are generally not satisfactory, because readers are more likely to misinterpret their values.

3.26 Determining class intervals.--For choropleth maps, class intervals are always required. It is important to select them carefully; otherwise, the message of the maps may be lost or distorted. Each map has different problems depending on the statistical data. If the data are spread over a wide range, the class intervals will be large; if the data range is narrow, the class intervals will be small. If the data are unevenly distributed, the class intervals will be irregular. For maps which have been prepared for a previous

census and are being repeated, it may be desirable to use the same class intervals for comparative purposes.

There are many ways to select class intervals and no one "best" way. For a particular map, some are better and some are worse. Class intervals can be based on arithmetic progressions, geometric progressions, equal numbers in the form of quartiles, quintiles, sextiles, or on unequal numbers. A simple way to help in selecting class intervals is to prepare a frequency distribution of the data to be mapped using a large number of class intervals. This may be done for all the data or for a significant sample if the number of areas is large. From this distribution, the high and low values and the total range of numbers may be determined. It may also be observed that there are some natural breaks in the distribution that indicate where interval limits might be placed. Figure 9n illustrates suggested class intervals which are suitable for statistical maps. Note that the intervals, as indicated by brackets, are natural breaks in an overall distribution.

Great care should be exercised in selecting class intervals for a map so as to avoid distortions of their distribution. It is more an art than a science. Some cartographers have advocated more sophisticated statistical measures for determining class intervals, but there is no conclusive evidence in most cases that any one method is superior. A measurement of error has been developed, but it is tedious and not a practical solution for most map makers.[3]

Setting limits to class intervals is one problem. Closely related to it is the number of class intervals which should be used in

Figure 9n. FREQUENCY DISTRIBUTIONS

Urban population as % of total	Number of cases	Persons per square kilometer	Number of cases
95.0 or more	-	10,000 or more	-
90.0 - 94.9	1	8,000 - 9,999	-
85.0 - 89.9	3	6,000 - 7,999	1
80.0 - 84.9	1	4,000 - 5,999	1
75.0 - 79.9	2	2,000 - 3,999	3
70.0 - 74.9	3	1,500 - 1,999	1
65.0 - 69.9	7	1,000 - 1,499	4
60.0 - 64.9	8	900 - 999	2
55.0 - 59.9	15	800 - 899	4
50.0 - 54.9	13	700 - 799	8
45.0 - 49.9	11	600 - 699	12
40.0 - 44.9	7	500 - 599	12
35.0 - 39.9	10	400 - 499	14
30.0 - 34.9	5	300 - 399	9
25.0 - 29.9	6	200 - 299	12
20.0 - 24.9	2	100 - 199	9
15.0 - 19.9	4	50 - 99	3
10.0 - 14.9	2	25 - 49	2
5.0 - 9.9	1	10 - 24	2
0.0 - 4.9	-	5 - 9	1
		1 - 4	1
		under 1	-

drawing a choropleth map. This is much easier to answer because human perception sets limits to the number of classes that may be shown and recognized clearly by most map users. While perception of the number of progressive shadings in black and white or color from light to dark on a map is finite, the capacity of individuals may vary to some degree. A total of 5 or 6 is considered ideal. Fewer than 5 intervals may not be a problem in perception but may sacrifice detail. When the number is 7 or 8, difficulty in perception becomes a real problem; more intervals should rarely if ever be used.

3.27 Making a preliminary design.--Rough drawings of the statistical maps are needed to see whether the planning decisions concerning these maps result in the best solutions possible. For a point symbol map, the selected symbols should be tried out on portions of the map to assure that the appearance is meaningful and pleasing to look at. For a choropleth map, the area subdivisions being shown should be shaded with distinguishing colors (using colored pencils) in order to determine whether

[3] *For an excellent analysis of class interval error, refer to George F. Jenks and Fred C. Caspall, "Error on Choropleth Maps: Definition, Measurement, Reduction," Annals of the Association of American Geographers, Vol 61, No. 2 (June 1971), pp. 217-244.*

the resulting patterns are helpful in understanding the distribution. In terms of other known facts about the country or area, are the patterns revealing? Have too many or too few class intervals been used and do the values of the intervals help or distract in understanding the major facts about the distribution? Such preliminary designs are particularly important where new subject matter is involved, because its distribution pattern may be largely unknown before it is mapped.

3.3 *Dot maps*

The preparation of statistical dot maps requires the orderly carrying out of several work procedures and making more decisions on the design of the maps. It is assumed at this point that all the planning decisions have been made.

3.31 Number of dots.--The first step is to obtain a list or table of all the geographic areas to be mapped with their populations, then to calculate the number of dots to be placed in each area. There are three basic ways in which the number of dots can be calculated.

(1) Adjoining areas method. In the example below, assume that the rural population of a 1st order division is to be mapped by dots, with each dot having a value of 1,000 inhabitants. If a 2nd order division has a rural population of 11,400, it would qualify for 11 dots with a leftover of 400 which is carried over and added to the rural population of an adjoining 2nd order division which might then total 14,700. A total of 15 dots would be assigned to the second 2nd order division. A debit of 300 would be carried over to a third 2nd order division which might then total 9,200. The third 2nd order division would have 9 dots with 200 added to the fourth division, and so on until numbers of dots have been assigned to all the 2nd order divisions within the first order division.

The first 2nd order division considered should be in a corner of the 1st order division, usually the northeast or the northwest, with the dot assignments following adjoining 2nd order divisions across the map and back and forth in a serpentine manner. This is the most accurate way to determine the number of dots for all 2nd order divisions for it assures that there is a dot for all the population except the last fraction, and that could be carried over to the next adjoining 1st order division.

Division	Rural population		Number of dots	Difference
	Total	Adjusted		
1st order...	60,200			
2nd order..	11,400	11,400	11	+400
2nd order..	14,300	14,700	15	-300
2nd order..	9,500	9,200	9	+200
2nd order..	8,700	8,900	9	-100
2nd order..	5,600	5,500	6	-500
2nd order..	10,700	10,200	10	+200

(2) Alphabetical order method. An alternative is to calculate the number of dots in the same manner by carry over of debits and credits but by alphabetical order of 2nd order divisions rather than by geographical order. This does not give quite as true a result because adjoining areas are likely to be more alike than areas some distance away, but the differences in most cases would be minor and not more than one dot different. This is usually a faster method because most tables are set up in alphabetical order. Because of this, the distribution may be less subject to calculation error and easier to verify; it should produce the same number of dots for the whole 1st order division.

(3) Rounding totals method. A third alternative, and probably the method most often used but not as accurate, is simply to round the figures to the nearest thousand, if the value of the dot is 1,000. As in any rounding the total may be higher or lower than the true total. In a sparsely settled area the loss or gain could be easily noticed, but in a densely settled area the difference would be unnoticeable.

As the number of dots for each area is calculated, it should be entered in the appropriate area on a copy of the same base map which will be used for preparing the final map. This is called coding the map.

3.32 Methods of making dots.--The final drawing may be prepared by drafting or by scribing (see chapter 10). If by drafting, a clear film copy of the base map with only the

1st order division boundaries is laid over the dot-coded copy on a light table, registered to it, and the dots drawn by using a drop bow compass or other dotting pen with ink. Care must be taken to make the dots as round as possible. If by scribing, the dot-coded copy is prepared as a scribecoat and the dots are cut by a dot scribing instrument. The latter method produces a much better quality of dots, making the map easier to read.

3.33 Placement of dots.--The actual placing of each dot on the map can make the difference between a good map and a poor map. Since the dots represent population, agriculture holdings, or whatever units are being mapped, they should be located insofar as possible in accordance with the distribution of these units within each 2nd order division.

There are various sources of information that can aid in the proper placement of dots. For rural population, it is known that rural dots should not be placed where there is urban population although rural population may be greatest immediately adjoining urban population. Rural population dot maps are rarely made except in combination with urban population as a total population distribution map. Accordingly, the urban population map should be placed as a further underlay or incorporated into the scribecoat so as to serve as a guide in the placement of nearby rural dots.

A further source of information may be available from census tables in the form of population totals for separate rural villages or for subdistricts. If so, the rural dots may be located in accordance with this information; for example, 2 dots for a village of 2,000 inhabitants, 4 dots for 3,900 inhabitants, etc. Rural open country population not located in compact settlements would be distributed between villages or adjoining cities or wherever there is evidence of population (such as known land use patterns).

Knowledge of land use patterns is particularly helpful in constructing dot maps of agriculture. The availability of a good land use map of the country can be used to guide in placing the dots only on agricultural lands.

The above paragraphs discussed proper and improper placement of dots. There are several additional cautions:

(1) Avoid placing dots in lakes or reservoirs which may not be outlined on the base map that is used.

(2) Avoid placing dots in rough mountain areas or arid areas unless there is clear evidence that sufficient population (for one or more dots) actually lives there.

(3) Avoid placing dots in a regular pattern so that the overall appearance shows lines of dots in linear order.

(4) Avoid placing dots so that the boundaries of districts, when removed, will show as empty white bands.

3.34 Title, legend, and marginalia.--The legend, frame, scale, north arrow, and other marginalia are needed to complete the map. The legend must identify the value of the dots. For title and marginalia, the suggestions for area identification maps previously given also apply to statistical maps.

3.4 *Graduated circle maps*

The idea of using graduated circles was introduced earlier in the chapter (section 3.25) in connection with planning statistical maps. In constructing graduated circle maps, attention must be given to the matters described below.

3.41 Calculation of circle areas.--For most graduated circle maps the area of each circle is proportional to the quantity it represents; thus, the maps are sometimes called proportional circle maps. To determine the radius of each circle, the square root of the number to be represented is computed. This computation is based on the fact that πr^2 is the formula for the area of a circle and since

π is a constant, it may be ignored. A scale is selected for the radii numbers and the circles may be drawn by a drafting compass. The final scale for drafting the circles on the base map will depend on the range of values of all circles from the largest to the smallest. The scale should be chosen so that the smaller circles are clearly visible and the larger circles overlap each other as little as possible. For example, if 10,000 is the value for the smallest circle, its radius value is 100 and a possible scale is 2 millimeters to 100. Assume that the largest circle has a value of 1,000,000, its radius value is 1,000 and the plotting scale is 20 millimeters. Such a scale might work well on a page-size map depending on the size of the divisions being mapped. The scale might be raised or lowered. Some preliminary drawings probably would be required to determine the final scales. Such calculations are not too tedious if a calculator with a square root function is used.

A graphic device may be constructed for measuring directly the radii of the circles. The procedure can best be explained by an example, as follows:

(1) Draw a horizontal line of convenient length. Label the left point 0 (zero); label the right point the largest value that is needed. In figure 9o, the maximum value is 1,000,000 and the length of the line is 15 cm. Note that, while the horizontal line may be of any length, a long line will give better gradations between values.

(2) The distances along the horizontal line are proportional to the square roots of the values. In the example, the square roots of 1,000,000 and 10,000 are 1,000 and 100 respectively. Thus, the distance from zero to 10,000 is

$$\frac{15 \text{ cm}}{1{,}000} = \frac{X}{100} \quad \text{or} \quad 1.50 \text{ cm}$$

The square roots for other values and their distances from zero are computed in the same manner. Below are the computations for the values shown in figure 9o.

Value	Square root	Distance from zero
10,000	100.00	1.50 cm
50,000	223.60	3.36 cm
100,000	316.23	4.74 cm
250,000	500.00	7.51 cm
500,000	707.11	10.61 cm
1,000,000	1,000.00	15.00 cm

(3) For the desired value points, mark the distance on the horizontal line (or base line).

(4) Construct a circle of desired size at the largest value. The size of the circle depends on the size of the map and the size of the divisions being mapped, as explained above. Mark the center of this circle (point A).

(5) Draw an oblique line from A to 0. Construct lines perpendicular to the base line for each marked value, so that they meet the oblique line. These points determine the center of the circles that represent the indicated values.

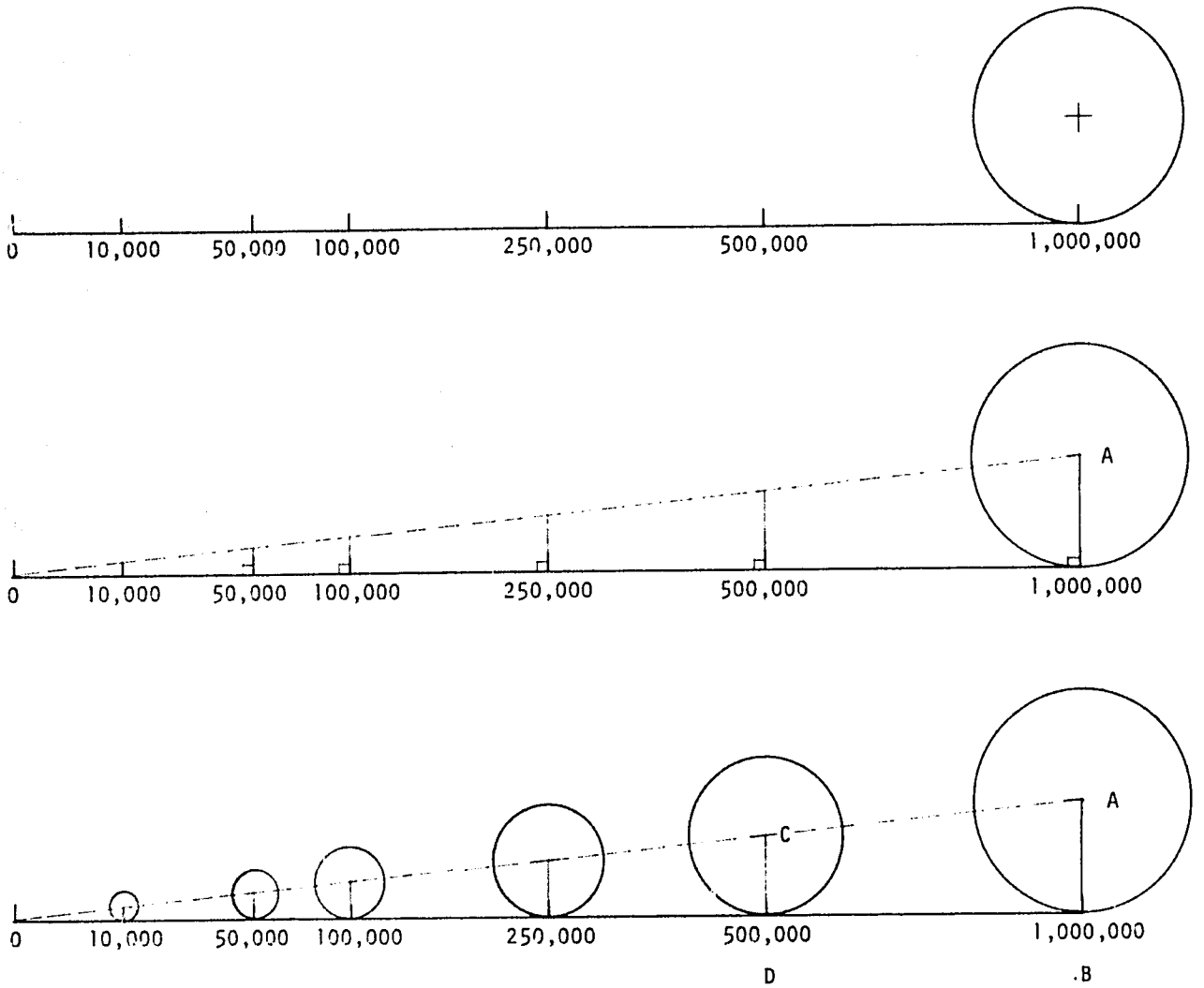
(6) The radius of each circle is the perpendicular distance from the base line to the oblique line at each value. With the use of a compass, the radius can be measured from the graphic device and circles drawn onto the statistical map.

This procedure is based on the principle that similar triangles have proportional sides. In figure 9o, triangles AOB and COD are similar. Therefore, side AB is proportional to side CD. Since AB and CD are radii of circles, the areas of the circles are proportional to the values they represent.[4]

3.42 Graduated circles and class intervals.--Graduated or proportional circles are sometimes used to represent class intervals rather than exact numbers. They are used particularly when a large number of small-scale national maps are required on similar subjects, and the representation of exact values for each

[4] *For a description of graphic methods for construction of proportional symbols, refer to F. J. Monkhouse and H. R. Wilkinson, Maps and Diagrams, Their Compilation and Construction (London, Methnan & Co., Ltd., 1972), pp. 22-25.*

Figure 9o. GRAPHIC DEVICE FOR MEASURING DIRECTLY THE RADII OF PROPORTIONAL CIRCLES



number is not deemed important enough to calculate each circle separately. In this case, the circle is calculated for the average or mean value of each class interval, and a standardized legend is developed for the series.

3.43 Divided or sectored circles.--On some circle maps, further values or proportions related to the area represented by the circle may be shown in pie chart form (see figure 9j). The number of pieces that can be shown is very limited and all should be of sufficient size to show clearly. For very small circles or for circles that overlap considerably, such representation should not be attempted. Divided circles are difficult to read and, if too complex, are not very satisfactory. Color printing is generally desirable for more than two or three sectors.

3.44 Drafting or scribing.--The drawing of the circles may be accomplished by either (a) drafting with a compass and ink on the map or on a drafting film overlay or (b) scribing the circles on a scribecoat with a scribing compass. If a limited set of graduated circles is used, with one for each class interval, the circles may be printed as black circles or disks on thin transparent film with adhesive backing; these can be cut and applied directly to the maps.

3.45 Placement of circles.--Circles are located at the center of administrative areas to which the statistics apply. The largest

circles are put down first; then progressively the smaller circles are added. At the same time, the smaller circles should be clearly visible; and the larger circles should overlap each other as little as possible. With a wide range of values and many small areas, there will be an overlapping of circles on some parts of the map. Two ways of handling this problem are illustrated in figure 9p. In A, the circles are transparent and are allowed to overlap; in B, smaller circles are placed on top of larger circles. In a large-scale map with many overlapping circles, it may be necessary to have insert maps for crowded areas, but the same circle scale should apply to the insets.

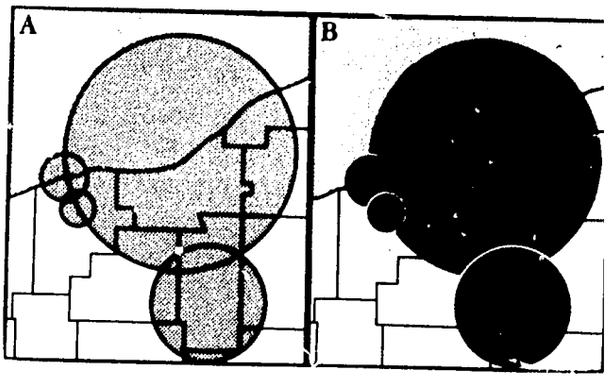
3.46 Perception of circle maps.--Investigations have shown that human visual perception of the apparent values of proportional symbols is somewhat less than their real values, especially at the higher end of the scale. Nevertheless, a correction factor is not suggested here, because of difficulties this introduces into the construction of proportional symbol maps.[5]

3.47 Title, legend, and marginalia.--Title, legend, frame, and other marginalia will complete the map. The legend for graduated circles may be presented in a number of different ways. One design that uses a minimum of space is to draw the largest circle and place within it a series of selected smaller circles, each within the next larger one, and all resting on the midpoint of the bottom side of the largest circle as illustrated in figure 9j. A value scale is provided beside the circles.

3.5 *Choropleth maps*

The construction of choropleth maps may be done by traditional drafting methods but it

Figure 9p. OVERLAPPING CIRCLES



Source: A. H. Robinson and R. D. Sale, "Elements of Cartography," 3rd ed. (New York, John Wiley & Sons, Inc., 1969). Reprinted with permission.

is more frequently accomplished by a combination of drafting and photography. The procedures for both methods are presented below.

3.51 Map coding of class intervals.--The first step in preparing the map, after determining the class intervals that are to be presented, is to assign digit codes in progression (for example, 1 to 5) to each class interval. Then, the class interval code for each subarea being mapped is determined from the statistical data. Normally these values will be in terms of densities, ratios, or percentages. At the same time, the codes may be marked in the proper subareas on a copy of the base map chosen for preparing the choropleth map. If the base map is to be used as direct final copy on which black and white shadings are to be imposed, the area codings should be done with a non-photographic blue pencil, so that they will not show when the map is photocopied for the printing plate.

3.52 Selection of black and white shadings.--Successful choropleth maps in black and white require very careful selection of black and white shadings so as to show graduated values correctly from high to low. Black and white graded shadings are shown by patterns of dots or parallel lines or combinations thereof. Contrasts in the shadings (see figure 9k) are

[5] *For further information on circle maps, see A. H. Robinson and R. D. Sale, Elements of Cartography, 3rd ed. (New York, John Wiley & Sons, Inc., 1969), pp. 125-126.*

achieved by (a) variations in the percent of area inked by dots or lines and (b) distinguishable patterns.

The human eye is not sensitive in distinguishing many shades from very light gray to black; for this reason, patterns generally must be introduced to permit recognition of individual shades as they are presented on a choropleth map. Normally high statistical values are represented by dark shades and low values by light shades. The aim is to develop an equally graded shading pattern from high to low. The contrasts should be great enough to clearly distinguish each class from the one above it and the one below it, but not so great that there are noticeably unequal jumps in shading values between classes. This is the ideal, but great care is required in selecting the patterns to achieve a balanced set of shadings that are graded.

3.53 Black and white maps and drafted shadings.--Graded shading to show each of the class interval areas on the map can be done by hand with pen and ink. The shading is accomplished usually by parallel lines of different width, spacing, and angling or by crosshatching of these lines. This drafting must be done on a base map which will become the final map when title, legend, etc., have been added. This is a tedious method and one that does not usually achieve as attractive a final drawing as other methods.

3.54 Black and white maps and preprinted shading patterns.--Graduated shading also may be achieved through the use of commercially printed shading patterns on thin film that has an adhesive backing. A sheet of the selected film may be laid over the subarea or group of subareas with the same class interval code, pressed down, and the excess film cut off the edges. The commercially printed shading patterns are available in a wide variety of line, dot, and other designs--all uniformly executed. From the selection of patterns a graded series of shadings, each distinctly recognizable, can be chosen and used. A choropleth map made with these shading patterns is not difficult to construct and presents a very uniform appearance.

3.55 Black and white maps and open window negatives.--An even more efficient and flexible method, and one that results in an improved final map involves the use of an open window negative. Such a negative is produced from commercially available coated polyester film, on which a positive image from a map is photochemically etched. The coated film is then manually stripped to produce an open window negative. The film has an emulsion coating (usually orange or rust color), much like rubber base paint, which can be peeled off the film with a sharp knife, leaving window-like openings; the patterns of the openings are controlled by the deep etched lines. If the map is to be prepared for black and white printing, a separate open window negative is made for each class interval. When combined with appropriate photographic pattern screen, a composite negative is prepared. The composite negative includes the base map to which have been added title, legend, frame, and marginalia. From this negative a printing plate is prepared.

3.56 Color maps and open window negatives.--Open window negatives are used also to produce a choropleth map in color. It is common to use only two or three basic colors plus black in order to minimize the number of press runs.

A tremendous variety of color shadings can be obtained by combining colors such as yellow and blue for green, yellow and red for orange, etc., and by using photographic screens in preparing the negatives for each color plate so as to obtain percentage values of the colors from 10 percent (light) to 90 percent (dark).

One way of achieving these color shadings in printing, is to prepare an open window negative for all classes that will have yellow, another for all classes with blue, etc. For example, this might mean that class intervals 1, 2, 3, and 4 would appear on the yellow open window negative and 3, 4, 5, and 6 on the blue negative. Again a separate negative is needed for the base map (with legend box, title, etc.) which is printed usually in black.

Another way of achieving color shadings in printing is to prepare an open window negative for each class interval, as is done for black and white printing, and then ask the printer to combine the colors by multiple exposure on a negative for each color printing plate. For example, if class interval 2 is 50 percent yellow and 10 percent blue, the photographer making the printing negative would use a 50-percent screen and the open window negative for class interval 2 and expose this on the negative for the yellow plate; the 10-percent blue negative would be exposed on the negative for the blue plate. If class interval 1 were 100-percent yellow this would be also exposed on the yellow negative. Thus, each color negative would receive multiple exposure to the open window negatives and screens for each class interval. The exposure from negative to negative is now possible without going through a positive because of the current availability of duplicating film.

3.57 Color values and gradations.--The use of color for graded shadings on choropleth maps serves to make them more attractive and therefore more widely used. Moreover, color strengthens the capability for communicating the value shadings that are required on a choropleth map. The task of selecting color values is even more difficult than selecting patterns for black and white maps. Color printing in cartography is usually achieved by combining various proportions of inks of three primary colors--red (magenta), blue (cyan), and yellow--plus black and the white of the paper. These offer an almost unlimited variety of colors. However, in presenting a graded series for progressive class intervals, the most important aspect is color value. As is true for black and white gradations, the darker the value the greater magnitude it should represent, and the lighter the value the lesser the magnitude. A single color in various shades for presenting gradations of value is not much better than various shades of gray, for the eye is strictly limited in the number of values it can distinguish. Therefore, different colors are added to permit recognition of more gradations in a manner similar to adding patterns to black and white or gray shadings.

What are the choices from an almost unlimited number? One choice might be the colors which appear in the rainbow, a progression from violet, blue, green, yellow, and orange to red. The problem with a full spectrum is that it represents two value progressions--from violet to yellow and from yellow to red. It has become customary to use the colors of the spectrum for elevation maps with blue for water, green for lowlands, yellow for intermediate levels, and brown and red for highlands; however, this progression is unsatisfactory for graded statistical intervals. The two separate progressions starting with yellow, the lightest tone, to either red or blue can work very well. These can be varied in many ways by using intermediate tones such as yellow-green, blue-green, yellow-orange, red-orange, or blue-violet. Red and blue may be introduced into the yellow so as to produce olive-greens or light browns or red-browns. In every series, the colors can be chosen so that the values increase from light to dark in steady progression without big jumps or gaps between any two. The values of colors are changed by using a series of photographic screens in preparing

final negatives from the open window negatives. The best screens are those that are rated in terms of percentages (10%, 20%, etc.) with each percentage indicating the amount of color that will be printed if that screen is used.

3.58 Selection of colors.--Assuming that the general color scheme for a given choropleth map is chosen, the question arises as to how the precise colors and their values should be selected. There are no clearly defined principles to follow except that values of the colors should range from dark to light and that each class should be clearly distinguishable from the one above it and below it. Color charts have been printed which indicate color combinations in various percentages.[6] By selecting colors from these charts, cutting each out and arranging in graded order, judgment can be made as to the color combinations suited to the choropleth map that is being prepared. A large number of good selections can be made.

3.59 Title, legend, and marginalia.--The legend for a choropleth map is prepared in the form of a series of rectangular boxes in a vertical arrangement. The class interval that each one represents is placed to the right of each box and is usually given in descending order of values from top to bottom. The map would be prepared so that the proper black and white shading or color would appear in each box (see figure 9k). The final steps are to add title, frame, scale, and other marginalia.

3.6 *Preparing the maps for printing*

Statistical maps must be very carefully verified before being printed. The geography staff must be sure that symbolization has been provided for all areas without any omissions, and that the correct number of dots or shading values have been applied to each area. Title, legend, and marginalia must also be verified.

If the final copy is a black and white drawing or print, verification is simpler. If the final product is to be a series of open window negatives for color reproduction, a color proof copy should be prepared. If areas have been omitted or incorrectly shaded, such errors will be much easier to detect and correct from a color proof. For any maps involving open window negatives, registration is important. Helping to achieve this registration throughout the process of preparation is a pin registry system (discussed in chapter 10).

Finally, if statistical maps are to be printed in color, it is very important that arrangements be made with the printer for the cartographer to review the printing at several stages in the printing process. This must be done to assure that the printing plates have been properly made, that the correct color inks are being used, and that proper color registration is achieved during the printing.

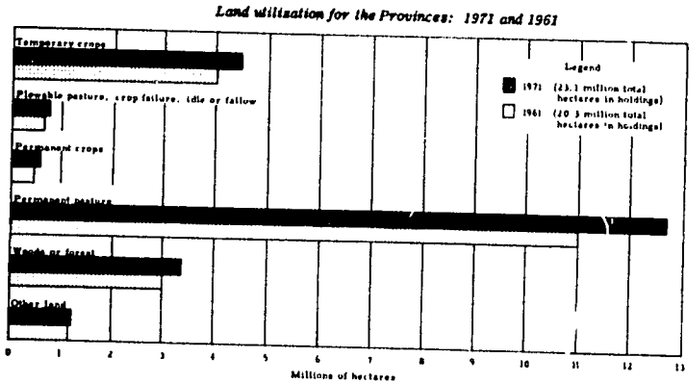
4. *STATISTICAL GRAPHS*

Statistical graphs (including charts) are discussed in this chapter because they are used widely in census publications to show quantitative relationships in statistics that are not readily apparent from the statistical tables. The same purpose applies to statistical maps; but in the case of statistical graphs, the emphasis is normally on statistics of a nongeographic nature or, perhaps more precisely, those referring to a single geographic area, such as the nation as a whole or its separate 1st order divisions. While it would be possible to construct one or more statistical graphs for every table of data, this is neither feasible nor desirable. Rather, the aim is to highlight the important relationships or changes and to interest the reader in examining the tables for further detail.

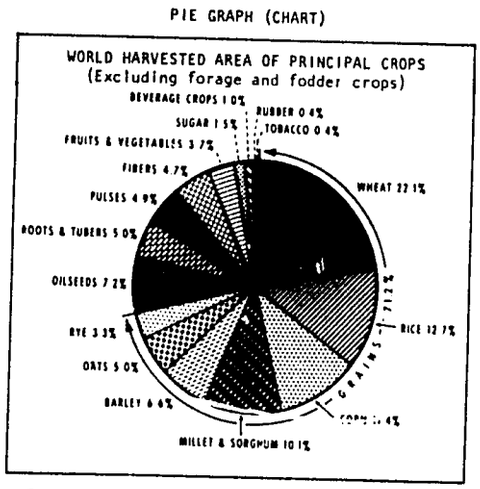
[6] *A chart prepared by the U.S. Bureau of the Census gives 1,100 color combinations of red, blue, and yellow.*

Figure 9q. TYPES OF GRAPHS

BAR GRAPH

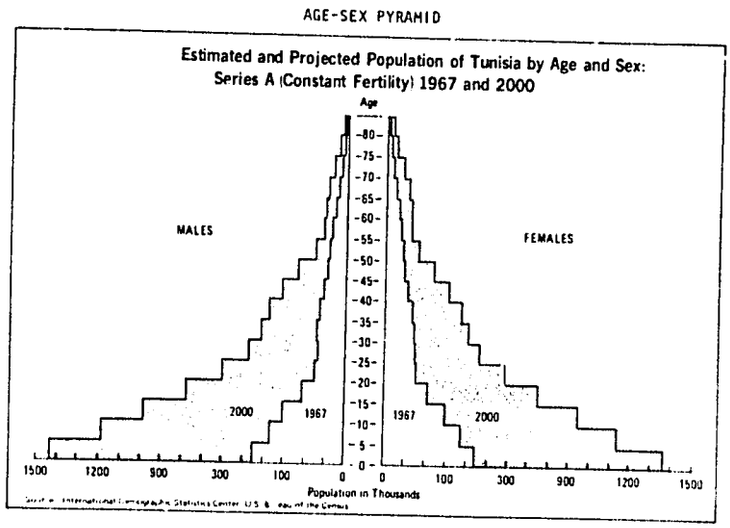


PIE GRAPH (CHART)

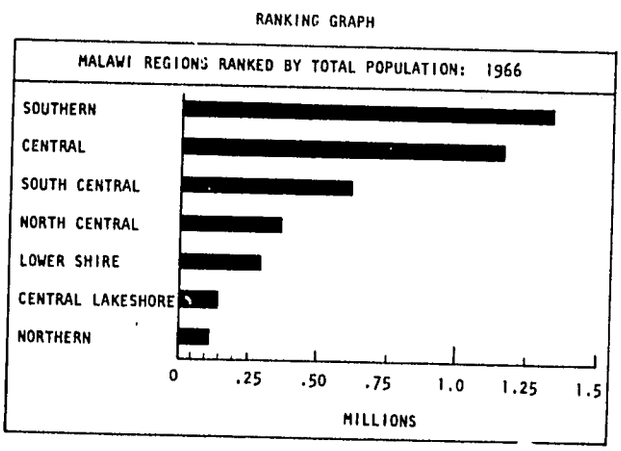


Source: U.S. Department of Agriculture.

AGE-SEX PYRAMID

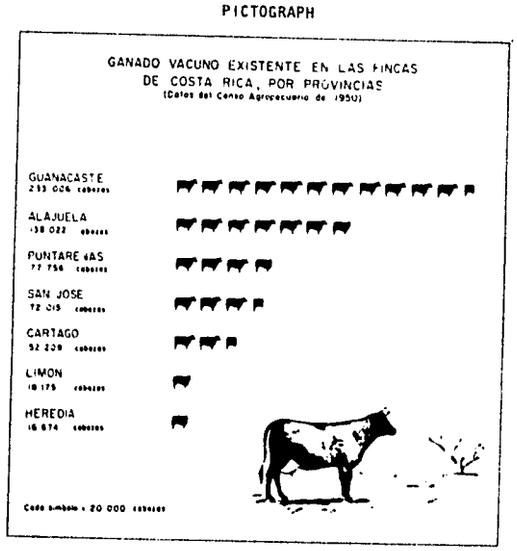


RANKING GRAPH



SOURCE: Based on data from "Malawi Population Census, 1966, Provisional Report," Department of Censuses and Statistics, Zomba, Malawi.

PICTOGRAPH



SOURCE: "Atlas Estadístico de Costa Rica," 1953. Courtesy of Dirección General de Estadística y Censos.

4.1 *Types of statistical graphs*

A great variety of types of statistical graphs exist. However, almost all that are in common use in census publications are of three major types: line graphs, bar graphs, and divided circle (pie or sector) or divided rectangle graphs. No attempt is made to cover all the countless variations of these types but only to note a few important ways that these graph types may be used. Several types are illustrated in figure 9q.

4.11 Line graphs.--The normal line graph presents a series of points each denoting two variables. They are plotted by means of rectangular coordinates and with a line connecting the points in progression. Most commonly in census reports, line graphs are used to show time series comparing the results of the past censuses with the present. Time, the independent variable, is indicated on the horizontal axis; population, percent change, or some other dependent variable is indicated on the vertical axis.

Line graphs are particularly good for emphasizing movement of data and for estimates, forecasts, or interpolated data. Multiple lines may be used on a line graph (to show data for a nation and its major regions, for example) if the lines are symbolized differently and do not intersect at too many points; otherwise, the graph would be difficult to read or would be unclear.

4.12 Bar graphs.--Bar graphs represent scaled values on a rectangular grid either by horizontal or vertical bars. Each has a constant width and each has space between bars (or group of bars). Bar graphs are also used for time series to show data at different census dates. In this case, the bars are vertical (also called column charts) and they are spaced to show the time period between each census.

A type of horizontal bar graph is the so-called age-sex pyramid. It shows the number of persons on the horizontal axis and age class groups from infancy to old age on the vertical axis. Number of males is indicated to the right of the center axis and number of females to the left with no space between the bars. In a normal distribution it appears like a pyramid (see figure 9q).

Another type of horizontal bar graph is the ranking chart where population, percent change, or other data for geographic areas or other components are represented by horizontal bars arranged from top to bottom in descending order. Losses as well as gains may be shown on the same graph. More complex information may be shown within each bar by subdividing it into components and shading each part differently; a legend should be added to identify the separate parts.

Another bar graph commonly used in census reports is the 100-percent bar graph. Regions, 1st order divisions, or non-geographic quantities are represented by a series of bars of equal length; the bars are divided into components and each part is shaded differently and annotated.

4.13 Divided circle or rectangle graphs.--There are forms of graphs in which a circle is divided into sectors, or a rectangle is divided into further rectangles to show the percentage of the total that is represented by the component parts. These are most often used for the nation as a whole or a 1st order division. They must be carefully annotated and preferably should show actual percentage figures. They can be used to show urban and rural populations and further breakdown by size of place. Or they can be used to show population characteristics such as ethnic origin, educational attainment, occupation, or employment.

4.14 Other variations.--So many variations in graphs exist that it is possible in this chapter to mention only a few. A line graph may have shading below the line to

emphasize up-and-down movement of the data over time. For a multiple-line graph that shows percentage of a total, the entire graph may have shadings between various lines; this is sometimes called a surface graph. Bar graphs may use a string of silhouettes of people lined up to show population numbers, or a stack of coins to show money, or other simple pictures. These are called pictographs. There are other types of graphs, such as the polar or circular graph and the triangular graph (used to portray three variables); these are rarely used in census reports because they would be difficult for most readers to interpret

4.2 *Planning and preparation of graphs*

After determining what data are to be highlighted by graphs, the next consideration is to determine the space each one will occupy in the publication. Will it be a full page, a half page, a quarter page, a column, or part of a column in the text? Knowing the overall dimensions facilitates efficient planning of the scale of the graph or group of graphs.

The second step is preparing a rough drawing of the graph on coordinate paper indicating the major components (lines, bars, or circles), the scaling frame, title, legend, lettering, and source of data. With this drawing and the necessary table from which the numerical data are obtained, the draftsman is in a position to draw the final graph. Line work is usually prepared for publications in black and white. If shading is required, it can be in black and white or color. If colors are used, a separate overlay is needed for each color or color combination. A limited number of coordinate lines should be indicated on most line and bar graphs to enable the reader to make approximate measurements easily.

It is best to keep the various parts as simple and sharply defined as possible. As a rule, simple, clean, block-type lettering is preferred. If reduction of the drawing is required (and it is preferable to reduce to avoid minor imperfections in drafting), the reduction scale for all graphs in a series should be the same so that lineweights and lettering will be comparable from one graph to the next.

To enhance the attractiveness of most graphs, it is desirable to add a light background shading of halftone gray or color either within the coordinates or as a frame around the graph. If this is done, a separate overlay for this shading is required.

Finally, all graphs must be carefully verified as to line work, measurements, lettering, and shading overlays. To avoid serious errors, the statistics on which the graphs are based also should be verified.

Chapter 10. DRAFTING OPERATIONS

1. INTRODUCTION

Chapter 10 discusses, in some detail, the organization, procedures, materials, and equipment needed for drafting enumeration base maps and publication maps and graphs. The chapter is intended primarily for technicians who are responsible for the drafting operations. Other census personnel may find the chapter useful in that it describes the scope of the drafting activity in relation to other aspects of a census mapping program.

2. DRAFTING FUNCTIONS

Drafting of census maps requires two major functions: (a) drafting enumeration base maps and (b) drafting publication maps and graphs. For the most part, these functions are performed separately. The first function, that of preparing base maps, will require more drafting personnel, because the maps must cover every part of the country in detail and must be as accurate and up-to-date as feasible. The second function, that of preparing publication maps, requires fewer personnel to accomplish, but these must be highly skilled and experienced personnel who can draft in a finished manner that will meet publication standards.

The work of each group should be reviewed and edited before being sent to copy reproduction or printing. Original artwork on maps or graphs, when completed and copied, is kept in the drafting files.

Personnel should be quite versatile, since they may be doing different drafting work at different times. Persons who have a greater aptitude for more complex drafting operations will become specialists; supervisors ordinarily will assign them to the more difficult tasks. Some persons will be particularly skillful at verification and editing and should be assigned to that function. Well trained and experienced persons will be needed to develop the specifications for drafting.

There is often a shortage of cartographers and draftsmen so that some inexperienced people must be trained to undertake the drafting work. While much of the training will occur on the job, it is advisable to have a formal training program initially which will acquaint new personnel with the use of all the drafting equipment and materials, and will give them some actual drafting exercises to complete satisfactorily before they receive any regular work assignments. The amount and type of training will vary depending on the jobs to be done.

Drafting of enumeration base maps will be finished before the drafting of publication maps is started. Therefore, it is usually possible to assign the most experienced draftsmen and those with the best technical and artistic abilities and knowledge of reproduction methods to draw the publication maps and graphs.

3. SPECIFICATIONS FOR DRAFTING

Standards must be established to ensure consistency of quality. A map is a system for coding a variety of geographic information so that a map reader can use it. EA maps must be especially clear because enumerators often are not skilled map readers. By preparing adequate and comprehensive specifications for map preparation, one can ensure that all maps of the same type are reasonably uniform and that training of enumerators in their use is simplified.

Specifications also need to be set up for publication maps and graphs. Maps and graphs that are properly drafted will be more easily read and used by the public.

3.1 *Preparing specifications*

In preparing specifications, accuracy requirements need to be considered, along with symbols, scale, size of sheet, format, and method of copy reproduction. The importance and description of map reproduction methods are covered in chapter 11. An overwhelming number of census maps are produced primarily for crew leader and enumerator use. Rarely is an enumeration map used for publication without redrafting.

3.11 Enumeration maps.--Maps for enumeration should be reasonably accurate. Points and lines should show the same general relationship to one another that they do on the ground. Shapes and turns of roads, blocks, rivers, and lakes must correspond with their ground positions. On the other hand, precise accuracy of scale and detail is not as necessary for census enumeration maps as it is for engineer-drawn topographic maps. To demand more accuracy in census mapping than is required is an unnecessary expense. (See also section 6 of chapter 6 regarding accuracy requirements for enumeration maps.)

For enumeration maps a set of general specifications that apply to all maps should be prepared. This set will include instructions on:

(1) Various sizes of map sheets and map scales that are acceptable for urban and rural areas (see figure 6c in chapter 6).

(2) Approved symbolization of landmarks, other features, and boundaries for each map scale (see exhibit 3-1).

(3) Prescribed format (layout, matching, orientation, lettering, etc.).

(4) Standards for title, legend, north arrow, graphic scale, framing, and other marginalia.

These base map specifications should be prepared in detail for urban and rural areas, and copies should be provided to all map draftsmen. One part of the specifications will cover lettering to be used for different map features. Another part will include all point, line, and area symbols that may be used. The letters or symbols will be shown at various reductions so that the draftsmen may select the letter size or lineweight that the final reproduced copy should have.

3.12 Publication maps.--Another set of specifications will need to be prepared for publication maps. The overall specifications will be rather general, because publication maps differ one from another. The specifications will include such items as title, framing, lettering, graphic scale, marginalia, etc., which are common to almost all maps. More detailed instructions will be prepared for each census area identification map series and for statistical maps of the various types--dot maps, choropleth maps, etc. Many statistical maps are one of a kind and special instructions and preliminary drawings must be prepared for each one.

It is wise to consult numerous informed persons as well as to follow cartographic standards in determining specifications. The person responsible for the specifications should consult with other qualified geographers as well as professional statisticians in the appropriate subject matter divisions of the NSO who have a special interest in the presentation of statistics.

3.2 *Using specifications*

Specifications must be closely followed by the draftsmen to ensure that standards of accuracy and quality are being met. Compilation staff, editors, and verifiers should follow the same specifications as the draftsmen follow. Maps returned to drafting for changes should, where appropriate, be marked with notes that

refer to paragraphs in the specifications. For a few maps, minor changes in the specifications may be desirable, but any changes should be approved by the supervisor.

A carefully designed set of standards clearly expressed in the specifications and approved by all concerned will make it possible to use base maps over a long period of time. It will also aid in updating and correcting information.

4. DRAFTING ENUMERATION BASE MAPS

The compilation staff determines which source materials will be used for the enumeration base maps and then prepares map packages for the draftsmen (as described in section 7 of chapter 6). This does not mean that the drafting staff cannot or should not question the materials and their use, although in most cases the compiler's instructions will be followed. If there are some questions about either the materials or the instructions, there should be discussion with the compilation staff, preferably between technicians who are doing the work rather than between supervisors.

After the maps are drafted, they will be returned to the compilers for verification. The compilers will be thoroughly familiar with the needs of enumerators in the field, will have the necessary map sources for checking, and will have prepared the original instructions. The compilers are the final authorities on what the maps ought to show, and they are the people who must be satisfied before the maps are sent to the field for use.

4.1 *Using the map package*

A map package will have been prepared by the compilers probably for each 2nd or lower order administrative division (as described in chapter 6). The package will contain the maps and other source materials which will be used for making base maps. Overlays or detailed instructions accompanying the materials will indicate the features to be drafted onto the base maps and the names to be transferred or added.

It is probable that the map sources will have some serious faults, such as small scale, missing features, unneeded information, lack of clarity, and poor reproducibility. Such faults make the maps unsatisfactory for direct use but satisfactory as a set of primary source maps. In this case, the maps must be updated for use as base maps. In other cases, it may not be feasible to update an existing map and a completely new one must be drafted.

The steps in updating an existing map include:

(1) Enlarging or reducing the materials as indicated

(2) Deleting unnecessary features

(3) Adding features in pencil

(4) Verifying the additions and deletions

(5) Inking in the additions

The steps in drafting a new base map are similar to those for updating an existing map. When drafting a new map, the format and the symbols used for the features should be standardized in accordance with the specifications established for each type of area. The steps in drafting a new base map include:

(1) Enlarging or reducing the materials as indicated

(2) Making a preliminary pencil copy incorporating the features indicated on the source materials

(3) Verifying the preliminary map

(4) Making an ink tracing of the preliminary map

4.2 *Enlarging or reducing source maps*

If the compilation staff has enlarging or reducing equipment, source maps may have been brought to the proper scale before the overlays

were made or the instructions written. Otherwise, instructions for enlarging or reducing scale will accompany any map that is not already drawn to the required scale.

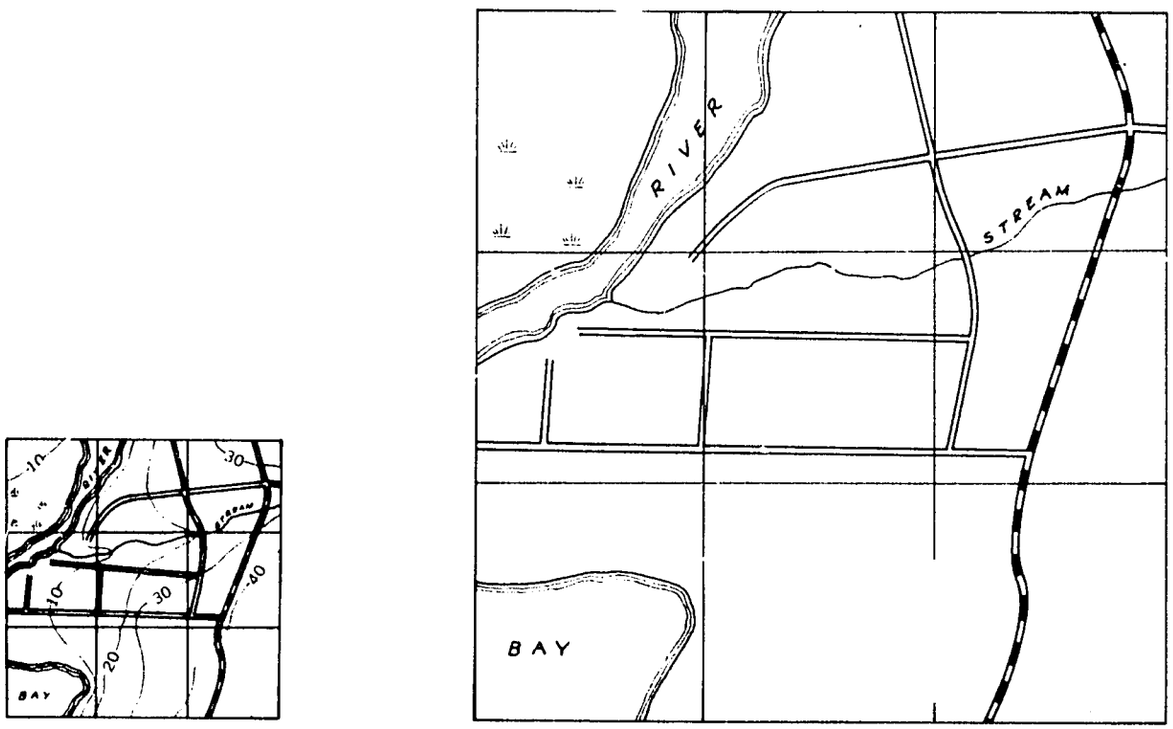
The methods and equipment for enlarging or reducing are varied. The use of photography for this purpose is the best method because it is quick and accurate. It requires that a negative and a positive print be made at the desired scale for each source map from which detail may be selected and traced on the new map base. Cameras and other equipment are necessary and involve considerable cost, but the results are well worth it if many changes in the scale of maps are required (see also chapter 11).

A second method for enlarging and reducing involves the use of reflective projectors which permit transfer of the map image in enlarged or reduced form by lens and light onto a surface where it can be traced by a draftsman (see section 7.35 of this chapter). This method involves at least a moderate cost for the projector, and tracing is subject to errors by the draftsman. Overall, it is not as satisfactory a method as photography.

A third method is the use of the pantograph (described in section 7.33 of this chapter). This is somewhat tedious and subject to human error, but it can be accomplished by a trained draftsman with proper equipment at a relatively low cost.

Still a fourth method is the most tedious and subject to the greatest error. This is direct drafting enlargement through the use of measurements of the map features to be transferred. Preferably, this is done with a grid similar to graph paper. The smaller the grids, the more precise the transfer. An illustration of this grid method is given in figure 10a. A map at the scale of 1:15,000 is redrawn to a scale of 1:6,000 simply by transferring the

Figure 10a. USE OF PREPARED GRID FOR CHANGING SCALE



detail from one small square to its counterpart square on the larger map.

4.3 *Tracing*

After the pencil copy of a map is complete, it is traced in ink using a light table. The tracings are made on tracing paper, tracing cloth, or drafting film (see section 7.21 for more details about these materials). The ink tracing may be done on the map sheet being updated by inking over the pencil lines. However, when a completely new map is drafted, it is better practice to trace in ink onto a clean sheet. This preserves the preliminary pencil copy for review and verification and also saves considerable time in cleaning off unwanted pencil lines. It also allows the use of different tracing materials for the pencil copy and the master ink copy. This is a distinct advantage, since the preliminary map is more easily done in pencil on paper, while the master copy is better preserved if a stable-base plastic drafting film is used for the ink tracing.

4.4 *Preparing air photo mosaics*

If no adequate maps are available, base maps may be made rather easily from good aerial photographs or photo mosaics. Interpreting the photographs and tracing maps from them were covered in chapter 4. The preparation of uncontrolled air photo mosaics, however, was not covered in chapter 4. Whenever more than two or three aerial photographs are used as a source for making a base map, it becomes desirable to match them together and construct what is called a photo mosaic before tracing. Since photographs have truer dimensions at their centers and more distortion at their edges, it is better to use only the central part of each photo in making the mosaic. If photos with large overlaps are not available, it is not always possible to use only the central parts. In that case, the existing photos must be put together by adjusting non-matching features to meet each other when the tracing is made.

In the construction of the mosaic, a photo in the center of the area of the base map is mounted first on a sheet of very heavy waterproof cardboard, plywood, or other special base. Before being pasted down, its surrounding edges are torn away in a manner called "feathering." This is done by holding the photo face up and tearing a narrow strip away all around the edge of the photo. This leaves a white feathered paper edge all around the photo. An adjoining photo is examined to determine the approximate line where it will match the torn edge of the central photo. It is then torn along this line in a manner that leaves the white feathered edge on the bottom with the emulsion side of the photo on top, taking care not to remove any images of this photo that are missing on the central photo already laid down. This operation is repeated for other photos joining the central photo. Also, the sides of the adjoining photos are matched. Each photo is pasted to the board after it has been matched on all sides to adjoining photos. A mounting paste with water base is used. The process is continued until all photos that cover the area to be made into a mosaic are used.

Unless the photographs making up the mosaic have been corrected in the printing process for the varying tilt and level of the airplane from which they were taken, the resulting mosaic will be what is called an uncontrolled mosaic. This means that features at adjoining edges of the photos may not match very well and distances are not completely accurate. However, it produces a reasonably good picture of the area. A map suitable for census purposes can be made by tracing in pencil selected features from the photo mosaic.

5. DRAFTING PUBLICATION MAPS AND GRAPHS

Maps and graphs that are to be published with census reports require planning and compilation in a manner similar to enumeration maps. The design and compilation of publication maps is generally undertaken by the chief cartographer in consultation with the subject matter staff. Publication maps are fewer in number than enumeration maps and they require special professional and technical abilities in planning and design.

Since chapter 9 has already covered the preparation of publication maps and graphs, this section is limited principally to selected technical aspects of planning and design and to the drafting and lettering operations.

5.1 *Initial planning*

Early in the planning, the chief cartographer should consult with the subject matter statisticians to lay out the needs for census area identification maps and statistical maps and graphs. If there are numerous area identification maps of several types, he will want to have his staff prepare preliminary drawings or outlines of each type and present them to the planning group for approval or modification. Likewise, if there is a series of similar statistical maps or graphs, preliminary copies should be drawn for approval. For one-of-a-kind maps or graphs, a general description or rough pencil outline should be sufficient for planning purposes.

In this initial planning, several basic questions must be answered. One has to do with the size of the publication page. Will maps larger than the page size be prepared and, if so, how will they be made a part of the publication? Will they be folded and bound in the report or folded and inserted in a pocket of the report? Will an existing base map be used or will a new one be prepared? How much detail needs to be shown? Will the maps and graphs be in color or in black and white? From answers to these questions and review of the preliminary outlines, instructions for the draftsmen can be prepared.

5.2 *Map designing*

Map designing is a process that begins with the initial planning by the chief cartographer and his staff, in cooperation with subject matter statisticians, and continues through the drafting stage to the final printing. For most publication maps, design involves placing an irregularly shaped area on a rectangular page or sheet. The empty spaces will be filled with title, legend, scale, insets, framing, and other useful map information. The composition of the map sheet is not always simple; it requires an artistic sense of balance as well as mastery of drafting techniques.

5.3 *Selection of base maps*

Whether to use an existing base map or to prepare a new base map must be decided before drafting can begin and is really a part of the initial planning. If a preliminary map was prepared, the question may already be answered. Almost all census publication maps are small-scale maps. The census area identification maps generally will be compiled from greatly reduced enumeration maps. The census area identification maps, stripped of their lettering, can be used as base maps for publication maps. For statistical maps for the country as a whole, an equal area map may be prepared by the NSO or a national mapping agency.

5.4 *Pencil and ink drafting*

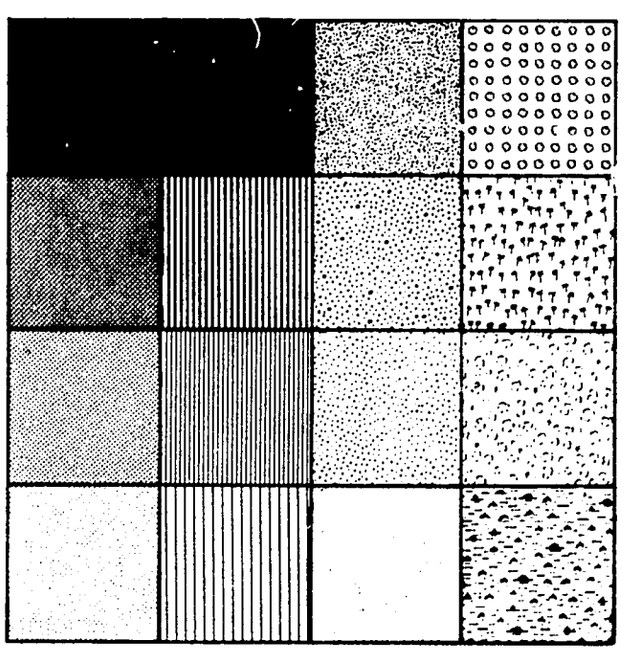
In the actual process of drawing, the maps may be sketched in pencil first and later inked. This will be done if the map is being copied from a map of larger scale by the use of a reflective projector, pantograph, or by the use of a prepared grid. It is preferable to reduce the map by photography to the

desired drafting scale, then to trace the lines directly in ink from the photocopy.

When a census area identification map is based on enumeration maps of much larger scale, it may be necessary to make a pencil tracing of only the map features to be shown on the final identification map (shorelines, boundaries, and names or numbers of census areas). Then, by a series of photographic reductions, the copy can be brought down to the size of the desired final map. At that point, the copy can be traced in ink as a final map. When the map is traced, the map frames are drawn first, then the lettering, followed by the shorelines and boundaries. The lettering is done by hand or with lettering guides before most of the line work is done, since lettering generally must interrupt some lines. The same is true for rub-on or stick-on lettering.

For statistical maps, the base map is prepared first. Symbolization in the form of shading, dots, circles, and the like is added last. Lettering is not often used on statistical maps except in the title and legend. Any shading may be drafted, or use may be made of

Figure 10b. PREPRINTED PATTERNS



preprinted patterns of lines, dots, etc., on plastic film with adhesive backing (see figure 10b). These film sheets are placed on the area to be shaded and pressed down lightly. The excess is removed, then the film sheet is rubbed down firmly. The careful selection of these patterns is a part of map design, as are any ink-drafted patterns (refer to chapter 9).

5.5 *Scribing*

Scribing is an engraving technique that now is being used in mapping as an efficient method for producing line drawings. A negative image is made on coated material, whereas in ordinary drafting a positive image is produced by drawing with pencil or ink. Because the scribed image is generally in negative form, the process is referred to as negative scribing.

Since the mid-1940's, when scribing was introduced to mapping, the technique has been improved continually by the development of stable-base film, good scribable coatings, and dependable scribing instruments. Scribing has been adopted by many mapping agencies and by many commercial map makers to replace ordinary drafting because of the substantial time saved in preparing map copy, better quality of line work, shorter employee training periods, fewer processing steps, and simpler correction and revision.

In scribing, a composite pencil or ink drawing is made of the map. This drawing is then photographically reproduced on a sensitized scribe coat film; at the same time, it is reduced to the scale selected for publication. The selected features on the scribe coat are then scribed with the proper instruments taking care that the correct lineweight and symbolization chosen in map design are followed. With the availability of pin registration, the map can be produced, if desired, on several plates and put back together in a composite negative (see

section 7.36). Reproduction on several plates may be desirable if the map is to be printed later in different editions (for example, with or without certain boundaries, boundaries printed in different colors, etc.) The lettering plate must be separate, because there is no efficient method of scribing lettering. If scribing is used, lettering almost always will be done by the stick-on or the photo reproduction method.

5.6 *Lettering*

Lettering plays such an important role in the appearance of maps and graphs that the need for near perfection in construction and placement of lettering is emphasized. The lettering establishes the initial impression of the work. Slight imperfections that might not mar symbols are quickly detected in lettering.

5.61 Size.--Lettering on census area identification maps is necessary to identify areas or boundaries or both. In many cases lettering is difficult to apply, because the words are long and the spaces on the maps are limited. The size of the lettering will depend on the size of the areas to be named. Also, if more than one type of administrative area is to be identified on a map, the more important divisions should receive larger lettering than the less important divisions. In any case, the smallest lettering should be clearly readable in its final printed form and each name should refer unmistakably to the feature or area it designates.

5.62 Placement.--If the lettering refers to an area or a city, it should be horizontal. Horizontal on a map means parallel to the parallels of latitude whether or not the parallels are shown. For very small areas where it is impossible to place all the letters horizontally or to use abbreviations, names may be hyphenated or be angled upward from left to right. As few variations as possible should be used so that the finished map will appear to have followed a consistent plan. If it is impossible to fit the lettering into the spaces, and if the scale of the map cannot be enlarged, an inset map for part of the area may be the solution. Or numbers may be used to correspond to names, in which case the names and identifying numbers should be listed in the margin of the map.

Lettering for an area should be centered in the area to which it refers. The best place for a city name is centered under its symbol; the second choice is on the right, and the third choice is above the symbol. If it must be placed to the left, it is advisable to put it above or below the city symbol in order to avoid running into the symbol when the length of the name is miscalculated in hand lettering. Names of lakes or other water bodies should be placed in the water if possible. Lettering for boundaries should always follow the trend of the boundary feature and be placed above the line. The lettering that identifies vertical boundaries should always be readable from the right side of the map and all other lettering from the bottom of the map. See figure 10c for illustrations of some of these rules.

Figure 10c. PLACEMENT OF LETTERING

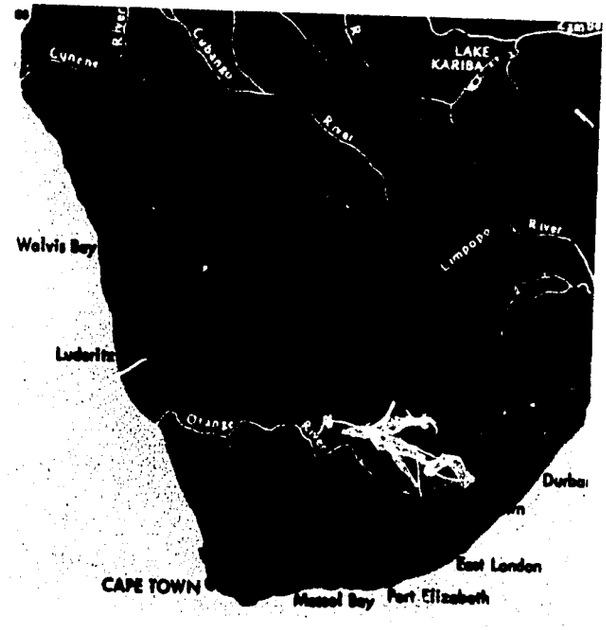


Figure 10d. SELECTED TYPE STYLES AND SIZES

ACTUAL SIZE

Type Style- Directory
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style- Mid-Century
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style - Modern
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style - Light Italic
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcedfghijklmnopqrstuvwxyz 1234567890

Type Style - Letter Gothic
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

75% OF ACTUAL SIZE

Type Style- Directory
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style- Mid-Century
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style - Modern
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style - Light Italic
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcedfghijklmnopqrstuvwxyz 1234567890

50% OF ACTUAL SIZE

Type Style- Directory
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style- Mid-Century
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

Type Style - Modern
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567890

5.63 Style.--The lettering style chosen for maps is a very important aspect of map design. Types of lettering highly effective in advertising, book, and decorative work might be a poor choice for maps. Lettering styles on maps should be reasonably simple to avoid calling attention to their design. They must be legible and open enough to reproduce well by the lithograph process, yet not so bold as to overwhelm adjacent types or to cause spottiness on the map. Lettering styles should blend in reasonable harmony when mixed.

If the lettering is done by hand or with lettering guides, the choices of lettering styles are very limited. While the plain lettering produced with lettering guides may be adequate for many census maps, this technique may fail when very small letters are needed. Then, unless the map is drawn at a much larger scale than normal, the lettering will be too large to fit into the proper space on the map. Accordingly, much lettering is now done with preprinted words on plastic adhesive film (stick-on) type specially prepared for the map in hand. With this technique, it is possible to select many different styles and sizes of type (see figure 10d); they are usually available in light, medium, or bold forms with

italics to match. Also, some type styles are available in condensed form; this makes the lettering easier to fit into small areas.

Stick-on lettering may be ordered from special commercial printers in many parts of the world. If materials and a photographic laboratory are available, stick-on lettering can be prepared at the NSO. Typewritten copy can be photographed and contact printed on a special translucent stripping film. When the underside of the resulting sheet copy is then waxed (using a waxer), it is ready to apply to the map.

5.7 *Color separation and screens*

In preparing maps for color printing, a separate drawing must be made for each color. For large areas of color, such as water or the shadings of a choropleth map, the use of open window negatives is required. This is most often accomplished by the use of sensitized coated film on which an area or areas to be shown in the same color are opened up by peeling off the desired area with a knife. (See section 3.5 of chapter 9 for a more detailed description.)

Black and white maps may also be prepared in the same manner by using a separate drawing or window negative for each different black and white shading. Photographic screens with different shadings and different patterns can be used with the window negatives to produce the final negative for the printing plate. In effect, the screens are used to produce shading that is similar to that obtained by applying shading patterns on plastic adhesive-backed film to a one-sheet drawing. There are some advantages to producing black and white shaded maps by using separate negatives. It takes less time to peel than to apply adhesive-backed patterns; moreover, the final product usually has fewer imperfections.

6. *EDITING AND VERIFICATION*

Suggestions for editing and verifying the drafted enumeration base maps were covered in chapter 6. For publication maps and graphs, some different operations are involved. It is recommended that the personnel who set up the instructions for publication maps be responsible also for editing and verification.

6.1 *Importance of review of publication maps*

It is an expensive operation to produce graphics from collected statistics and print them in large quantities. Therefore, this operation requires systematic and thorough review, often at several stages in order to produce reliable results. An editor-verifier should be thoroughly familiar with (a) the established drafting standards, (b) the normal techniques for producing illustrations in the various media, and (c) the practices followed by the drafting staff.

6.2 *Steps in editing-verifying publication maps*

When a drawing or illustration is to be checked, a copy should be made. On this copy, the editor-verifier can note any corrections. Thus the original drawing does not have to be marked up or handled unnecessarily. When the draftsman has made the corrections on the original, the editor-verifier can compare it with his annotated copy to be sure that all of the corrections have been made. If there are further errors, he can use a pencil of a different color to indicate them on his copy. This editing procedure refers primarily to line-type black and white drawings, but a similar system should be applied to drawings of all types.

In order to do a thorough job, a checklist of questions is suggested. With some adaptation, the following may be applied to most drawings.

First, ask whether the drawing fits the overall requirements. For example:

(1) Will the drawing reproduce? Will it be possible to make prints or other copies from it?

(2) Are the lineweights such that they will reproduce well?

(3) Does the drawing meet standard requirements for format? Is the size correct? Are the headings and legends properly placed?

(4) Has proper reference been made to source materials?

(5) Does the drawing carry the correct identification or code number?

Then consider whether the proper methods of representing the area have been used and whether the drawing shows that area and its subdivisions.

(1) Is the projection the proper one?

(2) Is the drawing adequate to clearly show all the information necessary, and is the material arranged properly?

(3) Are lines and symbols consistent with standard requirements?

(4) Is the proper drawing scale used? Is that scale properly indicated on the drawing?

(5) Do the dimensions agree with the original layout or information?

(6) Is there enough information shown so that the map can be understood? Note that information (such as names) should not be repeated unnecessarily; there is danger that a correction will be overlooked for a name that is duplicated.

(7) Are all necessary explanatory notes given and are they properly placed?

(8) Are all figures and letters properly formed?

(9) Are standard terms and standard abbreviations used?

(10) Does the map or graph accurately represent the statistical data on which it is based?

7. *MATERIALS AND EQUIPMENT*

Good materials and adequate equipment are necessary if quality maps are to be produced. The size of the operation will greatly influence what equipment is necessary; this in turn may affect what materials are needed. A larger or more populous country is likely to need more maps; unless more efficient equipment is used, it will take more time and staff to do the work.

7.1 *Basic considerations*

There are several basic considerations which the NSO should take into account when they are planning the drafting operations for the census mapping program. The considerations are important even when drafting is an ongoing activity.

7.11 Space.--Draftsmen need ample space because they are working on large documents and using a variety of large source materials simultaneously. Each draftsman should have an effective working surface of at least 2 square meters, plus space to store his equipment securely and to keep his various reference materials. The minimal floor area is at least 6 square meters per draftsman, not including walkways, central files, central material storage, or other common area. A total of 14 to 18 square meters per draftsman for everything is desirable.

The space must be well lighted, clean, dry, and equipped with adequate electrical outlets. A dangerous intertwining of extension cords should be avoided. It is desirable for each draftsman to have his own light source. If possible, the work area should be close to the central map files for convenience in moving drawings, map packages, and other source materials. Also, it should be close to the central storage area for materials.

7.12 Availability and applicability of existing equipment.--If equipment is available from earlier operations or other agencies, its use should be considered. However, the planners must consider whether they could get the drafting job done faster and cheaper using new equipment; the older equipment could cost more to use in the long run. The entire range of possible types of equipment, procedures, and materials must be considered before a final decision is made.

7.13 Resources.--Resources ultimately are financial. How much money is available for the drafting operation? Is available space usable? Should it be renovated or should new quarters be built? The same questions may be asked about equipment. The desirability of the various options must be calculated and measured against their cost and the resources available. The situation in each country is unique to a large degree, and there is no simple answer to these questions. However, these are points that NSO planners must consider in preparing for a successful census.

7.2 *Materials*

The quality of drafting media is very important. A draftsman using good materials may not always produce good work, but a draftsman using poor materials will never produce good work. For example, a draftsman should never try to do a finished piece of work on paper that has a grain in it. The grain will usually show up on the contact prints of the drawing, because it affects the evenness of the flow of ink onto the paper, creating an uneven line. Drafting media in general use are described in the following paragraphs.

7.21 Drawing and tracing paper, cloth, and film.--Drawing paper varies in quality. The highest grade has a smooth finish and withstands ink erasures without damage to the finish. Low grade paper may be satisfactory for pencil work of a temporary nature.

Vellum is white or slightly tinted and may be transparent or translucent. The more transparent vellums are used as tracing papers. Formerly, they were used almost exclusively for the ink tracing of pencil drawings made on opaque papers. Transparency was the prime requirement. Today, the usual drafting practice is to develop the master drawing directly on transparent paper from which positive reproductions can be made, thereby saving the time, expense, and checking involved in the tracing process. Therefore, in addition to good transparency, the modern high-grade tracing paper must be able to withstand repeated erasures, take pencil marks well, and be strong enough to withstand considerable handling. The paper should retain these qualities for a long period of time to avoid the necessity of recopying either manually or photographically. Natural tracing papers have properties which depend on weight, method of manufacture, and raw material. If made of rag, they are usually fairly strong for their weight; also, they are permanent but not transparent. If natural papers are made with high transparency, they usually possess only moderate strength and are recommended for sketching purposes where permanency is not a factor. Transparentized or prepared tracing papers have been strengthened and further improved by means of a solid, stable, synthetic resin which is permanently blended into the thicker paper to give it higher transparency.

Tracing cloth is a finely woven fabric which is coated heavily with a starch-like compound and rolled to produce a glossy surface on one side and a dull surface on the other. The dull side is intended as the working side, because it takes ink more readily, and it can be worked on with a pencil when changes in the drawing are necessary. Cloth combines the advantages of transparency, surface quality, strength, and permanence. It can withstand repeated erasures without major loss of surface quality, and aging does not materially affect

its drawing and reproduction qualities. Though paper may be better than cloth in one or more of these characteristics, paper does not equal the combined advantages of cloth. The so-called linen cloth is actually cotton cloth with starch to give a surface that takes pencil and ink, and makes the cloth transparent for tracing and reproduction purposes by penetrating the spaces between the fibers. Tracing cloth is becoming more difficult to obtain since it is rapidly being replaced by film plastic.

The most recently developed drafting medium is polyester-based film. This film has natural dimensional stability, great tearing strength, high transparency, high age and heat resistance, and is nonsoluble and waterproof. The polyester film has a matte surface on one side which accepts ink or pencil. A major use of the film is to serve as an overlay for lettering.

As indicated in the preceding paragraphs, there are many qualities to be considered in selecting a drafting medium for the job at hand. These include a consideration of whether the medium is designed to take ink or pencil or both. The color, the visual transparency, and the suitability for the reproductive process must be considered; the master copy must be transparent if the diazo process is used. Also, the strength, erasability, permanence, and the dimensional stability under varying conditions of temperature and humidity must be considered. Dimensional stability is of particular concern for color separation drawings and open window negatives. Dimensional stability, which is very important, is the degree to which a material will remain the same size or will not expand or contract more in one direction than in another.

Drafting material is available in rolls, in sheets, and in pads. Typical roll lengths are 18 and 45 meters (20 and 50 yards) and typical widths vary from 60 cm to 135 cm in increments of 15 cm (24 inches to 54 inches in increments of 6 inches). Sheets generally must be ordered; however, supplies of some of the popular sheet sizes are often available. These items are now more widely available throughout the world than ever before.

7.22 Scribing materials.--While various base materials have been used for scribing (including glass, thermally set plastic, black thermoplastic, and vinyl), only polyester film is now used for most scribing work. Scribing material is made by covering polyester film on one side with an opaque emulsion that can be either cut to permit light to pass through lines or peeled or scraped to permit light to pass through areas or "windows." In some cases an emulsion may be sensitive to light or chemicals; this permits the lines or areas to be made by washing off the emulsion after it has been exposed, as with photographic or diazo film. This technique can be used to produce either positives or negatives.

Polyester film, which is an extremely tough material with good dimensional stability under a wide range of heat and humidity conditions, has eliminated breakage and tearing problems. If the hard film surface is penetrated, however, the scribing point will dig into the material; thus the scribing touch is rather critical, but presents no real problem once the scriber acquires a "feel" for the material. With the proper touch and correctly sharpened points, the scribe coating is removed cleanly; in this respect, it is a distinct improvement over other materials, including vinyl. The film is available in various thicknesses from 0.006 cm to 0.025 cm (0.0025 to 0.010 inch). The 0.019 cm (0.0075 inch) thickness is generally used for color separation scribing. The most widely used polyester films are scribe-coated sheets in rust, white-on-rust, and yellow.

Although sensitized sheets are available commercially, sometimes an existing supply of sheets can be sensitized in the office. The

sensitizer may be applied to the sheets in a whirler, or by rubbing, flowing, or swabbing.

Expansion and contraction characteristics of base materials differ. Therefore one type of base material, preferably polyester film, should be used from manuscript stage through press negative stages to improve registration (see section 7.36).

Strip-coated polyester sheets, which can be peeled, are used principally for preparing area pattern and tint color separation plates for publication maps. When the deep-etched chemical process is used, the film is first sensitized with a deep-etch sensitizer, then exposed to the original copy, developed with deep-etch developer, and finally etched with alcohol. Exposed and developed areas are removed with water, after which the coating can be peeled from the desired areas. The outlines of areas to be stripped also can be cut with a swivel cutting knife, if the chemical etching process is not to be used. Another commercial type of strip coating, which is transparent, is designed for cutting only.

Commercial coatings, when they become old, sometimes break away from the base. This drawback can be partially overcome by coating the etched sheet with a flexible transparent paint which seals the edges of the etched lines. An even better safeguard is the preparation of a contact negative of the strip-coated negative when it has been completed.

After considerable experimentation, the colors of coatings have been narrowed to yellow, rust, and red for scribing plates that are to be processed directly to the printing plate. Several colors, presumably easier on the eyes, were discarded because they were not opaque enough for press plate work. (To satisfy scribers that the red and yellow coatings were not injurious to their eyes and that the scribing operation in general was not detrimental to their health, medical studies have been made; these have found no cause for uneasiness.)

7.23 India ink.--India ink came originally in the form of small cakes from which particles were rubbed into a small container and diluted with water. This ink in older times came from India--hence the name. As sold today, it is already dissolved. It consists of very fine carbon particles (lampblack) suspended in a liquid composed of various ingredients. This liquid has the same specific gravity as the carbon, and thus the carbon does not settle. India ink is deep black, has excellent photographic qualities and, when dry, is waterproof. It dries quickly for fine map work.

When not in use, ink bottles must be kept closed to prevent evaporation. It is advisable to buy a large bottle and fill a small one that can be washed and refilled every few weeks. This is better than adding water, which spoils the ink.

7.24 Reproduction white.--There are several mechanical aids available for correcting ink drawings so that they may be suitable for reproduction. Unnecessary ink lines can be removed by (a) painting them over with reproduction white; (b) scratching them out with a razor blade; or (c) erasing them with an ink eraser. The fastest method is the use of the opaquing liquid called reproduction white; it is applied with a fine sable brush. Reproduction white, even in a thin layer which is semi-transparent to the eye, has the quality of preventing photographic reproduction. It cannot be used, therefore, when contact prints will be made since the master copy must be transparent.

7.25 Pattern prints on adhesive-backed clear film.--Adhesive-backed transparent films that are preprinted with small dots, lines, or other patterns are available. The selection of the patterns depends on the effect desired

and the amount of reduction that will take place through the reproduction stages. First, a drawing is made with pen and ink. All pencil lines must be removed and all corrections made before the adhesive sheet is applied. The pattern is pressed on the drawing where the tone is desired; then a razor blade or a knife with a sharp pointed blade is used to remove the sheet from the areas where the tone is not wanted.

7.26 Lettering on adhesive-backed clear film.--Lettering, words, and point symbols on adhesive-backed film are also available. These are cut out, placed on the copy, and pressed down. In another process, the letters and symbols are rubbed directly onto the copy; the ink, which contains an adhesive, transfers to the paper and the film sheet is removed.

7.3 *Equipment*

Equipment and instruments of good quality should be purchased so that good workmanship is made easier. The costs for initial equipment and instruments can be considered a capital investment. Catalogs are available from manufacturers that give sufficient equipment information. An attempt will be made in this chapter to select and discuss the more basic types.

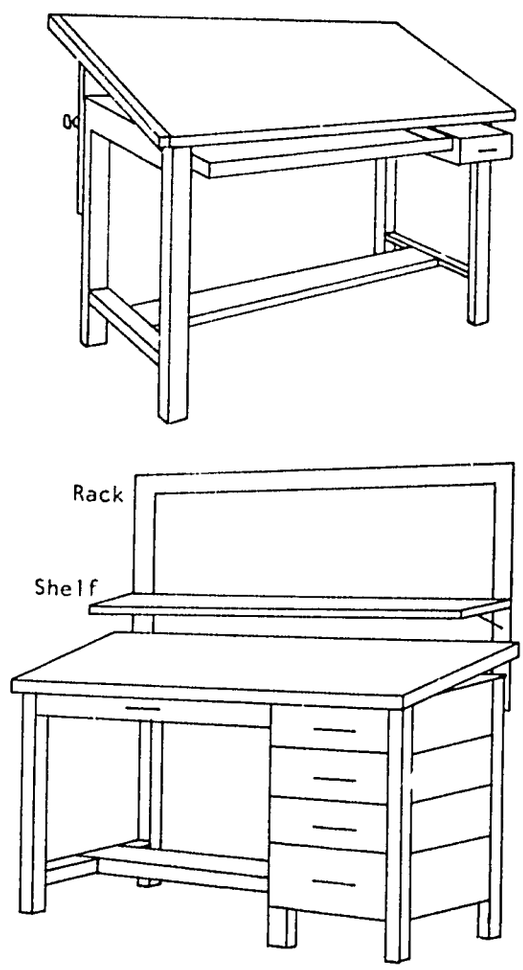
7.31 Drafting tables and related equipment.--Drafting tables are available in various sizes and styles and with various arrangements of drawers. A useful adaptation is the rack and shelf added to the drafting table as shown in figure 10e. The drawing paper can be moved freely under the shelf and can hang down on the outer side. The frame at the back permits attaching large reference maps and the shelf holds small reference material, books, atlases, field sketches, and photographs.

A drafting table can be constructed with 1-inch plywood or a drawing board which is generally made of white pine, basswood, or some other soft wood. It should have a smooth top surface and a straight working edge at the side.

Sometimes a drawing board on a regular table or desk is used. In such instances, it is raised on wedges placed under the board so that when the board rests on a table, the drawing surface slopes toward the draftsman. A recommended maximum slope is 1 vertical unit to 8 horizontal units.

It is common practice to cover drawing boards, especially the larger and more expensive ones, to ensure cleanliness, to protect them against nicks and scars, and to provide a resilient surface for pencil drawings. A desirable drawing board cover is made of some material that will lie flat with a minimum of

Figure 10e. DRAFTING TABLES



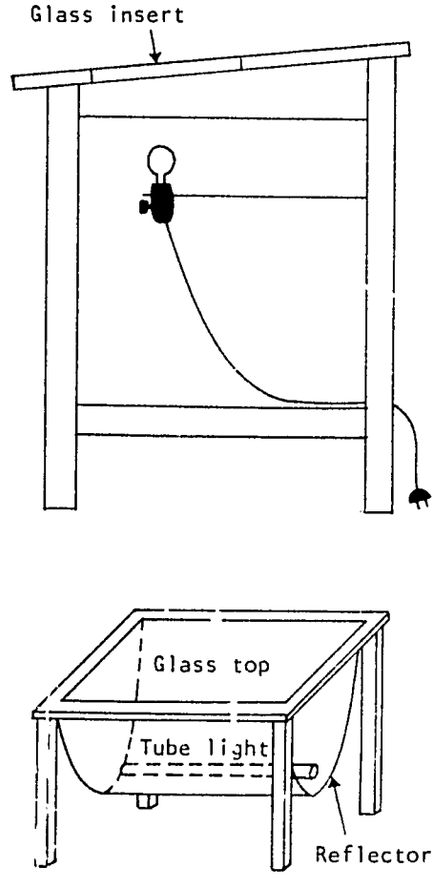
folds or wrinkles. It should have enough body to provide protection; it should not be too hard or too soft; and it should be strong enough to withstand considerable use. If it is too hard, a drafting compass needle point will not penetrate it, and the compass will not hold its position. If it is too soft, it will become grooved and will scar quickly. Manila paper is commonly used to cover drawing boards. There are, however, papers on the market with a high gloss waterproof finish on one side which will withstand many cleanings.

More light is required for drafting than for normal administrative office work. If overhead lighting is insufficient, lamps should be obtained for each individual drafting table. The most popular drafting lamp is the floating arm type of fluorescent fixture which clamps onto the desk or drafting table.

Drafting surfaces should be at a comfortable height for the draftsman to work while standing. This is usually about 1 meter (36 to 40 inches). A stool should be provided. It should swivel (turn freely), have a low or adjustable backrest, and a foot ring, and be adjustable in height from 70 to 85 centimeters (28 to 34 inches) as illustrated in figure 10f.

Figure 10f. SWIVEL STOOL

Figure 10g. DIAGRAM OF LIGHT TABLE



7.32 Light tables.--A light table, or tracing table, has a frosted glass surface and lights (preferably fluorescent) under the glas (shown in figure 10g). The better tables have switch mechanisms that allow the user to vary the light intensity. The light table, like the drafting table, stands about 1 meter (36 to 40 inches) from the floor and is the most used table in a map drafting room. It is an absolute necessity for scribing or for making tracings from originals on opaque material.

7.33 Pantograph.--The pantograph is an instrument for copying drawings to the same, a larger, or a smaller scale. There are a number of different types of pantographs, but the principle governing them all is the same. It consists essentially of a system of bars pinned together in parallelogram form (see

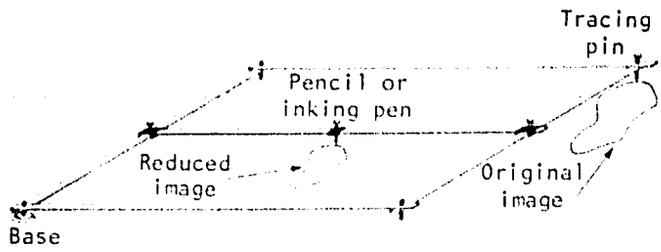
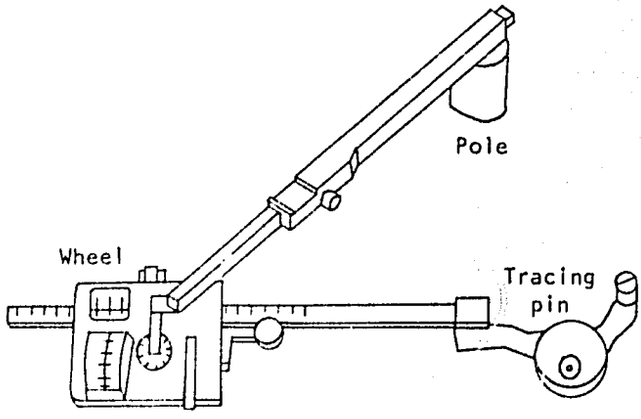


figure 10h). Holes are provided in the arms at certain measured intervals so that the instrument can be set to give a ratio of reduction or enlargement. The four arms, which may be made of either wood or metal, are joined at four points. The location of the tracing point relative to the pencil follower controls the amount of reduction or enlargement. The use of a pantograph is less efficient and accurate than photography, but it is a good method when photography is not available or when only a small section of a map is to be copied.

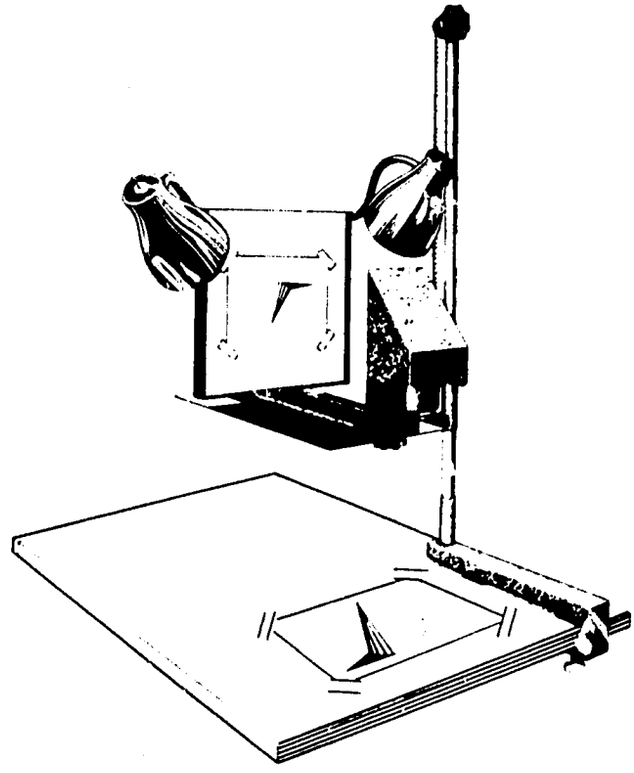
7.34 Planimeter.--A planimeter is an instrument used for measuring areas on maps. It is used when the shape is irregular since the operator can determine the size of the area by tracing the boundary. There are several types of planimeters, some designed for very specific purposes, such as the radial planimeter, but the one most available and best known is the polar planimeter. Its function is to determine areas (in units of wheel revolutions) with one simple tracing operation. The planimeter is supported on the paper at three points--the anchor point or pole, the wheel, and the tracing point (see figure 10i). The measurement is made by placing the tracing pin at a convenient point on the boundary of the area to be measured and recording the reading on the wheel. Then the tracing pin is carefully guided around the entire boundary of the area to the starting point and another reading is recorded. The difference between the two readings determines the size of the area. The average of several measurements may be used if more accuracy is desired.

Figure 10i. POLAR PLANIMETER



7.35 Reflective projector.--The best reflective projector projects an image onto a horizontal surface. The draftsman can pencil or ink the image directly onto his drafting surface. The projector can be hand-made, or it can be a fine piece of manufactured equipment with high-quality lenses available at high costs (see figure 10j). In equipment of this

Figure 10j. REFLECTIVE PROJECTOR

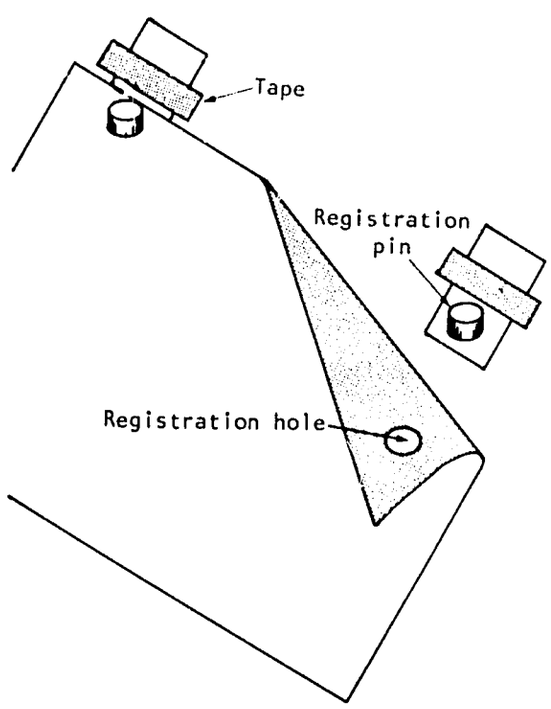


kind, light rays are used to transfer the picture from a reflective surface to either an opaque or translucent surface. A projector is particularly useful for enlarging and drawing images directly from air photos. These projectors are limited, however, to enlargements or reductions of four or five times. Reflective projectors are very useful for copying work that requires limited enlargements or reductions, but they lack the versatility and efficiency of cameras.

7.36 Registration punch and pins.--Whenever two or more tracings or negatives must be registered to match each other, it is necessary to use a registration punch and pins. The principal use of registration is in color separation work, but it is also required for black and white work if two or more drawings are used; for example, a drawing with boundaries of the administrative areas and an overlay with the names of the areas.

A registration punch is a precision piece of equipment that punches two or more holes in a complete set of perfectly matched file tracings, negatives, or positives. With a registration punch are separate registration pins that perfectly match the diameter of the holes. After the original work has been punched and separated, it may be put together again in perfect registration by using a pin in each hole (see figure 10k).

Figure 10k. REGISTRATION HOLE AND PINS

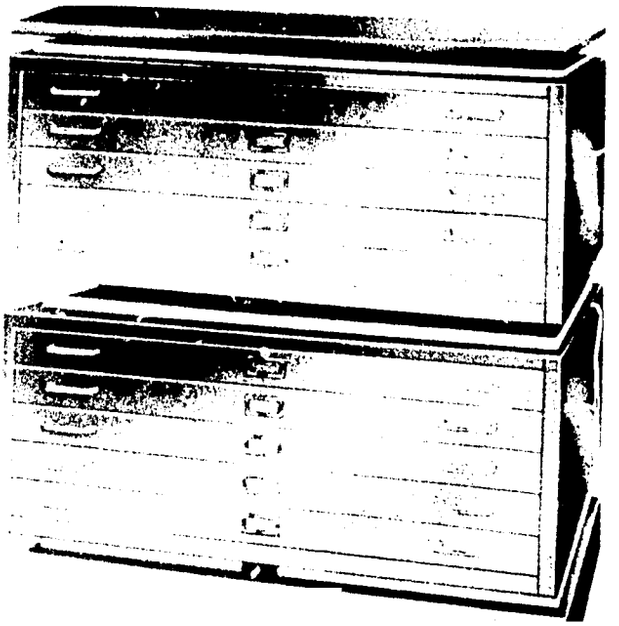


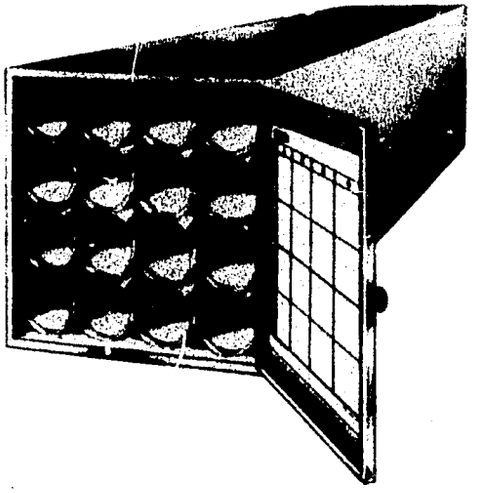
7.37 Filing equipment.--Map cases are available in steel or wood and in assorted sizes. The features one should look for in a map file are: drawers large enough to hold most maps without folding; shallow drawers, no more than 6 to 7.5 cm high (2½ to 3 inches) (thicker stacks of maps become unwieldy and heavy); drawers that ride on rollers and lock in an open position; dust covers; individual units that fit on top of each other and lock together; and smooth tops that provide work space (see figure 10ℓ).

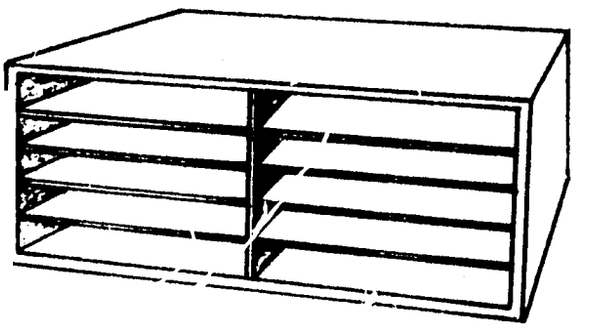
If map drawer units are not available, open stacks can be built that will serve reasonably well. Map stacks must be strongly built to carry the weight of paper when sheets are stacked together in piles.

7.4 *Instruments*

Few skilled workers can do a good job with poor tools, and draftsmen are no exception. Drafting instruments and equipment should be well made and should be kept in good condition. A competent worker will do better work if he is furnished proper instruments and good materials. Since such workers know the importance of good equipment, they will make every effort to keep them in good condition. Each instrument and piece of equipment is designed to do a certain job, and should be used to do the job for which it was designed. A good set of drafting instruments will last a lifetime if given proper care. There are a few basic rules for the care of equipment:







(1) Have a place for each piece of equipment and keep it there when not in use.

(2) Keep all instruments in their cases when they are not in use.

(3) Keep pens clean.

The basic equipment for most drafting assignments consists of a drafting table or board with a straight working edge on at least one side, a T-square, a set of triangles, scales, pencils, ink, a protractor, an eraser, curves for drawing irregular curved lines, and a set of drafting instruments. Each instrument set should include ruling pens, drafting compasses, and dividers. Special instruments are required for more complicated drawings. Many draftsmen prefer to use free-flowing pens instead of ruling pens. They have some definite advantages for drafting EA maps.

7.41 Pencils.--The selection of a grade of pencil lead is to some extent a matter of a draftsman's preference. The 18 grades of pencil lead, from 9H (hardest) to 7B (softest), may be broadly divided into three general categories as follows:

9H to 4H.....hard
3H, 2H, F, HB.....medium
B to 7B.....soft

In general, the harder leads are used more for precision drafting. The medium lead is used for general purpose work, for tracing, and for lettering. The softer leads are ordinarily used for shading.

The standard leads that are referred to above are used primarily on paper and cloth, although they may be used also on drafting film. However, there are pencils now on the market that are designed specifically for use on film. Since the grade designations vary by manufacturer, it is necessary to check them carefully before making a selection.

7.42 Erasers.--Many types of erasers are available. There is a rubberless vinyl eraser for use on films and cloth. Ordinary pencil and ink erasers are used on cloth and paper; these vary in softness--the softest are usually red, and the hardest are usually white. Then there are gum cleaning erasers. To clean finger marks or smudges from the surface of the drawing paper, a gum eraser is recommended. A hard eraser should not be used to erase pencil lines, since it will damage the surface of the paper. To remove eraser crumbs from the drawing after each erasure, use a dusting brush.

Many draftsmen also use kneaded erasers. These are made from synthetic rubber or plastic and may be kneaded in the hands to form a fine point. They have the advantage of leaving few crumbs on the drawing and can be used to pick up graphite dust, rather than to rub it off.

An electric erasing machine is a time-saver when there is much erasing to be done, but it is hard to use on paper without damaging the surface. It has a hard eraser at its tip, which revolves very rapidly when the machine is turned on. To use it, touch it gently to the line to be erased. Any undue pressure on the eraser will cause it to bite into the surface.

The erasing shield is a small plate of thin spring steel that has holes of various shapes punched out. The open holes in the shield make it possible to remove unwanted lines without touching other work. Further, the sharp edge of the metal cuts away the smudged exterior of the eraser permitting a clean portion of the eraser to rub against the surface of the drafting paper or cloth.

In addition to gum erasers, cleaning compounds that contain pulverized gum eraser particles may be squeezed onto the drawing from a plastic squeeze bottle. Gum eraser granules are also packaged in cloth bags (eraser pads) made of a soft mesh. The granules sift through the bag as it is rubbed over a drawing. The eraser pad also is excellent for pre-cleaning the drafting surface to prevent later soil buildup.

Frequently, ink may be removed more easily from drafting media, especially cloth, by scraping rather than rubbing. This procedure is facilitated by careful use of a steel knife eraser.

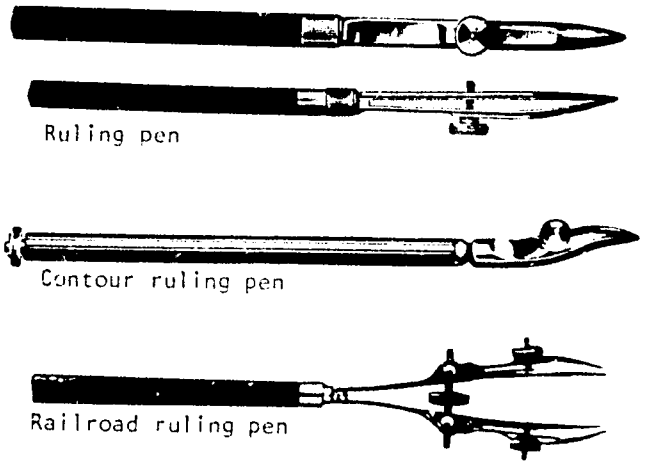
7.43 Ruling pens.--The ruling pen is used with a guide for ruling lines of uniform width. It should not be used for freehand work. It consists of two steel blades, called nibs, attached to a handle. The blades are of equal length, narrowed at their tips. A set screw is used for adjusting the distance between the nibs at the tip to correspond to the width of line desired. Tightening the screws brings the nibs closer together so that the pen makes a thinner line.

The standard ruling pen has an adjustable spring blade, flexible enough to permit opening it wide to clean the inside of the nibs. Another type has a hinged blade, which allows the pen to be opened, cleaned, and snapped back in place with the nibs the same width apart. This is convenient if there is a long piece of work to be done which requires many lines of the same width.

There are several useful variations of the standard ruling pen (see figure 10m). It can be used for very heavy ink lines as well as for light lines. The contour pen has blades attached to a shaft which rotates inside the hollow handle, and it is particularly useful for freehand drawing. The railroad pen has two sets of blades which can be set to draw parallel lines of equal width or of different widths.

The bow pen and the pen attachment for a drafting compass are also variations of the

Figure 10m. RULING PENS



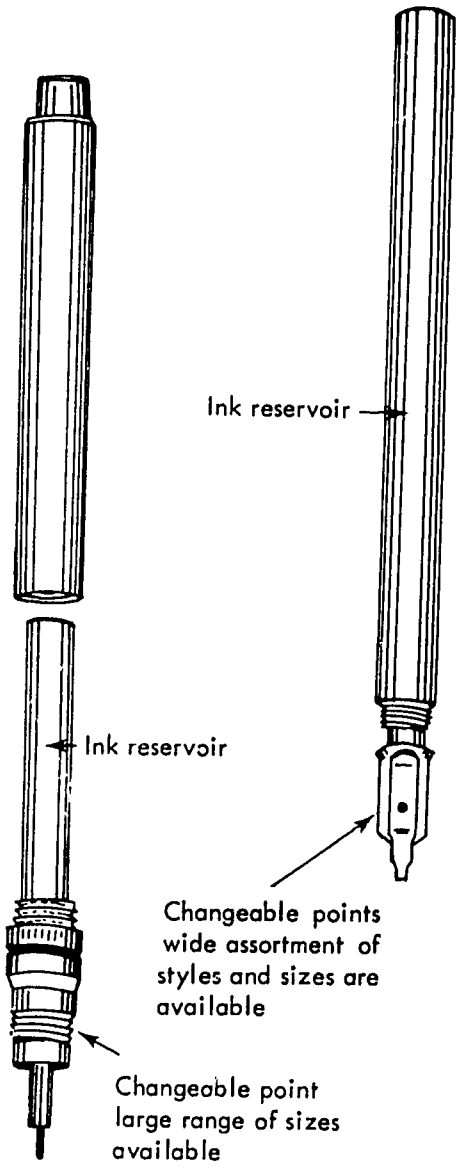
standard ruling pen. They both are used for drawing circles, and may be adjusted to make circles of different radii. They are filled and cleaned like the ruling pen.

7.44 Mechanical free-flowing pens.--Special pens are available in various sizes ranging from 0.13 mm to 2.00 mm, and will draw line widths in accordance with International Standard 1503098/1 for technical drawings. A number of them are well suited to freehand work. These pens are particularly good for drafting enumeration maps. They hold a large reservoir of ink and are much easier and quicker to learn how to use than the ruling pen (see figure 10n).

7.45 T-squares and straightedges.--The T-square gets its name from its shape. It consists of a long straight strip, called the blade, which is mounted at precise right angles on a short strip, called the head. The head is mounted under the blade so that it will fit against the edge of the drawing board while the blade rests on the surface. T-squares vary from 0.5 to 2 meters (or from about 18 to 72 inches) in length, with the 1-meter (or 36-inch) length being the most common.

The T-square is used for drawing horizontal lines; it also serves as a base for a

Figure 10n. FREE-FLOWING DRAFTING PENS



triangle when vertical and inclined lines are drawn. Lines should always be drawn along the upper edge of the blade. The T-square is moved up or down to position by sliding the head along the edge of the drawing board with one hand.

The T-square should be handled carefully. If dropped, it may be knocked out of true horizontal and vertical set and become useless. The T-square blade should not be used as a guide for a knife when cutting paper, because the knife may cut the edge of the T-square blade so it no longer is a straight line.

To keep a good T-square true, hang it up or lay it on a flat surface when it is not in use. Hang the T-square up by the hole in the end of the blade, not by the head.

For large drawings, many draftsmen prefer a parallel straightedge to a T-square. The parallel straightedge is permanently attached to the drawing board by a system of cords and pulleys so arranged as to give exact parallel motion to the straightedge as it is moved over the board.

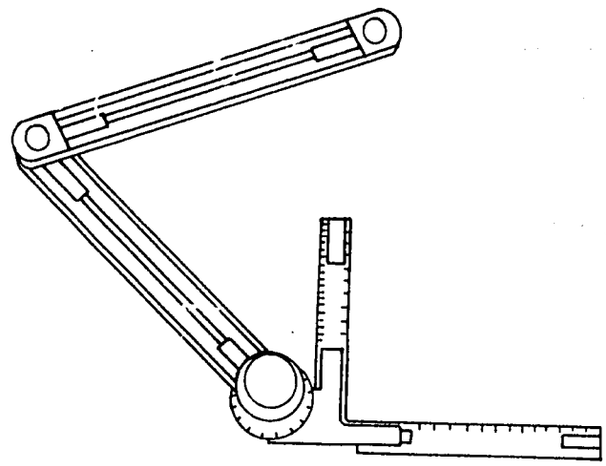
7.46 Triangles.--Right-angle triangles are used in combination with the T-square or straightedge to draw vertical and inclined lines. Plastic triangles are preferable to wooden ones because they are transparent and the work underneath them can be seen. The most common triangles have two 45° angles or have one 60° and one 30° angle.

Vertical lines are drawn by using the T-square as a base for one of the triangles. With the T-square in position, one edge of the triangle is placed against the blade so that a second edge is perpendicular to the blade; then the vertical line is drawn along the perpendicular edge.

7.47 Drafting machines.--The drafting machine combines the functions of a parallel ruler, protractor, and scale. Any drafting operation requiring straight, parallel, horizontal, perpendicular, or angled lines may be performed advantageously with a drafting machine. It is particularly useful on large sheets such as enumeration maps.

Drafting machines are constructed so that a protractor head may be moved over the surface of a drafting table without change in orientation; it is done by means of a parallel motion linkage consisting of two sets of double bars with pin-point linkage. However, the type of drafting machine with two single bars in which the linkage is provided by two steel bands

Figure 10o. DRAFTING MACHINE

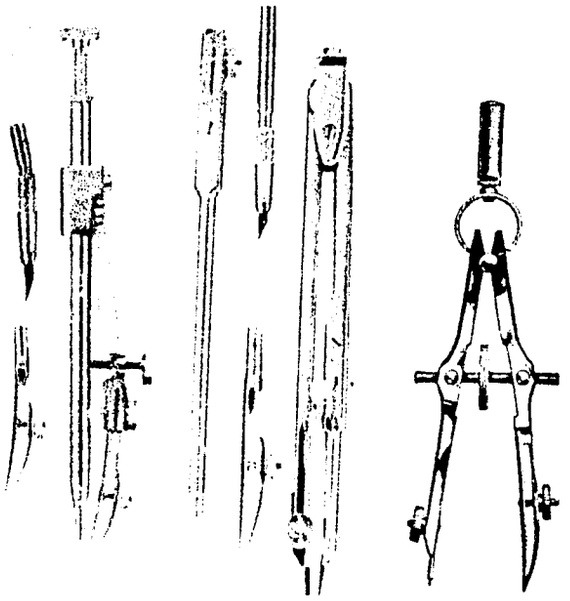


working against one another (see figure 10o) is superior to one with pin-point linkage because there is less motion. Another type has steel bands enclosed in tubes. If these bands become loose through wear or expansion, the tension may be increased; however, such adjustments seldom are needed.

The protractor head in a drafting machine is a complete circle, marked in degrees, to which a straightedge or scale may be clamped at any desired angle. If desired, two scales may be attached to the head at right angles to each other and used as a device for changing scale. A wide variety of scales can be added or removed as desired.

7.48 Drafting compasses.--These compasses are used for drawing circles or arcs of circles. The largest compass usually found in a set of drawing instruments is about 15 cm (6 inches) long. The compass legs are hinged at the top so that they can be set in any desired position. The leg that has the pencil or pen attached usually has a hinged joint in the middle of the leg. The other leg containing the needle point sometimes has a similar hinged joint (see figure 10p).

Pencil and pen are interchangeable so that the same compass can be used for either pencil or ink drawings. A compass can be obtained



with a shoulder on the needle point which prevents the point from sinking too deeply into the drawing surface.

The 15 cm (6 inch) compass is satisfactory for drawing circles to about 30 cm (12 inches) in diameter. For larger circles, an extension bar should be provided which may be fastened onto the adjusting screw in the middle of the compass; the pencil or pen leg then is attached to the end of the extension bar. Two or more extension bars may be used together to make larger circles.

For drawing even larger circles, beyond the range of the standard compass, a beam compass can be used. A beam compass set consists of one or more bars 0.5 to 2 meters (18 to 72 inches) long, a steel needle point, and a pen or pencil point. The bars may be of hardwood or metal. For drawing very small circles, a drop bow compass is needed. This is essentially a ruling pen on a swivel that can be raised and lowered.

7.49 Scales or rulers.--The importance of scales or rulers and their mathematical significance must be emphasized. Once the ratio between the actual size of the item or area being drawn and the size of the item or area as depicted on the drawing has been determined, drafting scales (or rulers) are used to measure distances on the drawing. Drafting scales are in constant use during the drafting operations.

Scales vary in their gradations, style of division, shape, and materials of construction. The most inexpensive scale is made of yellow hardwood. The scales usually used in drafting rooms are made of plastic or high grade boxwood. The plastic scales (less expensive than boxwood scales) have clear, accurate gradations. The boxwood scales have white plastic scale faces which are permanently cemented to the boxwood. Boxwood scales are engine divided--that is, the gradation lines are cut by a highly accurate machine. Various shapes of scales are available. The triangular type provides six scale faces.

7.50 Curves.--To draw smooth lines that are not arcs of circles, guides are used--French curves, splines, and ship curves (see figure 10q). Other guides, such as radius curves, may be used instead of a compass when drawing arcs of circles.

French curves and ship curves come in a variety of shapes and sizes and are made of transparent plastic. They are used to draw non-circular curves, such as ellipses, spirals, and parabolas. Points are plotted carefully on a drawing; then the section of the curve that fits these points is laid down, and a line connecting these points is traced along the edge of the curve.

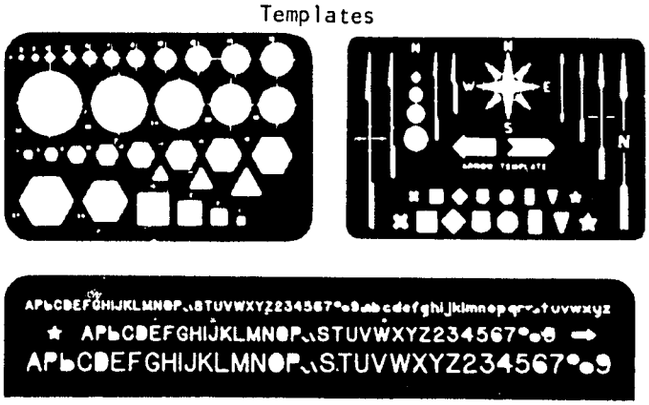
Splines are used to make long, smooth, irregular curves. They are made of flexible strips of wood, plastic, or metal that can be bent to fit almost any long curve or bend. Heavy metal weights (called ducks) are used to hold the spline in place while the line is being drawn.

Flexible curves may be made of rubber and metal and they have a clear plastic ruling edge. These curves can be bent to a radius of 7.5 cm (3 inches) and may be adjusted to fit more than three plotted points of a curve.

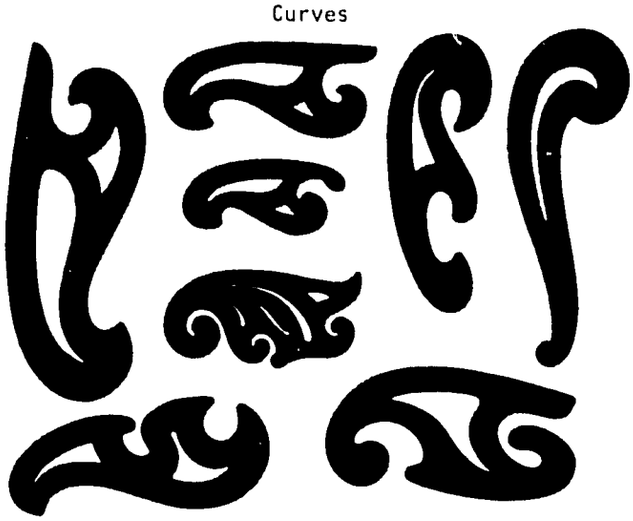
7.51 Templates.--When the same shape or symbol is to appear frequently, using a template (also spelled "templet") can save much time. Most of the templates on the market are made of transparent plastic and offer a wide variety of shapes, including ellipses, hyperbolas, circles, squares, hexagons, and arcs. There are special templates for symbols and shapes used in drawings. Typical templates are shown in figure 10q.

Figure 10q. TEMPLATES AND CURVES

Templates



Curves



There are templates for various standard symbols. However, if one is not available, it can be made from cardboard, plastic, or lead or other metal.

7.52 Lettering guides.--Lettering guides have the advantage of ensuring that letters and figures made with them will be uniform. Using these guides instead of working freehand produces lettering which is professional in appearance and usually more legible. However, they are a little more time consuming to use than freehand lettering.

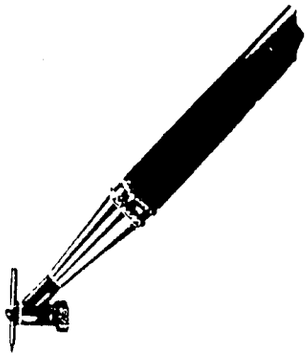
7.53 Photographic type setting.--A draftsman may be called upon to use a photographic process lettering machine. The device produces positive copies on sheets of various sizes or on 35 mm plastic finished paper. The processing is similar for both the film and the paper. Paper positives are generally preferred for design purposes.

7.54 Scribing instruments.--A number of instruments are used in scribing (graving). The following are some that are needed when working with the scribing materials described in section 7.22 of this chapter.

(1) Scribing points. Experiments have been conducted with various types of scribing points, such as diamond, sapphire, ruby, osmium, carbon alloy, and steel points. Phonograph needles and blade-type cutters have been selected by most agencies as standard equipment (although osmium-tipped steel points and some jewel-type points also are used). A steel phonograph needle requires frequent sharpening, compared to osmium, carbon alloy, or jewel-type points; however, a steel phonograph needle is much cheaper, does not require special handling to avoid damage, and can be sharpened to desired specifications without special tools.

(2) Angle pen. The fineline graver in its simplest form is a cutting point in a pin vise with a pen-like holder. For scribing lines up to 0.008 cm (0.003 inches) wide, steel phonograph needles are generally used as they come from the manufacturer, but the steel needle

Figure 10r. ANGLE PEN



can be used to scribe a wider line by simply brushing the tip with a fine abrasive paper. This procedure has the additional effect of improving its cutting quality by removing some of the polish. Because it is necessary that the point be vertical when scribing through a template, and because this position is helpful for other scribing tasks as well, fineline gravers have pen-like holders that hold the point in a near-vertical position when the graver is held in a normal writing position. This design keeps the handle out of the scriber's line of sight (see figure 10r).

(3) Rigid graver. The rigid graver consists of a plate supported by two legs and the scribing point. It has a vertical center rib for a handgrip. The graver has an adjustor (chuck) which permits the use of several sizes of scribing points. The adjustor may be raised or lowered to level the instrument (see figure 10s).

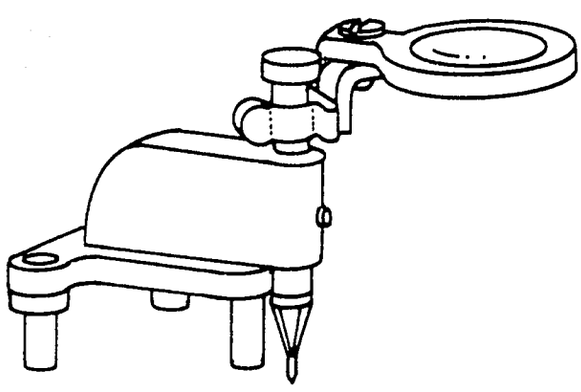
It is difficult to start cutting lines over 0.05 cm wide (0.02 inches) with a round point unless the graver is tilted slightly in the direction of the intended cut when a line is started. The coating can be removed exactly at the start of the line with a chisel-edged cutter, but this type of cutter is good only for straight line scribing with a straightedge, as the cutter must be kept at right angles to the direction of travel to avoid variations in line width.

A spring-loaded rigid graver has been developed that uses a third bell-tipped supporting leg. Scribing pressure is adjusted by compressing or releasing the spring tension. However, experienced scribers who have developed a scribing "feel" tend to prefer the standard rigid graver.

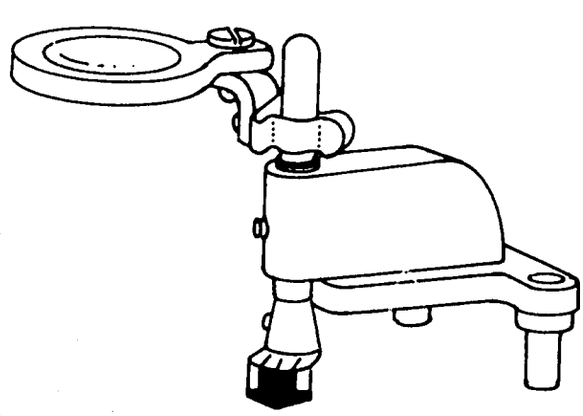
(4) Swivel graver. The swivel graver is a tripod graver similar to the rigid graver. However, the graver point or points are mounted in a swivel that is dragged behind the rigid part and turns freely to follow in whatever direction the main part of the graver is being pulled (refer to figure 10s). It is used in graving irregular lines. It operates efficiently only when the swivel shaft is exactly perpendicular to the work surface. Two initial adjustments are required to bring the shaft to a vertical position. The first is made with the adjustable leg, and the second by sliding the swivel shaft through the housing and then locking it in position with a beveled nut. Both blades and needles can be used in the graver. Blades are used for both single- and multiple-line scribing.

Figure 10s. RIGID AND SWIVEL GRAVERS

RIGID GRAVER



SWIVEL GRAVER



7.55 Screens.--Screens come in two basic types--halftone and tint. The first is used to convert continuous tone to varying sized dots or lines. The tint screen is a film that is interposed between a negative and a sensitized surface to produce a pattern. Those with closely spaced small dots or narrow lines produce the illusion of solid gray. These tints are available in a large assortment of patterns and percentage tones. The tones range from 50 to 200 lines per inch; the 133 lines per inch is the most popular in mapping when offset printing is being used to reproduce the maps. A number of different tint screens may be used in preparing maps for publication in color. The use of different tint screens will result in varying shades of gray, from light to dark, and when used in color reproduction will give different color values. The variation results from the use of different size dots on each tint screen (screen tint). Dots are used in combination to produce all of the different colors needed in the final product. Precision pre-angled screens, in which the lines for a given color are printed at a given angle across the film, should be used.

8. FILING AND STORAGE

The whole purpose of maintaining a filing system is for prompt retrieval of materials. The filing system must be one that allows rapid retrieval, is easily maintained, and permits growth.

Most of the materials stored will be flat map sheets. The best way to keep loose maps is to collect them in simple, brown paper folders or envelopes, about 1¼ meters by 1 meter (approximately 48 inches by 36 inches) or a similar size that will fit conveniently in the available filing equipment. Each folder can hold 25 to 50 maps. The folders can be identified by a number and name label on the outside near the edge where it is readily visible. Each loose map also should be numbered with the corresponding folder number. The folders should be arranged according to the geographic identification code scheme being used in other NSO operations. The drawers of the map files should be marked with these same codes and names. Materials to be filed are of four types:

(1) Map source materials--all of the available map references

(2) Compilation copy--all second generation materials and copies of original maps

(3) Originals--masters and original artwork

(4) Enumeration maps

8.1 *Types of files needed*

The types of files needed will be dictated by the type and scale of operation. Source materials come in many forms and usually consist of loose maps, charts, and photos; however, they may be bound in books, pamphlets, and atlases. These materials can best be preserved in cases and cabinets which permit minimum handling of materials. This is particularly important in storing master copies. For the loose maps and charts, the files should be map cases such as those described earlier (section 7.37). Atlases and gazetteers can be placed flat on shallow shelves, preferably with doors to control dust and to provide security. Books and pamphlets are more easily stored vertically on shelves. Photos are more often required in sets rather than individual prints. If stored in vertical letter file cabinets, they will be most accessible with the least amount of handling. References on large sheets of paper in the source map file folder can be made to those items which are stored elsewhere.

8.2 *Space requirements*

Space requirements are similar to file requirements--they depend upon the type and

scale of operation. There are ways of maximizing the use of space by stacking files several units high, but these are usually very unsatisfactory. It is difficult, and often dangerous, to handle large folders of maps while standing on a ladder. It is often more efficient to stack them only two or three units high and use the tops (about 1 meter above floor level) as working space. Care must be taken to assure that the floors on which the map files will be placed are capable of supporting the combined weight of maps and files. This weight may amount to several tons. Not all floors will sustain this heavy load for months or years.

Conditions for storing maps are the same as those required for storing books. They are best preserved in cool temperatures, 15°C to 18°C (60°F to 65°F), and moderate relative humidity (45 to 50 percent). Maps are preserved better in cooler temperatures, but the room must be warm enough for people to be able to work. The relative humidity is more critical. If humidity is too low, the paper will dry out and become brittle; if too high, mold or mildew will form.

Lighting is very important. It should approach the standard of what is provided in a library or drafting room.

9. SCHEDULING AND CONTROLS

As in most lengthy undertakings, such as censuses, scheduling is extremely critical. The entire operation must be well planned far in advance. The drafting operation depends on map acquisition and compilation, and sometimes on field work being done in advance. EA maps must be available for the census takers when they are required. Censuses are normally taken within a very restricted time. Once the data are collected, they are dated, and the sooner they are published the more meaningful they will be to the user. If graphics are to be included in census publications, they must be ready in time so as not to delay publication.

For an efficient drafting operation, a trained staff with proper equipment and materials must be available. To keep a trained staff, there must be work for them to do at all times. The work on enumeration base maps must be scheduled to meet the needs of the EA map staff, and drafting work on publication maps must follow without any undue delays.

9.1 Work flow

Work flow is the amount of work that goes from one operation to the next. Ideally, it is planned and arranged so that no one is out of work, no one is short of work, and no one has too much work at any time; instead, all have an adequate amount of work to do without either delaying or being delayed by other staff. The achievement of this condition requires a high level of supervision and management and requires excellent planning, all of which involve adequate work control.

Time, material, equipment, and personnel are the key elements in establishing a smooth work flow. Realistic plans must already exist that include estimates of the time needed to produce each unit, the number of units to be produced, and the available personnel, which together determine the rate of production. The actual production must be closely monitored in order to assure that work flows smoothly. Weekly production reports should be prepared; these will be used either to assure that work is moving as planned, or to relocate the personnel, material, and equipment as needed to make work move more evenly. These reports also will permit planning the purchase of more material in advance of its actual need, the recruitment of additional personnel if it becomes apparent that they will be needed (and

before the crisis arrives when they will be needed), and the rescheduling of work plans if this becomes necessary.

9.2 *Progress reports*

A progress report form should be prepared every week. This form should show the total amount of work to be done for a given project, the amount accomplished during the week, the total amount accomplished to date, and the rate at which work must be completed to meet the deadlines. This last item is particularly important, because it is this item that will act as an alarm to correct the situation by reassignments or by obtaining more resources.

9.3 *Control forms*

Control forms are needed for each of the map files and for recording the progress of work in drafting. Persons responsible for maintaining the map files should have a record at all times indicating where any map borrowed from the files is presently located. This may be accomplished by the use of forms stored in the files to indicate who the borrower is and where he is working. This may be a simple form with only the name of the borrower and his initials, his organizational unit, and the date that the map left the file. This should assure that any map can be found for other users when needed.

The control form for map drafting has already been covered briefly in chapter 6. See exhibit 6-3, which is part of the map package cover, and exhibit 6-7, which is a record of mapping operations. These forms provide for the description and date of each drafting action taken in preparing EA base maps. They also provide information for preparing reports on the progress of the drafting operations.

Chapter 11. MAP REPRODUCTION

INTRODUCTION

Chapter 11 discusses various processes for reproducing maps to be used in the census enumeration and in the publications. Although the chapter is intended primarily for technicians who are responsible for making copies of maps, it is of general interest to other persons concerned with the mapping program.

2. SELECTION OF METHOD OF REPRODUCTION

Maps prepared for use in all census operations and publications must be reproducible, since multiple copies will be required. Several factors should be considered in selecting the method or process to be used for reproduction. The more important of these factors are: (a) use of the map, whether in enumeration or in publication; (b) size of the sheet on which the map will be printed; (c) number of copies required; (d) quality of copy necessary; (e) whether in black and white or in color; (f) ease of revision; (g) reproduction timing; and (h) cost of reproduction.

Figure 11a summarizes these factors for each type of map needed for a census. It also indicates the recommended reproduction method and equipment for each map type.

2.1 Use of maps

It can be seen from figure 11a that the maps used in planning and taking a census (hereafter referred to as operational maps) require reproduction methods different from those needed for maps for publication. Different reproduction equipment is necessary for the final product in each case, although cameras (particularly enlarging and reducing cameras) are desirable in processing materials for each kind of reproduction.

2.11 Operational maps.--Enumeration maps are large scale and normally much larger in overall size than publication maps. EA maps are needed only in small quantities (see chapter 7) and require only medium quality paper. These requirements for EA maps indicate that the relatively inexpensive, non-print, diazo type duplication is satisfactory. Diazo type reproduction is also satisfactory for base maps for census work, and for office maps for the NSO, its field offices, and crew leaders. The non-print processes are described in section 3 of this chapter.

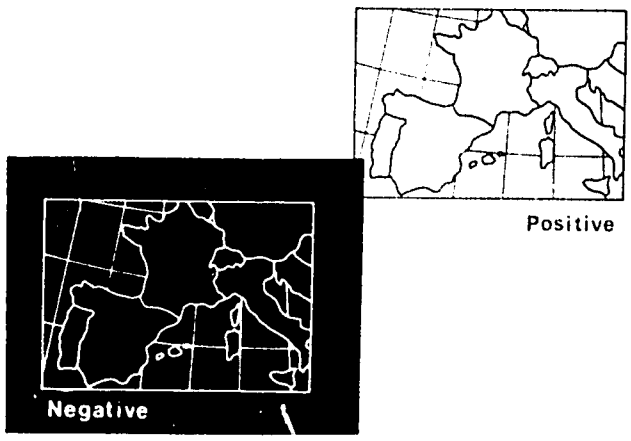
When individual EA's on the EA map sheets are too small when cut out (see section 7 of chapter 7), they need to be enlarged. One method is to make photographic film positives of each EA at a larger scale; diazo reproductions can then be made from these film positives.

A second method is to use a xerographic copier to make the enlargements from the original EA base map sheets. (As described in chapter 7, this is the map on which the EA's were delineated.) The xerographic method of reproduction is limited to an enlargement of about 45 cm by 60 cm (or about 18 inches by 24 inches). However, larger copies can be made by copying the sheets in two or more parts and joining the parts together. For producing one or two prints, the xerographic method is less costly than the photographic methods, because it does not require a film process. However, not all xerographic copiers are designed to make enlargements.

Figure 11a. SUMMARY OF FACTORS IN MAP REPRODUCTION

Type of map by use	Requirements						Method or process	Equipment
	Size	Number of copies	Color	Quality needed	Ease of revision; reproduction time	Cost		
Base maps for de-lineating EA's	Large sheets	Usually 1 to 3	Black and white	Must be clear with sharp lines; fine finished quality not necessary; paper suitable for notation and short-term use.	Master copy must be suitable for quick and easy revision. Need reproduced copies on short notice.	Lowest cost within quality standards	Non-printing process--diazo, photocopy or photography, electro-static	Diazo, printer-processor, enlarging and reducing photocopy film camera, contact printer, xerographic copier
EA maps for NSO field office, and crew leader	Large sheets	Probably fewer than 10	Black and white	Must be clear with sharp lines; fine finished quality not necessary; paper suitable for notation. NSO copy for permanent file; others for rough but short-term use.	Master copy must be suitable for quick and easy revision. Need reproduced copies on short notice.	Lowest cost within quality standards	Non-printing process--diazo, photocopy or photography, electro-static	Diazo, printer-processor, enlarging and reducing photocopy film camera, contact printer, xerographic copier
EA maps for enumerator	Small to large sheets	Normally only 1	Black and white	Must be clear with sharp lines; fine finished quality not necessary; suitable for folding and notation; for rough but short-term use.	Might need reproduced copies on short notice	Lowest cost within quality standards	Non-printing process--diazo, photocopy or photography, electro-static	Diazo, printer-processor, enlarging and reducing photocopy film camera, contact printer, xerographic copier
Maps and graphs for pub-lication	Page size or smaller; separate maps may be large sheets	Large quan-tities	Multiple colors desirable; may be black and white	Good finished quality	Reproduced in one printing in time for publication	Lowest cost for good printing quality	Printing process (usually offset)	Printing press, camera, and contact printer

Figure 11b. EXAMPLE OF A NEGATIVE AND A POSITIVE



Enlargements should always be reproductions of the appropriate portion of the original EA map. This is extremely important; enlarging by hand drawing with mechanical equipment can introduce new errors, a most undesirable result at this stage when the map has had its final check for correctness.

A negative is a film in which the image is transparent and the remainder of the sheet is opaque. A positive is the reverse--the image is opaque and the remainder of the sheet is transparent (see figure 11b). Sensitized materials, such as films and papers, are either negative or positive acting. A negative acting material will produce a negative from a positive and a positive from a negative, reversing each time a copy is made. Diazo paper, which is positive acting material, produces a positive from a negative.

2.12 Publication maps.--Maps for publication are mainly small scale, usually reproduced at page size, and bound in a book format. They must be durable because they will be used repeatedly; therefore use of high quality paper is desirable. Most of these are statistical maps; gradations of value shown in continuous areas over these maps sometimes require the use of color or photographic tint screens. Such maps generally demand a printing process--usually offset printing.

All printing processes require negatives since a negative image must be contacted to the sensitized press plate to produce a positive image for printing. The original copy may be drafted or scribed at a larger size for greater accuracy and then reduced by camera to produce a film negative. This negative is then used to contact to a press plate for printing. Since the original artwork (on paper) deteriorates over time, negatives are an easy and economical way of preserving material in storage.

2.2 Size

Size is a critical factor in reproduction. It is important not only in terms of material costs but also in terms of the size of paper which the printing press and other reproduction equipment can handle. Presses, cameras, contact printers, screens, film, and the like must be able to handle paper of the required size. In the non-printing (diazo) process, used for many operational maps, size is a lesser problem; most diazo-type machines will duplicate material about one meter wide, and meter-wide paper is generally available in rolls, which means that the length of a map is virtually unlimited. If film positives are to be used in the non-printing operation, film of the desired size must be available.

2.3 Number of copies

The number of copies required will often dictate the reproduction process to be used. The numbers quoted here are approximate and should be used only as a general guide. They will vary with labor and material costs in different regions or countries.

If only a few copies (less than 100) are needed, then a non-printing reproduction process would normally be used. The process may use a

xerographic office copier if the sheet size of the copy is small--from 22 cm by 36 cm up to 45 cm by 60 cm (or about 8½ inches by 14 inches up to 18 inches by 24 inches); the diazo process may be used if the sheet size is larger. These processes are constant cost-per-unit types of reproduction; that is, all copies cost the same amount. If one copy costs 10 money units, then 5 copies will cost 50; 10 copies will cost 100; etc.

If large numbers of copies are needed (more than 100), a printing reproduction process generally should be used. The smaller printers are usually less expensive but they are limited in the size of paper they can handle. Although the quality of the product is better than that produced by a xerographic copier or by the diazo process, it is inferior to that produced by larger printers.

Offset printing processes are decreasing cost-per-unit types; that is, the more copies printed, the lower the cost per unit. For example, if one copy costs 100 money units, then 2 copies will cost 50 each; 5 copies will cost about 20 each; etc. Sufficient copies should be printed while the offset plate is on the press, since a major cost is for making the press plate and setting up the press.

2.4 *Quality of copy*

The quality of the copy must meet the needs of the user. Diazo may produce a suitable copy for EA maps but may not keep well enough to use later for publications. Diazo paper tends to become yellow under long exposure to direct sunlight and becomes brittle with age. It is poor planning to choose quality that is not sufficient for the purposes it must serve; but for short-term use and limited quantities, diazo may prove to be the most efficient copy. Although printing processes produce better quality, they are costly and are seldom used for fewer than 100 copies.

2.5 *Black and white versus color*

In planning for reproduction of publication maps, the visual advantages and costs of multiple color over black and white (black ink on white paper) must be considered. The advantages and disadvantages of color were discussed in chapter 9. Cost is usually the primary consideration in making a decision whether or not to use color.

Multiple color printing requires one press run for each different color printed on a one-color press. Each color printed will cost approximately the same. For example, if printing with black ink costs 100 money units, then adding information in red ink will require adding the same charges as printing with black, except that no additional paper will be needed. Therefore, printing in two colors (for example, black and red) will cost almost 200 money units, and a third color will increase the cost by approximately another 100. There are two-color and four-color presses which are much more expensive, but they can reduce the printing time and cost of multiple-color maps.

2.6 *Ease of revision and reproduction*

Operational maps must reflect the latest information and should, as much as possible, be current at the time of the census. It is essential, therefore, that the drafted copy to be used in reproduction for base maps and for EA maps be capable of being quickly and easily revised for quick new reproduction as work progresses and as new last-minute information is received. Black and white copy using non-printing methods is obviously better for this.

Publication maps, on the other hand, are developed on the basis of final collected information and statistics. There is little need for immediate copies as the information is processed. Copy for such maps is final before reproduction is undertaken; then, many copies of continuous high quality are needed.

Thus, the requirement for publication maps is for reproduction by printing press.

2.7 *Reproduction costs and planning*

Materials, labor, and equipment for map reproduction all cost money. Costs vary greatly according to the type of map and its use. As figure 11a indicates, the best and most economical means of reproduction for one type of map use is not necessarily the best and most economical for another type. Reproduction costs must be known and budgeted for in the initial planning for the census. Both printing and non-printing processes should be available so that the most efficient reproduction method can be used for each job. To collect census data is expensive; to make the data inaccurate by not providing good copies of enumeration maps or to fail to make data available because of reproduction and printing costs implies poor planning.

2.8 *Lease or purchase of equipment*

Printing presses, cameras, contact printers, and diazo processors ordinarily are purchased; office copiers are frequently leased. There are two considerations: (a) durability of equipment and maintenance required and (b) rapid technological changes.

Printing presses, cameras, contact printers, and diazo processors are designed to last for decades. During the last 20 to 50 years, there has been comparatively little change in the way in which they operate.

Office copiers, on the other hand, are in a developmental stage and are constantly being improved. Models become obsolete within a few years. They require extensive maintenance, and maintenance costs increase with the age of the machine. Therefore, it is advantageous to lease them.

Frequency of use must also be considered in procuring any equipment. All reproduction equipment deteriorates when it is unused. It may require more maintenance if used only intermittently than if used on a regular basis. Investment in printing presses is high; if they cannot be fully utilized by the NSO, it would be better to contract with an outside printer to print the publication maps. For the efficient making of operational maps, however, cameras and non-printing reproduction machines should be available to the NSO staff.

2.9 *Staff work versus contracts*

Generally most reproduction is best produced "in-house" by a full-time staff. The amount of work required, however, and the timing involved are also factors to be considered in deciding on staff. If there is not sufficient work to keep a printing press in operation continuously on a daily basis, then from both the cost and staff aspects it is better to contract the printing to another government agency or to a private printer.

It is not as necessary to keep cameras, contact printers, office copiers, and diazo processors in constant operation. These items are essential for efficient drafting operations as well, and work will be greatly handicapped if they are not available. Possession of this equipment does not result in a duplication of effort between the map compiler and the printer, because it is then possible for the compiler to send negatives to the printer and thus exercise more control over the quality of copy. This equipment also saves the cost of contracting with outsiders for any camera work which must be done during both the drafting and reproduction processes.

3. *TYPES OF PROCESSES*

Described below for general information and background are the various reproduction processes already referred to. Non-printing processes are described first, then printing

processes. Additional specific information is available from companies which sell, lease, or operate the equipment.

3.1 *Non-printing processes*

If only a few copies of a map are needed, the non-printing (non-inking) processes are generally faster and less expensive; however, non-printing processes are constant cost-per-unit processes and are designed to make only a limited number of copies.

3.11 Diazo.--Diazo (also known as the ammonia process) is directly associated with the chemistry of azo dyes. These are the dyes frequently used to color clothing, yarns, and fabrics. With diazo reproduction materials, the dye-forming potential is present in the form of "diazo salts." In "dry-developing" diazo materials, the diazo salts are coated on the surface of acetate, paper, cloth, glass, and a variety of other materials. These materials are termed "dry-developing" because they do not require contact with, or immersion in, any liquid solution to create their dye image. The hard, sensitized emulsion on dry-developing materials will react to form a dye image of brilliant azo color when exposed to ammonia vapor.

Before development, the diazo emulsion is sensitive to light in the same way that a roll of photographic film is sensitive to light. But there is a significant difference. Whereas photographic film is very sensitive to almost any kind of light, the diazo emulsion is moderately sensitive to only one kind of light--ultraviolet. The diazo emulsion is not greatly affected by indoor lighting but is highly sensitive to all ammonia vapor. Because of this, special care must be taken to store all diazo emulsion products away from ammonia or ammonia vapors. A well-ventilated room with controlled temperature is the best storage space for diazo materials.

To produce a good quality diazo print, the coated material must react in a way similar to photographic film. It must "take a picture" and reproduce an image that contains the information desired. Ultraviolet light is used for a "picture-taking" exposure, since diazo is noticeably sensitive to this kind of light.

When the material is exposed to ultraviolet light and certain areas are protected with some sort of light-blocking material (usually the ink lines of the draftsman), the unprotected emulsion will have the undeveloped color destroyed or faded, while the protected emulsion will remain intact. Then, when this light-exposed material is exposed to ammonia vapor, those areas that have been protected will appear as full-color dye images and the rest of the material will remain blank or clear. Size of copy is limited in one dimension by the length of the roller which is usually slightly more than 1 meter (42 inches). The other dimension is virtually unlimited, since the diazo paper comes in 100-meter rolls.

3.12 Photography.--One of the most common processes in map making is the enlargement or reduction of a base map or other map sources to fit a certain scale. This can be done in various ways, but generally the quickest and best way is the use of photographic equipment. Usually, it consists of an enlarging-reducing camera which can be moved back and forth on a track in reference to the copyholder.

The camera has a large ground glass upon which the image appears. The camera is moved forward or back until the image is of the desired size. Re-focusing the lens after the adjustment for size may be necessary. The most efficient method of producing high quality photographic copy is to make a film negative and use a contact printer for paper prints.

One type of photography, generally the quickest, is produced by a photocopy camera.

Photocopies differ from photographs in that a low-speed sensitized paper may be used to make negatives instead of film. Paper is cheaper and faster to dry than film, but it is not as dimensionally stable. The paper comes in rolls and has a tendency to expand differently by length and width. Papers of various speeds and contrast are available. Photocopy paper is usually limited to about 45 cm by 60 cm (18 inches by 24 inches).

For enlargement or reduction of more than four times, the process may have to be repeated if a photocopy camera is used. For instance, in the first step, the copy may be reduced to one-quarter; in the second step the product of the first step is reduced to one-sixteenth of the original. Processing is similar to that of photographs, but it does not require as much or as expensive equipment.

Photographic copies are more expensive than photocopies but provide a better reproduction in many ways. The enlargements and reductions are sharper and of much better quality; moreover, they can provide images on much larger sheets. Copies can be made as paper or film positive prints and paper or film negatives. Almost any large-sheet film camera will produce better quality copy and have a wider range for reduction and enlargement than a photocopy camera.

3.13 Other duplicating processes.--Another common method for producing copy is by office duplicator, which produces positives from positive copy. Most copiers use sensitized paper of mediocre quality. One notable exception is an electro-static process (xerographic) which produces copy on most materials. This process uses static electricity and heat to fix carbon particles to the paper. It does not produce well from colored images nor from larger images of solid black, but does reproduce black lines very well.

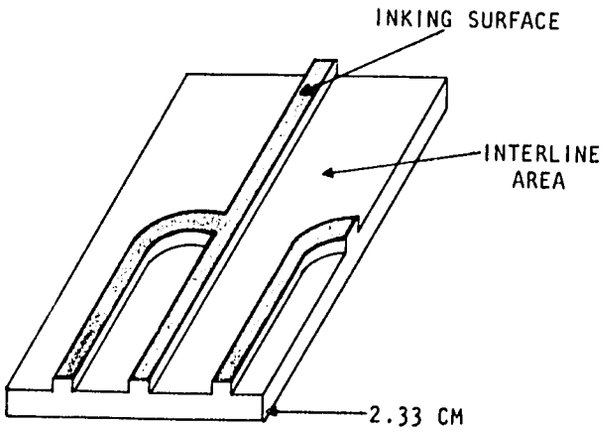
Most of these copiers are very limited in the size of copy that they will produce, which is 22 cm by 36 cm (8½ inches by 14 inches). A few produce copies as large as 45 cm by 60 cm (18 inches by 24 inches). A large map must be copied in sections and pieced together. Some copiers will produce the larger size prints from 35 mm microfilm negatives; some will produce smaller images than the original by reduction through a lens; but most copiers produce an image the same size as the original. The copiers vary in speed and cost per copy but all are constant unit-cost operations.

3.2 *Printing processes*

The ink process, as indicated earlier, refers to printing methods in which ink is deposited on the paper to duplicate the image. There are two different types of printing processes that are widely used: photo-engraving (letterpress) and lithography (offset). Both are decreasing unit-cost operations and both have the capability of making large numbers of copies.

3.21 Letterpress.--With the letterpress process the line drawings and type are usually set separately. The plates are etched deeply so that the surface that will print is raised (figure 11c). Type is often combined with

Figure 11c. PRESS PLATE FOR FLAT-BED PRESS OR LETTERPRESS



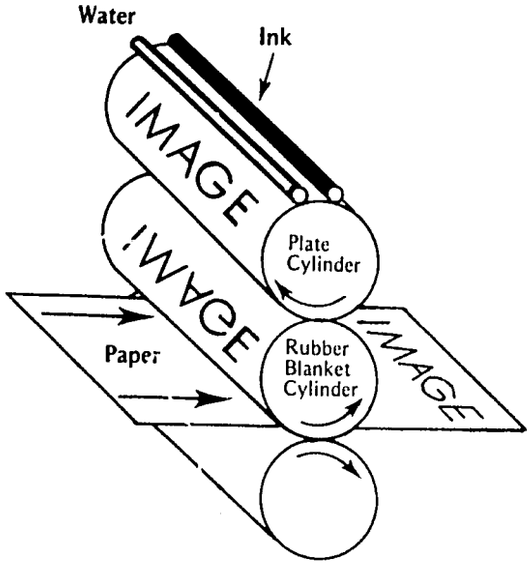
these plates and both are "locked up" together into one "form" for printing. Printing ink is transferred from the raised surface of this form directly to the paper. Maps in books are likely to be reproduced this way. The original drafted map is photographed, and the negative is contacted to a zinc plate exactly as it is in offset printing. However, the lines are strengthened with acid-resisting resin, and the interline areas are deeply etched by nitric acid. The plate is mounted type-high (2.333 cm or 0.9186 inches) upon a block of wood and is delivered to the printer, who uses a flat-bed press. The photo-engraver usually provides some proof prints but does not do the printing.

The map drafted for photo-engraving should be a little coarser (thicker lines and larger symbols) than for offset. Because the printing does not produce fine lines, dense cross-line patterns should be avoided.

3.22 Lithograph (offset).--The camera stage of the offset process is almost identical with the camera stage of the letterpress process. The drafted map is photographed and all tones (patterns), line elements, and type are transferred to a thin metal plate. With offset, the inked impression is transferred or offset from the image on the plate to the rubber "blanket" before it contacts the paper.

The present offset printing is the direct descendant of lithography in which the image was made on stone, which was then inked and used to make copies on paper. The stone plate is no longer used, because a finely kerneled[1] aluminum or zinc sheet has the same property and many additional advantages. The metal sheets can be curved around a cylinder and put on fast rotary presses which produce thousands of copies in a few hours. The printing

Figure 11d. DIAGRAM OF OFFSET PRINTING



is indirect (offset). The zinc sheet prints the image on a rubber-blanketed cylinder, and the rubber blanket prints the image on paper (figure 11d). The length and diameter of the roller on the offset press will determine the maximum size it will print. Paper of any quality may be used; however, the texture and absorbency will affect the lineweights.

4. OPERATIONAL STEPS

In map reproduction, as in most operations, a sequence of steps must be followed. Operations are simpler when non-printing methods are used; they are more complex for the printing process.

4.1 Non-printing operation

If the machines and materials for diazo or electro-static processes are maintained in good condition, the whole operation is simple. It consists of inserting positive map copy into the machine, which has been loaded with paper of the appropriate kind and size, and following the proper procedure to run the machine. For the diazo process, the input map must be on translucent paper or film; for the

[1] *Method of achieving finely textured surface by polishing a metal plate with small round stones on a vibrating tray.*

electro-static process, the input copy may be opaque, although some copiers will take 35 mm microfilm negatives. The operation is so simple that the persons who compile or draft the base maps can perform these steps for themselves. Likewise, the operation of photocopy cameras and the development of prints are fairly easy to learn.

On the other hand, the use of photographic cameras, the development of negatives, and the making of prints are not so simple; they require special personnel with training and experience. If the amount of photographic work required is not enough to justify setting up a photographic laboratory and if other laboratories in government or private industry are available and able to perform well, it would be economical to have them do the work. However, it is preferable for reasons of convenience and improved capability to have a photo laboratory in the NSO. The basic steps in producing map photographs are described below.

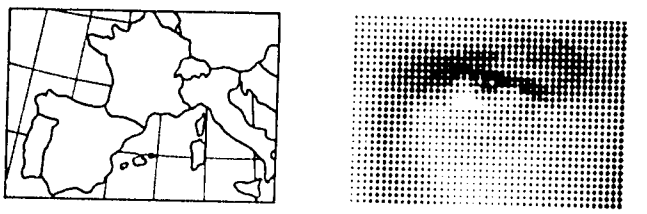
4.2 *Printing operation*

Upon receiving the map from the draftsman, film negatives are made. If the original map is drafted, it is photographed; if it is scribed, it is contact printed. Once negatives are made they must be processed and contacted t printing plates before the map can go to the p ing press. The final stage for publication is collating and binding the various maps and pages, if this is required.

4.21 Photographing.--When photography is used in making film positives for reproducing base maps or EA maps by the non-print process, the maps are reproduced as line cuts. Almost all maps for census publications also will be reproduced as line cuts.

For line cuts, a short-exposure, fast-developing, strong-contrast film is used so that the copy will have pure blacks and whites and no grays. Maps with plastic shading, maps

Figure 11e. LINE-CUT AND HALFTONE IMAGES



of varying colors, and faded or dirty maps may have to be reproduced through a halftone screen or with continuous tone film (figure 11e).

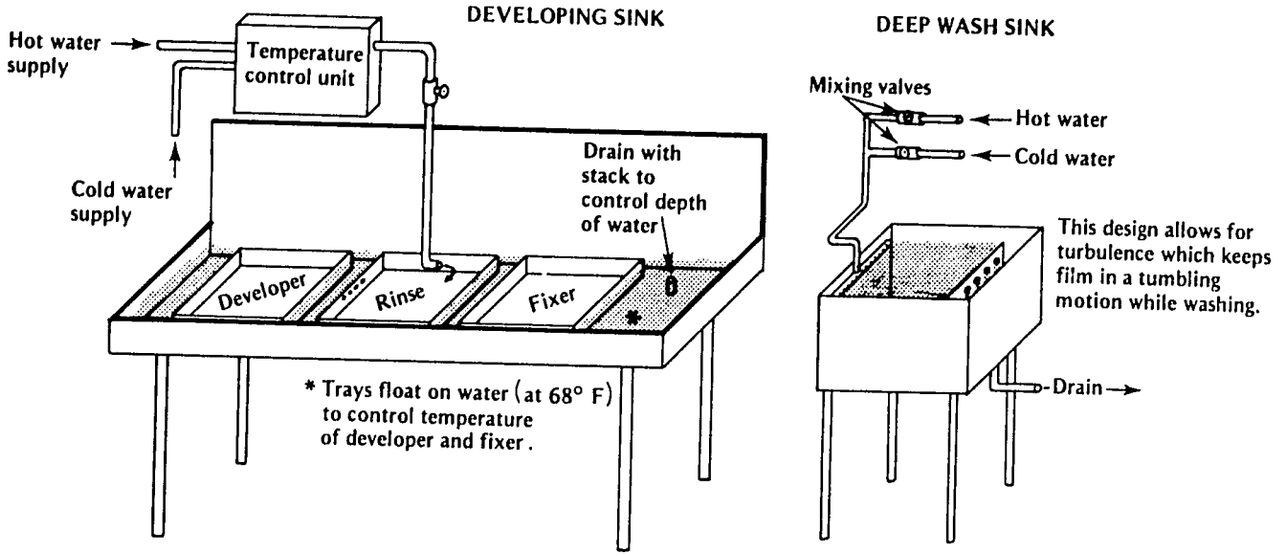
A large process camera will produce the best quality film copy; however, an enlarging-reducing camera can handle film as well as paper and can be used for photographing maps. With these large cameras, one must bring the map to the camera instead of carrying the camera to the map. The camera will be useful also in photographing pictures, air photos, and all kinds of materials whenever detail from these sources is needed in compilation or publication.

4.22 Processing negatives.--The exposed photographic film must be opened in the darkroom under red light, which does not affect the film. Processing consists of developing, fixing (hardening), washing, drying, and trimming. The minimum equipment of the darkroom consists of a table large enough for four trays of a size to hold the film; running water and sink; a drying rack or string; a cutter; a punch for registering copies; and a shelf for chemicals, films, and paper (figure 11f).

Developers are chemicals and are kept in durable containers. When mixed together in solution, as required for the developing process, they last only a day or so. Therefore, developers should be mixed only in the amounts needed at a given time.

The emulsion side (exposed surface) of the film should not be touched with damp fingers or gloves until after it is immersed in the developer, and immersion should be as instantaneous

Figure 11f. DIAGRAM OF PHOTOGRAPHIC DEVELOPING AND PRINTING



as possible. Therefore, it is advisable to insert the film in the solution emulsion side down, pushing it with the fingers on the non-emulsion side into the developer. When completely immersed, the film may be turned over to watch the progress of development.

When development is completed, the film is transferred to the next tray, containing a weak solution of acetic acid (stop bath), which halts the development process in approximately 10 seconds. This stop bath is not absolutely necessary but preserves the life of the fixing solution (popularly called the hardener or the "hypo") into which the film goes next. It is placed in the third tray containing the hypo for 2 to 5 minutes, after which a white light may be turned on without harm. In the hypo, the image is retained while the rest of the emulsion washes into the solution. The fourth bath may be another tray or sink. It must be supplied with plenty of fresh running water.

Hypo salts are very persistent, but with plenty of agitation the wash bath will remove them in about 10 minutes. The film is then dried on racks or hung on clips. Wiping with a soft sponge and fanning with warm (not hot) air will hasten the drying process.

A few cautions should be noted: (a) all chemicals contain active agents and should be mixed outside the darkroom in a well ventilated place; (b) a few seconds should be allowed for solutions to drip off the film before moving it to the next tray in order to avoid breakdown of the solutions; (c) one should not agitate the solutions vigorously but maintain a gentle ripple while processing; and (d) to be properly developed and fixed, all parts of the film must always be under the surface of the solution.

4.23 Stripping and opaquing.--After map negatives have been made, there are times when something needs to be added, such as a legend, scale, notes, etc. A small negative can be made of the piece to be added and it can be "stripped in" by cutting a matching hole in the main negative and fastening the substituted part with red lithograph tape. Stripping can only be done where there is open space on the negative. If the main body of the map needs corrections, it is almost always necessary to correct the original drawing or artwork and make a new negative.

Before any map negative is used to make a print or a printing plate, it is necessary to examine it over a light table and paint out

dust spots and any lines or words that are incorrect. This is done with special opaquing brushes and fluid.

4.24 Making printing plates.--The printer takes the film negative into the darkroom where he has a zinc plate already prepared and sensitized with an albumen compound which has the property of hardening when light strikes it. He places the negative on the zinc plate in a vacuum frame to make firm contact; then he throws strong light on it. The albumen becomes insoluble where the light passes through the negative (where the black lines were on the original drawing). The plate is covered with developing ink and the design appears. The unexposed albumen is washed off. The lines are treated with resin to add strength. The zinc plate is "wetted" (washed) with a weak solution of acid and gum arabic which slightly etches the interline areas, and the plate is ready for the rotary press. Offset printing of maps is fast and inexpensive, yet the lines are of fine quality. Some presses can print maps 1.5 meters (5 feet) wide, but the usual size is 0.6 meters by 0.9 meters (2 feet by 3 feet).

4.25 Printing presswork.--Modern offset printing has come a long way from the original lithographic process. The kerneled zinc and aluminum plates can be made to fit any size offset press. Automatic suction blowers deliver the paper to the rollers. Dozens of vibrating ink drums deliver the evenly distributed thin layers of ink to the plate cylinder; then the dampening is arranged with equal fineness by sets of rollers. The rubber or "blanket" cylinder contacts the plate cylinder with such precision that there is no widening of the finest line, even after tens of thousands of impressions. The paper cylinder delivers the printed map to a chain delivery and drying system. In some presses the print is dried so fast that a second color is printed in the same operation. A single plate can deliver 50,000 impressions or more in a few hours. The large sheets are delivered with such exactness that color overprints will register with perfect precision. Poor registration occurs more often as a result of a lack of precision in the preparation of the individual color plates than in the printing process.

Corrections on an offset plate are difficult and expensive and often a new plate is required. Minor corrections can be made on the negative by touching up the imperfections with opaque ink, cutting the lines with a sharp needle, and making a new plate. Major revisions usually require making a new negative from the corrected master copy and repeating the processes.

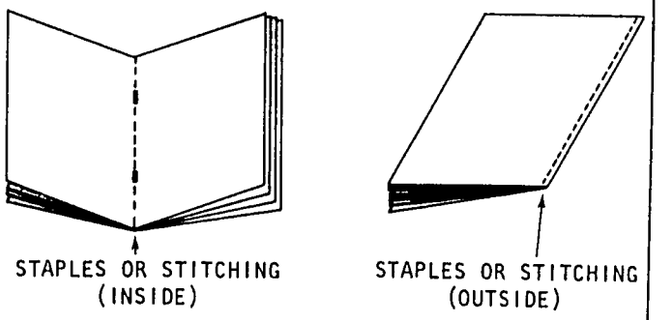
Almost all maps that are printed in books are now reproduced by offset. The lines are finer and yet the process is much cheaper than photo-engraving, and the rotary press allows incredible speed.

Contrary to the custom in photo-engraving the lithographer does the printing job himself. He usually sets the price for the whole job and does not deliver the zinc plate to the customer, but will retain or return the negative on request. Negatives can be stored but it is not practical to attempt to clean and store an offset press plate.

4.26 Binding.--There are several binding processes. The ones generally used in a print shop are gluing, stapling, and stitching. Stapling and stitching are suitable only for small publications consisting of a few pages (usually under 100). The publication is ordinarily stapled or stitched along the spine (figure 11g).

Larger publications generally are printed in signature (figure 11h). The binding should be stronger and a glue or combination glue and stitching must be used. These binding processes are specialized, are seldom part of a

Figure 11g. METHODS OF BINDING



printing operation, and are normally contracted for from a bindery. One bindery can usually service several printing firms, and printers usually prefer to contract for binding.

5. MATERIALS AND EQUIPMENT

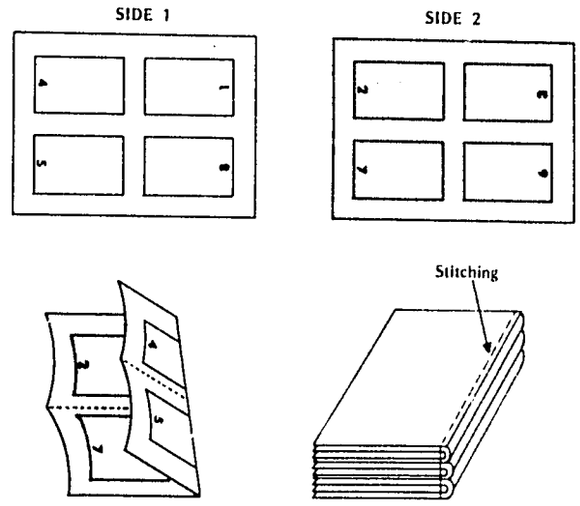
No final product can be better than the material and equipment used to produce it. It takes quality material and good equipment to produce a good map as an end product. Also it takes a staff familiar with the properties and capabilities of the material and equipment used.

5.1 Materials

Reproduction of maps and graphs requires specialized materials. The method used for reproduction will determine what materials will be needed (figure 11a). Most of the materials needed can be ordered in large amounts and stored indefinitely; however, some of the materials deteriorate with time and should be ordered only in amounts that can be used within the recommended times. This demands very careful planning and monitoring of supplies.

5.11 Paper.--Care should be exercised in choosing paper used in the printing process so that it has good inking quality and the end product will withstand rough use, often over a long period of time. An attempt should also be made to use paper which will resist shrinking when exposed to dampness. Paper covered with a thin protective plastic film (laminated) can

Figure 11h. LAYOUT FOR 8-PAGE SIGNATURE



Note: Numbers indicate page numbers for an 8-page signature.

be used for those maps which have to withstand much use. This plastic coated paper is available for both printing and major non-printing processes (diazo and xerography). For EA maps, the plastic coated diazo papers are particularly good. They not only will stand up under rough field use but they produce a sharper line image and will take ink better than the standard diazo papers.

5.12 Film.--Since most census mapping consists of line work, a high contrast, stable base film and high contrast developers should be used. These rules apply to both film negatives used in printing and film positives used for non-print reproduction. This will provide a copy which is uniformly black; there will be no grays. Thus, there is high contrast between the ink symbols and the paper color. It is important that the film emulsion be on a stable base plastic; unstable materials will expand and contract according to climatic conditions, and good registration will be impossible.

Unexposed film deteriorates with time; therefore, care must be taken to maintain an adequate supply without overstocking. Storage in a cool dry place prolongs the useful life

of film. Film that is out of date can sometimes be used by varying the exposure time.

5.13 Chemicals and chemically treated materials.--Chemicals used in making photographic developing solutions usually are received in powder form. However, there are excellent high-contrast liquid developers on the market. Developers should be stored (as all sensitized materials are) in the photo supply room. Only as much developing solution as is necessary for immediate use should be mixed at one time. All developing solutions contain mild acids, or they form poisonous fumes which may be harmful to some of the people who come in contact with them; care must be exercised in their use. Some persons are more susceptible to certain chemicals than to others and they may have to wear protective rubber or plastic gloves. It is always good procedure to wear an apron or laboratory coat to protect clothing. Developers should be disposed of after use but fixers (hardeners) may be saved from day to day and re-used until their strength is gone.

Ammonia for diazo processors is usually received in unbreakable bottles, which are in turn packed with some insulation in large boxes. If the ammonia is incorrectly packed, it should be transferred on receipt to a better container. The fumes from ammonia are very powerful and may temporarily blind anyone exposed to them even briefly. Diazo machines should always be used only in well ventilated areas.

5.14 Inks.--In the printing processes, standard printing inks are suitable for maps; no special types are required. Process inks are desirable for color printing in many cases, because they are transparent and can be printed over other inks to obtain additional colors. Process inks, however, will not produce strong or vivid colors; for this, an opaque ink must be used.

5.2 *Equipment*

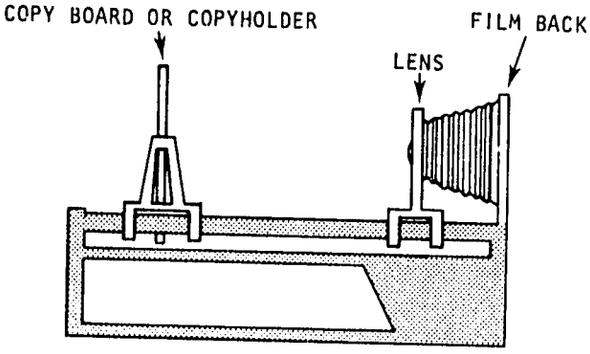
Equipment needed for census map reproduction is expensive; it must be capable of quality reproduction. Most of the larger equipment is durable and will last for decades; it will be a one-time acquisition. Careful consideration and planning should take place before large equipment such as printing presses and cameras are purchased.

5.21 Printing presses.--Most maps are printed on offset presses. These presses are capable of turning out high quality printing at great speed. Few census maps require color, so there is no need for elaborate and expensive multi-color presses. Color printing can be done on a standard one-color press by changing the color of the ink used for each printing run. (A multi-color press is basically two or more presses mounted end to end on a single frame.) Since a press is likely to be a one-time purchase, it is strongly recommended that several manufacturers be contacted and asked to provide information on the models they have available. It is also advisable to have an experienced printer who is familiar with census printing requirements review this information. If publication maps are printed on presses already available in another government agency, there is no need for the NSO to purchase this equipment.

5.22 Cameras.--A large process camera (figure 111) which is capable of quality production is a necessity. This also will probably be a one-time purchase. The same care used in selecting a printing press should be used in selecting a camera. The film back must be large enough to handle required film sizes plus screens. It is also desirable to have a very large copy board, at least four times as large as the film back (that is, twice as wide and twice as long).

A filter holder is needed also for use in compilation work; frequently it is necessary

Figure 11i. LARGE COPY CAMERA



Source: A. H. Robinson and R. D. Sale, "Elements of Cartography," 3rd ed. (New York, John Wiley & Sons, Inc., 1969). Reprinted with permission.

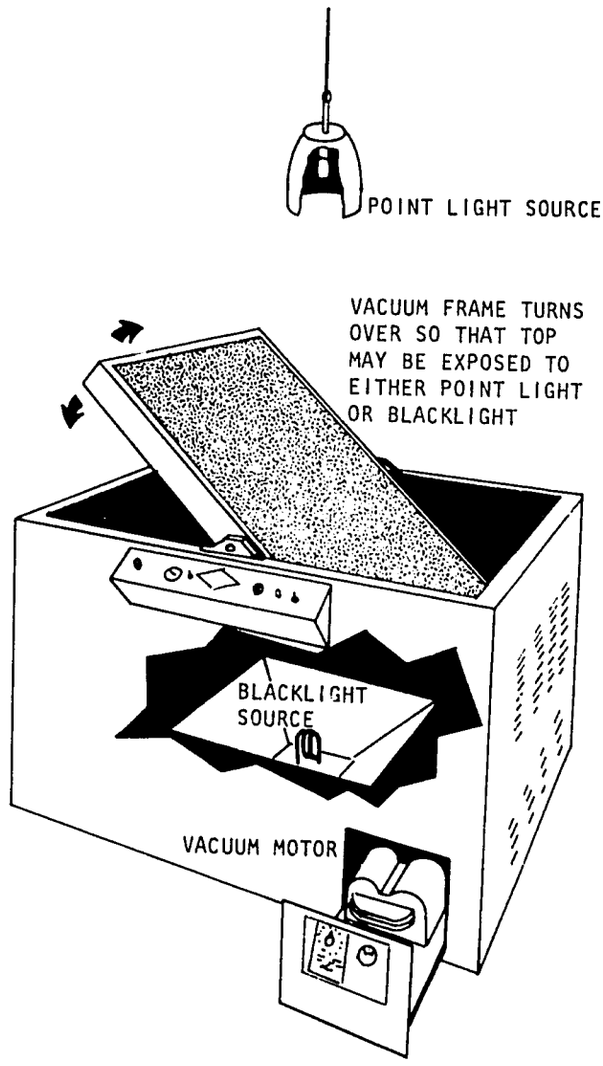
to eliminate (filter out) unwanted information that appears in color on the original source map or to "pick up" information, such as drainage, which is often printed in light blue--a color that is very difficult to photograph. In the area in which the camera is to be installed, the power source must be adequate and the space must be sufficient to allow ample movement of the lights in relation to the copy board.

With regard to microfilm cameras which are particularly useful for enlarging individual EA's from city and other EA maps, a 35 millimeter copying frame camera with a flat plane lens is needed. It may have manual or automatic film advance and the lighting should be a part of the frame. Room light should not be used because it usually comes from only one or two sources. A high contrast black and white film is required. The resulting negatives can be used to make enlarged prints, either by photography or xerography. In the future it appears that more use will be made of larger microfilm, particularly 105 millimeter film. Therefore, it might be wise to buy a copying frame with an interchangeable back that will accept 105 millimeter film.

5.23 Contact printer.--If printing press work is done at the NSO, a contact printer with a vacuum frame will be needed to make press plates and composites. It must be large enough to hold press plates and negatives the size of the largest maps required, with space for the screens. Two light sources must be available--a one-point light source that is variable in intensity for film copy, and a blacklight for exposing press plates or making proof copies (figure 11j).

5.24 Filters and screens.--In day-to-day operations, filters are seldom needed. Any camera, however, should have a filter holder on the lens; then, if a filter is needed, it is necessary only to buy or make one. Filters are used in map photography to enhance or diminish the effect of certain colors.

Figure 11j. CONTACT PRINTER WITH POINT LIGHT AND BLACKLIGHT SOURCES



Screens are another consideration. A wide assortment of tint screens is required for both the camera and the contact printer. Tint screens are used to produce printed areas which give the visual impression of various shades of gray or color. The tint screens are photographic film on which have been printed thousands of tiny dots, each separate from the other but arranged regularly in rows varying from about 50 lines per inch to 200 lines per inch. By varying the size of dots on different screens, different amounts of light can shine through and different shadings are produced. Tint screens with 133 lines per inch are most commonly used. Solid dot patterns when printed give an illusion of gray, and the eye does not see the individual dots. Values of 10 percent, 20 percent, 30 percent, etc., in tint screens may be obtained. Tint screens are usually used with open window negatives. While these tint screens are not very expensive individually, many kinds with different values are needed; therefore, they require special handling and storage to prevent damage and ensure quality work.

When two or more screens are superimposed, disturbing patterns may develop unless care is taken in angling the screen to avoid unusual or distracting patterns. These are known as moiré patterns, as illustrated in figure 11k.

Figure 11k. MOIRÉ PATTERN

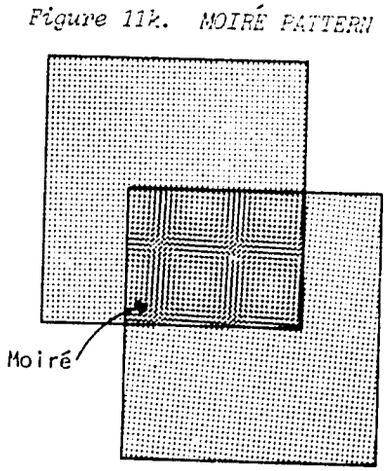
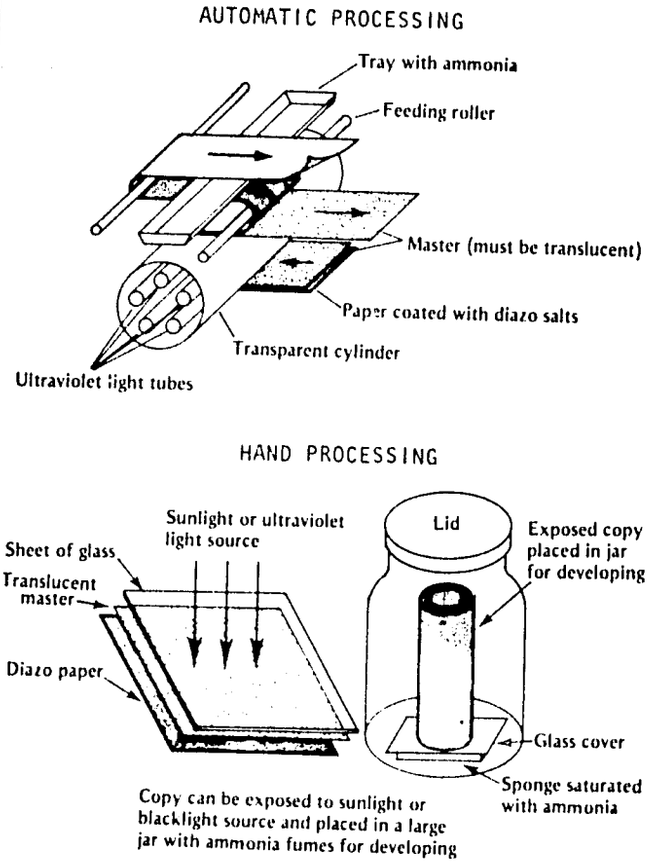


Figure 11ℓ. DIAZO PRINTING



5.25 Duplicating on machines.--The ammonia process duplicator for making diazo prints is probably the most useful piece of reproduction equipment for any NSO to acquire. The cost is nominal, probably less than 10 percent of the cost of a process camera. It is a relatively simple machine, and a substitute can be constructed rather economically (figure 11ℓ).

Another useful piece of equipment is an office copier. They are so designed that they will not only copy source maps but will make reproductions suitable for EA maps themselves. These copiers are slow and unsuited for publication work except when only a limited number of copies is needed.

5.26 Other equipment.--There are other pieces of equipment the NSO may find desirable

and useful if money and space permit. If publication maps are to be drafted and reproduced in the NSO, the following items are useful: opaquing and stripping tables (drafting light tables can be used), light panels for inspecting negatives, temperature controls for water, paper cutter, copyholder, collator, refrigerator for storage, print drier, etc. It is impossible here to cover all possibilities. It is best to acquire a few good catalogs and, after the operation has begun, decide which accessories will be most useful.

5.3 *Specification charts*

To make the most efficient use of the materials and equipment, especially photographic or printing supplies, it is advisable to test all the materials on the equipment that will be used. In this way, standard procedures can be established which will produce the best results. The procedures for each type of material according to the equipment to be used should be set down in chart form. Such charts will reduce the number of unusable copies and will save both man-hours and materials.

For example, if a copy camera is to be used and there are four types of film available, each type of film should be tested according to its intended use--whether for line copy negatives, halftone screened negatives, continuous tone negatives, etc. The testing should consider (a) safelight; (b) exposure for each f/r (focal ratio); (c) developing mixture and rinse time; and (d) special procedures, such as how to reduce contrast or how to drop out white areas. The resulting chart should show the procedures that produced the best results for each type of film according to the principal use of the film.

6. *FILING AND STORAGE*

Most materials to be filed or stored will be either paper or plastic. Both these materials are best preserved under cool dry conditions. An open file with material that is removed and used frequently does not need the same temperature and humidity control that a storage file requires. The longer the term of storage the more important are the climatic controls such as air conditioning.

6.1 *Filing system*

The important elements in a filing system are rapid retrieval of material stored there and avoidance of unnecessary handling. This is especially critical in a map reproduction work area where large numbers of negatives are stored. Files of negatives should be coded to indicate the publication in which they have been used or in which they will be used in the future. Maps and film positives, on the other hand, are best filed according to geographic area and by map series.

6.2 *Types of files*

The files should be very shallow drawers or vertical hanging folders or envelopes. Negatives should be stored in a cool dry area in plastic or other type of protective envelope--one negative per envelope. The size of the file will be dictated by the size and amount of material that should be filed together. Press plates are not stored; it is more economical to store the negative and make another plate. This is not true, however, for letterpress. Photo-engraved plates are very costly and can be stored indefinitely. The types of files needed are very similar to those described in chapter 10.

6.3 *Space requirements*

Negatives can be stored indefinitely. How long they are held depends on how often they are used. The file of negatives requires considerable space; but because it is a file that is relatively inactive, the stored units can

be piled high. The more active files can be returned to the drafting section.

7. STAFFING

The map reproduction staff which handles cameras, press plates, and the printing press is very specialized. Map reproduction requires employees ranging from unskilled to highly trained craftsmen. It can function with some of its personnel in training programs or apprenticeships.

7.1 Types of personnel

The size of a map reproduction staff is usually small in number compared with other NSO staffs. Its size will depend on the reproduction method that is selected, the use made of outside contracts for photography or printing, and the size of the overall NSO operation. Each press must have a skilled pressman in attendance during its operation, and only a skilled cameraman should operate a process camera. Many other employees are required, both semi-skilled and unskilled. Workers are needed to move and stack paper for the presses, strip and opaque[2] negatives, collate and bind reports, wrap and mail printed copy, etc. The skilled and some of the semi-skilled craftsmen should be permanent employees. Others can be trained quickly and therefore hired during peak production periods.

7.2 Functions

A map reproduction staff receives map copy; the photographer and his staff photograph and develop the copy, in either film negative or film positive form. For reproduction by printing, the staff will opaque, register, and strip the negatives, and make press plates (for the offset press). The pressmen print the copy. Others collate and bind small copy (larger volumes are usually sent to a specialized bindery), wrap and mail the finished product, file and store negatives, and return originals to the originating office. Each staff group must maintain its equipment and must order necessary materials. Staff must also be available to cut paper to size, move large stacks of paper from storage to presses, and move printed material to the collators.

8. SCHEDULING

It is difficult to develop an accurate time schedule over a long period. Most reproduction staffs plan their work 2 weeks in advance and depend on overtime for rush work or unscheduled requests. However, with regularly timed intervals between censuses, some longer range planning is possible, and less urgent jobs can be used to fill in the periods between active censuses. These less urgent jobs include printing quantities of base maps showing census boundaries to be used with published census data by planners, researchers, etc., or special maps of larger size, graphic summaries, and special reports. Equipment and personnel required for an NSO reproduction staff are highly specialized; neither equipment nor personnel should be idle.

9. WORK CONTROLS

A control system refers to the maintenance of records which show the location and movement of a package of materials at any stage of the reproduction operation. The many control functions are accomplished by using the records to (a) determine the location of the materials, (b) oversee the progress of the work, (c) make decisions relating to priority and work flow at each stage of an operation, and (d) identify trouble spots where special attention may be required in order to meet schedules.

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[2] *Block out unnecessary marks on negatives so that light does not pass through.*

9.1 *Work plans*

Work plans must be carefully developed and followed. Many elements are involved in a job. Originals, negatives, and prints require special handling so they are not mixed up or misplaced. Jobs that come in must be available on schedule, and major pieces of equipment should not stand idle. A smooth flow of work is necessary to maximize both personnel and equipment.

9.2 *Control forms*

Control forms are used to enable management to determine the current status of work in any operation at any time. This is necessary to monitor production, locate materials quickly, and reroute certain operations if a breakdown occurs. Control forms also are useful in making job assignments. Exhibit 6-7 is an example of the type of form that can be used as a production control form.

9.3 *Progress reports and reporting system*

Work that is moving in and out of any operation should be carefully controlled by records that are current at any moment, so that reports on the status of work can be compiled at any time. Progress reports by the map reproduction staff can be spaced at intervals that facilitate the smooth flow of work and allow for planning and estimating.

Chapter 12. DEALING WITH PROBLEM AREAS

1. INTRODUCTION

What is a "problem area" when a census is being taken? Most countries have problems of one kind or another, such as getting the best maps, establishing equitable enumerator assignments, making sure maps are prepared in time, selecting efficient methods of enlarging or reducing map scale, developing fast and economical procedures for reproducing map copies, etc. These are routine operational problems that most countries encounter when preparing for and taking a census; these matters have been dealt with in earlier chapters. Chapter 12 is concerned with the problem situations that are not normally found in all countries. Dealing with mapping problems means taking special steps in preparing base maps and EA maps so that enumerators can more easily accomplish the purposes for which maps were designed.

The need for maps in enumeration was discussed in the first chapter of this manual, and the purposes they serve have been mentioned frequently. Nevertheless, it must be emphasized that the enumeration maps serve as tools to locate people, agricultural holdings, or other units to be enumerated. In other words, maps help enumerators find their assigned areas and canvass them thoroughly. Missing some of the people or enumeration units is a major census concern. Duplicating enumeration, where different enumerators cover the same territory, is also a problem. Map improvement can help solve these coverage errors.

2. RECOGNITION OF PROBLEM AREAS

What constitutes a "problem area" differs from country to country, and may depend on the map and air photo resources that are available to the census organization, the nature and variety of the environment, etc. A problem area in one country may be a normal situation in another. For any given country, a problem area is one that has a significant non-typical situation.

The NSO develops an overall plan for preparing and taking a census. It then looks for the areas where the plan will not be adequate, where for some reason (often the absence of a critical element such as maps or transportation) the overall plan will not produce the desired good census results. These are problem areas that require special attention.

To the extent possible, the geography staff should identify potential problem areas early in the mapping program. Geographers and other specialists have considerable understanding of the climate, topography, vegetation, population distribution, and social and economic characteristics of the country. They can use their knowledge to locate many areas where problems are likely to arise. Even so, problems will arise unexpectedly, and the staff should be prepared to deal with them promptly or risk adverse effects on the quality and the timing of the census.

3. MAPPING VARIATIONS FOR PROBLEM AREAS

Problem areas, from a mapping point of view, require materials or procedures that differ from those used in most cases. Variations may be called for, either singly or in combination, to produce useful census maps for these areas. The most common variations are discussed below.

3.1 *Change in map specifications*

Change in the scale of maps, change in the size of symbols relative to the scale, and the use of insets are examples of the kinds of adjustments that can be made for certain problem areas. For large areas that have a low population density, small-scale maps may be economical and desirable so that the enumerators need not handle several map sheets. Ideally, no enumerator should be required to use a map sheet larger than about 40 cm by 50 cm (16 by 20 inches), which is the size that would fit a typical EA folder with a minimum of folding. For other types of areas, a large-scale map is needed so that trails, bicycle paths, walkways, and other details may be shown. A number of map insets may be the answer where several small settlements are located in an otherwise sparsely settled area.

3.2 *Addition or deletion of natural and man-made features*

For problem areas particularly, all established routes that can be traveled by vehicles should be shown, because people tend to live along such routes and the routes themselves serve as valuable landmarks. In addition, routes that may be passable only by bicycle, animal, or foot should be shown in order to help the enumerator to cover his area. Adding symbols or names for swamps, forests, watering points, and man-made landmarks may be helpful. The needs vary with the kinds of problems.

In congested areas, there may be so many features that they cannot be readily identified. To represent all of them on a map drafted at the usual scales for urban areas may make the map cluttered and illegible; yet if the scale is enlarged too much, the map may become large and hard to handle. Careful editing is needed to ensure that enough detail, but not too much, is included. Streets in particular should not be omitted in an effort to reduce map clutter, because they are elements around which other features are located and they are ordinarily used for EA boundaries.

3.3 *Modification of EA size*

Sometimes a fairly simple solution for a problem area is to modify the size of the EA. For example, if there are unusual barriers or if there are no visible features or guidelines for boundaries, the EA may be made smaller or larger than the ideal size. In many cases, contour maps or air photos can be very helpful to the geography staff in setting EA limits.

3.4 *Use of air photos*

In some cases original source materials show useful landscape features that are not shown on the usual census maps; the NSO may want to supply the enumerator with copies of these source materials. Aerial photography, particularly if recent, can be an especially valuable tool in dealing with problem areas. It can help locate wells, springs, irrigated lands, and likely population concentrations in arid areas. It can assist in locating mining and lumbering camps, and it is virtually the only feasible way of locating slash/burn areas of shifting cultivation. For urban areas, air photos can provide information on new housing sites, redeveloped areas, squatter developments, and multi-story buildings.

3.5 *Map sketching*

Map sketching (discussed in chapter 5) is another source of supplemental map information. It is discussed here as a variation of mapping because normally it is not used for large areas. However, if a few small areas exist that lack adequate maps or air photos, a sketch map may be the best substitute. An up-to-date sketch can be produced that will show all the features that are needed for census purposes. Nevertheless, it should be noted that sketching requires field visits and may be relatively expensive.

3.6 *Quick count or prelisting*

In some parts of the country, a quick count or a prelisting operation may be necessary to provide the information for delineating EA's. This occurs when local officials are unwilling or unable to supply HU or population estimates for small areas. In the quick count operation, the enumerator divides the area into sectors and estimates the number of HU's in each sector (a procedure similar to the sectoring requested of local officials, described in exhibit 6-4). In prelisting, each HU is listed by address or other identification, and a count is made from the list. Both operations require field work.

4. EXAMPLES OF PROBLEM AREAS

The problem areas that are discussed in this section include those for which some modification of the usual census mapping specifications would be needed. Specific problems require specific solutions within the resources available to the census staff. As explained earlier in the chapter, the suggested solution may involve a single modification or a combination of modifications to the usual procedures.

4.1 *Areas with sparse populations*

Areas may be sparsely inhabited for a variety of reasons. An area may be dry, cold, hot and rainy, poorly drained, mountainous or hilly; may have occupancy legally restricted; may be isolated; or may have other hindrances to settlement. Small areas of low density are not a problem; but when the population density over thousands of contiguous square kilometers is much lower than the typical rural density, changes in the specifications for census mapping should be considered.

Sparse population is a problem because more effort and expense are involved in finding and enumerating the people in such areas. More time and money must be spent in traveling between housing units, with the result that enumerators canvass fewer people during the enumeration period. Frequently, travel is more difficult because of climate or terrain. Where population is sparse, the need to allow for extra travel time should be reflected in the optimum population size established for EA's. There also may be a decision to establish a maximum land area size for an EA, regardless of its population; the enumerator is expected to thoroughly explore the EA and enumerate all the people in it.

Another method of adapting general census mapping specifications to areas with few inhabitants is the use of a smaller scale, along with modified rules for the use of symbols and insets. Also, since the network of roads tends to be limited, complete representation of all known footpaths, trails, etc., is recommended.

4.11 <u>Areas with physical environment problems</u>.--Areas of steep slopes (hills, mountains, or canyon lands) are frequently sparsely inhabited; so are poorly drained areas (swamps or marshes), frequently flooded lands, areas with hot wet climate (tropical rain forests), and areas with dry or cold climate (steppe, desert, or tundra). In all these areas, crop agriculture is difficult, if not impossible, over most of the land. Less intensive forms of land use are prevalent, and these generally support fewer people. Topography and drainage problems tend to make surface transportation difficult, slow, and expensive.

These physical characteristics usually are not shown on census maps. Landform features shown by contours or hachures require a great deal of technical expertise and equipment to plot; moreover, they require color reproduction equipment to show them well on EA maps. Their representation would multiply the cost of map preparation many times. However, their presence could be indicated by general names, such as "Black Hills," and by point symbols and names for occasional scattered specific landmarks to alert the enumerator to difficult terrain in the EA.

Drainage problem areas usually are not shown, but names like "Cypress Swamp" may be used to alert the enumerator. Marshes and swamps often have indefinite and variable margins. A solution may be to extend the EA to some identifiable boundary to assure coverage of the area bordering the swamp.

4.12 Nomadic areas.--In some areas nomadic or mobile people form a substantial part of the population and cause special problems during the taking of a census. Such people usually are found in areas of climatic adversity. Their nomadism appears to be a response to the need to exploit the resources of territory larger than the area that can be reached from any one permanent residential site; their residential sites have become mobile ones that can be picked up and moved.

There are many different kinds and degrees of nomadism. Some groups move every few days, some move with the seasons, others move every few years. As long as there are groups in the population who are known to move, there are problems of mapping and enumeration control for census takers; the more frequent the moves, the more difficult the problems.

In dry or cold areas, nomads generally depend on their animals for subsistence. When the grazing land in one area has been exhausted, the nomads move to another area. Other nomads move seasonally. In many cases, these movements are related to the availability of pasture land and water in cooler mountain areas during the summer, and the need to return to areas of lower elevation and milder climate in the winter when the higher elevations are snowbound.

Nomadic movements ordinarily are not random; rather, they tend to be systematic and often cyclical. The NSO should study nomadic patterns in order to locate traditional routes, trails, and camp sites. These features should be indicated on the maps in addition to wells, springs, watering holes, and other key points where nomads are likely to be found.

In the wet humid tropics, nomadism takes a different form. In these areas, which usually are forested, clearings are made and crops are planted, but soil fertility declines so rapidly that every 2 to 3 years the old clearing is abandoned and a new one is made, usually nearby and near water sources. This type of land use and movement often is referred to as slash/burn agriculture. It differs from other types of nomadism in that it is based primarily on crops instead of animals. Recent air photos would be helpful in identifying such settlements.

4.13 Other areas of sparse population.--There may be legal restrictions on human settlements in some parts of a country. National parks, game reserves, and military installations are examples. Information for mapping and delineating such areas ordinarily must be sought from government officials.

Some areas are so isolated and remote that population has not spread to them. Others are sparsely populated because of disease-bearing insects or other serious health hazards. Maps at smaller-than-usual scale may be satisfactory.

4.2 *Rapidly growing areas*

Areas in which the population settlement patterns are changing rapidly are particularly troublesome for census mapping. The problems do not result from any unusual characteristics of the settlement itself, but rather from the fact that the settlement is new. The first problem is to discover the area of growth. After that comes the problem of updating maps. A new housing development, for example, may not occupy the area in the way the planners had anticipated, either because it is not complete or because of some change from the original plan.

If the settlement on the ground is not represented accurately or in its entirety by

any existing map or maps, there will be problems. Here again, census personnel must verify or expand the details shown on existing maps by investigating in the field, using recent air photos to update maps, or preparing sketch maps if necessary.

4.3 *Congested areas*

These are areas in which population density may amount to many thousands of persons per square kilometer. Moreover, there may be only a few clearly identified or named streets, city blocks may not exist, and there may be no clear order or pattern to the arrangement of housing units. Dwellings often are built of scrap materials.

Congested areas need a larger map scale than is used for most cities in order to show the relevant detail needed by enumerators. It may not be possible to map these areas without expensive and time-consuming field investigation. Nevertheless, because of the large numbers of people involved, good coverage of such areas is important.

The problem of congestion may be complicated by the fact that such areas often are dynamic. They grow as more and more people move into them from smaller towns and the countryside. At the same time, internal rearrangements may result as the municipality extends streets or water lines. Temporary make-shift housing may appear or disappear suddenly to change the character of the area.

The basic map problem in congested areas is that adequate current base maps are lacking. As a minimum, field sketch maps should be made as close to the census date as possible (preferably within the last year), and the scale of these sketch maps should be fairly large, perhaps as large as 1:2,000. Recent air photos also may be useful.

4.4 *Areas lacking adequate maps*

Some areas, like areas of rapid growth, lack an accurate cartographic base. A map may never have been prepared. Without a good base, census planners have a difficult job in laying out statistical and administrative areas and in planning enumeration areas.

Where the areas lacking adequate maps are primarily rural and sparsely inhabited, maps on a scale of 1:250,000 may be adequate. Such maps may be traced from enlarged copies of satellite images, then annotated with boundaries, place names, names of rivers, etc. Maps of villages and hamlets must be developed from large-scale air photos or from map sketches unless better maps of these places are known to exist and can be obtained.

In other areas also, maps must be developed from the best sources available. Existing aerial photography may be used, as well as other source materials; these materials may include maps prepared for military purposes or they may be statistical maps of various types that contain useful planimetric detail. In any case, the census cartographer will be faced with the difficult problem of compiling a useful map for census purposes when a usable base map does not already exist.

4.5 *Areas with undefined or problem boundaries*

In order to separate areas from one another so there is no duplication or omission during the census-taking process, it is highly desirable that all areas be clearly and distinctly bounded. Statistical areas are defined by the census organization, which can establish such boundaries for its own convenience. However, administrative divisions have their own boundaries which must be observed during a census enumeration; these boundaries must be determined and located in the best possible manner.

When administrative boundaries have never been legally established, the census staff may (a) request another government agency to establish boundaries, (b) determine boundaries that are agreeable to all parties, or (c) establish boundaries for statistical purposes only. Of the last two alternatives, both may be costly to the NSO in terms of time, personnel, and expenses involved in reaching a decision. None of these is a good alternative to having an officially established legal boundary. The only other option may be the politically unacceptable one of ignoring the boundaries of such administrative divisions for purposes of the census.

In some countries the problem is not that administrative divisions lack boundaries, but that the decrees defining them are not codified or indexed, and are scattered among thousands of other government decrees. This situation amounts to not having any legal boundaries because the information is not available to the NSO; the resulting conditions and alternatives are the same as those described above for divisions lacking legal boundaries.

A different type of problem exists when boundaries have been established and the information is readily available, but the boundaries do not follow any identifiable features. Instead, they are arbitrary lines drawn without regard for rivers, roads, or any other visible feature. Such a boundary may cross a road at an imaginary or unidentifiable point. Enumerators are not sure how far to go in order to reach the boundary, and they tend not to go far enough, resulting in omission and underenumeration. In extreme cases, it may be necessary to have the field supervisor establish the location of boundaries (see chapter 7).

In some countries extensive areas may lack distinctive natural or man-made features that can be used as boundaries. Straight lines running between landmark points may be used as boundaries; or points can be established by measuring distances from landmarks, and lines connecting these points may be used as boundaries. Such boundaries are normally considered undesirable, but they may be necessary in areas where nothing else is available.

Sometimes boundary lines must be set between different tribal or language groups for enumeration purposes. This is a problem that requires careful field investigation in advance of the selection of EA boundaries. It does not require special mapping procedures as much as it does field work. The preparation of maps for use in these areas may involve the printing of different languages on the maps. The location of language areas is especially needed if questionnaires in different languages are to be used in the census.

A significant contribution to census improvement can be made by having administrative divisions redefined to follow features that are visible on the ground and are permanent, to the greatest possible degree. The census organization has a great interest in having good administrative boundaries. If these do not exist, the staff will be helping the census program by taking a strong positive role in seeking to have good boundaries established.

Chapter 13. MAPPING FOR SAMPLE SURVEYS

1. INTRODUCTION

There is a great similarity between the uses of maps and air photos in a survey and in a full census. This chapter will focus only briefly on those elements which are common to both and which have been described in other chapters. Instead, it will concentrate on issues which are treated in a somewhat different manner in a survey as opposed to a census. The basic difference between a census and a survey[1] is that a census ordinarily is a complete count of a population, while a survey samples, or selects, certain units from that population and attempts to estimate the characteristics of the total (sampled and non-sampled) population from the selected units. The total resources available for a survey are usually less than for a census but the resources per unit usually are higher in a survey.

Sample surveys vary considerably in the extent and manner of their use of maps and air photos. In some cases, a sample is selected directly from the census listings; here, the mapping materials prepared for the census are used simply to help the field staff find and collect data from the selected units. At the other extreme is the area sample, for which a multi-stage sample design is generally used. The entire country is divided into areas which are the primary sampling units (PSU's), using small-scale maps for this purpose. A sample of PSU's is selected, and each sample PSU is divided into smaller areas using larger-scale maps or photos. A sample of these secondary units is subdivided, using maps or photos of even larger scale. Finally, a sample of very small areas (segments) is selected and, within each segment, all units eligible for the survey are interviewed.

The roles of maps and photos in a census situation are (a) to assure complete areal coverage and count of the population within all areas and (b) to improve speed and accuracy of field operations. These roles are also common to the use of maps and air photos in a survey. A major difference is that only the small-scale maps that delineate the PSU's are needed for the whole country. At subsequent stages, larger-scale maps or air photos are needed only for the areas selected in the preceding stage. It should be pointed out that (a) in defining the PSU's, it is important that every part of the country is included in one and only one PSU (unless the survey deliberately excludes some area) and (b) every part of every sampling unit at the kth stage is included in one and only one of the smaller units defined for the $k+1$ stage.

One distinction between mapping for area sample surveys and mapping for censuses is the greater precision required in delineating boundaries, particularly at the final stage. In a census, when the boundary between two EA's is poorly defined, it is expected that the crew leader will clarify the boundary so that the enumerators involved will know exactly where their EA's end. Moreover, interested citizens are likely to report that they were missed or were interviewed twice. No such verification exists for a sample survey. The adequacy of the survey coverage is completely dependent on

[1] *In the context of this chapter, "survey" refers to any inquiry that is based on a sample.*

having well-defined and clearly understood boundaries for every segment in the sample. Accurate coverage within well-defined segments relies on maps and air photos to provide satisfactory information on roads and trails that give access to homes, agricultural holdings, or establishments. As in a census, enumerators must canvass every street, road, and trail that appears on the segment map or air photo and all other roads or trails they encounter.

Geographic and statistical operations cannot be completely separated in a survey. For purposes of organization and responsibility, tasks may be split; but planning and operations require close integration of the geography, statistical, and field staffs.

It is highly desirable that technical personnel, especially at the senior level, share knowledge and experience in "census geography" and "census and survey statistics." The sampling statisticians are responsible for the sample design.[2] However, such procedures as stratification, multi-stage or single-stage selection, preparation and updating of the sampling frame, and quality control operations require inputs from the geography staff. The geography staff must provide maps, interpretation of air photos and satellite imagery, and other information that will be helpful in carrying out the sample design, planning enumerator assignments, and estimating housing unit (HU) or population counts when no statistical data are available.

Most of the procedures which are outlined in chapter 2 of this manual will be required to carry out a survey, as in a census. In general, the geography staff for a survey can be smaller than for a census because less land area is involved in the mapping operations. On the other hand, greater flexibility and a wider range of tasks may be required because of the more complex operations associated with a sample survey (see figure 13a above).

Figure 13a. COMPARISON OF CENSUS AND SURVEY MAPPING OPERATIONS

	Census	Survey
Area coverage	Complete country at several scales; EA maps at large scale	Sample areas only at large scales; coverage of complete country at smaller scale for sampling and for publication
Lead time	Suggested 2 to 3 years for complete mapping program	Usually shorter depending on size of survey and quality (age, scale, coverage) of existing materials
Geographic work	Preparation of administrative division lists; preparation of base maps; EA delineation; field checks; updating; training; quality control; publication of maps	Smaller but more flexible staff to carry out specialized work related to sampling (field checks; stratification; segmenting; quick count; prelisting; etc.) and certain census-type operations in the selected areas

2. *SURVEY DESIGN CONSIDERATIONS*

Survey planning requires that a number of questions be asked. Answers to these questions will determine what detailed operations must be carried out. For example, does a previous census exist? This is an important consideration for survey mapping. If a good census base exists, then census data and materials may be used in the design and implementation of the survey. If not, other courses of action will be necessary. They are conditioned by the availability of detailed air photos and imagery, index maps, topographic or planimetric sheets with or without administrative division names and boundaries, and special maps (such as population

[2] *The strengths and limitations of the sampling approach have been clearly described in a previous publication, U.S. Bureau of the Census, Supplemental Courses for Case Studies in Surveys and Censuses, Sampling Lectures, ISP Supplemental Course Series No. 1, Washington, D.C., 1968, pp. 2-4.*

density and distribution maps) which may help guide the survey.

Surveys usually have limited resources, and results must be available fairly quickly if the survey is to be useful. At the onset of survey planning, it is useful to look forward to the end of the survey, ask what the users want, then examine the time and resources which can be made available to achieve the desired results.

2.1 Major types of surveys

Surveys can be characterized by the type of information to be collected. Household surveys seek demographic, social, economic, or health information for household units, household heads, or individual people. Agricultural information is collected from a sample of agricultural holdings. For economic data, surveys of manufactures, construction, wholesale and retail trade, and services will use the establishment as the element to be sampled. Surveys of employment may use either the establishment or the household as the element.

The appropriate sampling technique may vary according to the type of survey and the materials (including census data, maps, and air photos) available for sample design. Questions of sampling theory and practice are beyond the scope of this chapter but it can be noted that some form of multi-stage sampling is often designed, utilizing maps and air photos to a great extent.

Some countries have adequate map or air photo coverage but poor lists of units (households, agricultural holdings, establishments, etc.) to serve as a sampling frame. Area sampling is quite common in such cases.[3] Maps and air photos can be used to modify, update, or supplement sampling frames. New air photos can provide information on recently built-up areas of cities, and they can show the existence of settlements which have been recently established and may not appear on the maps or village lists at survey headquarters.

2.2 Area sample versus list sample

As stated above, area sampling is commonly used in surveys. Small land areas with recognizable boundaries are selected and enumerators are expected to cover each area. If the sample is selected from census records, the sample area may be a census EA or part of an EA. In large urban places, a selection of city blocks would be an example of area sampling.

In many surveys, a list sample is used--in whole or in part. The sampling frame may be a list of villages, a list of HU's or households, a list of agricultural holdings, or a list of establishments. Usually systematic random sampling is used. The sampling plan will indicate which units have been selected, or it will provide a procedure for selecting the units once they have been delineated on maps or air photos or prelisted in the field.

2.3 One-time versus continuing surveys

One-time surveys require that map and air photo coverage be provided in the most practical manner consistent with available resources and existing information. Continuing surveys can afford to put more resources into mapping to spread costs over future operations.

Continuing surveys require constant updating and careful identification and filing of maps for later use. Boundary stability for statistical areas is especially important in continuing surveys.

2.4 Geographic coding system

The importance of a geographic coding system has been discussed in chapters 2 and 6.

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[3] *For agricultural surveys, see U.S. Department of Agriculture, Statistical Reporting Service, Area Frame Sampling in Agriculture by Earl E. Houseman (Washington, D.C., 1975), SRS No. 20.*

If the country has had a census, the same geocoding scheme may be used for the survey.

In the coding system, a small administrative division or census EA with known boundaries is identified by a number. The number serves to provide a simple, unique identification for (a) planning operations, (b) selection of sample units, (c) assignment of enumerators, (d) compilation of existing data, (e) control and processing of survey data, and (f) storage, retrieval, updating, and numerical analysis of the information. Space might be retained in the coding system for designation of the stratum from which the sample was selected. The advantages of such a numerical identification are present whether or not a computerized information system is available.

One feature of a geographic coding system is that it is expandable to finer and finer levels of detail by the addition of digits. With the addition of a unit number or a serial number, every unit (sampled and non-sampled) would have a unique identification. In the sample areas, this number can be used to establish correspondence between a map (or photo) location and a line on the listing form.

The more widely a coding system is applied, the more useful it becomes. Ideally, a coding system will be common to all ministries in the government as well as to the NSO. The coding system applicable to any national survey must be "exhaustive" and the codes must be "mutually exclusive," meaning that the entire territory of the country (and at any single moment the entire population of the country) is covered, no areas are left out, and no areas are included twice. A useful principle is to make the initial territorial subdivision as fine as possible. It is very simple to aggregate totals for small areas into large areas, but much more difficult to break up large areas correctly if the initial subdivision was not fine enough.

3. *EVALUATION OF EXISTING RESOURCES*

The design of a survey must satisfy a number of requirements. Mapping activities in particular are guided by the answers to several fundamental questions:

(1) What is to be achieved by the survey, what variables are of interest, and what level of detail is needed? The survey design must consider what characteristics are to be measured to achieve the objectives, and for which subdivisions of the country.

(2) What are the existing resources? These include staff, organization, census data, administrative and cadastral records, and lists of villages, as well as mapping sources. The survey staff needs to consider how they can use the resources most effectively within the limits set by the survey goals, time, and budget.

(3) What new sources must be developed or what modifications must be made in the existing materials to meet the survey goals? In answering this question, the survey staff should consider whether there are alternate or multiple uses for the required materials so that the costs may be shared among several projects.

Existing mapping sources may include but are not limited to the following:

(1) Administrative division maps.

(2) Census EA and crew leader area maps.

(3) Topographic or planimetric maps with or without boundaries and settlement names.

(4) Air photos and satellite imagery, either black and white or color, of varying dates and scales.

(5) Photo mosaics and orthophotomaps.

(6) Index maps and air photo indexes.

(7) Specialized large-scale maps such as maps of urban centers.

(8) Specialized small-scale maps; for example those showing land use, soils, population densities, languages, and transportation linkages.

Some field checking of these sources will be necessary to (a) make a general assessment of quality and (b) update mapping materials in

areas undergoing rapid change. Usually the checking and updating will be concentrated in the areas selected for the survey. Mapping materials should be evaluated for a survey in much the same way as for a census (see chapters 3 and 6).

4. COORDINATION, TESTING, AND TRAINING

Coordination, testing, and training are essential preliminaries to full-scale survey operations. The work of the geography staff will be coordinated with the sampling, enumeration, and data processing operations. All procedures need to be tested and incorporated in training sessions for the staff. The geography staff will have specific training responsibilities in the interpretation and use of maps and air photos, and in the production of sketch maps where necessary.

5. ROLE OF MAPS AND AIR PHOTOS IN SURVEY OPERATIONS

Adequate maps and air photos are just as essential for carrying out a survey as for a census. High-cost maps and air photo coverage may not always be feasible but there is a minimum level of adequacy required. Moreover, much can be done with lower-cost mapping materials and careful supervision.

5.1 Construction of PSU's

Primary sampling units (PSU's) are the first-stage units in a multi-stage sample. A PSU may be an administrative division, an EA, or a combination of administrative divisions or EA's. When combinations of EA's or administrative divisions are necessary, maps are helpful in indicating which areas are contiguous.

5.2 Stratification of PSU's

Stratification is often important in a sample survey but is not required in a census. Stratification is simply the grouping of those administrative divisions (districts, villages, cities), EA's, or other units that have similar characteristics. The homogeneity principle discussed in Chapter 15 is the basis for stratification.

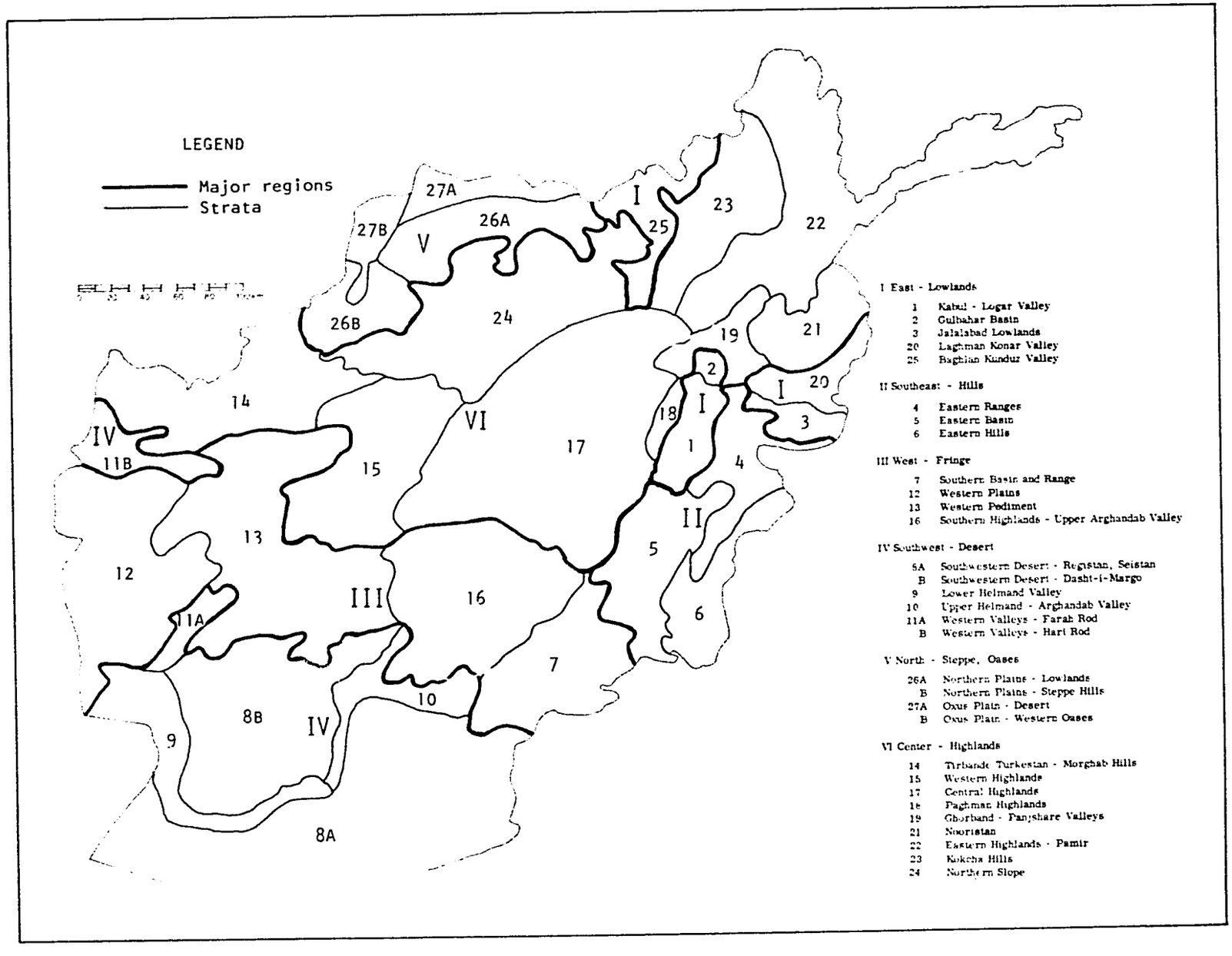
Usually urban areas are first stratified by size, using the definition of "urban" that was established for the previous census (or, if no previous census, the definition established before selecting PSU's). Within urban areas, strata may be based on population or structure density, housing characteristics, income level, health factors, or other variables of interest to survey users. Non-residential land use may delimit other urban strata.

In rural areas, strata may be defined by agricultural characteristics, land use, and population density. Figure 13b represents the rural strata used in a demographic survey in a country. In this case, topography and water distribution are closely correlated with labor intensity on the agricultural land which supports the population. Housing types, settlement patterns, and population density are also correlated with these physical, agricultural, and water distribution characteristics. High quality irrigated land supports a higher population density than marginally irrigated land, dry farming land, or pastures. For the country in question, these broad characteristics were sufficient for the stratification system required.

5.21 Use of air photos.--The ordering of PSU's by characteristics is a form of stratification that makes it possible to select a more efficient systematic sample. For example, if all PSU's in which cotton is grown are listed consecutively and a systematic selection is made, there is some control on the sampling error of the results.

Stratification is most helpful when it achieves a high degree of homogeneity within strata and heterogeneity between strata. Census

Figure 13b. RURAL STRATA OF A COUNTRY
(Six major regions and 31 survey strata for demographic survey of Afghanistan)



results or administrative records are the primary basis for stratification. However, if such data are not available, estimates of pertinent characteristics can be made by examining air photos, topographic maps, or statistical maps. Air photos can be helpful in stratifying PSU's, as illustrated in figure 13c, which shows an urban area (U), a rural area under crops with scattered farmsteads (R1), and a sparsely settled area (R2). Another type of stratification applicable to an agricultural survey is shown in figure 13d. Clear contrasts in agricultural land use are visible in the irrigated and non-irrigated areas. Close cooperation between the geographic and statistical operations is most desirable at this stage of the survey design.

5.22 Panel assessment.--In some countries numerical data for creating strata do not exist. Assuming that some kind of map coverage and a list of administrative divisions are available, it is possible to stratify based on the subjective knowledge of a panel of experts who are familiar with all parts of the country. Relevant variables might include agricultural characteristics, settlement patterns, and housing types, all showing similarity within a stratum but dissimilarity with nearby strata. This type of stratification would normally be a cooperative operation carried out by the geography staff and the sampling statistician.

The point is that for any given problem there will always exist within a country a number of persons whose knowledge of the area is very considerable. A task of survey design is to structure this knowledge in a manner which is most useful for conducting the survey.

5.3 *Segmenting*

Most sample designs require that PSU's be subdivided into smaller units (sectors) with clearly defined boundaries. Often these, in turn, are divided into segments and one or more segments are selected for the sample.

Ideally, segments should be small enough so that all the units in the selected segments can be included in the survey sample. Thus, in addition to knowing the boundaries of each segment, it is essential to have an estimate of the number of HU's each segment contains. It may be possible to delineate segments using existing materials. For example, where there is a moderately recent census, the EA's can be used as segments, since the census counts for most EA's will still be satisfactory and the EA boundaries will be identified adequately on the census maps or air photos.

Where EA boundaries are unsatisfactory, or where there have been major changes since the census (for example, construction of a housing development on previously unused land), it will be necessary to send someone to the field to try to (a) locate the EA boundaries and make sure they are marked on the map or photo and (b) count or list the units in the EA. Where there are air photos of sufficiently large scale, it may be possible to identify EA boundaries (or redefine some EA's if necessary) and make a satisfactory count from the photos.

Where there are no satisfactory existing materials, it will be necessary to create them, obtaining maps or photos for delineating segments and getting HU counts either from air photos or by sending someone to the field. The process is similar to that of redefining EA's (mentioned above).

5.4 *Aid in enumeration*

As in censuses, maps and air photos are necessary for enumeration in a sample survey. They should be as current as feasible and at a scale that will enable the enumerator to mark the general location of each sample unit, particularly if the survey is a continuing one and repeat visits are required. For purposes of planning and control, small-scale maps also are needed.

Figure 13c. USE OF AN AIR PHOTO FOR URBAN-RURAL STRATIFICATION

AIR PHOTO INDEX (MOSAIC)

Note: U--Urban area. The framed area was selected for the sample.
Source: U.S. Geological Survey.

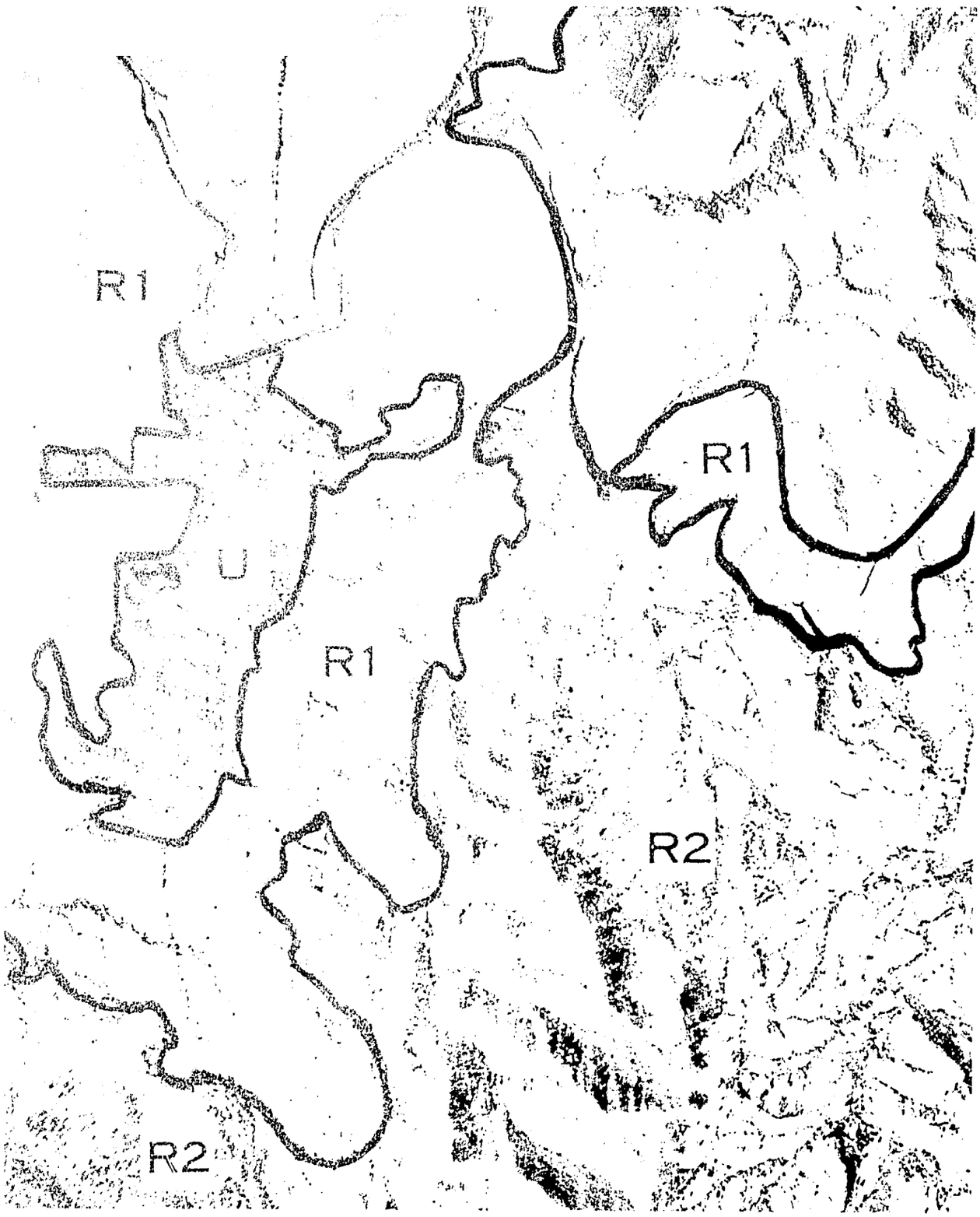

R1
R1
R1
R2
R2

Figure 1-4. USE OF AN AER PHOTO FOR LAND USE SELECTION

AIR PHOTO INDEX (MOSAIC)

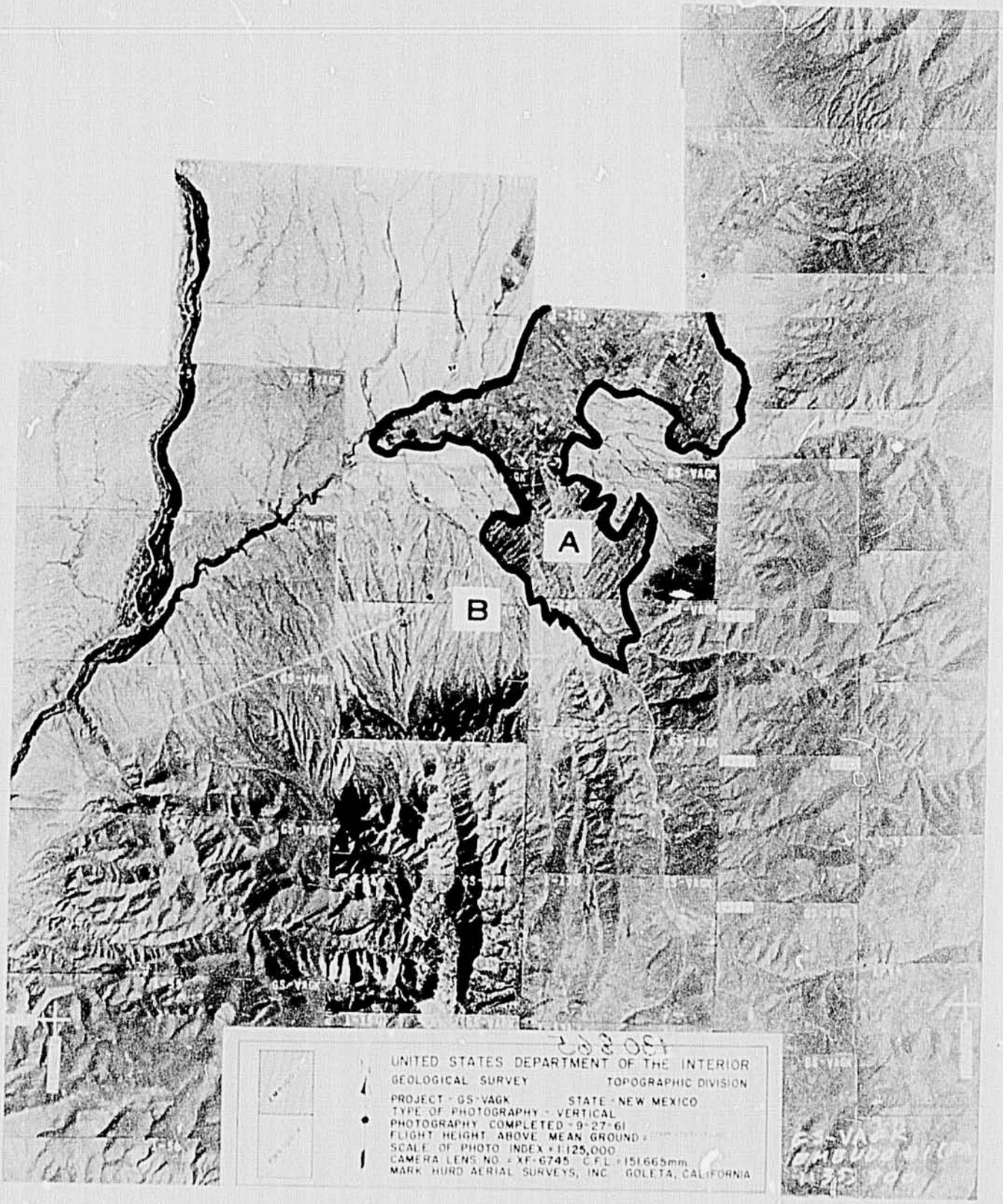
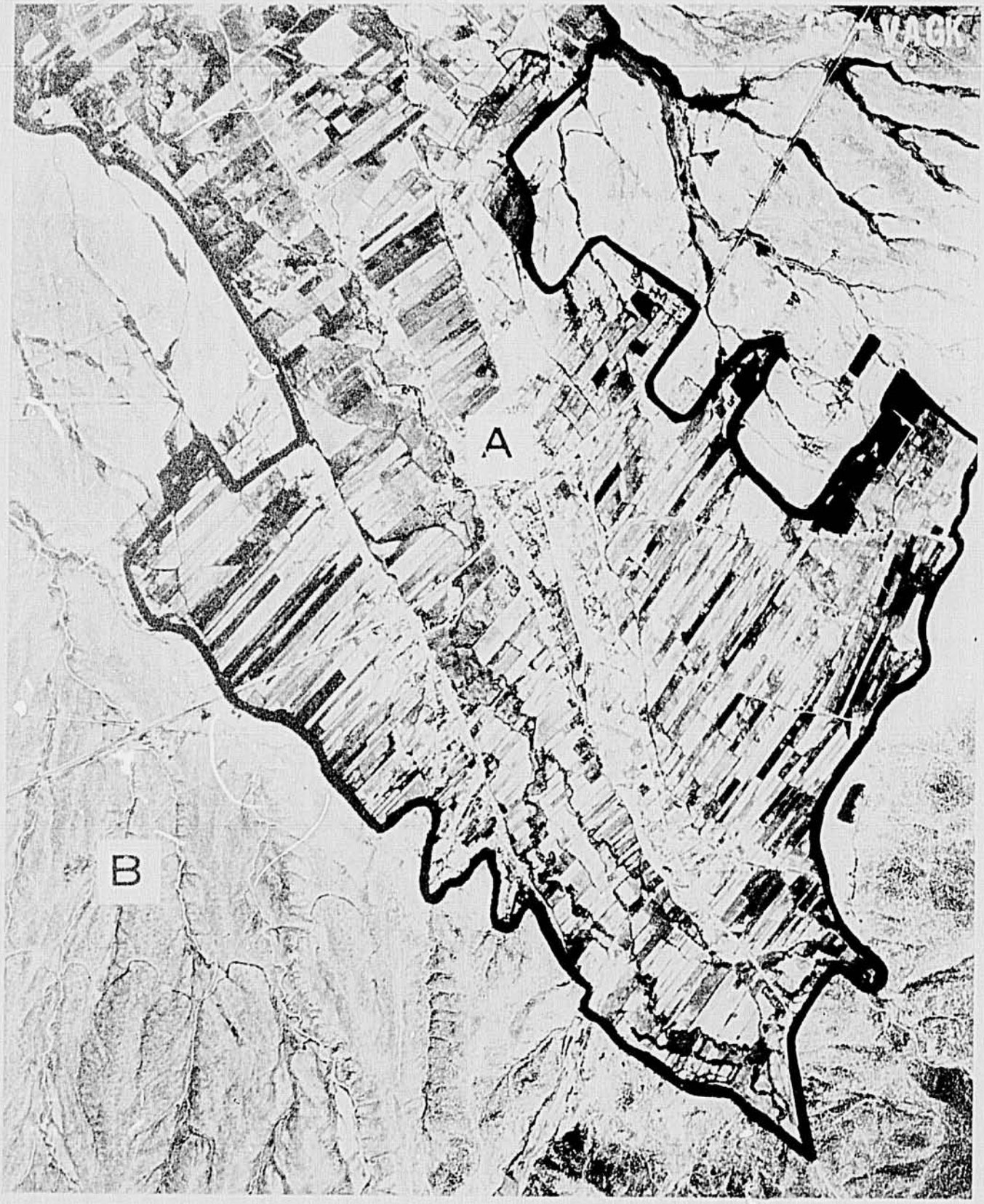


Figure 13-4. USE OF AIR PHOTO FOR LAND USE STRATIFICATION--Continued

LARGE-SCALE AIR PHOTO OF PORTION OF SELECTED AREA



NOTE: A--Irrigated with sprinkler; B--Non-irrigated, partially uninhabited.
Source: U.S. Geological Survey.

5.41 Delimit sample segment.--One of the major uses of a map or air photo is to indicate the boundaries of the land area that is to be covered in the sample. If the sample design is based on data for a precisely defined area, then the map or air photo must clearly indicate the boundaries of that area and the enumerator must cover that area--no more and no less.

5.42 Indicate location of sample unit.--For list samples, a map or photo can be helpful in indicating the location of the sample unit. In some cases, if recent mapping materials exist, the sample units can be selected directly without the need for listing individual units. It is important that the list and the map or photo be keyed to each other so that the sample units can be easily located and identified in the field.

5.43 Aid in planning, administration, and quality control.--Natural features such as mountain ranges, rivers, and areas of difficult access, as revealed on topographic maps, may influence clustering of sample units since it is desirable to keep travel costs and time at a minimum consistent with good statistical practice. Maps and air photos can also assist the survey staff in planning the location of field offices, making enumerator assignments, and dispatching staff and vehicles.

Most surveys involve quality control of the field enumeration. Comparison of the HU listing and other survey materials with the identification of structures on an air photo, for example, would reveal possible omissions or over-enumeration such as including structures outside the segment boundaries.

5.44 Reduce error.--Statistical surveys are subject to both sampling and non-sampling error. The careful use of maps and air photos at all stages of survey design and implementation can reduce total error principally by assuring inclusion of all units in the sampling frame and by helping to assure accurate coverage of units in the sample. Other forms of non-sampling error can be reduced through training and quality control, again involving the use of maps and photos in the field.

5.5 *Estimating in the absence of supporting census data*

A serious problem in most sample surveys is that, in spite of precautions, survey coverage is inconsistent with census coverage; that is, when the survey results are inflated by the reciprocal of the sampling rate, the resulting totals are below or above those projected from the last previous census (due to sampling variance and differences in coverage). These difficulties can be partly corrected by the use of a ratio (instead of the sampling rate reciprocal) of some known value of the population to the corresponding value for the sample. For example, the "inflation factor" for an agricultural survey might be the ratio of the total land in crops for all holdings as reported in the previous agricultural census to the total land in crops reported for the holdings in the sample.

When suitable data are not available from the census, mapping materials can sometimes offer a substitute. For example, a count of the total number of residential structures for the entire population might be made from air photos and divided by the corresponding count for the sample segments. This ratio could be used to inflate the survey count of HU's or persons. Although not very precise, inflation factors derived from air photo counts or measurements (for example, measurements of land area with a planimeter) may give better results than the unbiased sampling rate reciprocal.

6. *MAPPING MATERIALS*

If the country has had a census, the survey staff should examine the mapping materials to determine how they can be used in surveys. In evaluating them, the staff should consider whether they are the best materials for a survey

or whether new materials should be obtained and what kind. For example, obtaining an air photo instead of making a sketch map to subdivide an EA may save time and travel and thus be more economical as well as more accurate. The choice of materials to be used may depend somewhat on how the sample is selected--whether census or other data are used.

6.1 *Topographic and other maps*

Most censuses use a variety of mapping materials to prepare the base maps, EA maps, supervisors' maps, office maps, and publication maps. For samples selected on the basis of EA counts, EA maps are essential. If the sample selection is based on some other division of the country, then maps for that division are needed.

Ordinarily, if adequate census maps are available for the selected sample areas, they would be used for the survey. The EA maps particularly will have been corrected, boundary lines will have been drawn, major features will have been added (or deleted), and possibly the location of HU's will have been indicated on the maps for rural areas.

A country with complete sets of topographic sheets is in a very advantageous position for many aspects of survey work. Just as physical or specialized maps at small scales may be used for stratification of the country, larger-scale topographic map series may be used for more detailed stratification or sectoring and as the base for photo index maps. These same topographic sheets, when issued to field teams, can serve to guide the team to the correct survey locations and to make certain that all of the selected areas are correctly canvassed and that no extraneous areas are included.

Topographic sheets normally provide selected coverage of natural and man-made features and selected names. In general, they do not include boundaries of administrative divisions which are important for survey operations. If this is the case, it is often desirable to place administrative boundaries and their geo-coded reference numbers on the topographic sheets. This step can be carried out jointly by the NSO geography staff and the mapping agency (if they are separate organizations).

6.2 *Sketch maps*

For some areas, sketch maps may be available. If they are more current than other maps, they may be satisfactory for use in a survey. For example, sketch maps of certain unmapped areas may have been made for the census or for malaria control programs.

6.3 *Air photos*

As mentioned earlier, air photos, photo mosaics, and orthophotomaps can be useful in stratification, especially for agricultural surveys. For later sampling stages also, there are considerable advantages to the direct use of large-scale photographs or of tracings made from photographs. Note that administrative boundaries must be indicated on air photos.

If air photos were used in the census, the survey staff should examine them for use in survey operations. If none are available from the census, the staff should look to other sources for availability of photography--at least for the areas selected for the sample (refer to chapter 4 for possible sources of aerial photography). Ordinarily, photos from such sources are not of large enough scale or clear enough in detail for direct ground use at the enumeration stage.

Two options are then available. The first, depending on the quality of existing coverage and available facilities, is to produce photographic enlargement of details of areas which have been selected for the survey. If time,

money, and other resources permit, a second and more desirable option is to undertake large-scale photography of the selected survey sites.

The final selection of the sites to be included in the sample is usually the result of several stages of stratification and segmenting to the point where small areas are selected for enumeration. The survey design can incorporate clustering and other measures to reduce the number of sites. There is no question that taking new large-scale photos is a costly process that presents problems of timing and procurement of supplies. Frequently, the air photo approach is rejected on this basis. Such objection would be an important consideration in the case of a full census, which requires detailed mapping of all areas of the country. However, it may be feasible for surveys, which require detailed mapping only for selected areas.

Because air photo operations can be carried out in less time than updating maps or ground sketching, the overall cost may well be lower and the speed and accuracy of the survey operations can be increased. Again, survey planners should be aware of multiple uses of photography so that the costs can be shared with other projects. For example, water supply projects may share costs for urban coverage, and irrigation and land management projects may serve the same purpose in rural areas.

In general, the use of current large-scale photographs produces better quality results than making a sketch map of each site. Walls, buildings, and other large objects generally conceal a complete view at ground level, so that the map sketcher cannot complete his task accurately. With the help of an overlay or markings on the air photo to identify key features by name, enumerators can be trained to use the photos as enumeration maps. Such training may not be easy, however.

It is desirable that the air photos be current and large scale. Compared with a map, an air photo has more detail to help the enumerator find his way in and around the sample area. On the other hand, too much detail or information that is out of date can often be more confusing than helpful.

6.4 *Satellite imagery*

Satellite imagery may be of assistance in stratifying rural areas, based on land use or vegetation. Greater use is often limited by small scale, poor resolution, lack of ground truth, and unavailability of proper equipment. However, satellite imagery is a field of rapid advance and may soon become significant for purposes of conducting surveys (see chapter 14).

7. MAPPING FOR HOUSEHOLD SURVEYS

If a household survey is part of a census program (such as a post-enumeration aurvey), it may be a list sample of every nth household enumerated in the census; or it may be an area sample, especially if it attempts to measure coverage. It is assumed that most other types of household surveys use area sampling.

7.1 *If good census base exists*

It is expected that countries which have a good census base (data and mapping materials) will use the census resources in designing their surveys. A good census base makes the task much easier. Thus, it is important that countries take necessary precautions to keep all the census mapping materials and small area tabulations (for example, EA maps and tabulations).

When a census base exists, it will almost always be desirable to start by selecting a sample of EA's. Sometimes, EA's will be small enough so that all the HU's in a selected EA can be included in the survey sample. In other cases, EA's can be divided into sufficiently small segments on the basis of census materials without further field work. For example, the houses may be numbered (either by the census

enumerator or by a source such as the malaria control authority), and these numbers may be entered in the correct locations on a map or air photo; or it may be possible to count the number of houses in each small area on a large-scale air photo.

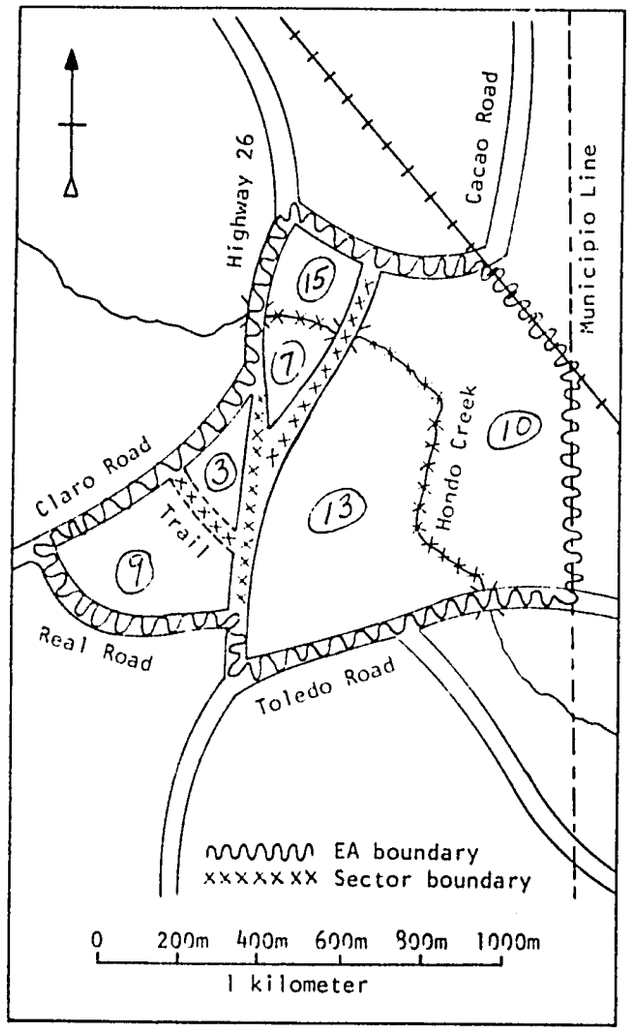
Where EA's or segments are too large to include all the units in the sample and it is not possible to subdivide the EA or segment further, using census materials, it will be necessary to make a field visit to obtain the required information for subsampling. This subsampling may be on an area basis (quick count) or a list basis (prelisting), or on some combination of area and list sampling.

7.11 Quick count and prelisting.--In the quick count operation, an EA is divided into smaller land areas (sectors) with identifiable boundaries, and an estimate of HU's is obtained for each sector (see figure 13e). The quick count may be approximate, but must not contain large errors.

Sectors defined in the quick count are subsampled. If the selected sector is small, all the HU's in it are interviewed. If it is too large to permit interviewing all households, it would be prelisted and subsampled. If the area is remote or access is difficult, it may be more economical to omit the quick count and prelist the entire area on the first visit.

In the prelisting, the enumerator records every HU in the selected sector by address or other identification adequate for finding the HU later. If there are no good addresses, it may be permissible to mark HU's with metal tags, paper stickers, chalk, felt-tipped pens, or paint. These identification marks should be keyed to the listing form and placed on the map or air photo where possible. Since a subsample of the prelisted units may be selected for interview, the prelisting must be complete and accurate.

Figure 13e. RESULTS OF QUICK COUNT OF AN EA (Subdivision by sectors and estimates of housing units)



The quick count procedure to subdivide an EA is usually more economical than prelisting a large number of HU's. To make the savings of a quick count possible, it is important to have good maps or air photos so that the enumerator will be guided by easily recognizable features (roads, trails, streams, etc.) which can be used as sector boundaries.

7.12 Use of maps or sketch maps in quick count and prelisting.--If the survey design selects census EA's, then copies of the census EA maps or sketches would ordinarily be used for the quick count and prelisting and later

for interviewing. In addition to a large-scale EA map, the geography staff might provide a small-scale map of the general area to help the enumerator to locate the sample site.

In the quick count, the enumerator can mark the sector boundaries directly on the map. In rural areas particularly, it may be difficult to find a specific HU on a later visit. During prelisting the enumerator can indicate the approximate location of each HU by putting a symbol on the map and entering the listing sheet line number next to the symbol. To do this, the map must be of reasonably large scale.

If the census map for a selected EA is missing, it may be possible to reconstruct the EA by examining the boundaries of surrounding EA's. Other adjustments may need to be worked out between the sampling statistician and the geography staff.

7.13 Use of air photos in quick count and prelisting.--Air photos, or tracings from them, that were used in the census ordinarily would be used in a survey for the quick count and prelisting, as well as for interviewing. Sector boundaries can be marked directly on the photo with a special pencil (grease pencil). As with maps, each HU selected for the final sampling stage can be specifically identified by marking the location of the HU on the photo.

7.2 If poor or no census base exists

The situation may arise where census EA maps were lost or destroyed and where EA counts are no longer available. In other cases, a country may not have conducted a full census. Nevertheless, a successful survey can be conducted. Careful coordination will be needed between the geography and statistical staffs. Even more than in other problem situations, it is likely that heavy reliance on maps and air photos will be required in the sample design. Mapping materials should be supported by some crude estimates of population size based on administrative data, analysis of air photos, or other available indicators. The staff will need to be sure that all administrative divisions, down to the lowest level, are included in the estimates.

It is assumed that the final selection of sample sites will likely be the result of several stages of stratification and segmenting. At some point, the selected PSU will need to be subdivided. The quick count and prelisting procedures will be required in the same way as described above when a good census base exists. Mapping for these operations can be handled in several ways.

7.21 Acquire maps of the sample PSU's.--To acquire maps and to prepare them for use in a survey require the same procedures as for a census (see chapter 6). Materials should be updated, and they should be of reasonably large scale. Sector boundaries can be marked on the map and the appropriate location of each HU, particularly in rural areas, can be indicated directly on the maps. It should be pointed out that maps are needed only for the areas that are selected for the sample--not for the entire country. The survey staff should consider the map sources that are available and whether the acquisition and updating of maps will be more advantageous than acquiring and working with air photos.

7.22 Make sketches of unmapped PSU's.--In some instances, map sketching is necessary. During the sketching, the sketcher can make a rough outline of the area and carry out the quick count. If considerable travel time is involved, it may be economical to prelist at the same time. As discussed in chapter 5, map sketching requires some special training and usually is not the most economical mapping procedure.

7.23 Obtain current air photos of PSU's.--Current large-scale air photos or photo enlargements can be satisfactory mapping materials for

the quick count and the prelisting. If the PSU is large in area, photos can be taped together into a crude mosaic. Boundaries of the sectors may be marked directly on the photo and the prelisted units can also be indicated. If the air photos are not current, it is usually necessary to visit the sample site and update the photos in the same way that maps are updated. However, with up-to-date enlarged air photos, it is often possible to do the quick count in the statistical office without a field visit. Except perhaps in densely populated areas, the survey staff may be able to divide the PSU into sectors and estimate the number of HU's in each sector. In some cases, it may be possible to eliminate prelisting and select the final sample units (HU's) directly from the photos.

The following are some suggestions with respect to the preparation and use of air photos for a sample survey. They are concerned mostly with ways to economize, particularly when no photos from the census are available.

(1) Use air photos or tracings of air photos instead of making map sketches. Experience has shown that it is generally easier to train field personnel in simple interpretation of large-scale photos than in preparing sketches.

(2) Enlarge existing air photos instead of re-photographing at a larger scale.

(3) Insofar as possible, take photos in the appropriate season.

(4) Use black and white photos if color film is very expensive to process.

(5) Use special pencils (grease pencils) or pinholes to indicate features so that the photos can be used again.

(6) Use photo indexes, photo index maps, and uncontrolled mosaics instead of controlled mosaics (see chapter 10). The mosaic may be re-photographed at a smaller scale.

(7) Avoid working with stereopairs; obtaining stereopairs will double the cost of the photos. If most buildings are only two or three stories high, relative heights of shadows can be used to estimate building heights.

(8) Prepare photo index maps. If topographic maps are available, photo coverage identified by roll and exposure number can be plotted directly on the topographic sheets. If topographic sheets are not available, it is recommended that photos be plotted on some kind of outline map as a guide. Topographic sheets have the advantage of associating any names on the map with features on the photos.

(9) Use photos to make quick counts or, where possible, to select sample units and avoid making field visits.

Although it may increase the cost, duplicate sets of photos and indexes should be made. Sets should be available in the NSO for (a) reference when the first set is being used in the field, (b) replacement of photos that are lost, and (c) use in quality control and training.

5. MAPPING FOR OTHER TYPES OF SURVEYS

A number of surveys use the household approach to identify the unit for which data are to be obtained. For example, although an agricultural survey collects data for holdings, it may identify the holdings through a sample of households or HU's. Similarly, some types of economic censuses use the household approach to identify the economic unit for which data are to be gathered. The basis for stratification is different but the other mapping considerations are much the same as for household surveys.

Agricultural surveys may use maps or air photos directly to stratify and to select the sample. One way is to superimpose on the map or photo a grid on which dots have been placed in a systematic random pattern; each <u>field</u> in which a dot falls is then included in the sample, or the <u>holding</u> represented by the dot may be included in the sample. This procedure requires that the maps or photos be of large scale so that the field can be located on the ground.

Air photos can be used also in the sample design to select areas of cultivated or uncultivated land, or to select clusters of fields.

Another use is for determining area in crops. For example, the enumerator can report which crops are grown in an area, but the actual land area of the fields may be more accurately determined if they are measured on current air photos by using a planimeter. Still another application is to measure entire sample segments on recent air photos and adjust the enumerators' entries for the areas of the fields that make up the segments.

Economic surveys may use the establishment and the household as the units of enumeration. In some surveys, a list of large establishments is compiled and a sample selected from the list; it is supplemented by an area sample so that the small establishments and household industries are represented in the survey results. In the absence of a list of establishments, maps and air photos may aid in the selection of segments that are largely non-residential.

Chapter 14. NEW DEVELOPMENTS

1. INTRODUCTION

New types of maps and materials to make maps have been developed and used in census operations in recent years. Three new developments that are gaining worldwide acceptance are discussed in this chapter. They are remote sensing, or more specifically the use of satellite images for obtaining data; automated cartography for presenting data; and geographic base files for storing and retrieving data. The discussions will not be comprehensive; rather, they will be an overview or summary.

2. SATELLITE IMAGERY

"Remote sensing" usually refers to the collection of information through the use of instruments, such as cameras, that are sensitive to electro-magnetic energy reflected or radiated from man-made and natural features. The most familiar type of remote sensing used for census purposes is aerial photography; that is, photography taken from an airplane from an altitude of less than 32 kilometers (20 miles). This type produces an image on sensitive film that can be reproduced at scales of 1:125,000 or larger. (See chapter 4 for a discussion on the interpretation and use of this type of imagery.) A less familiar type, which is discussed in this chapter, is the collection of information through the use of satellites; that is, information collected from an altitude of 320 kilometers (200 miles) or more.

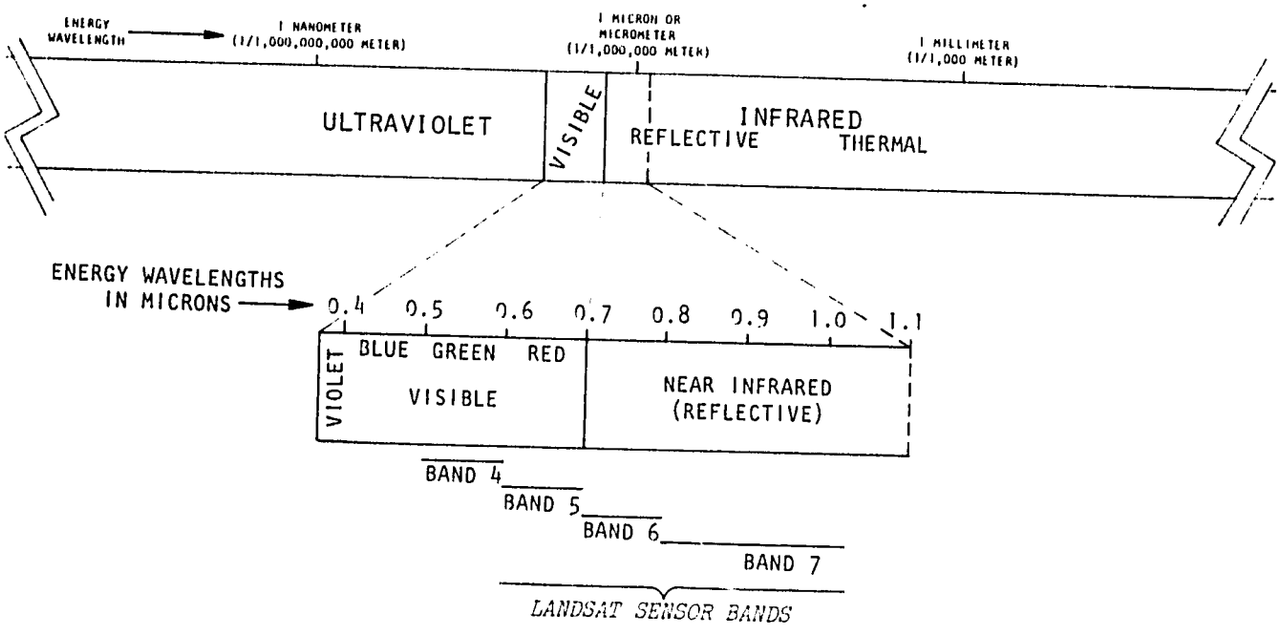
2.1 Type of equipment

Through 1977, there have been two classes of space platforms, or satellites, which have produced imagery that is or could be useful in census mapping. These classes are manned and unmanned satellites. Manned satellites, such as Skylab, have operated only for relatively brief and irregular intervals, and the images obtained have provided only partial coverage. Unmanned satellites, such as Landsat 1 and 2, have passed over the entire inhabited Earth many times on a regular basis, providing almost complete coverage of the Earth's surface. As with air photos, indexes and catalogs show the satellite coverage available for each area of the Earth.

2.11 Manned satellites.--Manned satellites have produced photographs using camera and film systems. These are like air photos, except that they are taken from a much higher altitude and are at a much smaller scale. Even when they are enlarged, they are not as detailed as air photos.

2.12 Unmanned satellites.--Unmanned satellites cannot effectively use ordinary photographic cameras and film; for example, there is no way to re-load the cameras after the film is exhausted. Such satellites must use other sensing systems. The most common type of sensor used in these satellites is called a scanner. The scanner senses the amount of energy being reflected or radiated from a series of points, translates these sensations into numerical values, and radios these values to receiving stations on the Earth. The values, then, may be processed to make pictures for use in the usual form of interpretation, or they may be refined and re-formatted (put into another form) for use in a semi-automatic or automatic interpretation process involving a computer. The images are less detailed than are photos from manned satellites; however, they contain much useful information.

Figure 14a. DIAGRAM OF A PORTION OF THE ELECTRO-MAGNETIC SPECTRUM



2.2 Forms of energy sensed

As stated earlier, remote sensing involves the detection of electro-magnetic energy being reflected from or radiated by objects. This energy moves in wave form. The distance between the crests of successive waves is called the wavelength. Wavelength varies from very short (billionths of a meter) to very long (many kilometers, perhaps even hundreds or thousands of kilometers). The total range of wavelengths constitutes the electro-magnetic spectrum (EMS). Figure 14a is a diagram of a portion of the electro-magnetic spectrum.

As shown in the diagram, the EMS consists of several parts. Only the energy wavelengths of one very small part are visible to the normal human eye without the aid of special equipment. In the visible part of the spectrum, energy with the shortest wavelengths appears violet; energy with the longest wavelengths appears red. In the invisible parts of the spectrum, energy with shorter wavelengths is called ultraviolet; energy with longer wavelengths is called infrared (IR). Although the Landsat satellite has seven sensor bands available, only bands 4 to 7 are presently assigned to parts of the electro-magnetic spectrum.

Features on the Earth's surface reflect or radiate energy in varying amounts in different parts of the spectrum. It is this reflected or radiated energy that is recorded in the various processes of remote sensing. Variations in lightness or darkness of features are caused by differences in the amount of energy being reflected or radiated. Variations in color result from differences in the capacity to absorb or reflect energy of different wavelengths, or from the temperature of the object radiating energy. For example, green vegetation appears green because it reflects more green light and absorbs more light from other parts of the visible spectrum (however, green vegetation reflects a considerable amount of infrared energy just outside the visible spectrum).

The Landsat scanner system currently in use is designed to simultaneously sense different parts or bands of the spectrum (hence the term multi-spectral sensing). Some of the Earth's features appear more clearly on one

band, some on others. However, most features are detectable on all bands.

The information collected by the Landsat system is available to the user in the form of (a) color or black and white images (photographic-type pictures), (b) digital imagery which uses computer printer characters to represent colors or shades, and (c) digital data on magnetic tape. In order to produce color images, two or more of the four available bands are printed over one another using different colors. In this way, the strong points of the different bands are combined in one picture. Black and white images, in effect, show the data sensed in only one band of the spectrum. The digital imagery (especially on magnetic tape) contains much more specific data than the photographic-type pictures; but they are more difficult for the ordinary user to comprehend and interpret.

2.3 *Advantages of satellite imagery*

As mentioned earlier, information has been collected by Landsat 1 and 2 for almost every part of the Earth's surface. In addition to providing complete coverage, there are other advantages that make satellite imagery useful for any mapping program.

2.31 Repetitive coverage.--Observation of changes that occur over time can be useful to census planners and mappers. Such observation can aid planners in delineating urban development and permits them to identify those dynamic growing areas that tend to be problem areas for mapping purposes. Repeated overflights allow observation under different seasonal conditions, permitting a choice of the best one for any specific area.

2.32 Minimal operating cost.--Once a satellite is launched, it usually stays aloft for years at no additional cost. It is not necessary for a country to have its own satellite, nor its own receiving station. Users who desire copies of the images (either in photo or magnetic tape form) can acquire them at the cost of reproduction, under current policies, from countries with receiving stations.

2.33 Multi-spectral capability.--The ability to record data separately in different parts of the spectrum improves the ability of analysts to interpret what is revealed in the image area. This is particularly true of the near-infrared spectral bands, since they can reveal information not detectable by normal vision or normal photography. Furthermore, the products of the various spectral bands can be selectively put together in various color combinations to emphasize those features that are of interest to the analyst; the color combinations make these features more apparent to the user.

2.34 Large-area coverage.--The area that is covered by an individual Landsat image is approximately 33,800 square kilometers. This area is larger than can be viewed at one time by any other readily available imaging system. The Landsat image permits a regional view and understanding to be obtained--a valuable asset during the planning phase of census operations. It covers the same area that would take more than a thousand air photos to cover; even with high-altitude photography, several dozens (or even hundreds) of photographs would be needed to cover the same area.

2.4 *Disadvantages of satellite imagery*

Unfortunately, there are some distinct disadvantages in using satellite imagery for census mapping programs. The images are harder to interpret than air photos; moreover, since they are not produced specifically for census purposes, they may not include the information required for census mapping.

2.41 Lack of census-type details.--Even though a large amount of data about the Earth's surface is collected by the Landsat system, the

system does not supply all of the detailed information that is needed in census and survey work. At the present time, on the images available, individual residential or smaller commercial structures cannot be recognized; most individual streets, minor roads, trails, small streams, bridges, or railroad tracks cannot be recognized. Skylab images show more detail, but even they do not have the detail that can be recorded by the same camera systems mounted on aircraft. In addition, Landsat images contain so much information that it is difficult to pick out the features that are important for census purposes. Moreover, like air photos, the images lack administrative boundary lines and names of features; this information must be obtained from other sources and matched to the correct features on the images.

2.42 Lack of good images due to weather conditions.--Aircraft flights can be scheduled to take advantage of good weather conditions for collecting imagery. Satellites cannot be so scheduled; they will pass over given points on the Earth's surface at given times regardless of the weather. Clouds or other adverse atmospheric conditions may prevent the acquisition of useful pictures. In fact, periods of bad weather may prevent useful images from being made for several months. Sensors that can penetrate clouds and haze may lessen this problem in the future, but imagery from such sensors is not available from satellites now.

2.43 Scarcity of receiving stations.--Landsat images can be transmitted directly only within a radius of about 2,000 kilometers of a good receiving station. Otherwise, the imagery must be collected and stored on magnetic tape until the satellite is within range of a receiving station. The magnetic tapes have been the first pieces of equipment to wear out from repeated use; there now is a reluctance to use them except in high-priority or emergency situations. Therefore, although the data to make certain images on given days could be obtained, the satellite is not activated.

The number of receiving stations is growing. Nevertheless, there still are large areas of the world, especially in developing countries, that are not yet within range of any receiving station antenna.

2.44 Need for special training.--Special training is required to interpret and use all forms of imagery. In the photographic-type satellite imagery, things are seen from an unusual position; moreover, the color tones may be misleading, especially in infrared images. The use of digital imagery demands specialized training in interpreting the characters that are used to represent the Earth's features. To use and interpret digital data on computer tapes, the staff must be able to interpret the characters used and to interact with the computer.

2.45 Need for special equipment.--The same type of equipment that is used to interpret air photos is needed for interpretation of photographic-type and digital imagery. To use and interpret data on magnetic tape, a computer and special computer programs are required. Although most statistical organizations have access to a computer, there remains the problem of acquiring the necessary computer programs to process the data. Even if the programs can be acquired, converting them to run on the available computer may present an additional problem.

2.5 *Availability of satellite imagery*

Landsat satellite imagery for any part of the world is available to anyone for the cost of processing and shipping, although the exact costs may vary from time to time and among source countries. It may be obtained in a variety of sizes, in individual bands as black and white prints or negative or positive film transparencies, as color composite prints or

film transparencies, or in the form of computer compatible tapes. Information on specifications of currently available imagery, or the imagery itself, may be obtained from the U.S. Geological Survey at the EROS[1] Data Center in Sioux Falls, South Dakota.

Other countries with Landsat satellite data receiving stations can supply comparable information and imagery; they include Canada, Brazil, and Italy. Additional countries are planning for receiving stations, and the list is expected to increase. The imagery available is not limited to any one country; rather, it is limited by a radius of about 2,000 km from the site of the receiving antenna. For example, Brazil receives data for all of Bolivia, Peru, Ecuador, Paraguay, Uruguay, and some other countries, plus large parts of Venezuela, Colombia, Chile, and Argentina, in addition to all of Brazil.

2.6 *Applications of imagery*

Satellite imagery is useful, in varying degrees, for mapping operations--in planning, preparation of base maps, stratification for sampling, etc. This section describes some of the possible uses and the considerations involved.

2.61 Initial planning.--For initial census or survey planning, satellite images provide up-to-date information about the area in terms of its major types of land cover. These types include the general categories of cropland and pasture, woodland, water, barren land, urban and built-up land, etc. In some cases, subtypes can be distingushed (residential versus industrial urban land, for example).

Such information can be useful in planning census operations. Certain problem areas can be delineated; the current margins of urban development can be recognized in many cases; and other types of area distinctions can be detected. If enough is known about the density of the population that is associated with the different types and subtypes of land cover, estimates can be made of the population in given areas. With such information, estimates of the number of enumerators and questionnaires, decisions on the locations of field offices, and other determinations vital to carrying out a successful census can be made.

2.62 Preparation of base maps.--For preparation of base maps for EA delineation, satellite imagery may be of only limited use. Imagery is excellent for detecting water bodies that are large enough to show on such images. It can be used to detect changes in the size and shape of large lakes and reservoirs, or changes in the location of major streams. The relative position of settlements and streams can be observed, as can the alignment of some roads. Roads under construction or recently built are particularly evident from the cleared land that borders them. Roads cut through forests also often stand out.

Satellite imagery may reveal isolated settlements that were not known to the NSO census planners. Also, for remote rural areas for which there are no adequate maps, enlarged satellite images may be used to compile base maps. If existing maps are old, these enlarged images may serve as sources of information for updating them. Many experts believe that 1:250,000 is the largest scale suitable for reproducing an image. For remote rural areas, this scale may be adequate; however, when necessary, images can be enlarged further for map compilation purposes.

Satellite images can be made into image mosaics (similar to air photo mosaics) for limited use as base maps for statistical or publication maps. Such a composite picture

[1] *Earth Resources Observation Systems.*

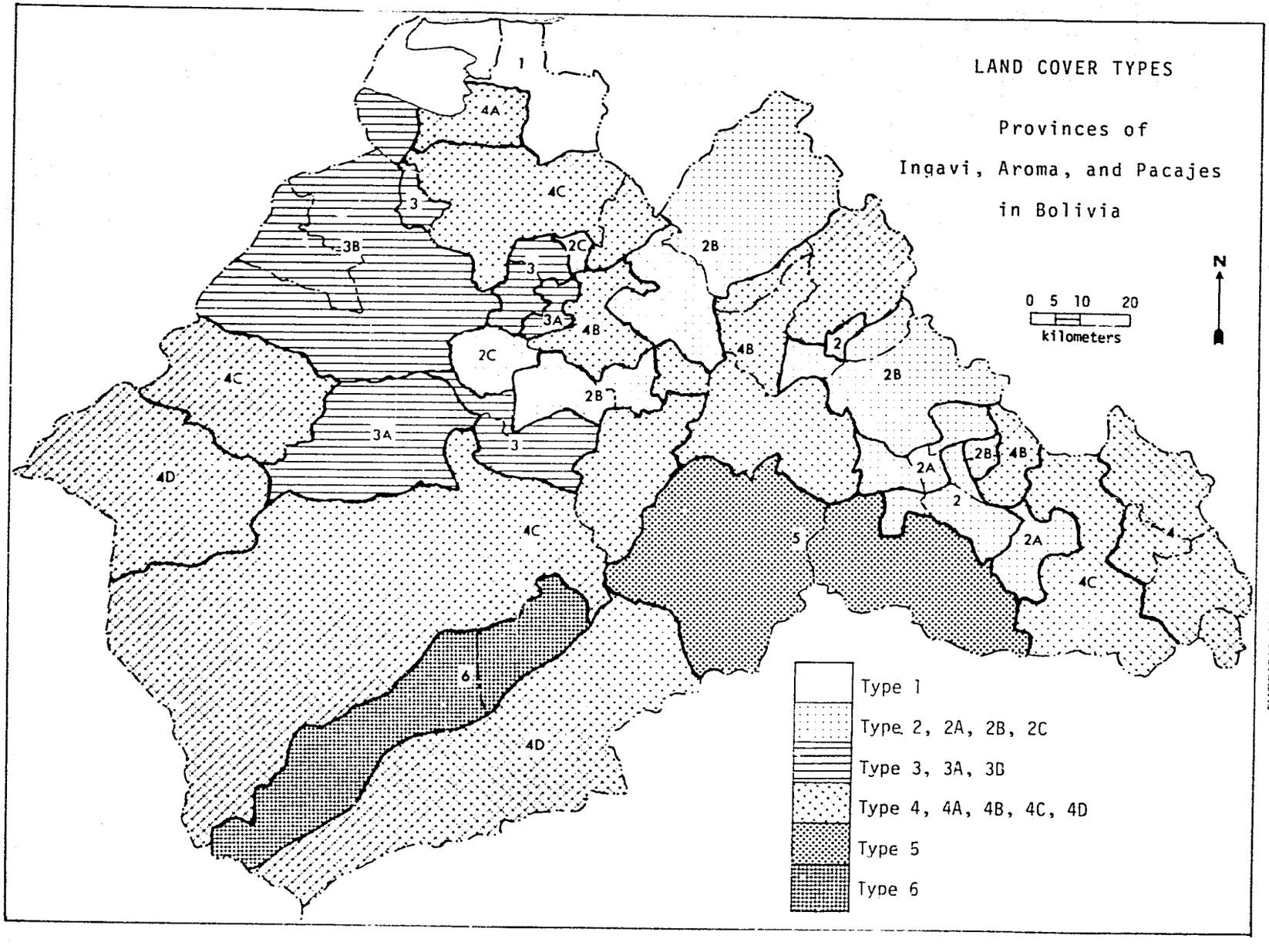


Figure 14b. LAND TYPES ESTIMATED FROM IMAGERY

Figure 14b. LAND TYPES ESTIMATED FROM IMAGERY--Continued

LEGEND

Type 1 -- Cropland, the leading land use, covers about 50% of total land area; dry non-saline pasture with some barren rocky ground covers some 40%.

Type 2 -- Undifferentiated cropland and pasture covers 85% or more of total land area.

Type 2A -- Undifferentiated cropland and pasture covers 45%-85% of land area; dry non-saline or seasonally wet pasture covers 10%-45%.

Type 2B -- Undifferentiated cropland and pasture covers 45%-85% of land area; dry non-saline pasture with mixture of barren rocky land covers 10%-45%.

Type 2C -- Undifferentiated cropland and pasture covers 45%-85% of land area; dry non-saline pasture with mixture of saline pasture covers 10%-45%.

Type 3 -- Dry non-saline pasture mixed with some saline pasture covers 85% or more of land area.

Type 3A -- Dry non-saline pasture mixed with some saline pasture covers 45%-85% of land area; undifferentiated cropland and pasture covers 10%-45%.

Type 3B -- Dry non-saline pasture mixed with some saline pasture covers 45%-85% of land area; dry non-saline pasture mixed with barren rocky land covers 10%-45%.

Type 4 -- Dry non-saline pasture mixed with some barren rocky land covers 85% or more of the land area.

Type 4A -- Dry non-saline pasture mixed with some barren rocky land covers 45%-85% of the land area; undifferentiated cropland covers 10%-45%.

Type 4B -- Dry non-saline pasture mixed with some barren rocky land covers 45%-85% of the land area; undifferentiated cropland and pasture covers 10%-45%.

Type 4C -- Dry non-saline pasture mixed with some barren rocky ground covers 45%-85% of land area;* mixed dry non-saline and saline pasture covers 10%-45%.

Type 4D -- Dry non-saline pasture mixed with some barren rocky ground covers 45%-85% of land area; barren rocky ground, sometimes mixed with some pasture, covers 10%-45%.

Type 5 -- Saline pasture mixed with dry non-saline pasture covers about 50% of total land area.

Type 6 -- Barren rocky land or barren rocky land mixed with pasture covers about 40% of land area; dry non-saline pasture mixed with barren rocky land covers up to 40%.

*In one case, the proportion is only 37%.

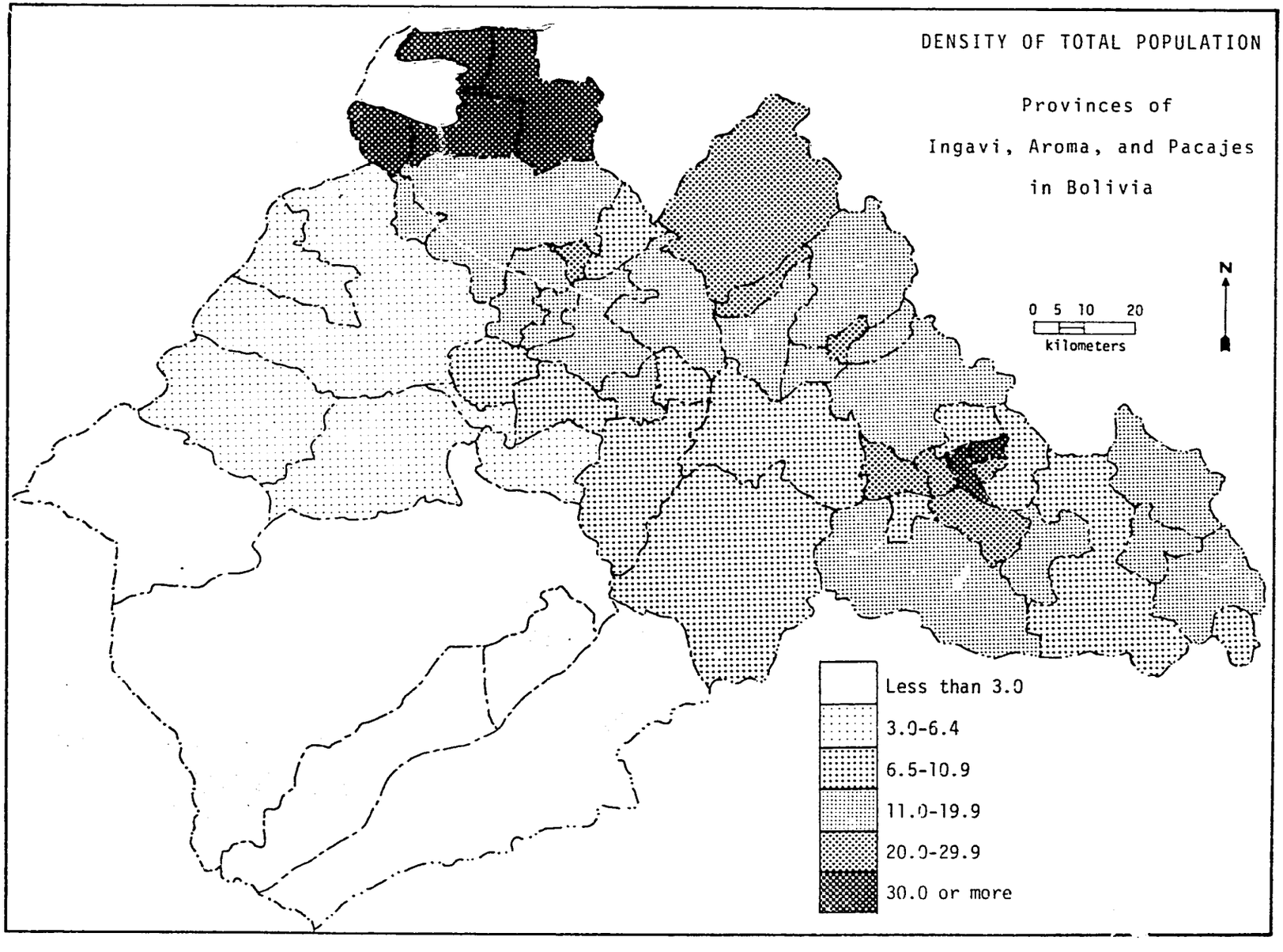


Figure 14c. POPULATION DENSITY COMPUTED FROM CENSUS DATA

of the surface of a country, for example, can provide an informative background against which to portray the distributions of many types of data. A screened mosaic printed in shades of gray permits the data user immediately to associate data overprinted on a base that shows valleys, highlands, cleared land, or other natural and man-made features.

2.63 Stratification for sampling.--The classification of areas into strata is a common procedure for sampling purposes. If detailed maps already exist and if data by small areas from a census are available, satellite imagery would probably be used as a supplemental rather than the primary source of information for delineating strata. If mapping information or available data are very poor or non-existent, then satellite imagery could be the primary source of information for delineating strata and for delineating sample areas.

One way to use satellite imagery in stratification is to determine the proportion or density of an element in an area and prepare a map. The element could be the percentage of total land area that is cultivated, percentage in pasture, amount of barren land, etc. Such a map could be used in conjunction with a map showing population density calculated from census or survey results; or crude estimates of population could be made from the imagery. The analyst will need to superimpose appropriate area boundaries on the imagery and determine a set of classes from the data that are developed. Figure 14b shows the extent of major land types in three provinces of a country as estimated from satellite images; figure 14c shows population density calculated from census results for the same provinces.

2.64 Other applications.--Satellite images may be useful in estimating population change after a census. Repeated observations of the same area will reveal significant changes in land cover. These changes frequently are associated with changes in population. Effects of land cover changes on the population can be determined and incorporated into the estimation process. This is done by measuring the areas that are affected and calculating net changes in the numbers of people, using appropriate population density figures for each type of land cover.

Monitoring the spread of cities and urbanized areas is a specific and often critical example of this type of application. The explosive growth of such areas in many developing countries frequently requires that officials and planners look for data on which to base decisions. Data from satellites may help them, even though the data will not satisfy all of their needs.

Other significant applications occur in agriculture. The spread of desert and deterioration through erosion can be observed over time. Effects on the size of the cultivated area and, to a lesser degree, on the quality of crop production can be measured. Also, major changes can be observed in land use, such as between forest and cropland, and in the pattern of occupancy, such as a shift from large fields to small individual holdings. Ability to distinguish individual crops is limited, especially in small fields or when several crops are grown in the same field. Future technical developments may result in images that can be reproduced at larger scales; this may make satellite images more useful for regular programs of agricultural statistics.

2.7 *Specific examples of applications*

In one country, satellite images covering a large part of the eastern lowlands were enlarged to a scale of 1:250,000. Tracings then were made of the planimetric details that were

visible on the images and useful to enumerators. In general, the tracings included the drainage pattern plus those towns and segments of roads that could be detected on the images. Additional features, names, and boundaries were added from other sources. The result was a series of up-to-date base maps for an area of about 300,000 square kilometers. Less directly related to taking a census have been other achievements. Creation of the first national image mosaic of the country was the result of the remote sensing project. It was to be used both as a possible base on which to display the distribution of any type of statistical data, and as a base for a 1:1,000,000 national land use map developed from the multispectral analysis of Landsat imagery.

In another country, a number of internal boundary lines have been identified in conjunction with land use boundaries. The identification is not consistent, but occurs often enough to be worthy of note. This phenomenon is associated with an increasing interest of the government in redefining administrative areas in terms of visible features.

In a third instance, one of the most direct objectives has been reduction of the cost and the time needed to determine the boundaries of urbanized areas. Tests show that it is possible to distinguish residential areas on the perimeter of urban areas.

In summary, satellite images have been useful in some census operations. However, it is premature (in 1978) to attempt to list all the potential applications of satellite imagery for census and other statistical purposes, and to say how successful each may be. Furthermore, new satellites with enhanced capabilities will be launched in the next few years, and a continuing program of experimental application and analysis is needed to keep up with possible applications of this new tool.

2.8 *Interpretation of imagery*

The techniques for interpreting digital imagery and data on computer tapes are complex and beyond the scope of this chapter; therefore, the following discussion will be limited to the interpretation of photographic-type images. In most cases, these are the types of images that would be used for census or survey purposes.

The techniques used in interpretation of imagery are similar to those used in interpreting ordinary air photos. However, the features identified in satellite images are usually composites. Individual buildings may not be identified; but the composite of rooftops, grass, gardens, streets, etc., that comprise an urban landscape can be distinguished and separated from the various types of rural landscapes. In this way, settlements from large cities to rural villages can be located In the same way, cultivated areas may be distinguished from heavily wooded areas.

Verification is even more important for interpretation of Landsat and other satellite imagery than it is for aerial photography. The broader but less detailed picture obtained from a satellite is one that most people are not accustomed to seeing, and it is often difficult to relate to known features or conditions. A person who already has some knowledge of an area can interpret an image more accurately by extending his interpretation outward from the points or areas he already knows. Ground truth investigations serve a similar purpose by providing information that verifies or permits corrections to the interpretation. For areas of tens of thousands of square kilometers, such as those shown on single Landsat images, it is helpful if the interpreter has some knowledge of at least part of the area. The more information or knowledge of an area the better the interpretation.

2.81 Black and white images.--Satellite images reproduced in black and white resemble air photos, but they show a much larger area and much less detail. Some of the elements of air photo interpretation (described in chapter 4) can be applied to satellite images, but others are irrelevant. Important elements for interpretation of black and white images are size and shape, tone and texture, and contrast. However, shadows are no longer significant, because the individual shadows and shadow-casting features normally are too small to be detected on satellite imagery. Further, satellite imagery is not designed to be used stereoscopically; thus, concepts of height measurement are irrelevant. However, a stereoscopic imaging satellite has been proposed for launch in the early 1980's.

As mentioned earlier, Landsat produces images in four spectral bands. Each band produces its own unique black and white image. Each band has its strong and weak points.

Bands 4 and 5 are similar; both show agricultural distinctions well, as well as other vegetation-cover types. Band 5 is superior to band 4 because it is less affected by the scattering of light rays due to dust and moisture in the atmosphere, and generally makes a clearer picture that shows more contrast.

Bands 6 and 7 are similar; both show landforms and water features well. Band 7 excels with water features while band 6 shows a little more influence of vegetation in the imagery.

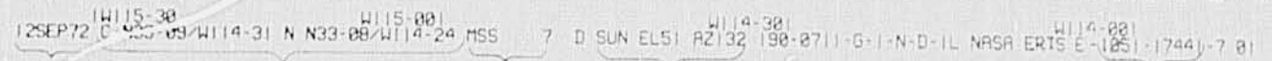
Urban phenomena are difficult to identify on all of the bands. Variations in the environment, differences in building construction materials, prevalence or lack of paved surfaces, and other factors all affect the ability to consistently distinguish urban features.

Bands 5 and 7 are judged to be the most useful for census purposes; which band is better depends on the type of area, type of census, and the personal preference of the staff. Use of both bands is recommended.

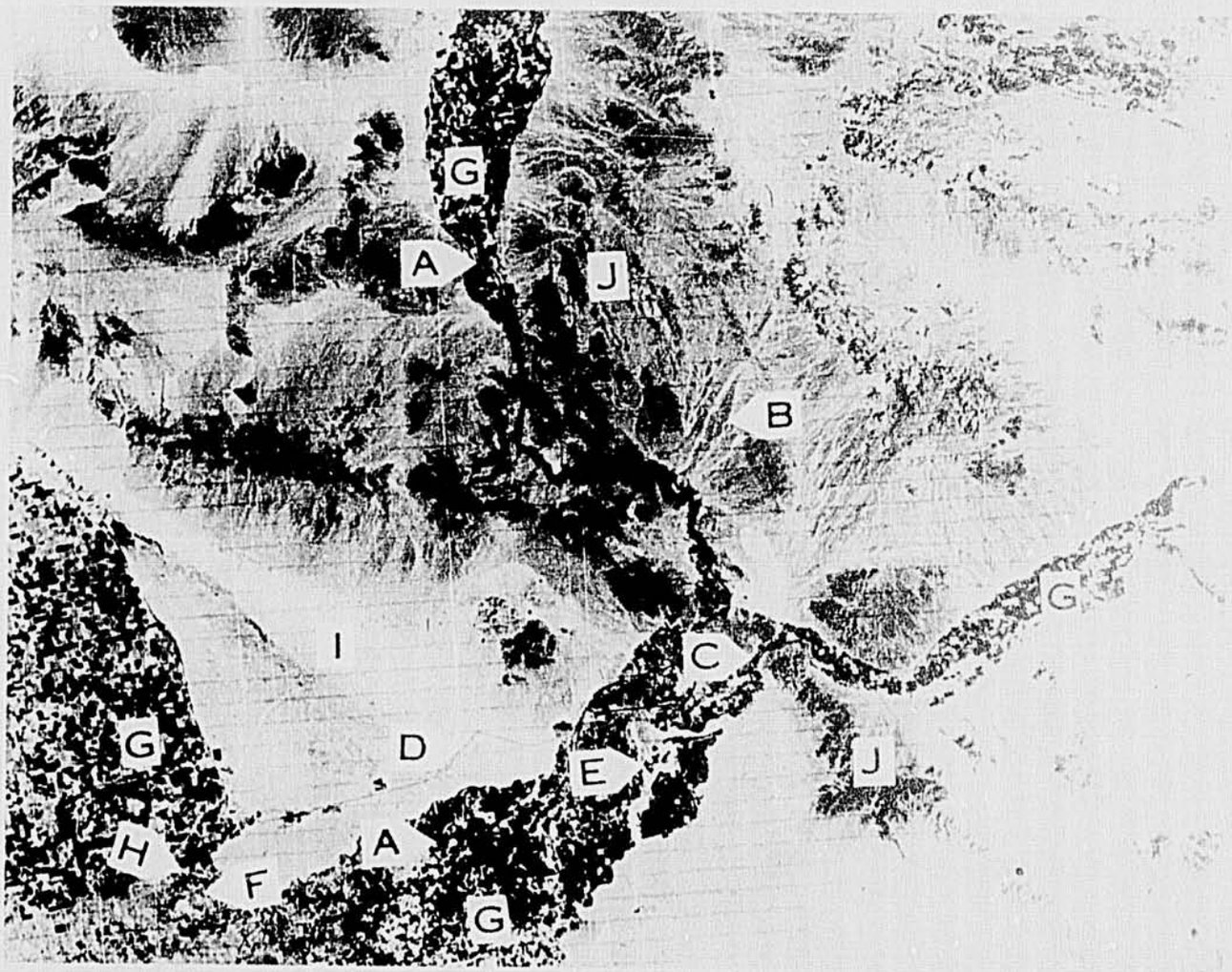
2.82 Color images.--The use of color is an important aspect of interpretation. It is much more useful to the interpreter than are variations of gray. Color is produced by projecting the bands through a filter, then superimposing them. The combination of colors blends the strong points of the various bands. Color helps to compensate for the loss of detail caused by the altitude of the satellites. Color information is available through both film and scanning sensor systems, and usually includes the near-infrared part of the spectrum. However, care must be taken when using infrared images. These images involve a shift in spectral values, so that what is naturally red is shown as green, natural greens show up as blues, and normally invisible infrared is shown as red. It is important to note that healthy growing vegetation reflects much more energy in the near-infrared part of the spectrum, which cannot be seen by the normal human eye, than in the visible part of the spectrum. Therefore, trees, grass, crops, etc., no matter what color they appear to be to the human eye, appear red in an infrared image.

2.83 Identification of images.--To help identify the coverage of each image, certain information is printed around the margins; included are latitude and longitude readings for the image, together with short horizontal or vertical lines that indicate the position of the respective parallels and meridians to which these values refer. In addition, to aid in interpreting the image, a line of information is printed for each Landsat image immediately below the bottom line of latitude and longitude. For example, in figure 14d, the information includes (a) date of image, (b) coordinates of image center, (c) band number, (d) sun elevation and direction, and (e) image identification number.

FIGURE 14.—SUPERIMPOSITION FOR PRINTING OF A LANDSAT IMAGE



BAND 5



G
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because they do not gain enough water from tributaries or springs to replace what is lost by evaporation and diversion for irrigation and other human uses. Specific features which can be identified in figure 14c are listed in the note at the bottom of the figure.

Band 7 is particularly good for showing water bodies and geologic features. These are very dark on band 7; in a color composite they will appear as very dark blue or black. Note that the Colorado River has water in its bed as far as the beginning of the All-American Canal, but the presence of water in the river below that point is questionable. Dry stream beds appear very bright; this is characteristic of intermittent stream beds and other areas of recent disturbance of the surface. The sand dune area also is extremely bright, and rather large and smooth-looking. The rocky hills and low mountains also can be seen clearly, particularly south of the Gila River where they appear as linear ridges.

Band 5 is particularly good for showing land cover; irrigated farmland especially contrasts with its immediate surroundings in this area. In band 7, farmland can be identified largely by its small block-like texture, but on band 5 this is reinforced by distinct contrasts in tone; the well-vegetated areas are darker. Different crops or crop stages in fields can be detected, as can land that may be between harvest and planting.

Cities appear rather clearly where they have distinct settlement clusters (not shaded by trees) in contrast with surrounding farmland; where they are adjacent to the desert, their urban limits are less distinct. Yuma is more distinct from its surroundings than is Mexicali. Depending on the individual situation, either band 5 or 7 could be used.

Most roads are too small and do not contrast enough with their surroundings; although it is known that there is a major road (four-lane divided highway) in the area in the southwest section of the image, it is not easily detected. However, note that the international boundary in the Imperial Valley can be identified. The block-like agricultural field pattern north of the border reflects different systems of agricultural and water use on the two sides of the border.

3. *AUTOMATED CARTOGRAPHY*[2]

During the last few years, great strides have been made in the production of maps using computers, automatic drafting equipment, and microfilm systems. The basic reason for the development of automated cartography is that it can increase the speed and accuracy and thereby reduce the cost of map production. In some countries, mapping agencies are using automated cartography to produce and update topographic maps from old maps and air photos.

The basic concept of automated cartography depends on the availability of computer-readable coordinates associated with a specific geographic unit. Each point on a map must be identified and recorded in machine readable form, producing a computer file that can drive an automatic computer printer, a line plotter, a light beam (that records on microfilm), or some other graphic output device.

The primary use of automated cartography by statistical agencies has been to produce statistical maps and charts. The technology for compiling and producing base maps for EA delineation exists, but the costs of the equipment and the initial input for such a system have been deterrents. However, once the basic

[2] *Adapted from Frederick R. Broome, "Micrographics: A New Approach to Cartography at the Census Bureau," in U.S. Bureau of the Census, Geographic Base (DIME) System--A Local Program. Series GE-60, number 6, April 1975, pp. 28-38.*

file is prepared, it can be updated, at minimal cost, when necessary.

3.1 *Elements of a basic automated system*

All automated cartography systems have certain common requirements and elements. They include data and boundary inputs, data extraction, boundary file processing, matching the files, preparing an output tape, and driving an output device.

3.11 Input files.--Any system that is used to produce statistical maps automatically will have two principal input files: (a) data file and (b) area boundary file. The first contains the statistics that are to be mapped, although it usually contains other data as well. It may be the same file that is used to prepare statistical tables for publication. Any data file may be used, as long as it contains data for a specific subject for individual areas that are to be shown on a specific map.

The second file contains a digital description of the boundaries of all administrative and statistical areas that may be shown on a map. Such a file contains the geographic codes for each area and coordinates for a series of points around the boundary of each area. The coordinates may be in any given system as long as all areas in the file are related to the same coordinate origin. The geographic codes must be the same, or must be made the same, as in the data file.

3.12 Data extraction.--This process uses a program to (a) extract data from the original data file and (b) assign the data to one or another of the various data classes that are to be used for the map. The class intervals usually are determined by the geography staff in consultation with the subject matter statisticians. A computer record containing the geographic codes and the data class is created for each area.

3.13 Boundary file processing.--The core of the automated mapping system is the program which converts digital descriptions of area boundaries into class boundary images. (See also section 3.3 on digitizing.) The boundary coordinates are converted to values that designate positions on the graphic device. At the same time, scale can be changed automatically. Images may be plotted on drafting film, paper, or photographic microfilm. For maps using color, a separate plate must be plotted for each color.

3.14 Matching the files.--The next step is to match the image of the area with the data record produced from the data extraction program. A new record is created and written on an intermediate file. This intermediate file then is sorted by class, and the resulting tape goes to an output device.

3.15 Output device.--The final automated step is the production of a map or chart by means of a graphic output device. This may be one of a number of different types: computer line printer; automatic plotter, either flatbed or drum; automatic graver or scriber; cathode ray tube (CRT); or a computer output on microfilm (COM) unit. There may be still other devices.

Each of these devices has its own advantages in terms of its accessibility and cost to acquire, install, and maintain; its simplicity or complexity; the availability and dependability of the programs needed to drive the device; the appearance of the final automated output; and the need for subsequent manual operations. The selection of the best output device in any given situation is not a simple decision.

3.16 Subsequent processing.--Many automated cartographic systems are not complete. They leave something more to be done. Often, lettering must be added from other sources.

Even though many systems also can provide lettering, manual placement of the lettering usually results in a better looking and more legible product. Films coming out of microfilm units must be developed and frequently enlarged. Sometimes screens or patterns must be added photographically before the plates are ready for use in the printing process. The agency planning to install an automated cartographic system must find out how much of the map-making process will be affected by automation and how much will still have to be done manually.

3.2 *Graphic output devices*

There are a number of graphic output devices. A few of them, and their characteristics, are mentioned here.

3.21 Computer printers.--The earliest form of automated thematic cartography, and the form easiest to implement initially, is the one that uses a computer line printer. For countries that have computers, the outstanding advantage is that the equipment is already in place; no additional capital investment is necessary. The acquisition of existing programs may be necessary, but such programs should be relatively inexpensive. Just about any make or model of computer can be used.

Using computer printers has definite disadvantages. Individual printer characters are used to produce the appearance of different shades of gray. Sometimes these apparent shades are not very distinct, and the map user must distinguish among individual characters. A block-like appearance is produced because the individual characters occupy their own rectangular character spaces and do not come into contact with one another to form a continuous tone. This block-like appearance can be eliminated somewhat by photographically reducing the output, perhaps to 10 percent of the original. A final disadvantage is the inability of the system to draw smooth curved lines; these must be approximated by combinations of straight vertical, horizontal, or diagonal lines.

With the availability of mini-computers, low-cost drum plotters, CRT's, multi-color pen plotters, and other devices, the use of computer line printers has become less attractive for statistical mapping. A computer printer may be used for in-house file review and class interval selection, but it is generally regarded as a poor choice for making publication maps.

3.22 Plotters.--Plotters produce line drawings in ink (or pencil) on film or paper. They have heads that go in the direction indicated by the driving computer tape. Sometimes the head may carry several pens, each a different color, for marking different kinds of features; the computer tape must specify the feature type and therefore the color to be used for each line on the plot.

Plotters come in a wide variety of models and sizes. Flat-bed plotters tend to be more expensive than drum plotters. In the flat-bed plotter, the drafting surface is held down by a vacuum, and the head goes in any direction commanded by the tape.

Drum plotters have paper that moves to or from rolls. The paper moves under the pen to permit lines to be traced in one direction; the pen moves only at right angles to the direction in which the paper moves (similar to a seismograph). Paper and pen moving together produce lines other than vertical or horizontal. The width of the paper on a drum plotter generally is narrower than on a flat-bed plotter, but its length is limited only by the amount of paper in a roll; it may be much longer than can be accommodated on even the longest of flat-bed plotters.

Inexpensive plotters may not be able to draw straight lines in directions other than directly vertical and horizontal. They have

to approximate curves or straight lines running at other angles with step-like increments of horizontal or vertical (or perhaps 45°) lines. Reduction of the final drawing is needed to minimize or obscure the appearance of these steps.

3.23 Engravers.--Automatic engravers are like large and expensive flat-bed plotters, except that they are much slower and they are designed to cut into the coating on a polyester film base. They are much slower because the engraving must be done relatively slowly to avoid damaging the coated surface on the film. Rapid engraving can cause unwanted chips, breaks, or skips in the coating. Engravers may be used primarily for work requiring great precision, such as the preparation of latitude and longitude grid lines or marks. Statistical offices ordinarily have little or no use for this type of equipment.

3.24 COM units.--COM (Computer Output on Microfilm) units use a light beam to plot lines or dots (or both) on microfilm. The output is one or more negative images on microfilm that may vary from 35 mm to 240 mm in width (as of 1977). The film must be put through a photographic film-developing process after the image is recorded. Separate images are produced for each color separation plate. The COM unit is extremely fast and precise. Precision is important because the microfilm negatives often have to be enlarged for use as reproduction plates and the several color plates must register with each other very precisely. The transfer of data from the computer to a COM unit is similar to the transfer from the computer to a flat-bed plotter or engraver; the difference is that a light beam, instead of a pen or cutting tool, is being driven.

COM units are quite expensive; however, they may be used for recording many types of data from a computer. In this respect, a COM unit may be used instead of a line printer. It is faster and the data produced are much more compact, but the film must go through a photographic developing process.

3.25 CRT display devices.--A CRT (cathode ray tube) is a device that has a screen (similar to a television screen) on which map information can be displayed in plotted form. If a record of the plot is desired, the image can be copied photographically or with a hard-copy duplicator if one is connected directly to the CRT mechanism.

The great advantage of CRT's is that many of them form an integral part of interactive systems. These systems permit the user to see what the plot of data from a given tape will look like, and to edit that tape when errors are detected or more recent material becomes available.

CRT's vary widely in price; however, some are relatively inexpensive. They can be used as separate units linked to their own minicomputers, or they can serve as remote terminals linked with large computers that may be located elsewhere.

Not all CRT's produce maps of publication quality, but they can be extremely effective tools for editing map data. The editing is accomplished before the computer tape is to be used by the plotter, engraver, or COM unit.

3.3 *Digitizing*

Map information needs to be converted into a form which computers and other types of automated equipment can recognize and use. For this purpose, the area boundary file is created. As explained earlier in the chapter, the area boundary file consists of codes and coordinates. The question of how the coordinates are determined and put into the file is another matter.

There are now available relatively inexpensive machines called digitizers. Such a machine is capable of (a) recording the X and

Y coordinates of any point within the limits of its digitizing board, and (b) associating certain codes with those coordinates (or with the two pairs of coordinates that specify a line) by means of a keyboard. A device called a cursor is used to specify points or to follow lines on the board. A series of individual points may be specified by the operator, or the machine may automatically record a series of coordinate pairs for points along a line which the operator traces with a cursor.

For any individual map, a series of control points must be established. The precise location of each point is entered into the file in terms of the desired grid system--latitude and longitude, Universal Transverse Mercator (UTM), or other. These points establish the scale and orientation of the map, provide reference points which permit the conversion of the coordinates of all points digitized on that map to the NSO's general grid system, and permit the linking of points digitized on different maps into a single common coordinate system that is independent of the individual source maps.

No system of automated cartography can function unless there is a way of converting the locations of Earth features into a series of symbols that can be manipulated by a computer. This applies to boundaries needed for thematic mapping and other types of features needed for planimetric or topographic mapping.

3.4 *Kinds of maps produced*

Theoretically, any kind of map can be produced by automated cartographic systems, but operational systems have not yet been developed for all kinds. Census publication maps can be prepared most readily by using existing systems that are operational.

3.41 Choropleth maps.--These are maps that show values by shading. Such maps may be produced by computer printers, plotters, engravers, or any of the other types of output devices. Figure 14f illustrates a choropleth map produced by a computer line printer. If maps are to be published in color, the various output devices can prepare a drawing for each separate color plate that is required on the printing process.

3.42 Dot maps.--These are the maps that show patterns of distribution by means of the placement of dots over the mapped area. The simplest type of dot mapping system places the appropriate number of dots uniformly over the individual area to which the data pertain. However, this may lead to absurdities, such as showing large numbers of inhabitants or crops on mountaintops, in swamps, or in non-irrigated desert areas. A more desirable approach is to develop and use a filter (for example, a land use filter) which reduces the probability of placing dots where inappropriate. Figure 14g illustrates dot maps produced by a COM unit.

3.43 Base maps.--These maps, unlike choropleth and dot maps, are not statistical maps. They are maps that are intended to show the location of features on the Earth's surface. The system for producing them is basically the same, but the inputs required are different. Instead of having two files (one of data and one of boundaries), there may be several different files, each of which contains one or more different types of features to be shown on the map. For example, the typical EA base map shows boundaries, drainage features, roads, and other selected man-made features (such as bridges, buildings, railroads, etc.). The input file or files will have all of these features recorded as lines or points; coordinates locate line ends or positions, and sometimes intermediate points (as described above for the area boundary file).

The technology exists for the automated production of base maps, but it is not yet practical. The digitizing of all of the base

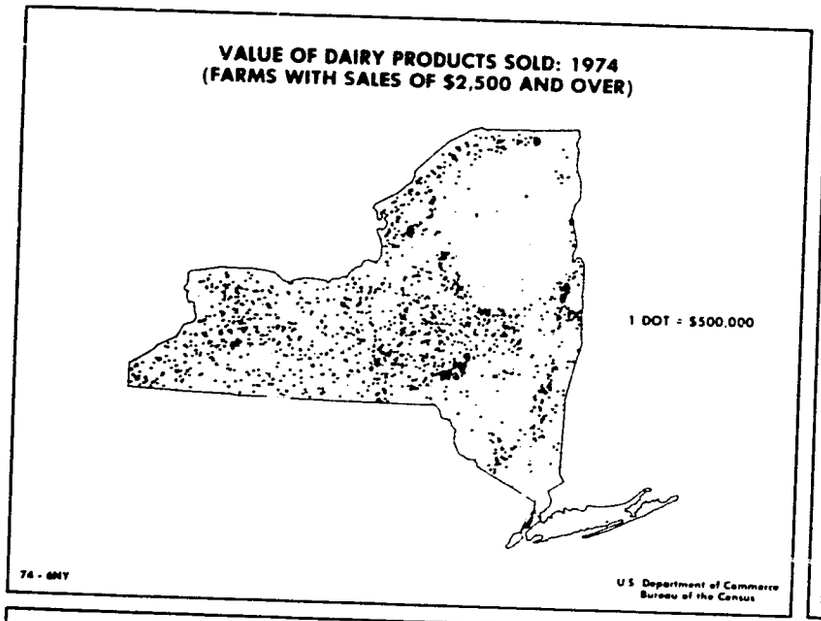
AVERAGE HOUSING VALUE OF OWNER OCCUPIED UNITS

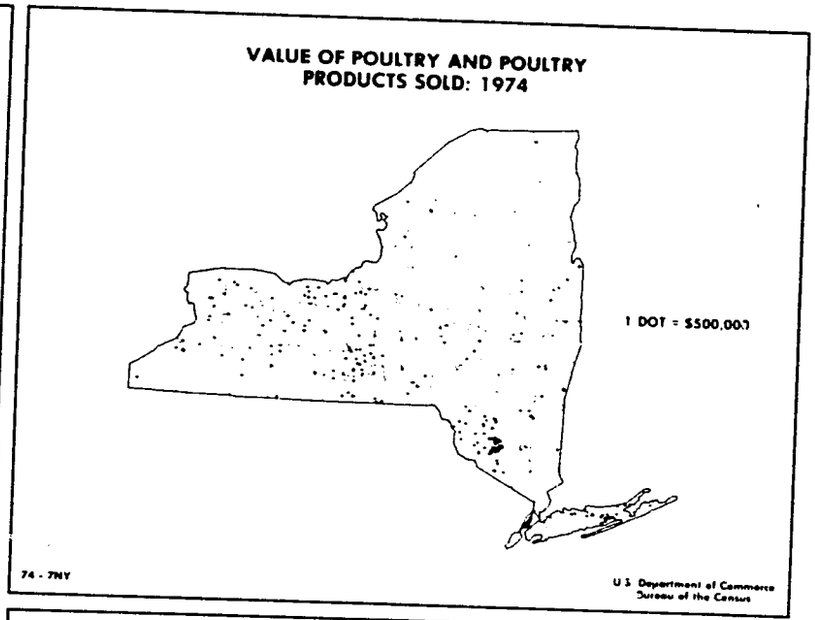
Washington, D.C. - Md. - Va. SMSA (part)

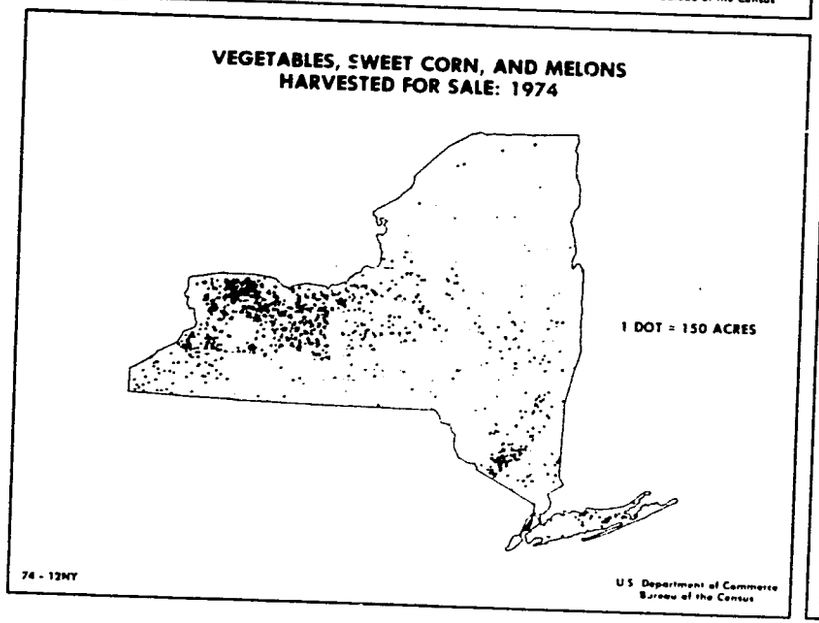
VALUE

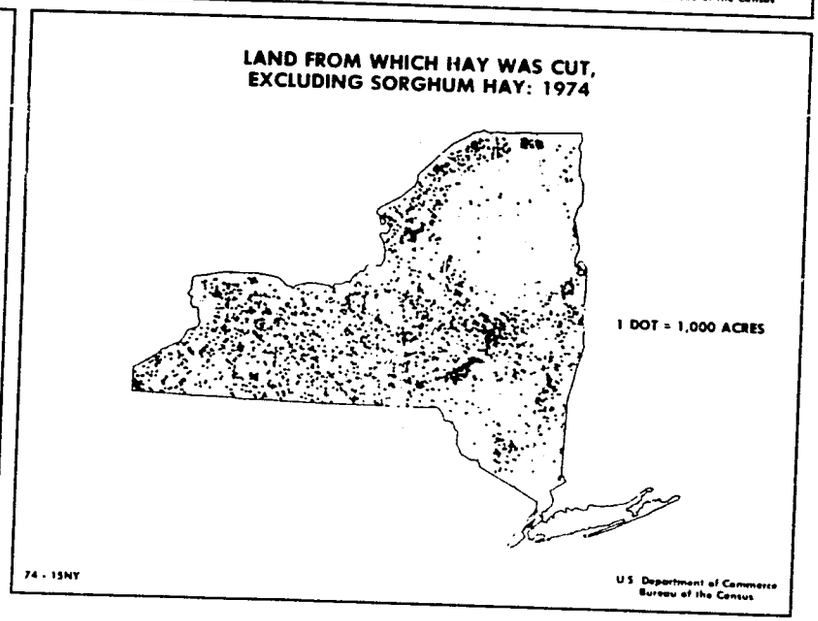
- under $15,000
- $15,000 - 19,999
- $20,000 - 29,999
- $30,000 - 39,999
- $40,000 - 49,999
- over $50,000

Figure 14g. DOT MAPS PRODUCED BY AUTOMATED CARTOGRAPHY









maps in a country would represent a major investment in time and resources. However, once such a file is established, it could be kept updated at relatively modest cost, and could be plotted out as needed. The coming decade may see further developments in this field.

3.5 *Graphs and charts*

Automated production of graphs and charts is a simple process compared with automated map-making. Graphs and charts serve a valuable purpose in making data more intelligible in published form. Automatic production makes the preparation of such materials much cheaper and permits a much greater variety to be prepared than heretofore. Computer programs, or sets of programs, are available for use in preparing graphs and charts automatically.

4. GEOGRAPHIC BASE FILES

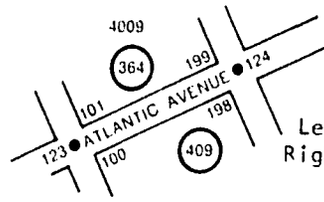
One of the more recent applications of the principles of automated cartography has been the development of Geographic Base Files (GBF). The purpose of the system is to facilitate the conversion of administrative records into statistical data which, in turn, can be associated with other statistical information relative to the same points or areas.

In the same way as the boundaries for automated thematic mapping are digitized, the system identifies each point on a map where a street or special feature (such as a river) intersects another street or feature, ends, or changes directions. Therefore, each street or feature is digitized in segments. These points or nodes are marked on the base map with a dot and are labeled with a unique identifying number as in figure 14h.

4.1 *Example of GBF*

Several countries have developed or are in the process of developing GBF's. The system that has been in existence longest and is the most complete is the one developed by the U.S. Bureau of the Census.[3] The entire system consists of a set of computer programs for establishing, maintaining, and using GBF files. For each segment in the GBF, the file record contains the following information:

Figure 14h. GBF RECORD FOR A STREET SEGMENT



"From" node	123
"To" node	124
Street name	Atlantic
Street type	Avenue
Left addresses	101-199
Right addresses	100-198
Left block	364
Left tract	4009
Right block	409
Right tract	4009

(1) Coordinates of the "from" node

(2) Coordinates of the "to" node

(3) Name of street or other line feature

(4) Type of street or other line feature (street, avenue, boulevard, river, boundary, etc.)

(5) Address ranges on both sides of the feature (when applicable)

(6) Geographical codes for the areas on each side of the feature (block, tract, city, country, etc.)

The GBF uses a standard system; coding proceeds from lower address numbers to higher address numbers along a street. Therefore, the node at the lower address end of a given street segment is called the "from" node, and the node at the higher address end of that segment is called the "to" node. Where the segments are continuous, the "to" node of one segment record becomes the "from" node of the next segment record. Figure 14h illustrates the map features that are contained in a GBF record, except for the coordinate values.

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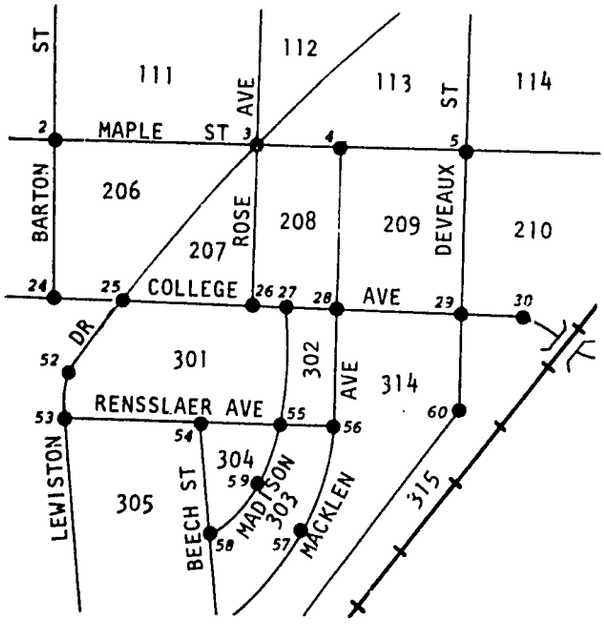
[3] *The complete name of the system is Geographic Base File/Dual Independent Map Encoding or GBF/DIME.*

Figure 14i. SECTION OF A METROPOLITAN MAP SHEET WITH NODE DOTS AND NUMBERS

(Three-digit numbers indicate blocks within census tracts)



The first step in creating the basic GBF file is to code two separate sets of data on a map or map series: (a) the nodes at the ends of each segment, and (b) the areas enclosed by nodes and segments. The second step is to use these codes in preparing a series of computer-usable records that include the information described in the preceding paragraph. The third step is to digitize or determine coordinate values for each node on the base map or maps for the area. Figure 14i shows a portion of a metropolitan map sheet with node dots and numbers.

The fourth step is a computer operation in which the digitized node values are converted into latitude and longitude, UTM, or other grid system values, and are entered into the various GBF records. The coding can be checked and edited by using a computer to compare the network of nodes and segments with the areas on each side of each segment; this is done in a way that assures that the network is completely represented and that all of the map area is included.

When the file is ready, a computer with a plotter or other visual output device can plot a complete replica of the original map, with streets at the proper angles and blocks of the proper dimensions. Curves are not plotted; all lines between nodes are straight lines. This plot also can be used to make a final visual check of the completeness and accuracy of the segment and node coding.

4.2 *Application of the GBF*

The GBF can serve as the base for a highly integrated city or regional information system. Most cities and regions have many different agencies, governmental and otherwise, that collect data for their own purposes, in their own formats, and within their own unique frameworks of administrative areas. However, these data records usually have one common element--a street address to which they relate. The GBF system makes it possible to bring together different types of data by means of the area identification codes in the GBF. This eliminates the need for duplicating data collecting activities. One agency already may have collected some of the data that another agency needs. The GBF system permits the data from various other agencies or other sources to be coded to any set of areas that a user agency may require. The amount of data available to each agency is increased; moreover, the speed with which data are made available and analyzed can be greatly increased.

The basic problem in using the GBF system is how to bring the data together geographically. School enrollment data may be kept by school district, fire information by firehouse district, crime information by police precinct, etc. The GBF can be constructed so it will contain codes for each area of each different type that any user agency may require. New sets of codes can be added later as needed. A computer matching program is

used to take files of administrative records containing street addresses, and to add to these records the correct common area identifiers or codes. This permits the records to be matched and compared with data from other sources that also have been processed by the matching program. Once this has been done, the user can proceed to manipulate, analyze, compare, associate, and otherwise use his data and the other data available to him through the GBF in any way desired; this can be done cheaper and faster than if all of the data needed had to be collected and coded first by the user.

It should be noted that two elements are necessary for a workable GBF system. First, a country must have a regular systematic program of assigning house numbers, street names, or other property identifiers. Alternatively, there may be a systematic program of small area identification. Secondly, the country must have good detailed maps.

Chapter 15. STATISTICAL AREAS

1. DEFINITION OF STATISTICAL AREAS

Governmental or administrative areas for which statistics are available might be called statistical areas; but the term statistical area generally is limited to those areas which are specifically defined to represent geographic regions,[1] metropolitan areas, or smaller areas of various types. Statistical areas may be groups of administrative areas or they may be areas that are formed without regard to official boundaries and thus comprise parts of several administrative areas. Designation of statistical areas usually rests on specific criteria that are to be followed in defining such areas, and these criteria usually relate to social and economic characteristics.

2. NEED FOR STATISTICAL AREAS

Census planners may well ask whether there is any need for presenting statistics by special statistical areas in addition to all the governmental or administrative areas that make up the total divisions of the country. Several answers can be given. Administrative areas are rarely defined on the basis of the social and economic characteristics which are used for defining statistical areas. Many administrative areas have a long history, and tradition is against change. It is only by coincidence that boundaries of administrative areas delimit areas of current social and economic significance. Also, administrative areas are numerous; and the ability to understand their statistics is often improved by combining them into groups that constitute meaningful statistical areas. For example, some countries may be divided into regions of lowland and highland, into wetland and dryland, or into woodland and grassland, or perhaps some of each. These regions may have developed different economies, cultures, and possibly even administrative characteristics which are reflected in the statistics that are gathered. Often it is desirable to have the statistics for each of these regions, rather than have the data separated into the individual administrative divisions. Areas with similar environments are likely to have similar statistical characteristics and similar problems. Statistical data are used primarily for understanding and solving problems.

The case for small statistical areas can be stated in a similar fashion. The need again is separate statistical data for individual areas having common characteristics. At the smaller level, areas can be more finely differentiated on the basis of social and economic characteristics--in other words, more homogeneous and less heterogeneous. As a result, small statistical areas provide data that help to focus sharply on such local problems as housing needs, health and welfare conditions, adequacy of education, employment, marketing and distribution of goods, and a host of other local problems. Small administrative areas frequently fail to provide the statistics needed because their boundaries are drawn without reference to many local characteristics. For example, rich and poor areas may be combined so that the data (expressed as averages) indicate medium income areas; the same situation may exist with regard to health or education.

[1] *As used in this chapter, the term region is applied to broad geographic divisions within a country--not to the broad regions of the world, which comprise groups of countries.*

A further need relates to areas whose boundaries do not change from one census to another as do some administrative areas. With stable boundaries, it is possible to compare data for an area from one census to another, and know that the changes that occurred are real and not caused by changes in boundaries.

For countries that do not have a large number of experienced data users, there are simple ways of determining how much emphasis should be devoted to developing statistical areas. For small countries with small populations, the need will be least; for large countries with large populations, the need will be greatest. Large populations generally have more diverse physical and cultural characteristics. In addition, countries with large populations are subject to many kinds of social and economic problems which need better analysis at both the macro and micro levels.

For countries that have not used statistical areas in past censuses, the initial use should be limited. Thus, the countries gain experience in developing such areas and in promoting their significance to both national and local data users.

3. *TYPES OF STATISTICAL AREAS*

Statistical areas could be classified in numerous ways. Considering how they have developed historically it seems best to recognize their differences in terms of relative size. On this basis there appear to be four types: (a) major regions, (b) metropolitan and urban areas, (c) small areas, and (d) intermediate and other subregions.

3.1 *Major regions*

Division of a country into a few major regions for the presentation of statistics may be the first recognition of a need for statistical areas. Figure 15a illustrates the four regions of Thailand.

Such regionalization is particularly required if the country has many 1st order divisions such as provinces or states. Summary data for a few regions can be analyzed and compared quickly, whereas the data for many 1st order divisions will take time to comprehend.

Usually the major regions will be defined in terms of groups of the 1st order divisions of the country. The ideal would be three to five major regions which would recognize the major physical, cultural, and economic differences in the country. In a very large country with many 1st order divisions it may be desirable to have a second level, or subregions; the subregions could comprise groups of 1st or 2nd order divisions. Figure 15b illustrates economic subregions and State economic areas for part of the United States. The State economic areas consist of single counties or groups of counties with similar economic and social characteristics. Economic subregions represent combinations of State economic areas.

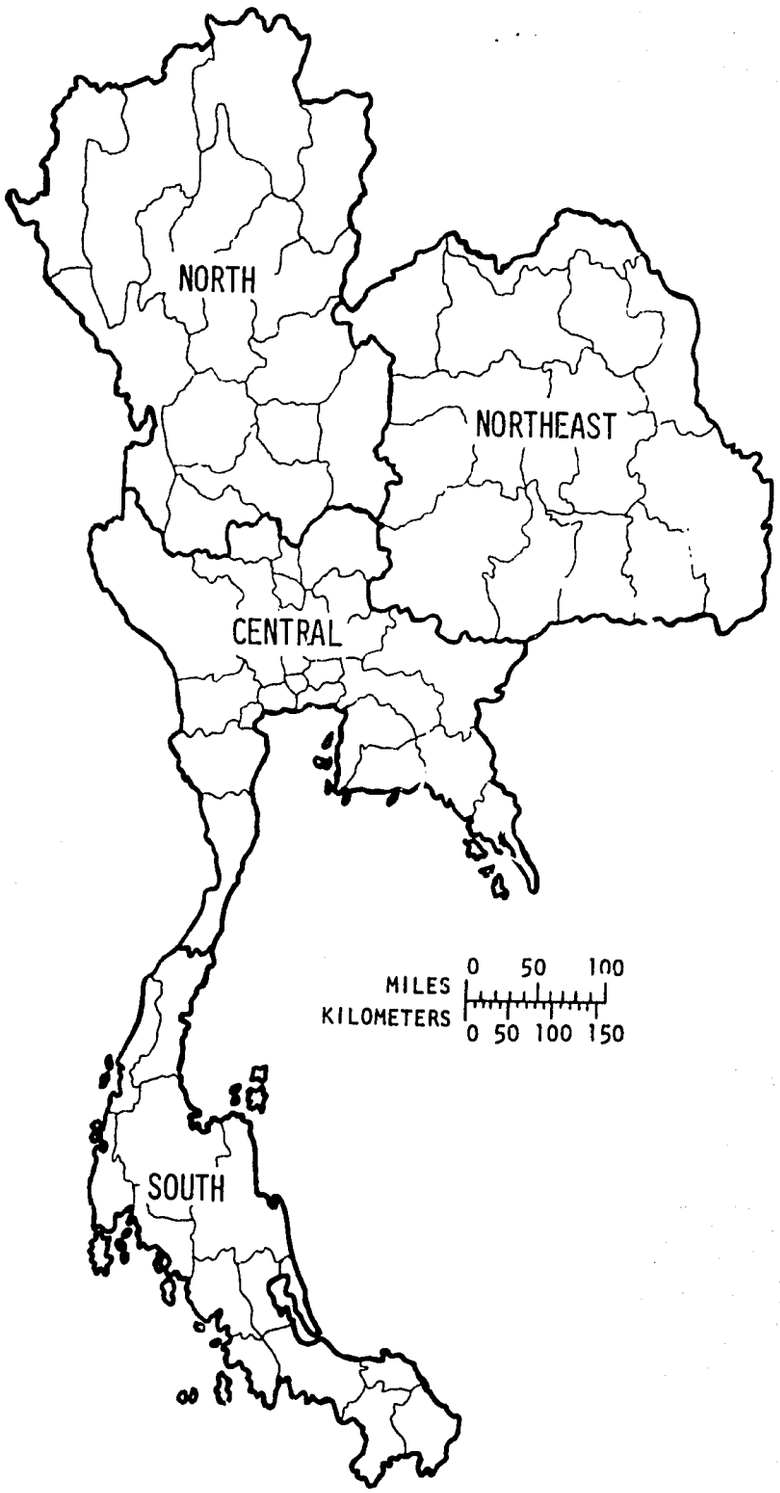
The boundaries of the 1st order divisions may not be ideal for separating the major regions or subregions; but for a summary set of geographic areas, precision of definition is less important. Continuity over time is important and any major regions that are established should be observed without change for a series of censuses to be of value for trend analyses.

3.2 *Metropolitan and urban areas*

After major regions, the statistical areas that are most commonly recognized throughout the world are metropolitan areas and urban areas. Urban growth has been so great in recent decades that most countries have some large cities that might be considered the centers of metropolitan areas.

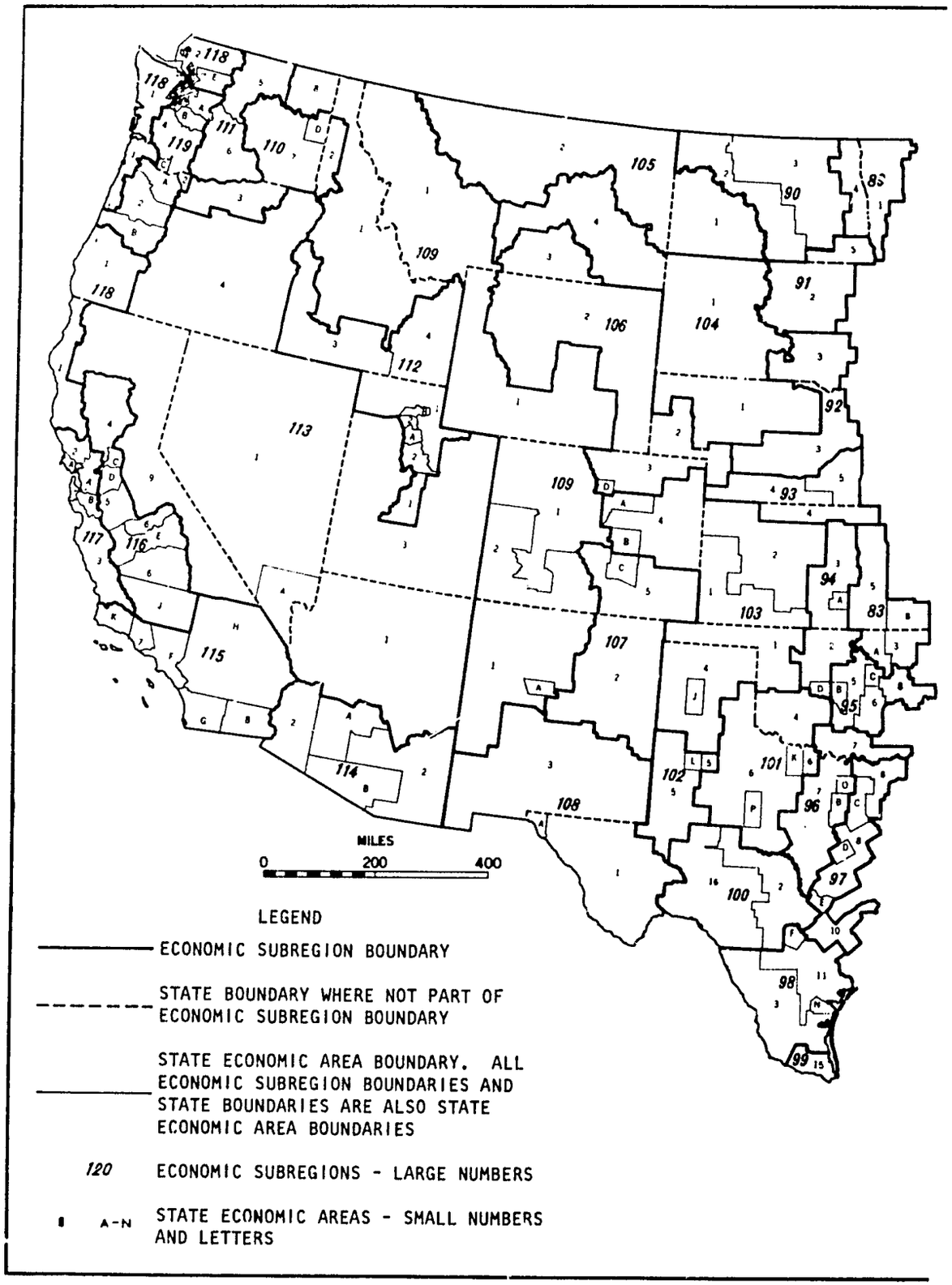
3.21 Metropolitan areas.--A metropolitan area usually includes not only a large central city but also all surrounding administrative areas that have some urban characteristics and

Figure 15a. REGIONS OF THAILAND



Source: Adapted from a map in Ralph Thomlinson "Thailand's Population," 1971.

Figure 15b. ECONOMIC SUBREGIONS FOR WESTERN PART OF CONTINENTAL UNITED STATES: 1970



whose populations have regular, usually daily, contact with the central city. In most cases, "metropolitan" refers to a densely settled area which has a large central city or cities and an integrated economic and social life; the definition includes all contiguous administrative areas which conform to the above description (see figure 15c). Metropolitan areas normally include some rural population because they are defined in terms of whole administrative areas. Since metropolitan areas may represent a significant proportion of the population of any country and also its most densely clustered population, they are important areas to define and analyze separately.

3.22 Urban and urbanized areas.--It may also be appropriate for statistical areas to distingush between urban population and rural population. Generally speaking, urban population is regarded as that population living in closely spaced settlement and not engaging in agricultural occupations. One of the major difficulties in defining urban population is that city boundaries (established for administrative purposes) rarely delimit the actual extent of urban settlement.

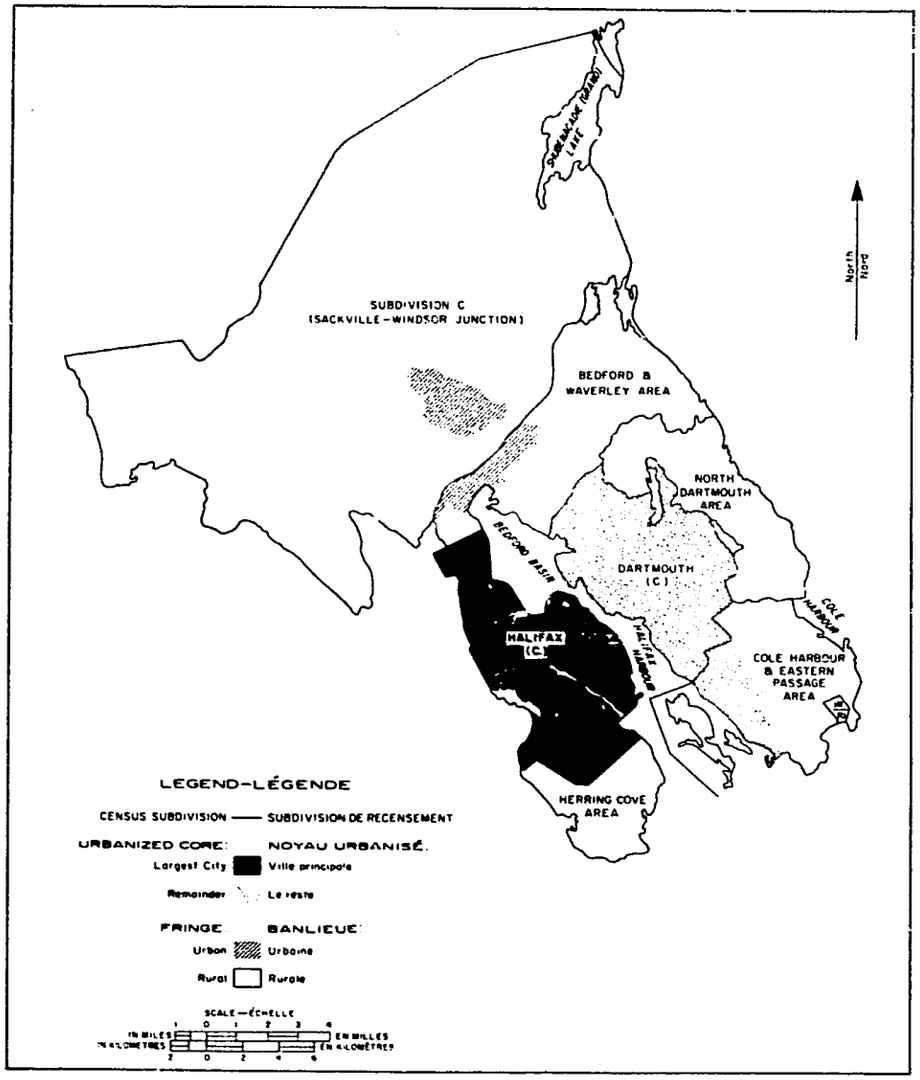
In some countries, the cities or municipalities include considerable rural areas and population. In other countries, cities fail to include considerable urban population outside their limits. In the first case, the city could be called overbounded and in the second case, underbounded. One way of correcting for these conditions so as to achieve a better separation of urban and rural population is to develop statistical areas which carefully bound the urban areas mainly on the basis of high population density. In the United States, such statistical areas are called urbanized areas and are named after the principal city or cities. The urbanized areas are customarily defined to include the (a) central cities of metropolitan areas and (b) their closely built-up surrounding territory. They may be defined also for somewhat smaller cities. All of the population within urbanized areas is regarded as urban population.

In Canada, the urban portion of each metropolitan area consists of the central city or cities, known as the urbanized core, plus the adjacent closely built-up area called the urban fringe. In Argentina, the Greater Buenos Aires area (shown in figure 15d) consists of the Federal Capital and urban portions of the surrounding partidos, which are similar to districts or counties in other countries.

Urban population, as it is defined in many countries, recognizes cities, towns, and other selected administrative areas above a certain minimum population size. This minimum number customarily varies from 1,000 to 5,000. In many cases, the smaller cities and towns are overbounded and include much land and population that is outside the closely settled area. To improve the definition of urban and rural population, special boundaries may be drawn to separate the closely settled area from the surrounding open country in a manner similar to the definition of urbanized areas. Statistical areas of this type may be designated "places." The boundaries of these "places" may be delineated by census field teams from the Geography Division of the NSO or with the help of some of the local officials of 2nd or 3rd order divisions. "Places" have been defined by many countries.

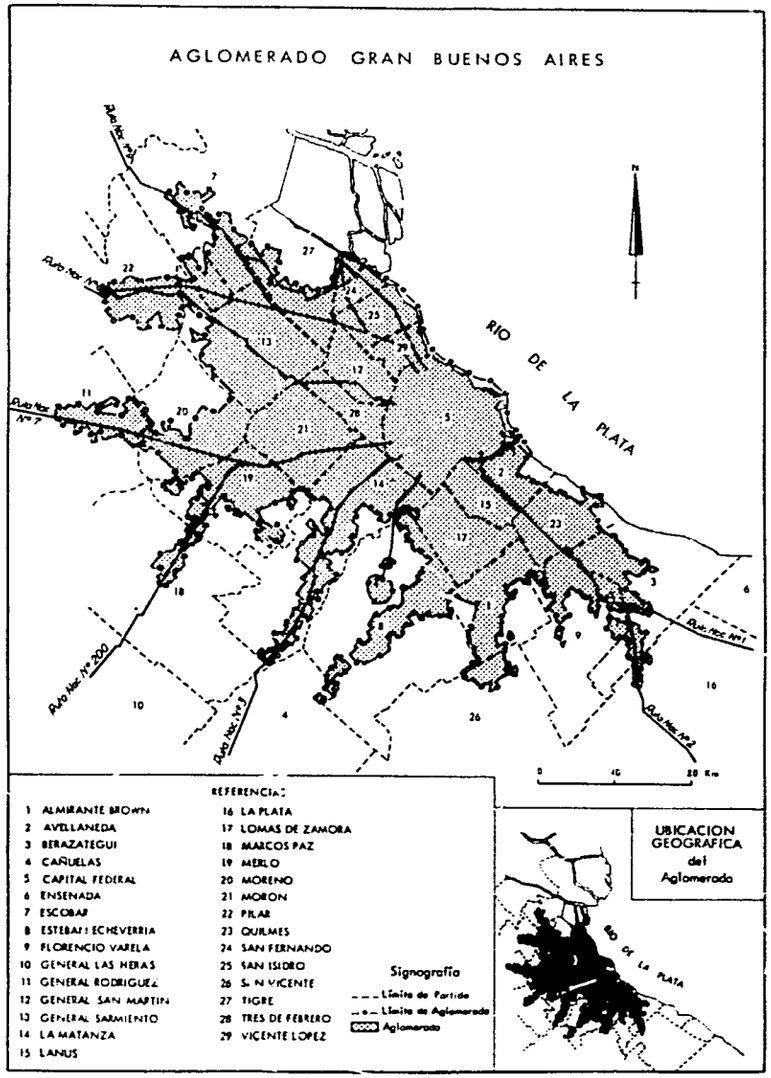
In summary, the term urban refers to places (cities, towns, urbanized areas, etc.) that are above the minimum population, and whose inhabitants live close together and engage in non-agricultural occupations. The area definitions include all or parts of administrative divisions that meet the criteria. The remaining areas are defined as "rural."

Figure 15c. METROPOLITAN AREA OF HALIFAX, NOVA SCOTIA CANADA: 1971



SOURCE: "1971 Census of Canada: Population Reference Maps." Reproduced by permission of the Minister of Supply and Services Canada.

Figure 15d. AGLOMERADO GRAN BUENOS AIRES, ARGENTINA: 1970



Source: "Censo Nacional de Población, Familias y Viviendas - 1970." Courtesy of Instituto Nacional de Estadística y Censos, Republic of Argentina.

3.3 *Small areas*

The third major type of statistical area includes the various small areas used for detailed analysis of metropolitan or urban areas and, in some instances, of rural areas. These include such areas as census tracts or sectors, census divisions, city blocks, central business districts, school districts, planning areas, communities, neighborhoods, voting precincts, and the like. Not all of these areas have been recognized in census taking, but they could be recognized if it were deemed desirable.

A census tract, or sector as it is sometimes called, is a general purpose area and is one of the most significant and useful types of small areas that can be developed. Figure 15e shows the division of communes into statistical sectors for part of Belgium.

Census tracts are small, permanently established, geographical areas into which large cities and their surrounding areas have been divided for statistical purposes. In some countries an average tract has about 4,000 people. It is originally laid out with good visible boundaries and with attention to achieving some uniformity of population characteristics, economic status, and living conditions. Such areas serve as permanent meaningful units of analysis in cities where most administrative divisions are defined for a single purpose (elections, utilities, administration, etc.) and are subject to frequent change. Figure 9d (in chapter 9) shows a portion of a city that was divided into census tracts and city blocks.

A census division is another example of a small statistical area. It is a subdivision of 1st or 2nd order divisions where administrative subareas are unsatisfactory for statistical purposes. Administrative subareas may not exist, their boundaries may be unknown to both the inhabitants and the local authorities, or the boundaries may change so frequently that their usefulness for statistical comparisons is impaired. In any case, the census divisions are relatively small areas which may be defined by the NSO for census use. They should possess good boundaries and usually represent areas that are community, tribal, or trading areas.

Rural agricultural villages also are small statistical areas. They may be delineated on the basis of close settlement and recognized as rural "places." In a number of countries, some agricultural villages have many thousands of inhabitants; they may have a larger population than some urban places.

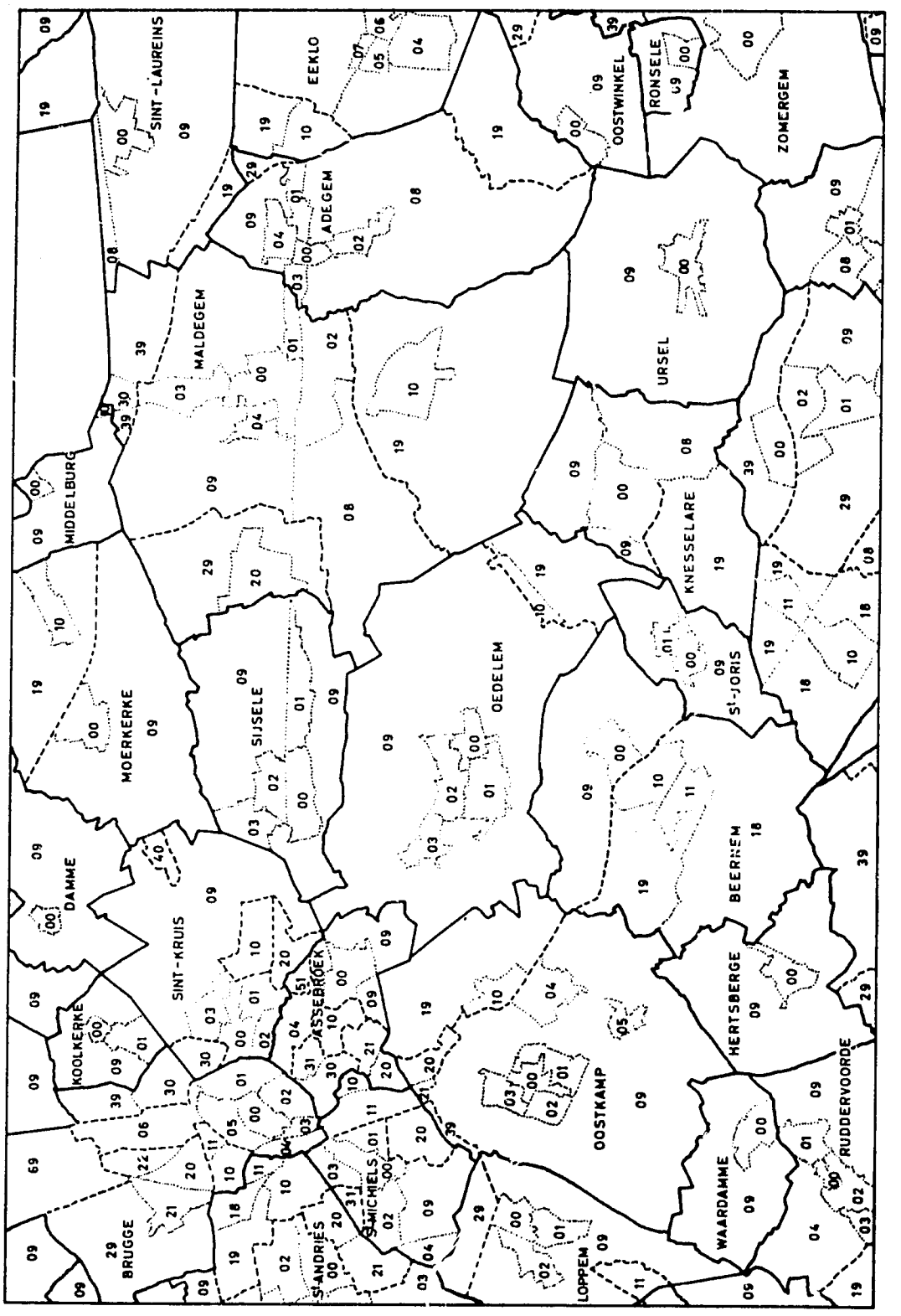
3.4 *Other statistical areas*

Although the three general types of statistical areas discussed above are considered more important, there are several other types (including intermediate and other subregions) that have value and may become very significant in the future. Three are mentioned briefly.

3.41 Subregions.--The first are subregions of 1st order divisions. These consist of groups of 2nd order divisions. Such areas have been developed to recognize agricultural and economic support areas. In many cases, they are related to natural subregions with special physical characteristics of climate, topography, drainage, and soil.

3.42 Metropolitan regions.--The second type is the metropolitan region. Regions of this kind represent an attempt to define the areas of influence of metropolitan centers and in some cases those of smaller cities. The entire country may be subdivided into metropolitan regions. Metropolitan regions comprise groups of the 2nd order divisions of the country and usually do not observe the 1st order division boundaries. Metropolitan areas form the nucleus of these larger metropolitan regions. The usefulness of metropolitan regions is primarily for market and economic analysis.

Figure 15e. LA DIVISION DES COMMUNES EN SECTEURS STATISTIQUES EN BELGIQUE: 1970



SOURCE: "Extrait du Bulletin de Statistique," 1972. Courtesy of Institut National de Statistique, Belgium.

3.43 City or metropolitan subareas.--Small areas such as census tracts may become too numerous in large cities for general data analysis; therefore, summary areas composed of groups of census tracts may be needed. These city or metropolitan subareas are often described as communities within the city, but may also be employment or economic subareas.

4. CONCEPTUAL BASIS FOR DELINEATION OF STATISTICAL AREAS[2]

The considerations on which the delineation of statistical areas rests are numerous. They are outlined here to provide an understanding of how the definition criteria for such areas might be developed. For each type of statistical area the emphasis will vary, depending on the purpose or use desired in statistical presentation.

4.1 Homogeneous or functional emphasis

Two fundamentally different principles are observed in defining statistical areas. One is to define a statistical area by the likeness of the characteristics of its component parts--the homogeneity principle. The other is to define a statistical area by the presence of a nucleus and an area of influence--the functional integration principle. Boundaries should be maintained for a long time without change, so that statistics can be compared for the same areas from one census to another.

4.11 Homogeneity principle.--Applying the homogeneity principle requires grouping together in a single statistical area those parts which have similar characteristics and separating those which are different. Often the differences along the border are not sharp, and careful judgment is required to assure that the similarities in characteristics and trends outweigh the differences. The characteristics may relate to population, economy, land use, or physical environment or, more commonly, a combination of characteristics. The technique of selecting boundaries involves the use of statistics, maps, and frequently field work or aerial photographs for smaller statistical areas. Statistical areas delineated on the homogeneity principle are particularly useful for analyzing trends as well as differences between areas.

4.12 Functional integration principle.--A statistical area designed on the functional integration principle comprises all the area that is organized around a centralizing node (or nucleus) and which generally operates as a unit. Functional areas include metropolitan areas, community and neighborhood areas, tribal areas, trade areas, traffic flow areas, and all other areas that are integrated through communication or movement of one kind or another.

Integration, like homogeneity, may be based on a single factor or a group of related factors, and may be difficult to measure. Few statistics are collected on movements, commuting, traffic flow, trading patterns, or communications; fewer yet are readily available or published. What is available is often difficult to interpret. Yet considerable information on the boundaries of statistical areas may be obtained through field observation, interviews, and mapping of the results. Such techniques may be costly and often they are not precise; however, they are valuable in defining areas properly.

4.13 Use of principles.--In the delineation of most statistical areas, both principles are used to some extent. The difference is

[2] *Some of the ideas expressed in this section are adapted and updated from a previous publication by Morris B. Ullman and Robert C. Klove, "The Geographic Area in Regional Economic Research," presented at the Conference on Research in Income and Wealth, and published in a report of the National Bureau of Economic Research, Regional Income, Studies in Income and Wealth, Vol. 21 (Princeton University Press, Princeton, New Jersey, 1957), pp. 87-111.*

mainly in emphasis. For example, census tract (or sector) criteria emphasize homogeneity but also recognize the importance of such major barriers as railways, freeways, waterways, and topography, which often separate one community from another. Indeed, some census tracts are neighborhoods, and in many cities combinations of census tracts are recognized as communities, planning areas, employment districts, or central business districts. In the case of metropolitan areas, the criteria may be divided into two kinds: (a) those concerned with identifying metropolitan character, including population concentration and size, concentration by place of work, and possession of other important activities, and (b) those concerned with economic and social integration between the central city and outlying areas in terms of daily commuting to work, shopping, and communication. Also, considerations of scale or level in the hierarchy of areas are always pertinent, and what may be homogeneous among large areas may be very heterogeneous among small areas.

4.2 *Number, size, shape, and grid*

While homogeneity and functional integration principles are basic to the selection of criteria for the delineation of statistical areas, many other factors require careful consideration. These are discussed from the point of view of both the analyst (or user) of statistics and the collector of statistics (the NSO).

4.21 Number of areas.--It is important to have only a few statistical areas if one seeks a quick and general overall view of the distribution pattern of a large area. This is true if one is looking at the whole country and wants to know what are the major regional differences. Likewise, in examining the statistics of a large 1st order division, it is desirable to determine what are the major subregional differences. The same can be said for a large city and its major subareas. How many statistical areas are needed for this purpose would certainly vary, depending on the population and area size of the country, 1st order division, or large city. Depending on the complexity, the number might vary from 2 to 10 (but rarely more) and preferably from 3 to 5.

On the other hand, once the general view of the distribution pattern is determined, detailed analysis requires statistics for many small areas. It is difficult to advise on how many are needed because this depends upon the complexity of the overall area and the goals of any statistical and cartographic analysis. Since there are additional costs involved in the collection, tabulation, and publication of statistics for statistical areas, it is desirable to seek the minimum number necessary for the detailed analysis required. With the widespread use of electronic computers, the tabulation costs are not as significant a limiting factor as they were in the past.

4.22 Size of areas.--Closely related to number of areas is the size of areas. "Size," as used here, usually refers to population size (or to the amount of economic activity within an area in the case of economic censuses). For small statistical areas particularly, it is important that each is of sufficient size to assure that meaningful data can be provided.

When statistics are collected by sampling, the sampling error of the results for areas of small population may be high, depending on the sampling fraction used. In addition, there is a strong likelihood of disclosure of private information in any detailed tabulation of areas of small population (this is true also in a complete enumeration). To avoid disclosure of private information is one reason why very few small-area tabulations are available from certain census inquiries, such as the census of manufactures.

Equality of population size is of lesser importance but is significant for some area

analysis. Each region should have a significant proportion of the total population to be called a major region. The populations may vary greatly among regions, since many large areas have low populations. Normally, mountain areas, desert and semi-arid areas, and heavily forested areas have small populations yet may occupy large land areas. For metropolitan and urban areas, equality of population size is not a major factor in setting up the areas, because separate data by size group can be provided in the analysis. For small statistical areas, rough equality of population size is of considerable significance; at the lower end of the scale almost all areas should have at least a minimum size for presentation of meaningful statistics.

Equality of land area is generally of still lesser importance in designing statistical areas; statistics from most censuses relate primarily to people and their characteristics and activities. Nevertheless, the relationship of land area to people is important in understanding distribution. Therefore, when delineating small statistical areas, it might be desirable to divide very large areas with low population density into as many statistical areas as feasible even though in a few cases the reliability of sample data may be rather low. Rough equality of land area facilitates the presentation of statistics in cartographic form.

4.23 Shape of areas.--Compactness of shape is a desirable quality in statistical areas, particularly for functional-type areas, so that even the peripheral parts are about equal distances from the centers. In twisted or elongated areas, there is the possibility that the statistical characteristics of the extensions may be quite different from those of the center. Irregularities of shape also can be a distinct handicap in cartographic presentation.

4.24 Completeness of grid.--Completeness of grid refers to the land area coverage of the various types of statistical areas. To be of use, major regions and subregions must always cover the entire country. Metropolitan and urban areas are selected areas distinguished from the rest of the country and therefore do not have complete grid coverage; but their selection from all parts of the country must be on a comparable basis. Small statistical areas such as census tracts and blocks are normally limited to metropolitan or other urban areas and thus lack a nationwide grid. Where defined, they should completely cover the metropolitan or urban area. With other small areas, such as 3rd or 4th order divisions, census tracts may be used to complete a nationwide grid of small areas.

It is important for data users to know the exact coverage of each type of statistical area. For the NSO, it is doubly important to know the exact coverage or grid so that each statistical area is properly coded for recognition in statistical tabulations.

4.3 *Boundary and recognition problems*

There are several other essential aspects of the identification of statistical areas that are meaningful to knowledgeable data users. Included are matters of boundary selection and area definition.

4.31 Definiteness of area boundaries.--Boundaries should be definite, well known, and easily identifiable through observation or inquiry in the field; otherwise, the accurate allocation of data is impossible. Incorrect boundary information may result in some omission or duplication during enumeration, and the resulting statistical tabulations may adversely affect any analysis. Boundaries of statistical areas must follow features such as roads, railroads, trails, streams, or similar visible lines that may be readily identified by enumerators. If statistical areas are defined in terms of administrative divisions, their

boundaries must follow the administrative boundaries. The name of each boundary feature should be determined if possible and indicated on the enumeration maps and, if the map scale permits, on the census area identification maps prepared for publication.

4.32 Contiguity of area.--Each statistical area should consist of one contiguous area. This is a very sound principle to follow; however, like all good rules, there can be a few exceptions, such as small islands and a few administrative exclaves[3] which ordinarily do not cause problems. The presentation of combined statistical data for two or more non-contiguous areas is a handicap in cartographic presentation and in analytical studies; combining non-contiguous areas should be avoided if possible in defining statistical areas.

4.33 Recognition of area.--To all users of statistical areas, it is important to be able to easily recognize each area under analysis; that is, to know its general location and limits. For this reason, statistical area identification maps should always be provided by the NSO in its publications. Recognition is also aided by giving names to statistical areas, especially the larger types such as major regions and metropolitan areas. The names should be descriptive of the area in terms of major features or places, preferably names that are known and already used. For small statistical areas such as census tracts or sectors, this is ordinarily not possible, and identifying numbers must be assigned; as a result such areas can be located only by using a census area identification map.

4.34 Precision of definition.--Certain statistical areas are more precisely defined than others in terms of their principles of definition, whether homogeneous or functional. The boundaries of a homogeneous area may be sharp and may easily distinguish the area from its surroundings; however, the area is more likely to have transition zones between it and its environs. The same is likely to be true for functionally integrated areas.

For major regions composed of groups of 1st order divisions, the definition normally is not precise because boundaries of 1st order divisions are drawn for administrative purposes that may have little relationship to the criteria for defining regions. The same is true of metropolitan areas which are composed of 2nd order divisions or other administrative areas; they may include considerable area that generally might not be considered as metropolitan in character. On the other hand, urban areas may be defined more precisely, provided they are defined on the basis of closely built-up settlement with lesser regard for administrative areas. Finally, small statistical areas such as census tracts (or sectors) which may be drawn without much regard for 3rd order divisions or smaller divisions, can be defined much more precisely. Even here there is some lack of precision, because there is less statistical information for defining these small areas and much reliance must be placed on field observation, local knowledge of conditions, and subjective judgment.

In the final analysis, the definition of statistical areas is as much an art as a precise scientific achievement. It rests heavily on common sense and good judgment in the application of the criteria. Consideration of all the factors discussed here is essential in developing good statistical areas, even though some cannot be precisely quantified.

4.4 *Data comparability*

Changes in the definition of statistical areas from one census to another make it difficult for the user to compare the results in any

[3]An exclave is a portion of an administrative area which is separated from the main part.

trend or historical study. The user does not know how much of any change was caused by the boundary modification. For statistical areas that are composed of administrative areas, it is possible to assemble statistics for earlier censuses using the current area definitions, provided that the administrative areas have not substantially changed their boundaries. The NSO should prepare retabulations of data from previous censuses for all statistical comparisons; this is highly desirable for major regions, subregions, and metropolitan areas. To avoid the necessity for retabulation, changes in statistical areas should be minimized. For metropolitan areas which are growing rapidly, area changes occur; therefore, retabulation is needed at least for total population counts.

For small statistical areas such as census tracts (or sectors) whose limits are unique and determined largely without reference to any administrative boundaries, retabulation is very difficult or impossible. Therefore, it is important for comparative purposes that changes in their boundaries be held to a minimum.

For the urban type of statistical area, the problem of comparison with a previous census is most difficult. Many urban areas are growing very rapidly and expanding their settled area. Users want to know the total population change, but many also would like to know how much of the change occurred in the expanded area and how much in the former area. If the boundary of the former area is observed in the current census, the growth in the former area is available. The growth in the expanded area is much more difficult to determine and, indeed, can only be estimated by reconstructing the previous census totals for the expanded area from the records of the previous census.

5. PROCEDURES FOR DELINEATION OF STATISTICAL AREAS

As discussed in the preceding section, census planners and data users must determine what type of statistical area is needed, then evaluate the principles and factors that are important in the conception and understanding of the area. When this is done, the definition criteria may be developed.

5.1 *Development of definition criteria*

It is obvious that the definition criteria will be very different for each type of statistical area. They also will vary from country to country depending on user needs; the cultural, economic, and physical characteristics of the country and its geographic parts; and the availability of statistics and other information sources for defining the areas. No attempt will be made here to provide criteria for specific types of statistical areas other than the suggested considerations on area concepts given earlier.

The criteria for defining each type of statistical area must be clearly stated in objective and quantifiable terms insofar as possible. These definition criteria should be provided for users in the explanatory text of reports in which data are presented for statistical areas.

5.2 *Responsibility for delineation*

The responsibility for defining statistical areas will ordinarily rest with the NSO of the country; but the delineation can be shared with others (and frequently this is done). The need for statistical areas may be pointed out by users at the national, 1st order division, or local level, both from government and private sources. If the NSO carries out the actual delineation, there should be some review by users to assure that the definitions meet their needs. For major regions and subregions, the reviewers should include other departments of the national government that might use regional statistics in their planning. For metropolitan areas, the reviewers should include the major governments within the metropolitan areas as

well as the national government departments. For smaller statistical areas such as census tracts, the reviewers should include all local governments within the area that is subdivided. In addition, for all areas where informed users of statistical data are known, their advice should be sought for both the development of definition criteria and the resulting statistical data delineations.

In planning for the delineation of small statistical areas, it may be determined that representatives of local governments or other informed citizens may be able to delineate the areas more effectively than the staff of the NSO because they know the character of the city or administrative area better. If this is so, they should do it, with the NSO providing the definition criteria and any available detailed area statistics. Nevertheless, review, modifications, and final approval should still be the responsibility of the NSO.

There are other possible arrangements for achieving statistical areas that might be adopted and used by the NSO. Some other department of the national government may have developed acceptable statistical areas which the NSO might find useful. Or a group of national government agencies, including the NSO, might jointly agree on a standard set of areas. There may be other arrangements which would suit even better the situation and resources in a country. However, in all cases the needs of data users and the particular requirements of the NSO should be satisfied insofar as possible. The NSO in any case must have a strong role in developing the definition criteria and approving the final delineations.

5.3 *Practical steps in delineation*

There are six steps in delineating statistical areas. At the start, it should be noted that their boundaries must be used as EA boundaries so that separate data can be tabulated.

5.31 Assembly of data and maps.--All applicable statistics for the area or region to be divided into statistical areas need to be assembled. These should be prepared for subdivisions of the area and in a statistical form (percentage, average, total, etc.) that is practical for immediate application of the requirements specified by the definition criteria. Also, appropriate detailed base maps are needed for the area being subdivided.

5.32 Preliminary delineation.--In the course of applying the criteria to define the statistical areas, it is usually necessary to draw preliminary boundaries on a map. First, the core areas must be identified. For major regions, the core areas are those 1st order divisions which are contiguous and have very similar characteristics. For metropolitan areas, the core areas are the large cities. For small statistical areas, such as census tracts, the core areas are less apparent; thus, the city or urban area must first be divided into major parts which will be later subdivided. The second part of the definition analysis requires study of the transition zones around and between the core areas to locate the boundaries that represent the best choice in terms of the criteria.

5.33 Analysis of problem areas and modifications.--There are always some parts of an area or region where it is more difficult to apply the criteria and delineate the statistical areas. These will require special analysis and consultation with local officials and other informed persons to assure that the criteria are equitably applied. As a result, modifications of the initial delineation may be made.

5.34 Assignment of names or numbers.--When the delineation is complete, all statistical areas must be identified by a name or number In the selection of names, this determination may already be relatively complete if it was a part of the criteria application process.

For numbered areas it is a final step; assignment must be in an orderly manner with progression from one area to another to permit easy location on a map. For small statistical areas where numbers are normally employed, a customary system is to assign number 1 in the northwest corner of the area. Number across to the northeast corner, then drop down to a second row of areas and number from east to west, continuing in a serpentine manner until all statistical areas have been numbered.

Another method of numbering is to assign number 1 to the center of the city and proceed to number the other areas in a circular and clockwise pattern until all have been numbered.

5.35 Review of areas.--All statistical areas should receive some review and verification to assure that they follow the criteria and meet the objectives sought in developing the criteria. First, some method of review within the NSO should be established; second, some outside review is desirable, either formal or informal. Review of major regions and metropolitan areas may be sought from other interested government agencies.

For small statistical areas, it is desirable to have a field review of the areas and their boundaries. A field review involves sending the person (or persons) responsible for delineating the statistical areas out into the field where the statistical areas are located to examine the boundaries and consult with the local officials. This is needed for two principal reasons. One is to assure that the areas are meaningful to local informed people who know the areas from personal experience. A second reason is to assure that the selected boundaries (shown on a map) actually do exist and to obtain boundary names if these are not available from maps.

5.36 Final delineation.--The review may uncover errors in delineations or may suggest changes on the basis of additional information. If so, the area definitions should be restudied and any justifiable changes should be made. In any event, the final approval of statistical areas should rest with the NSO.

6. *PROMOTING THE USE OF STATISTICAL AREAS*

The NSO does not normally produce statistics for its own use. Its goals are to produce statistics that are needed by others and to assure, to the extent possible, that they are used wisely. Publishing data for statistical areas is one technique for achieving the goals. The task of developing and reporting on a set of statistical areas places certain responsibilities on the NSO.

In the first place, sufficiently detailed tabulations of data must be made available for the statistical areas to meet the needs of the various users. If the users and their needs are not well known, some effort must be made to identify them.

For new types of statistical areas, efforts are required to publicize them and to make known what data are available for them. Such efforts should describe how the areas are defined and what are conceived to be the advantages of using the data for these areas in analytical studies. This can be partly covered in text accompanying statistical reports but also needs publicity in census news releases and in selected academic and trade journals.

A more difficult endeavor is to learn how the census data for statistical areas are actually used, evaluate these uses, and publicize this information so that the number of users and their ability to use the statistics may be expanded. Learning how statistical areas are used requires contact with the users and development of sources of information among government, academic, and business users of statistics. More

specifically this involves consultation with users in national goverment departments, large city planning agencies, and private commercial interests (banks, transport companies, wholesalers, etc.)

In seeking information on the uses of the various statistical areas, it may be discovered that the definitions can be improved through modification or that there is need for some new types of statistical areas. Moreover, different users may desire different modifications. An evaluation should be made of what changes will serve the most important uses and the greatest number of users.

While it is desirable to maintain statistical comparability of areas over time, conditions do change. Some updating of statistical area definitions may prove necessary and should be undertaken for subsequent censuses.

7. CONCLUSION

Finally, the question may well be raised as to whether the NSO can afford to develop statistical areas. An ambitious and extensive program can be costly in research, development, tabulation, and publication, particularly for small areas. On the other hand, the delineation of major regions and metropolitan areas as well as some improvement in the urban-rural classification can usually be introduced at minimum cost and with maximum benefit to many users of the statistical data.

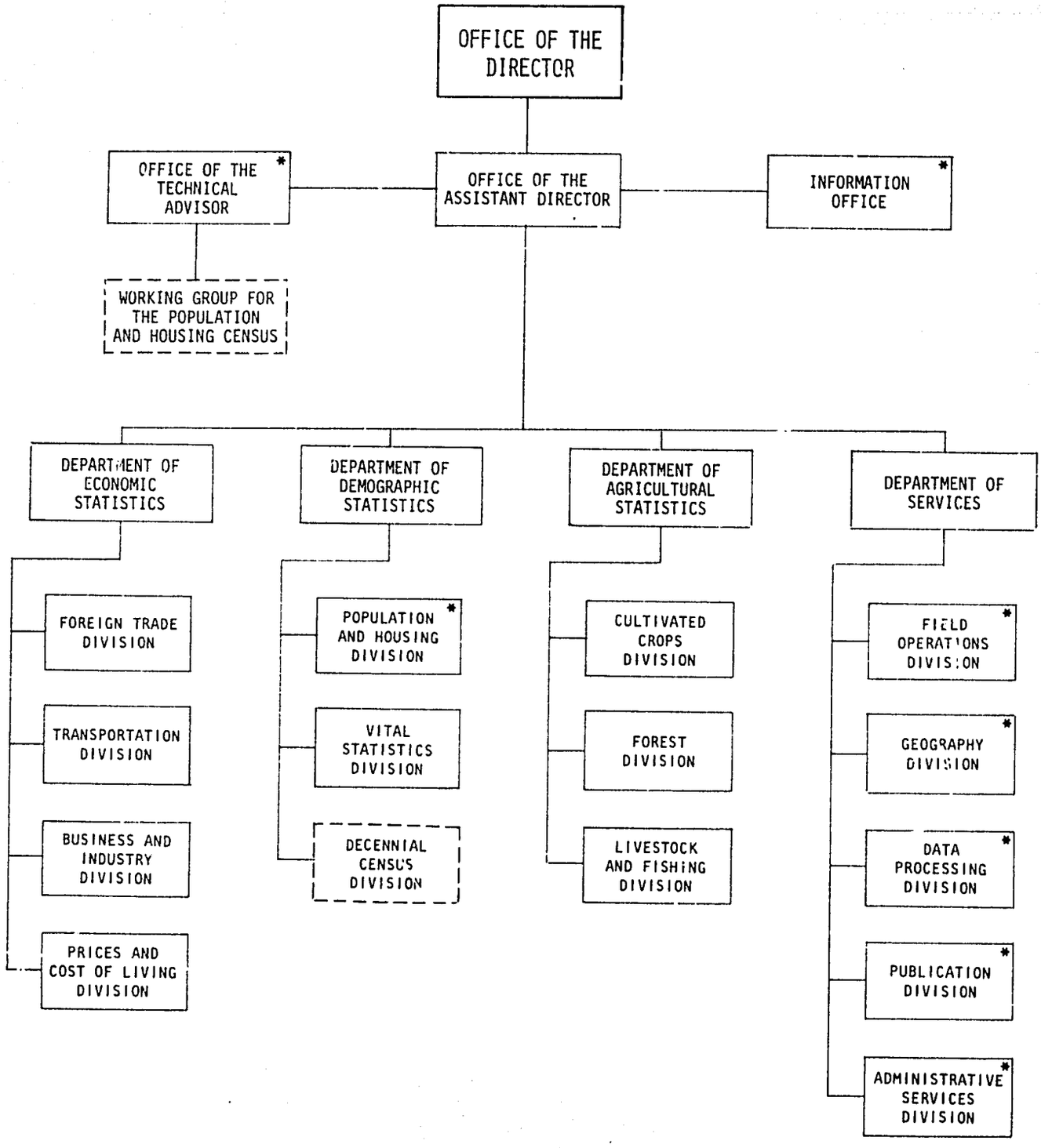
The objective of a census is to provide useful statistical data for a government and its citizens. The mapping and geographic work, which has been the subject of this manual, facilitates accurate enumeration and provides information by geographic areas; such information is useful for understanding the significance of much of the data.

This final chapter on statistical areas presents only one of the many ways in which the usefulness of data may be enhanced. A large investment goes into a census or survey and this is recovered only when the data are used effectively. The NSO should be a leader in research concerning ways to make more effective use of statistics. An important part of this research should be directed toward developing mapping techniques and uses.

APPENDIX

(Exhibits are arranged in numerical sequence; titles of the exhibits are listed in the contents)

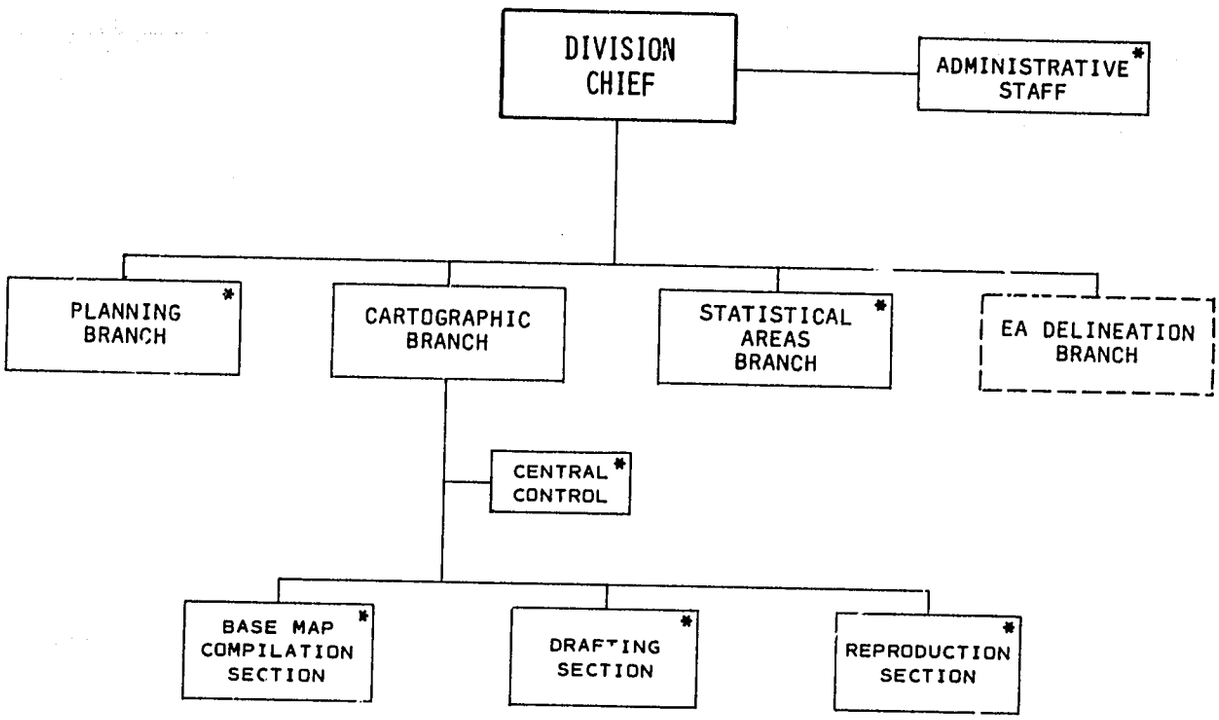
Exhibit 2-1. NSO ORGANIZATION CHART



* Expansion for decennial census

[ ] Newly formed for decennial census

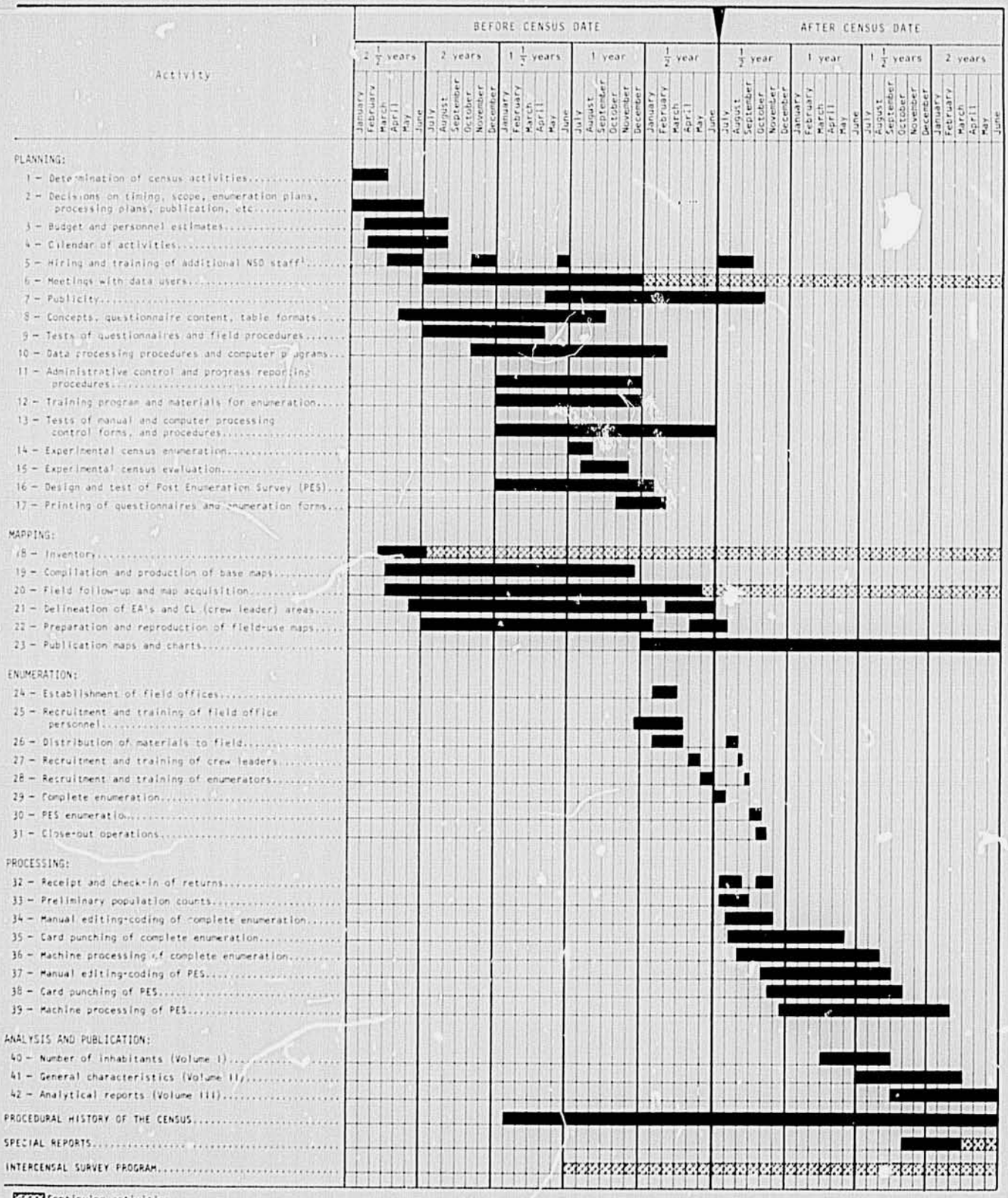
Exhibit 2-2. GEOGRAPHY DIVISION ORGANIZATION CHART



* Expansion for decennial census

[ ] Newly formed for decennial census

Exhibit 2-3. CALENDAR OF MAJOR CENSUS ACTIVITIES



Continuing activities

[1]Activity intermittent; covers hiring and training of mapping personnel, programmers, junior professional staff, and processing clerks.

Exhibit 2-4. CALENDAR OF MAPPING ACTIVITIES

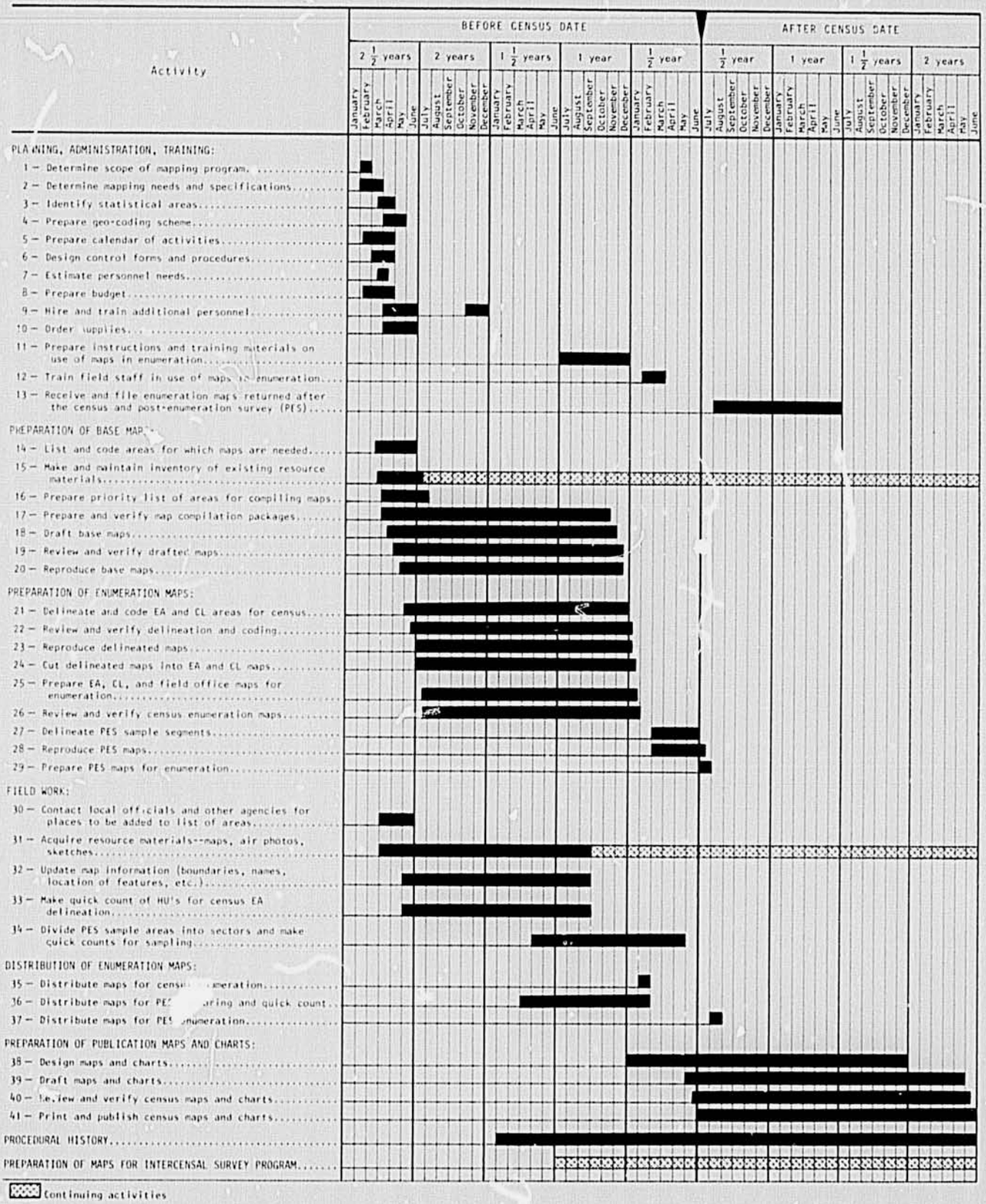


Exhibit 2-5. FLOW CHART OF OPERATIONAL CONTROLS FOR MAPPING ACTIVITIES

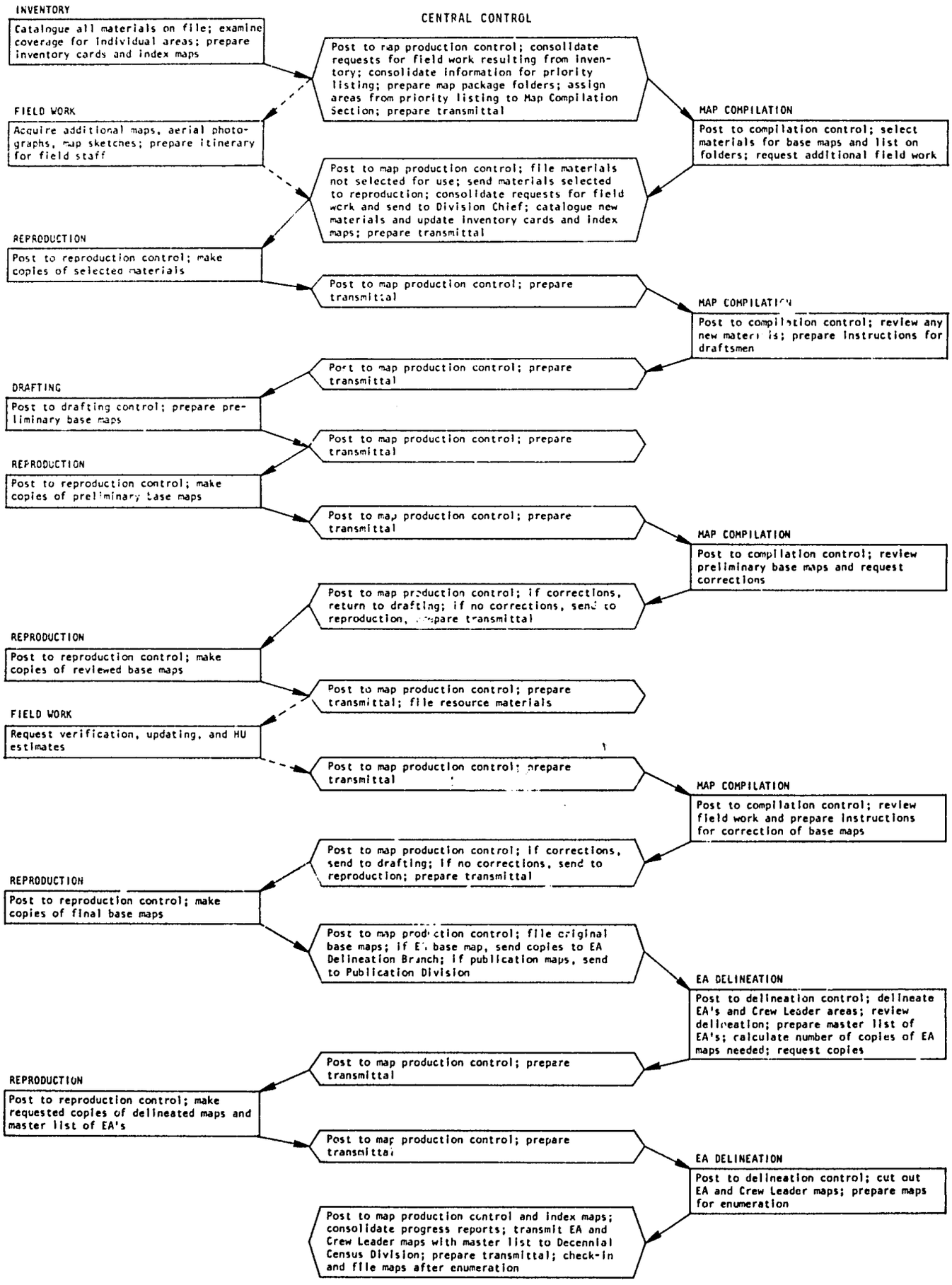


Exhibit 3-1. SYMBOLS FOR SMALL-SCALE, MEDIUM-SCALE, AND LARGE-SCALE MAPS

Feature	Map scale: Small	Map scale: Medium	Map scale: Large
BOUNDARIES			
International			
1st order division			
2nd order division			
3rd order division			
Enumeration area (EA)			
Crew leader area		XXXXXXXXXX	XXXXXXXXXX
CAPITALS[1]			
National		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
1st order division		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
OTHER URBAN PLACES[2]			
Large		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
Medium		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
Small			(Show area, boundaries, all streets)
Urban place limits		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
Urbanized area		(Show area, boundaries, major streets)	(Show area, boundaries, all streets)
TRANSPORTATION AND COMMUNICATION[3]			
Major highway with route number	3	3	3
Primary road or street			
Unpaved road			
Trail or footpath			
Transmission line			
Railroad			
Bridge			
Airport			(Show area, boundaries, runways)

Feature	Map scale: Small	Map scale: Medium	Map scale: Large
NATURAL FEATURES[4]			
Large river or stream			
Small river or stream			
Intermittent stream			
Rapids or falls			
Lake			(Show area and shape)
Intermittent lake			(Show area, shape, pattern)
Swamp			(Show area, shape, pattern)
Bench mark (for elevation)	BM X 2479	BM X 2479	BM X 2479
SELECTED CULTURAL FEATURES			
School			
Church			
Dwelling			
Group of dwellings with number of units		10	10
Commercial building			
Government building			
Industrial plant			
Electric power plant			
Radio station			
Hospital			
Mine or quarry			
Cemetery[5]			(Show area and boundaries)
Park[6]			(Show area and boundaries)
Camp			
Reservoir and dam			(Show area and shape)
Fence or property line			

[1]The size of the symbol may vary with the size of the city, or the symbol may be used in combination with color or in combination with another urban symbol.

[2]Color may be used to emphasize urban places. If the urban place is large and the scale of the map large, the map may extend over several sheets.

[3]In addition to using weights of lines, color may be used to distinguish between types of roads; for example, red for primary roads and blue for secondary roads.

[4]The color blue may be used to emphasize water features.

[5]If the cemetery is large, the area and boundaries may be shown on small- and medium-scale maps.

[6]If the park is large, such as a national park or a game preserve, the area and boundaries may be shown on small- and medium-scale maps.

Exhibit 6-1. INVENTORY CARD, FORM GEO-101

(FRONT OF CARD)

FORM GEO-101
(February 1978)

INVENTORY CARD

Card 1 of 3

Province	Code	District	Code
Alegro	03	Antigua	05

Subdivisions (List barrios/villages, urban places, hamlets, etc.)
Ariel barrio, Cuta barrio, Beri hamlet, Tori hamlet, Doreta barrio, Casseta City, Hutta hamlet, Londia barrio, Eddy City, Tangiers City (Port), Zuni hamlet, Moro barrio, Berria hamlet, Tangiers City (Port)

PART I. EVALUATION OF AVAILABLE MATERIAL

Type of material	Areas/divisions covered	Catalog No.	Location in files	Date(s)	Scale	Source	Comments
Topo Map	Ariel all	03-006	Province file	65	1/50K	Geological Survey (GS)	Possible rural base map
Topo Map	Cuta part with Beri hamlet	03-007	"	62	1/50K	GS	Possible rural base map
Topo Map	Cuta part with Tori hamlet	03-008	"	76	1/50K	GS	Possible rural base map
Road Map	Cuta all	03-010	"	72	1/100K	NRD	Has roads and streams
Administrative Map	Cuta all	03-011	"	71	1/250K	Ministry of Interior	Has approximate location of administrative boundaries
Place Map	Beri hamlet	03-012	"	75	1/5K	District official	Possible base map

(Continue listing on back of card)

PART II. NSO ACTION REQUIRED

Type of action	Yes	No	Project or program	Area(s)	Date Requested	Date Received	Results
1. Acquire newer maps	X		1980 Census	Tori hamlet	7/9/78		
2. Obtain map sketches	X		1980 Census	Hutta hamlet	7/9/78		
3. Obtain air photos							
4. Other (Specify) Boundary information	X		1980 Census	Cuta and Moro barrios	7/9/78		

Exhibit 6-1. INVENTORY CARD, FORM GEO-101--Continued

(BACK OF CARD)

PART I. EVALUATION OF AVAILABLE MATERIAL--*Continued*

Type of material	Areas/divisions covered	Catalog No.	Location in files	Date(s)	Scale	Source	Comments
Place map	Tori hamlet	03-013	Province file	62	1/2 K	District official	Usable as base but search for newer map
Air photos	Cuta all	03-021	"	77	1/20 K	GS	Use to update rural base maps
	(etc.)						

(Continue listing on additional card)

Exhibit 6-2. LAYOUT OF COVER OF MAP PACKAGE

(It is suggested that the sections of the control form be prepared separately and pasted in the lower half of the front cover of the folder, near the open side and opposite the fold. Map folders are usually stacked in the files with the open side of the folder closest to the front of the drawer; therefore, the control information should be placed where it can be referred to easily)

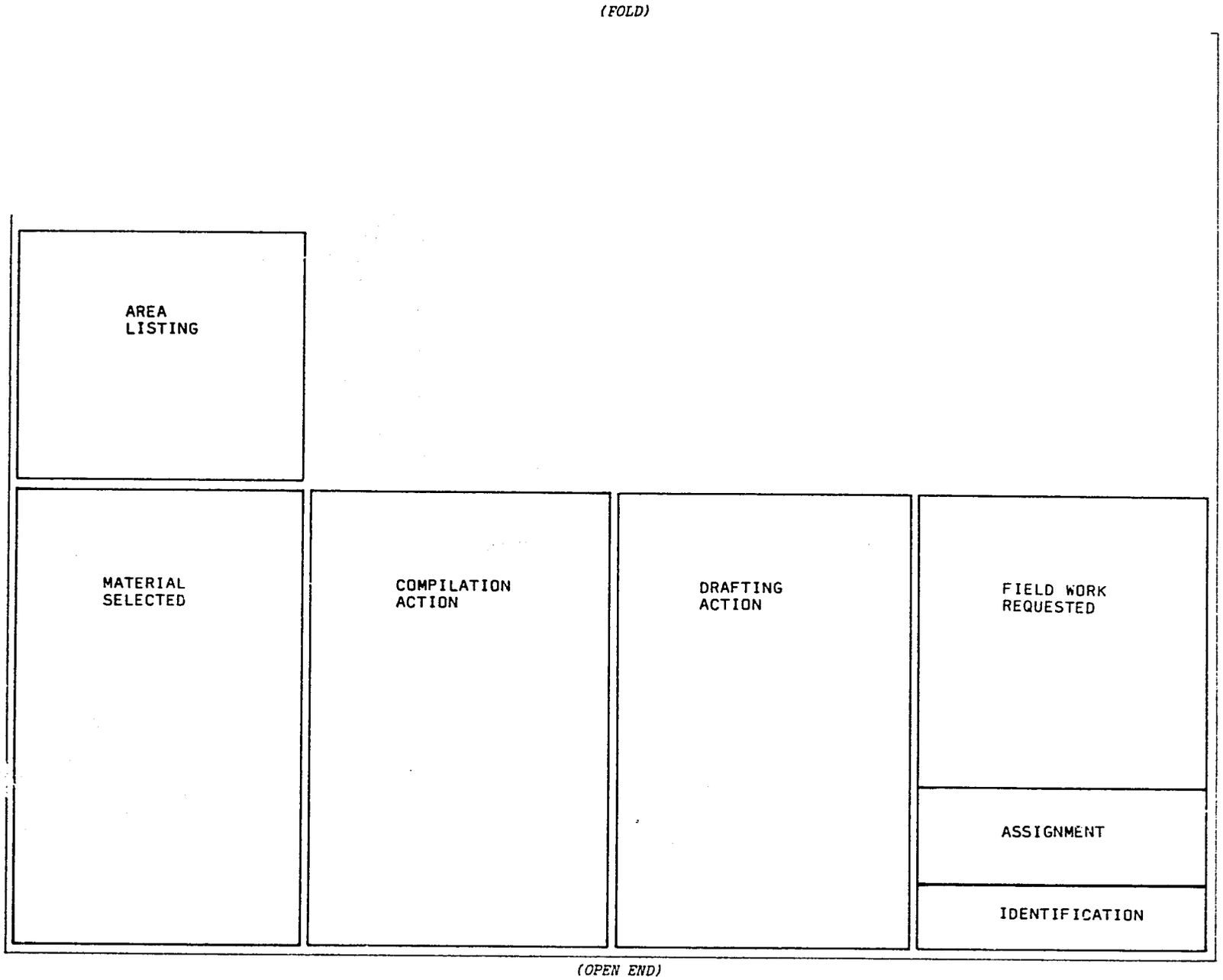


Exhibit 6-3. SECTIONS OF CONTROL FORM FOR MAP PACKAGE COVER

MATERIAL SELECTED		COMPILATION ACTION		
AREA	CATALOG NO.	DESCRIPTION	DATE: STARTED OR REQUESTED	DATE: COMPLETED OR RECEIVED
Ariel	03-006	Selection of sources	10/10/78	18/10/78
Cuta	03-007, 03-008,	Sent sources for copies	18/10/78	24/10/78
	03-010, 03-011,	Preparation of instructions	25/10/78	1/11/78
	03-012, 03-013	(etc.)		
	03-021			
(etc.)				

Exhibit 6-3. SECTIONS OF CONTROL FORM FOR MAP PACKAGE COVER--Continued

DRAFTING ACTION

DESCRIPTION	DATE: STARTED OR REQUESTED	DATE: COMPLETED OR RECEIVED
Sent for enlargements	15/11/78	21/11/78
Urban base maps	25/11/78	
(etc)		

FIELD WORK REQUESTED

TYPE	AREA/DIVISION
ACQUIRE NEWER MAPS ☐ Yes ☐ No	
OBTAIN MAP SKETCHES ☐ Yes ☐ No	
OBTAIN AIR PHOTOS ☐ Yes ☐ No	
OTHER (Specify) ☒ Yes ☐ No HU estimates and field review	All of district

ASSIGNMENT

OPERATION	ASSIGNED TO--	DATE
Compilation	K Vargas	9/10/78
Review of package	M Kali	2 11 78
Drafting	B Abdul	13/11/78

IDENTIFICATION

PROVINCE	ALEGRO	CODE 03
DISTRICT	ANTIGUA	CODE 05

Exhibit 6-4. EXAMPLE OF MATERIALS SENT TO LOCAL OFFICIALS FOR ANTIGUA DISTRICT
(Content of letter will vary according to the information that is needed)

MINISTRY OF ECONOMIC AFFAIRS
National Statistical Office

OFFICE OF THE DIRECTOR
St. Regis, Popstan

8 July 1979

Mr. Carlos Hassan
District Commissioner
Tangiers, Antigua District
Alegro Province

Dear Sir:

The National Statistical Office is preparing for the 1980 Population and Housing Censuses. As you probably know, the Minister of Economic Affairs has forwarded a letter to all the district offices, requesting that they assist the National Statistical Office (NSO) in this important effort.

Essential tools needed to ensure an accurate and complete census include up-to-date maps for every district in the country. It would be extremely difficult, both administratively and financially, to send NSO officials to all areas of the country to obtain local information. Therefore, we are requesting your help in updating the enclosed maps and providing other current information as outlined in the instructions.

We are providing two sets of maps, one of which may be retained for your use. Please return the other set along with forms GEO-202 and 203, and any separate maps or sketches that exist for places you add to the list.

Thank you for your time and assistance in this matter. Your cooperation will contribute to the success of the census as well as enable us to provide accurate data for all the urban places, hamlets, and barrios or villages in your district.

Yours truly,

Ahmed Libertus

AHMED LIBERTUS
Director
National Statistical Office

Enclosures

Exhibit 6-4. EXAMPLE OF MATERIALS SENT TO LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

INSTRUCTIONS

1. NAMES AND LOCATIONS OF CITIES AND HAMLETS

The National Statistical Office plans to publish data for all urban places and for rural settlements of 500 inhabitants or more. Information is available in our office files as to the names and locations of many of these places, but we would like to be sure that none are overlooked. Accordingly, we are requesting your cooperation in completing the enclosed form GEO-202. The list contains the names of all urban places enumerated in the 1970 Census and any rural settlements for which we have information as to size and location. Please follow the instructions below in completing form GEO-202:

(a) Verify the name of each city or hamlet already listed on the enclosed form GEO-202. Place an "X" after the name in column 1 if the place still exists. Estimate the population of the city or hamlet and enter this figure in column 3 of form GEO-202. If any city has words that are not shown on the form, please add them to the end of the list.

(b) Add to the list the name of any city or hamlet having an estimated 400 or more inhabitants (the settlement may reach a population of 500 or more by the time of the 1980 Census) On the map, draw the boundaries of the city or hamlet. Use red crayon. Place the name of the settlement on the map within or near the area you have bounded. Estimate the population of the settlement and enter this figure in column 3 of form GEO-202.

(c) Verify the location of all places on the maps.

2. NATURAL AND MAN-MADE FEATURES

Correct misspelled names and indicate the proper locations of old and new roads, railroad lines, trails, power lines, large industrial buildings, churches, schools, cemeteries, or parks. Use the same symbols for these features as shown in the legend. Also, verify the location of rivers, streams, and mountains. If incorrect or not shown, indicate on the maps their approximate locations.

3. BOUNDARIES

Verify that city, district, and barrio or village boundaries are shown correctly on the maps. Cross out (with a series of X's) any incorrect boundaries and draw in the correct ones in red. Be sure to print the names of the boundaries on the map, if they are not already given.

4. LARGE SPECIAL DWELLING PLACES

Verify the information regarding large institutions or group quarters (such as hospitals, army camps, prisons, hotels, dormitories, orphanages, monasteries, etc.) on form GEO-203. Add to the list any that are missing. Note that only those with an estimated 100 or more residents need to be identified. Indicate the approximate location of each on the maps.

5. HOUSING UNIT ESTIMATES

It would be helpful if you could provide some additional information that would enable us to divide the area into more efficient assignments. On the urban as well as the rural maps, please divide the area into subareas that have recognized boundaries and estimate the number of housing units (not population) in each. Place the figure in a circle in the middle of the area, and outline (in green) the area to which the figure relates. The subareas should not overlap administrative area boundaries. On the rural map, do not include figures for settlements for which there is a separate map. Approximate the number of housing units in multiple dwellings as well as single dwellings. The estimates need not be precise; you may round them to the nearest 5.

6. LOCAL MAPS

If you have any maps or map sketches that are more up-to-date than the enclosed, please include them in the materials you return to us. Verify that the maps are identified as to name of place and barrio.

Exhibit 6-4. EXAMPLE OF MATERIALS SENT TO LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

FORM GEO-202
(June 1978)

MINISTRY OF ECONOMIC AFFAIRS
National Statistical Office

Sheet 1 of 1

Province: Alegro — Code: 03

District: Antigua — Code: 05

Prepared by: M. Broda — Date: 1/7/79

LIST OF CITIES AND HAMLETS

Name of urban place or hamlet (1)	Barrio/ village No. (2)	Estimated population (3)	Comments (4)
Beri hamlet	06		
Tori hamlet	06		
Casseta city	09		
Hutta hamlet	09		
Eddy city	12		
Tangiers city (part)	12		
Ward 01			
Ward 02			
Tangiers city (part)	15		
Ward 03			
Zuni hamlet	12		
Berria hamlet	15		

DISTRICT OFFICIAL:

(name) (title) (date)

Exhibit 6-4. EXAMPLE OF MATERIALS SENT TO LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

Sheet 1 of 1

FORM GEO-203
(June 1978)

MINISTRY OF ECONOMIC AFFAIRS
National Statistical Office

LIST OF LARGE SPECIAL DWELLING PLACES
(100 or more persons)

Province	Code
Alegro	03
District	**Code**
Antigua	05
Prepared by	**Date**
M. Broda	2/7/79

Barrio/village No. (1)	Name (2)	Address or location (3)	Description of dwelling place (4)	Estimated population (5)	Enter "T" if transient* (6)	Comments (7)
09	Urba Hotel	Camo Street and Nati Road, Casseta city	Hotel			
12	Tangiers School	Muni Road and Sora Street, Tangiers city	Boarding school for boys			
12	Memorial Hospital	Alba Road and Tangiers Road, Tangiers city	Dormitory for nurses			
12	Tangiers Jail	Argo Street and Robi Road, Tangiers city	Jail for persons serving 30 days or less			
15	Tangiers Hotel	Labba Street and Dorset Road, Tangiers city	Resident hotel			

DISTRICT OFFICIAL:

(name) (title) (date)

*Transient dwelling places include transient hotels, motels, YWCA's, tourist camps, etc.

Exhibit 6-4. EXAMPLE OF MATERIALS SENT TO LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

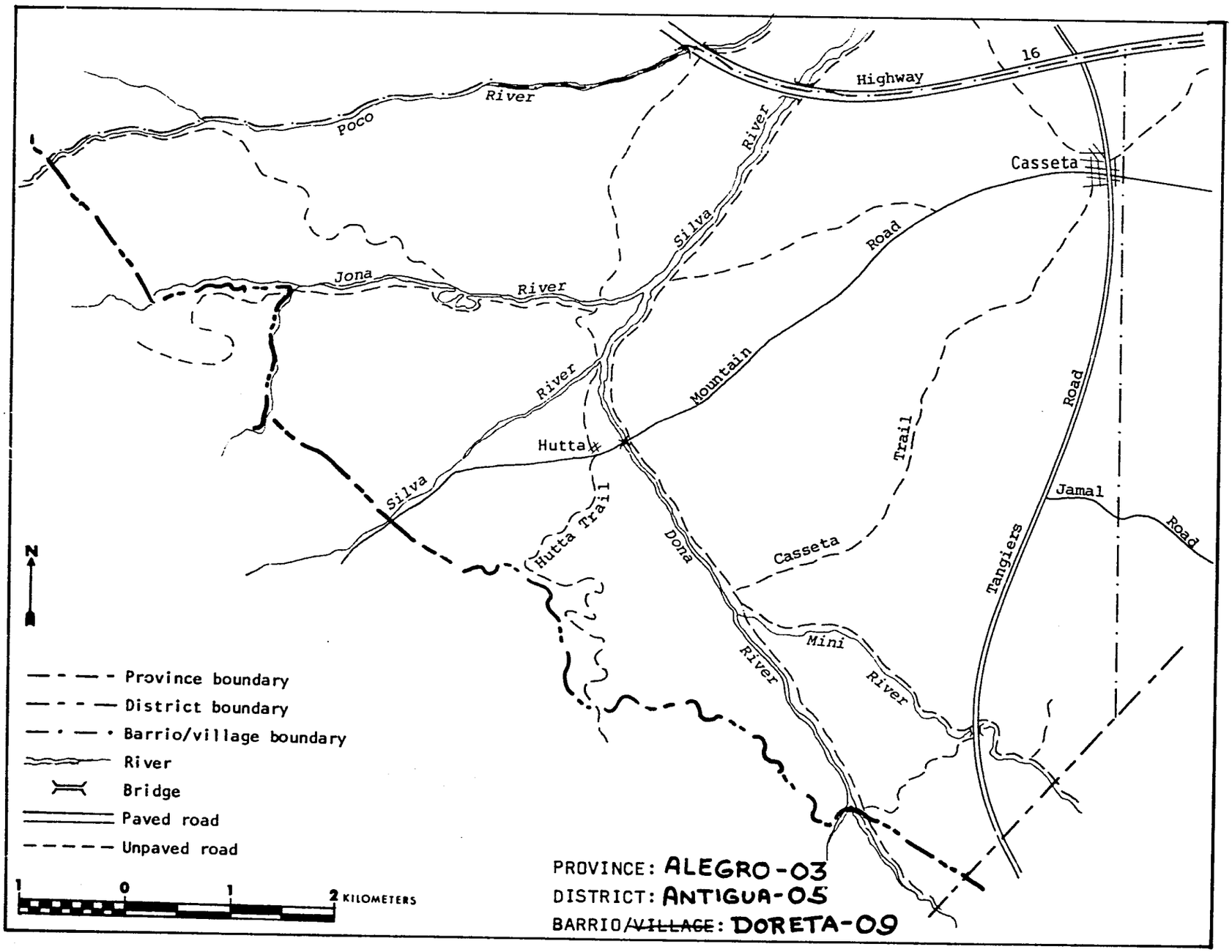


Exhibit 6-5. EXAMPLE OF MATERIALS RETURNED BY LOCAL OFFICIALS FOR ANTIGUA DISTRICT

FORM GEO-202
(June 1978)

MINISTRY OF ECONOMIC AFFAIRS
National Statistical Office

Sheet 1 of 1

Province Alegro — Code 03

District Antigua — Code 05

Prepared by M. Broda — Date 1/7/79

LIST OF CITIES AND HAMLETS

Name of urban place or hamlet (1)	Barrio/village No. (2)	Estimated population (3)	Comments (4)
Beri hamlet X	06	1,105	
Tori hamlet X	06	1,900	
Casseta city X	09	2,500	
Hutta hamlet X	09	985	
Eddy city X	12	3,150	
Tangiers city (part) X	12	—	
Ward 01		1,055	
Ward '		1,890	
Tangiers city (part) X	15	—	
Ward 03		1,365	
Zuni hamlet X	12	720	
Berria hamlet X	15	640	
FERI hAMLET	09	475	See map sketch

DISTRICT OFFICIAL:

C. Cassa (name) — Commissioner (title) — 19 September 1979 (date)

Exhibit 6-5. EXAMPLE OF MATERIALS RETURNED BY LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

FORM GEO-203
(June 1978)

MINISTRY OF ECONOMIC AFFAIRS
National Statistical Office

Sheet 1 of 1

LIST OF LARGE SPECIAL DWELLING PLACES
(100 or more persons)

Province: Alegro	Code: 03
District: Antigua	Code: 05
Prepared by: M. Broda	Date: 2/7/79

Barrio/village No. (1)	Name (2)	Address or location (3)	Description of dwelling place (4)	Estimated population (5)	Enter "T" if transient* (6)	Comments (7)
09	Urba Hotel	Camo Street and Nati Road, Casseta city	Hotel	7	T	Owner and his family live in hotel
12	Tangiers School	Muni Road and Sora Street, Tangiers city	Boarding school for boys	160 boys 40 other		Teachers and their families have separate quarters on school grounds
12	Memorial Hospital	Alba Road and Tangiers Road, Tangiers city	Dormitory for nurses	50		
12	Tangiers Jail	Argo Street and Robi Road, Tangiers city	Jail for persons serving 30 days or less	—	T	
15	Tangiers Hotel	Labba Street and Dorset Road, Tangiers city	~~Resident~~ hotel	9	T	New owner Ricardo Monti lives in hotel
09	Antigua Prison Camp	Mountain Road 1.1 Kilometers West of Hutta	Prisr for persons ser...g 30 days or more	87 prisoners 16 guards		See map of barrio

DISTRICT OFFICIAL:

C. Hassan (name) — Commissioner (title) — 19 September 1979 (date)

*Transient dwelling places include transient hotels, motels, YWCA's, tourist camps, etc.

Exhibit 6-5. EXAMPLE OF MATERIALS RETURNED BY LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

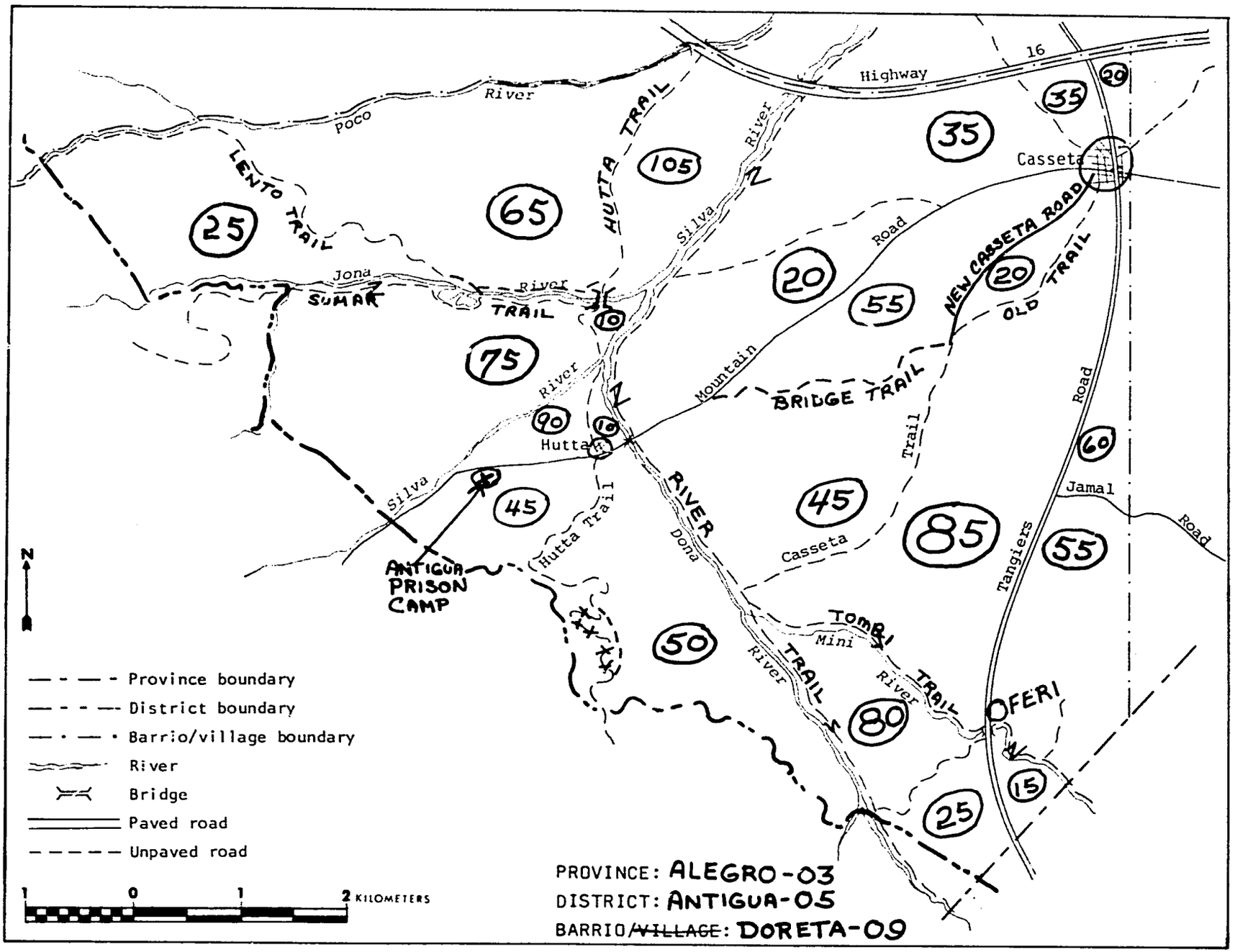


Exhibit 6-5. EXAMPLE OF MATERIALS RETURNED BY LOCAL OFFICIALS FOR ANTIGUA DISTRICT--Continued

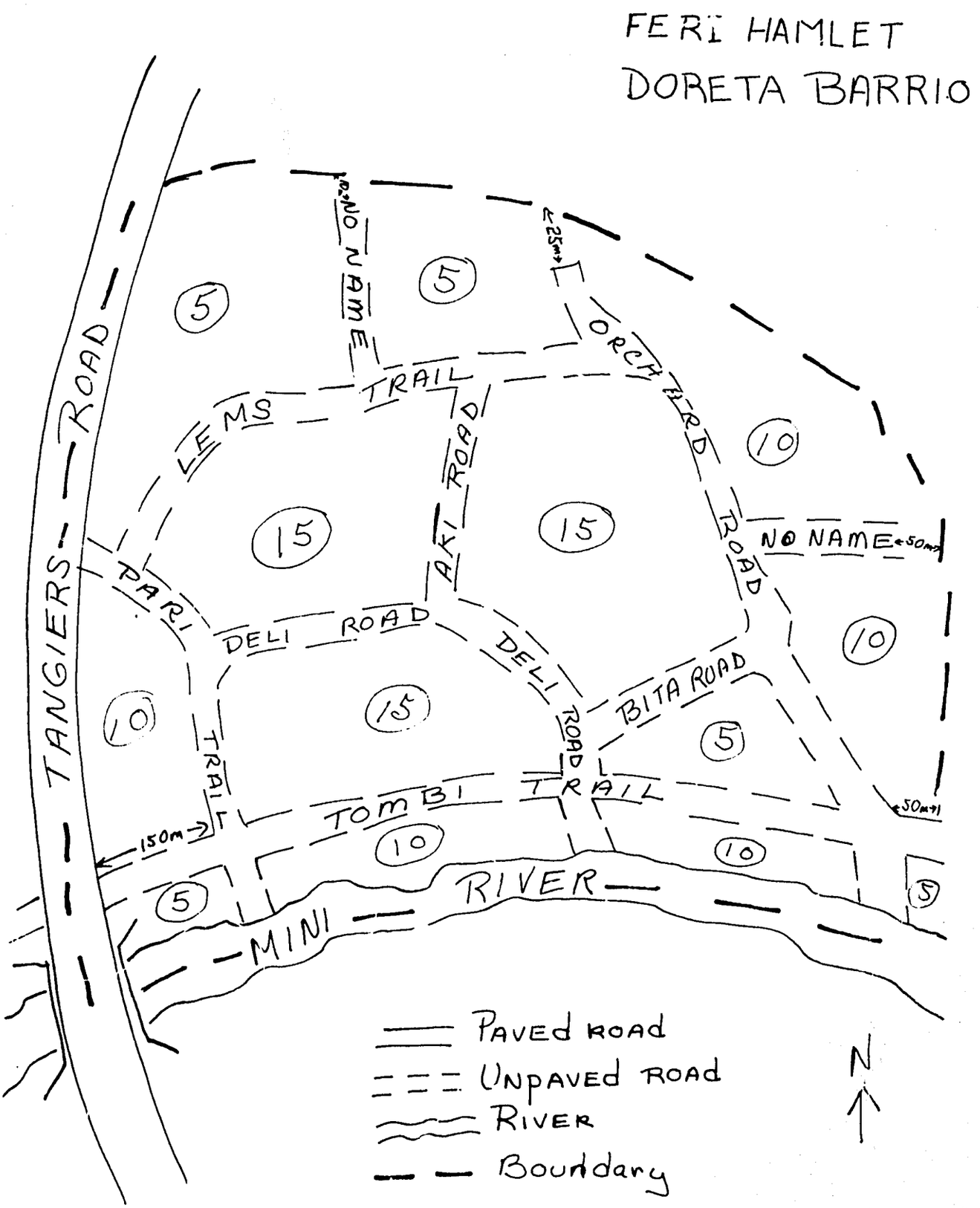
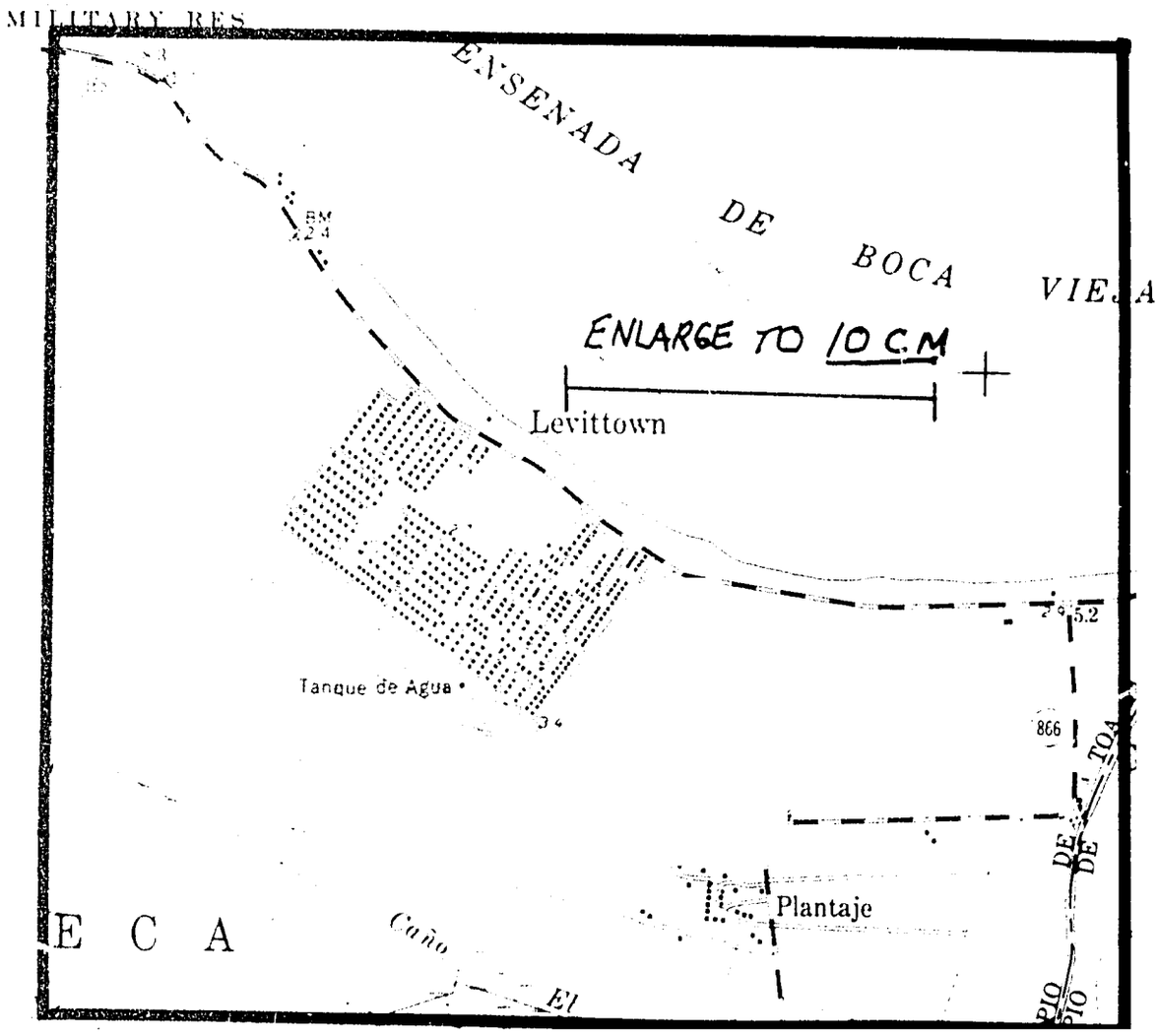


Exhibit 6-6. SELECTED MATERIALS AND INSTRUCTIONS FOR BASE MAP PACKAGE FOR LEVITTOWN

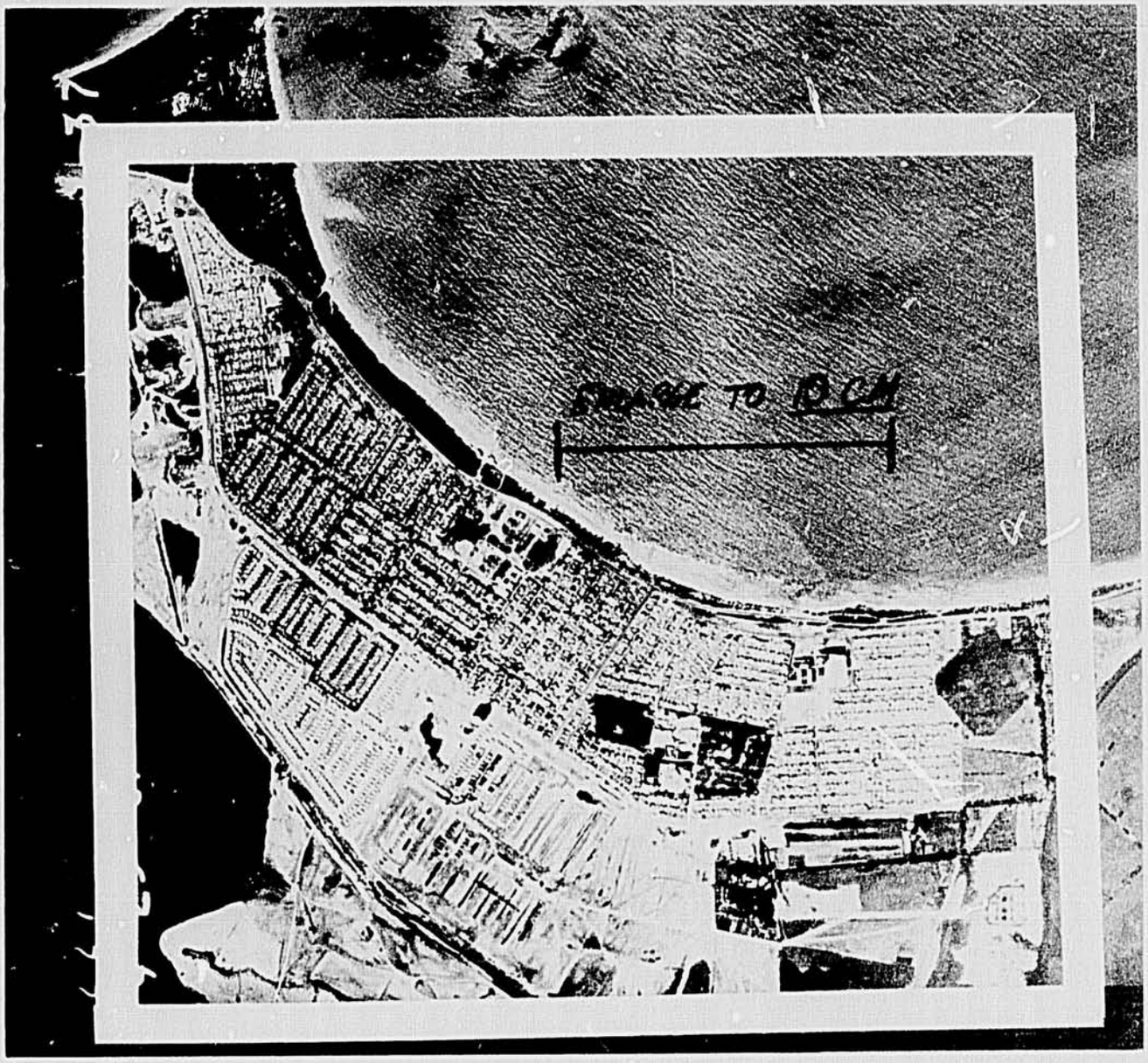
PRIMARY SOURCE--TOPOGRAPHIC MAP



Note: The black line on the map is put on by the compiler to show the area that is to be enlarged and drafted. Masking tape is ordinarily used to outline the area.

Exhibit 6-6. SELECTED MATERIALS AND INSTRUCTIONS FOR BASE MAP PACKAGE FOR LEVITTOWN--Continued

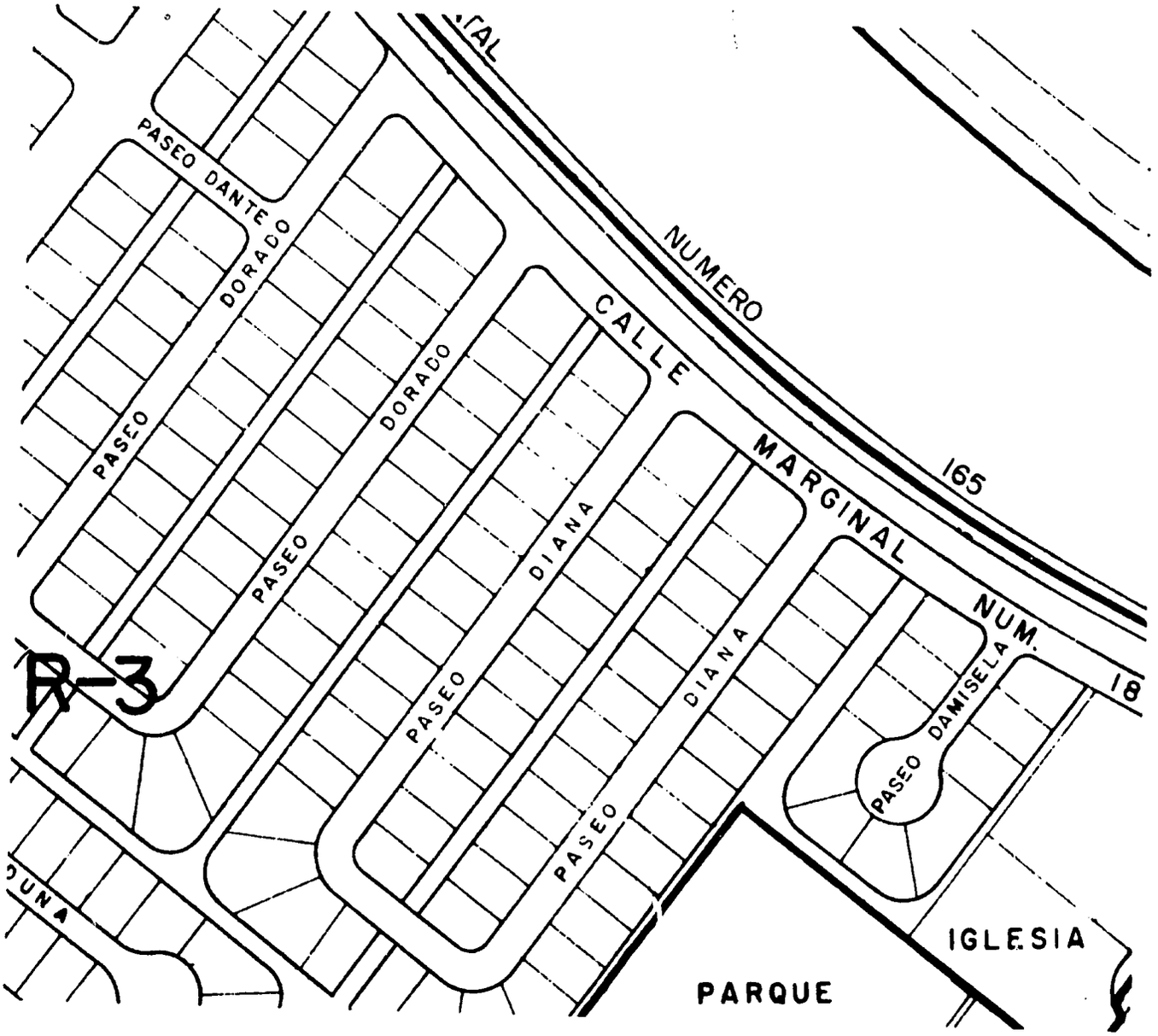
SUPPLEMENTARY SOURCE--AIR PHOTO



Note: The white line on the photo is put on by the compiler to show the area that is to be enlarged; information from the enlargement is transferred to the topographic map. Masking tape is ordinarily used to outline the area.

Exhibit 6-6. SELECTED MATERIALS AND INSTRUCTIONS FOR BASE MAP PACKAGE FOR LEVITTOWN--*Continued*

SUPPLEMENTARY SOURCE--PLANNING MAP



INSTRUCTIONS TO DRAFTSMAN

1. Enlarge photo and topographic map as indicated They should be of the same scale after enlargement.
2. Add, delete, or change street patterns and other features on enlarged map, as shown on air photo.
3. On topographic enlargement, add names of streets, names of other features, and boundary lines from the planning maps.
4. Draft clean copy.

Source: "Mapa de Zonificación de Toa Baja," 1956. Courtesy of Puerto Rico Planning Board.

Exhibit 6-7. COMPILATION, DELINEATION, OR DRAFTING CONTROL, FORM GEO-102
(Map compilation is illustrated in this exhibit. Note that "X" is entered in the first column when operation is completed)

(LEFT HALF OF FORM)

FORM GEO-102
(February 1978)

OPERATION: COMPILATION

Completed	District code	Action 1 Description	Action 1 Date Started or sent	Action 1 Date Completed or received	Action 2 Description	Action 2 Date Started or sent	Action 2 Date Completed or received	Action 3 Description	Action 3 Date Started or sent	Action 3 Date Completed or received	Action 4 Description	Action 4 Date Started or sent	Action 4 Date Completed or received
X	05	To K. Vargas for compilation	9/10/78	1/11/78	To reproduction for copies of materials	18/10/78	24/10/78	To Kali for review of map package	2/11/78	8/11/78	To drafting	9/11/78	23/11/78
	10	To B. Caro for compilation	10/10/78		Requested field work - sketches	17/10/78							
	20	To M. Kali for compilation	16/10/78	21/11/78	To reproduction for copies of materials	1/11/78	7/11/78	To Tomba for review of map package	23/11/78	29/11/78	To drafting	30/11/78	21/12/78
		(etc.)											

(RIGHT HALF OF FORM)

Sheet 1 of 2

Province Alegro

Code 03

Action 5 Description	Action 5 Date Started or sent	Action 5 Date Completed or received	Action 6 Description	Action 6 Date Started or sent	Action 6 Date Completed or received	Action 7 Description	Action 7 Date Started or sent	Action 7 Date Completed or received	Action 8 Description	Action 8 Date Started or sent	Action 8 Date Completed or received.
To Vargas for review of drafting	24/11/78	28/11/78	To field for HU estimates and corrections	1/12/78	29/12/78	To Vargas for review of field work	3/1/79	10/1/79	Released for EA delineation	11/1/79	
To Kali for review of drafting	22/12/78		To drafting for corrections.	25/12/78	2/1/79	To field for HU estimates and corrections	4/1/79	29/1/79	To Kali for review of field work	31/1/79	5/2/79

Exhibit 7-1. EA DELINEATION WORKSHEET, FORM GEO-122

Sheet 1 of 2

FORM GEO-122
(June 1978)

EA DELINEATION WORKSHEET

(a) Province	ALEGRO	Code	03
(b) District	ANTIGUA	Code	05
(c) Posted by--	B Kahlil	Date	17/1/80
(d) Verified by--	D Ricardo	Date	24/1/80
(e) Total estimated population	51,135	(f) Total number of EA's 103	(g) Total number of CL areas 17

Area name (1)	Code: Barrio/village (2)	Code: Urban place/hamlet (3)	Code: Ward (4)	Code: Type of place (5)	EA No. (6)	CL No. (7)	Estimated population (8)	Date EA map cut out and prepared for field (9)	Comments (10)
Ariel barrio	03								
Rural balance	03	999	99	9	001	01	510		
					002	02	495		
					003	02	505		
					004	02	480		
					005	01	495		
					006	01	510		
					007	02	51		
		99	99		01	03			
Landia barrio	12								
Eddy city	12	127	99	2	001	09	505		
					002	09	515		
					003	09	490		
					004	09	535		
					005	09	570		
					006	09	535		
(etc.)									

Note: For illustration purposes, province, district, and barrio/village are the names used for 1st, 2nd, and 3rd order divisions respectively.

Exhibit 7-2. MASTER LIST OF EA'S, FORM GEO-501

FORM GEO-501

PAGE 1

PROVINCE: ALEGRO 03

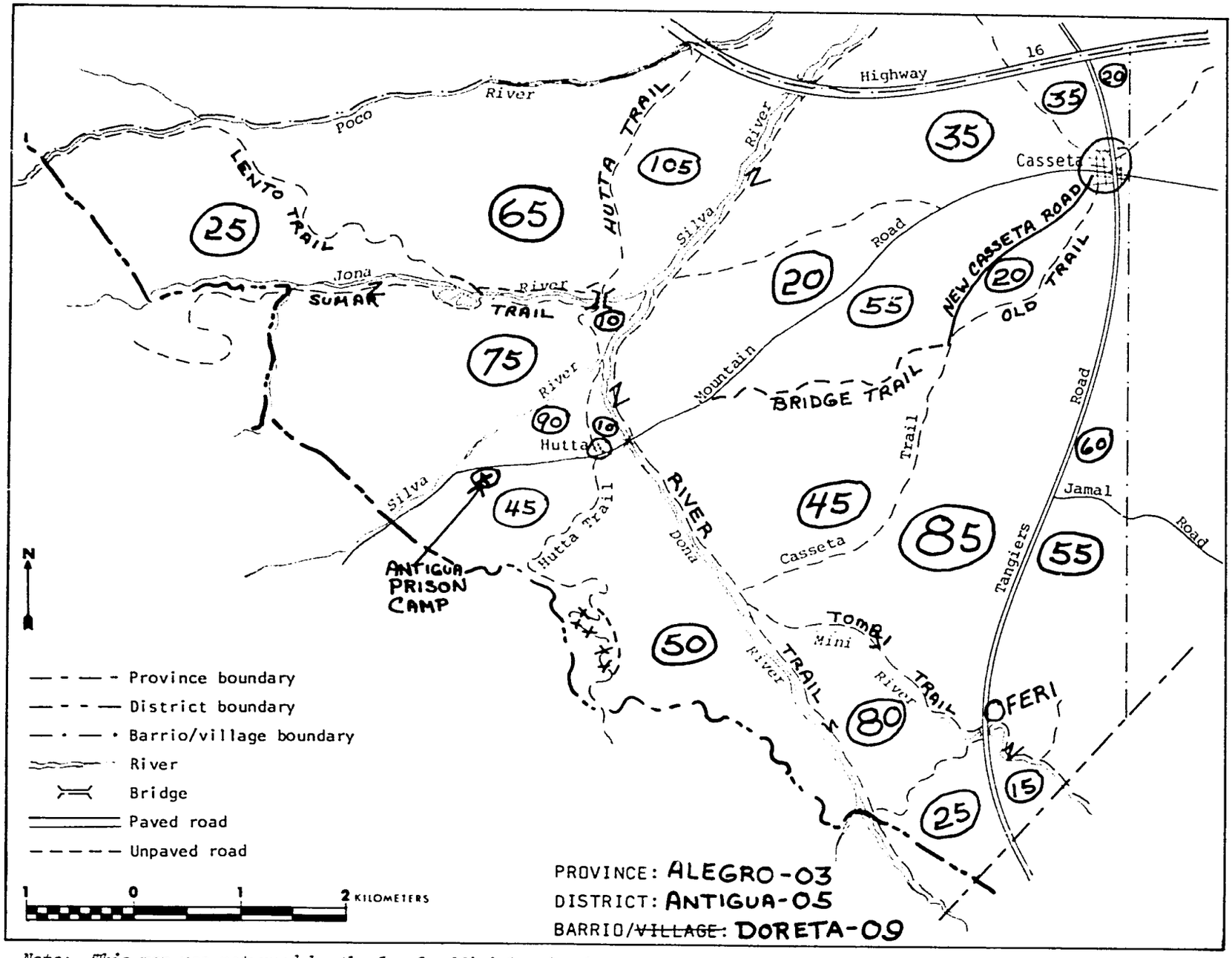
DISTRICT: ANTIGUA 03 05

MASTER LIST OF EA'S

AREA NAME (1)	CODE: BARRIO/ VILLAGE (2)	CODE: URBAN PLACE/ HAMLET (3)	CODE: WARD (4)	CODE: TYPE OF PLACE (5)	EA NO. (6)	CL NO. (7)	ESTI-MATED POPU-LATION (8)	FIELD SPLIT (9)	AREA CODE CHANGE (10)	NEW IDENTI-FICATION NUMBER (11)	COMMENTS (12)
ARIEL BARRIO.....	03										
RURAL BALANCE....	03	999	99	9	001	01	510				
	03	999	99	9	002	02	495				
	03	999	99	9	003	02	505				
	03	999	99	9	004	02	480				
	03	999	99	9	005	01	495				
	03	999	99	9	006	01	510				
	03	999	99	9	007	02	515				
	03	999	99	9	008	02	490				
	03	999	99	9	009	01	480				
CUTA BARRIO.....	06										
BERI HAMLET.....	06	059	99	4	001	01	565				
	06	059	99	4	002	01	540				
TORI HAMLET.....	06	522	99	3	001	03	460				
	06	522	99	3	002	03	505				
	06	522	99	3	003	03	420				
	06	522	99	3	004	03	515				
RURAL BALANCE....	06	999	99	9	001	01	405				
	06	999	99	9	002	01	440				

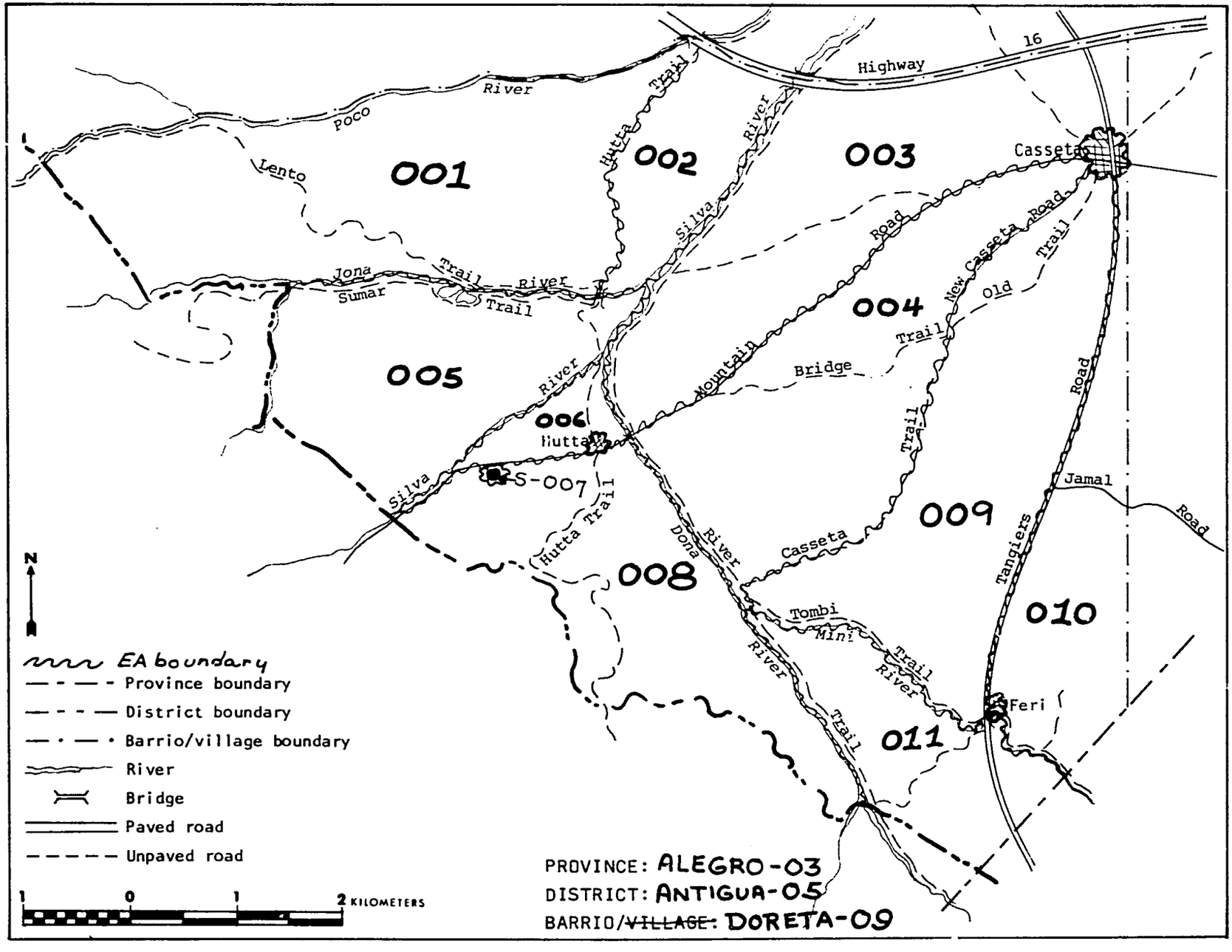
(Continued)

Exhibit 7-3. RURAL PORTION OF BARRIO MAP SHOWING HU ESTIMATES AND EA'S FOR ANTIGUA DISTRICT



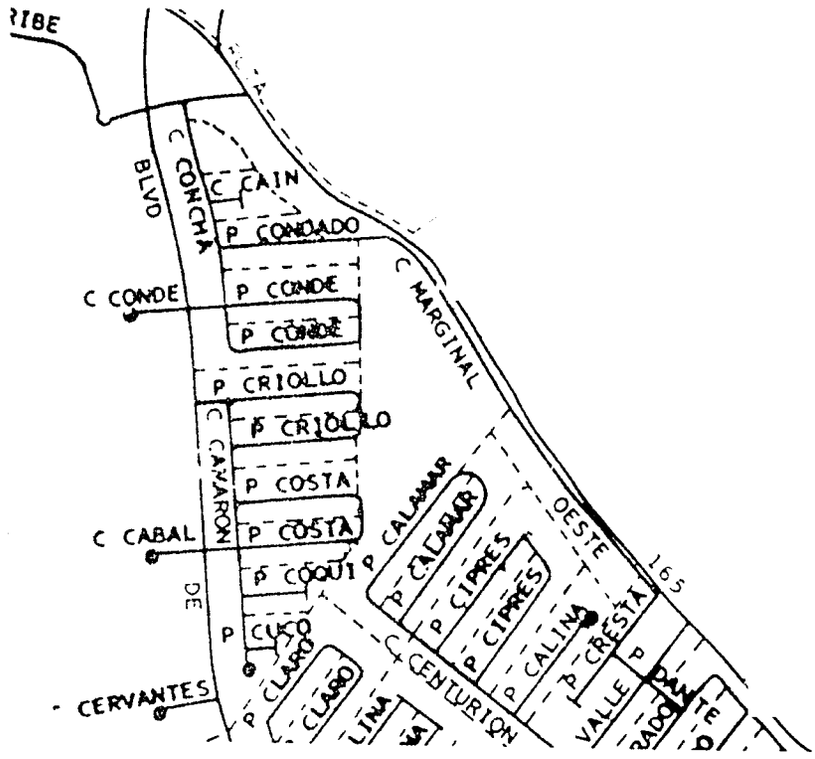
Note: This map was returned by the local officials; it shows corrections in features, estimates of HU's, and location of a Large Special Dwelling Place.

Exhibit 7-3. RURAL PORTION OF BARRIO MAP SHOWING HH ESTIMATES AND EA'S FOR ANTIGUA DISTRICT--Continued



Note: This is the corrected base map divided into EA's, using the information supplied by the local officials.

EXHIBIT 7-1. PORTION OF PRELIMINARY BASE MAP, AIR PHOTO, AND FINAL LA BASE MAP FOR LEVITTOWN



Mapa Amplio
Vea Hoja Núm

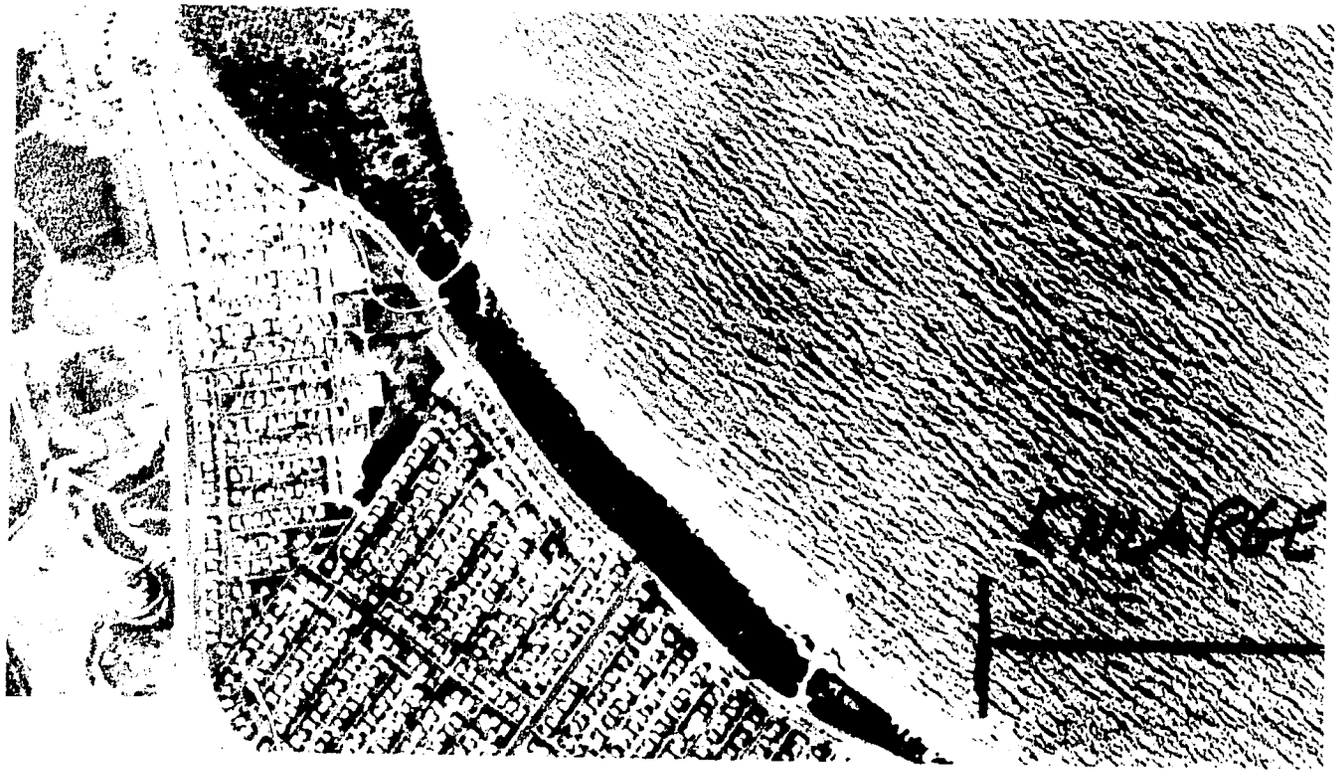
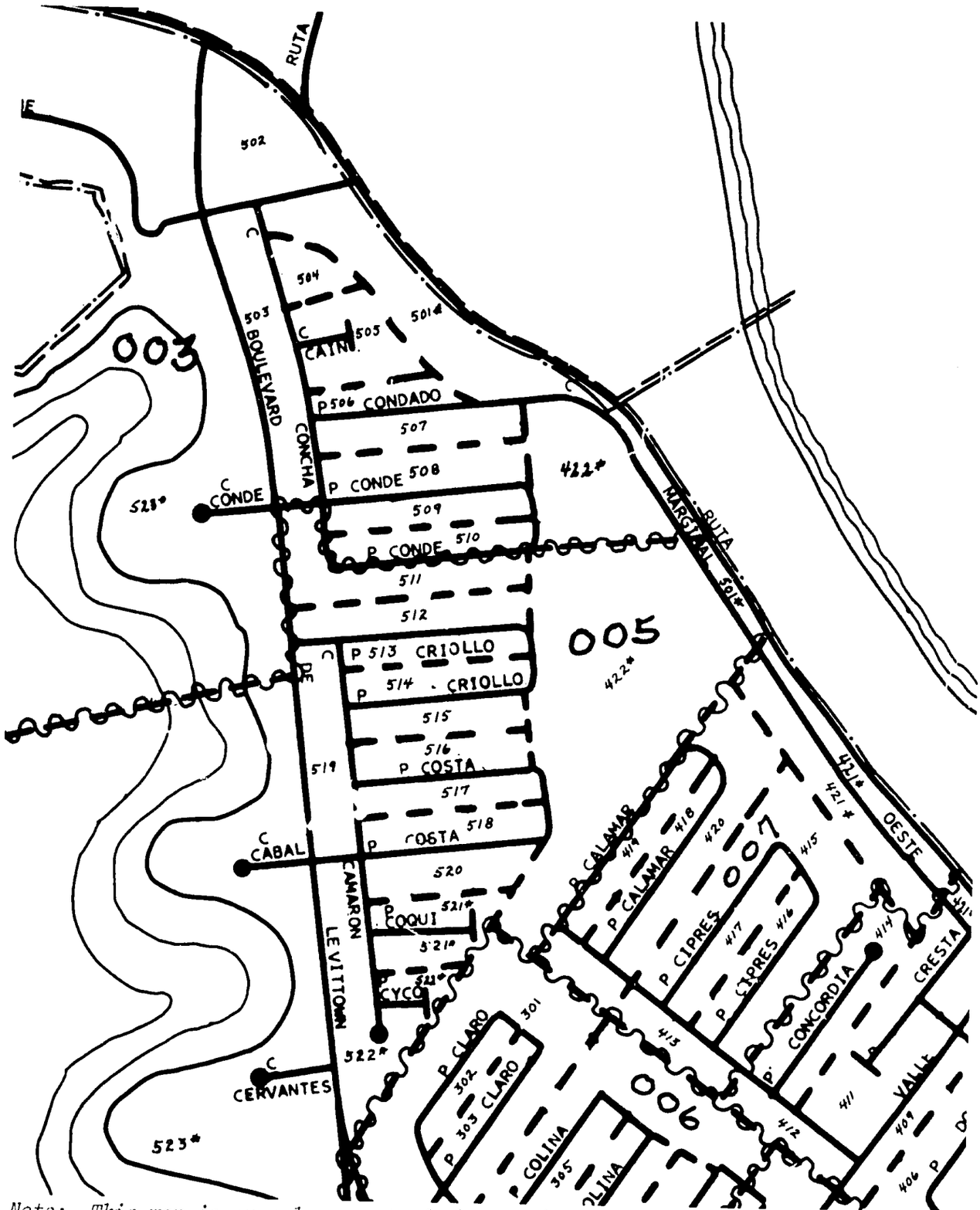


Exhibit 7-4. PORTION OF PRELIMINARY BASE MAP, AIR PHOTO, AND FINAL EA BASE MAP FOR LEVITTOWN--Continued

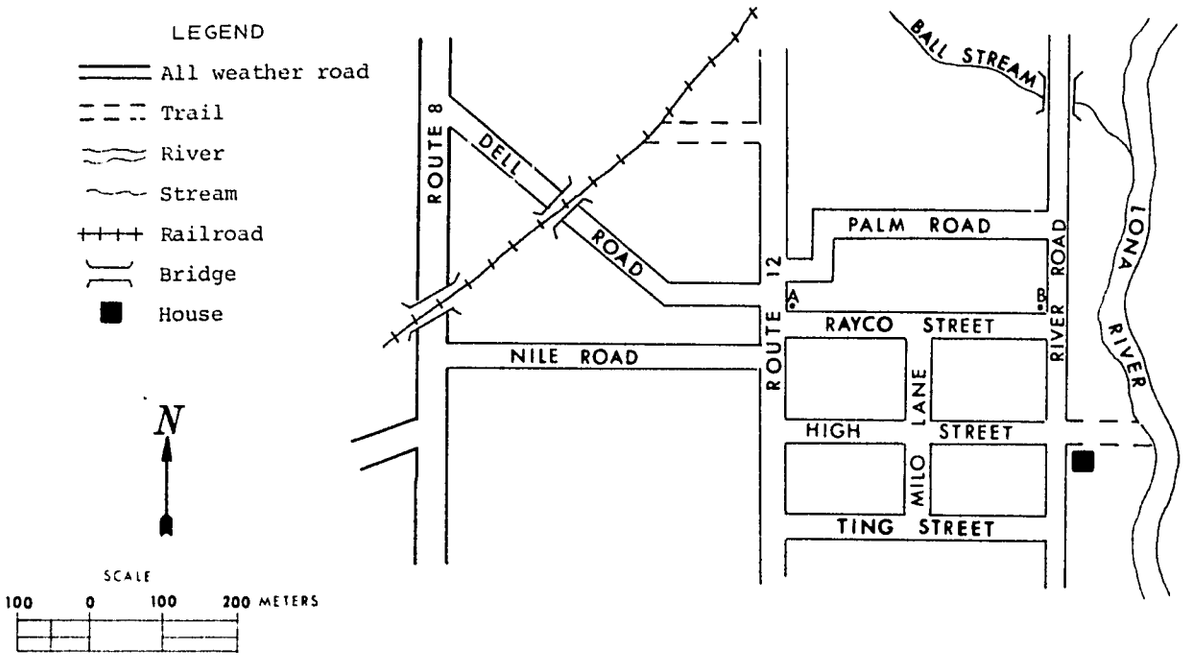


Note: This map is an enlargement of the portion of the base map shown on the preceding page. EA's were delineated on the basis of HU counts estimated from the air photo.

Exhibit 8-1. PRE-TRAINING TEST OF MAP READING SKILLS

MAP READING

Read each question carefully and enter your answer in the space provided (or on the map)



1. You are instructed to work in an area shown on the above map. The boundaries of your area are as follows:

   northern boundary – Rayco Street
   eastern boundary – River Road
   southern boundary – Ting Street
   western boundary – Route 12

   a. On the map, draw a line down the middle of the streets or roads that form the boundaries of your area..... ANSWER (on map)

   b. How many blocks are in your area?..... ANSWER _____

   c. There is a house on the southeast corner of River Road and High Street (indicated by ■). Is this house in your work area?..... ANSWER _____

   d. On the map, draw arrows (⟶) to indicate the direction of travel you would take if you walked by the shortest route from the intersection of Route 8 and Dell Road to the intersection of Route 12 and High Street..... ANSWER (on map)

2. How many bridges are there east of Route 12?..... ANSWER _____

3. One centimeter on the map represents 100 meters on the ground. If Point A on the map is 3½ centimeters from Point B, what is the actual (ground) distance from Point A to Point B?..... ANSWER _____ (meters)

4. A man on a bicycle rode 60 kilometers in 5 hours. On the average, how many kilometers did he ride in 1 hour?..... ANSWER _____ (kilometers)

Exhibit 8-2. PORTION OF GUIDE FOR TRAINING CREW LEADERS
(Instructions to the trainer are in italics)

Outline	Narrative
1. Practice training	Good morning. I hope all of you are ready for this part of your training. Today we are going to be concerned with how you train enumerators; one of your most important supervisory duties is the training of your enumerators. You will use the same Guide for Training Enumerators that I used in training you--the one which I gave you to study yesterday when we completed the enumerator training. A little later this morning, each of you will have the opportunity to do some practice training, using the portion of the Guide which I assigned to you.
a. Importance of role as trainer	I can't stress too much the importance of your role as trainer. Census work is highly specialized work for which the necessary knowledge and skills must be taught quickly and effectively. Successful enumeration in your district will depend in a large measure on a successful training session. The success of your training session will depend on how thoroughly you prepare yourself for training and how effectively you use the training materials.
b. Training principles	As you probably know, there are certain basic training principles which pertain to all types of training. Some of these are particularly applicable to your training of enumerators when you will be using a verbatim Training Guide.
	As you begin discussing each principle, write a brief version of it on the blackboard. For the first principle, write: *1. Prepare yourself.*
(1) Prepare yourself	The first principle is to prepare yourself by knowing your material thoroughly. Go over the main concepts and procedures for enumeration until you understand them fully. Study your Training Guide and practice using it, so that you are completely familiar with it. Trainees can tell very quickly when their instructor is not well prepared. Now, for the second principle.
	Write: *2. Plan your presentation.*
(2) Plan your presentation	Plan your presentation by selecting key points in your Guide for emphasis and repetition. Also write down special explanations or illustrations from your own experience which will help to clarify certain points. Here's the third principle.

Exhibit 8-2. PORTION OF GUIDE FOR TRAINING CREW LEADERS--Continued

Outline	Narrative
	Write: 3. *Present topics in logical order.*
(3) Present topics in logical order	Present topics in logical order by following the exact order of presentation in the prepared Guide. The order of topics in your Guide has been carefully planned. Just follow it.
	Write: 4. *Encourage trainee participation.*
(4) Encourage trainee participation	Fourth, make full use of trainee participation through the various ways provided in the Guide. These include asking questions, doing practice exercises, having trainees read, and so on. Having trainees participate will help hold their interest and keep them alert. A word of caution about calling on trainees--be sure to call on the timid trainees as well as the eager ones who are always volunteering.
	Write: 5. *Vary the presentation.*
(5) Vary the presentation	Make full use of any devices which are called for in the Guide to vary the presentation. These include use of the blackboard for emphasis or sketching, use of illustrations, and use of any other visual or audio-visual training materials provided, such as film-strips, recordings, and movies.
	Write: 6. *Create interest.*

CONTINUE WITH TRAINING PRINCIPLES

Exhibit 8-3. PORTION OF GUIDE FOR TRAINING ENUMERATORS

Chapter 2. USING YOUR MAP

NOTE TO TRAINER: Verify that the trainees have their workbooks.

1. Introduction

You learned earlier that you will be assigned a small land area to enumerate. This small area is called an enumeration area, or EA.

In census work, canvassing means systematically traveling every road or street in your EA and finding all places where people live, or might live.

> Q: If you are responsible for traveling every road or path in your EA, what will you need to make sure you have the right area?
>
> A: *An EA map*

Before we look at a typical EA map, let's take a look at some key items that will appear on all EA maps. Turn to pages 7 and 8 of your workbook. Take a few minutes to study the illustrations.

Allow a few minutes.

> Q: What is the EA number of the map on page 8?
>
> A: *073*
>
> Q: On page 8, what color is the EA boundary?
>
> A: *Orange*

2. Boundaries

You are to stay inside the orange boundaries. If you go outside, you will be going into another EA.

Most EA boundaries will follow land features that you can see as you travel through the EA--a road, a river, or perhaps a railroad track. Note also the arrow that points in the direction of north. When you locate north, then you will know that east is on the right, south on the bottom, and west on the left. On the map on page 8, please follow the boundaries around the EA. On the north, find the EA boundary, which is Calicut Road. On the east, you see that it is Highway 3.

> Q: What is the name of the next boundary--on the south?
>
> A: *Lima Trail*
>
> Q: And the next boundary--and what direction is it?
>
> A: *Rolling River--on the southwest and west*

Exhibit 8-3. PORTION OF GUIDE FOR TRAINING ENUMERATORS--Continued

3. Map scale

Sometimes your boundary will be an invisible line. For example, the boundary may be the city limits or an imaginary line between two provinces. You could ask people living in the area how far the province extends. Usually residents in the area know which province they live in. But there may be times when you may not find anyone living near the boundary.

> Q: What could you do in this case?
>
> A: *Use the scale to measure from some landmark to the boundary as shown on the map.*

Yes, you can use your map scale to determine when you are close to an invisible boundary line. Let's try using the map scale on page 7 to measure the distance to the Lacuna Province boundary going along Iran Road from the intersection of Bangkok Highway and Iran Road.

> *Make sure each trainee understands what to measure.*

Place your scale along Iran Road. Make sure that the "zero" point is at the intersection of Iran Road and Bangkok Highway.

> Q: At the boundary line, how many meters is it?
>
> A: *125 meters*

4. Pacing

If you are walking, you may wonder how you will know when you have walked 125 meters. One way you can tell is by pacing the distance. Turn to page 97 of your Reference Manual and read section 5.21, which explains how to measure distances by pacing.

> *Allow 5 or 6 minutes.*

I would like to have three of you pace the length of this room and we shall show you how to measure your average pace and estimate distance. This room is exactly 12 meters long. In actual practice, you would pace for a distance of 100 meters or more.

> *Have three volunteers pace the length of the room three times and count the number of paces. On the blackboard, show the calculations to get average length of pace for each.*

CONTINUE WITH CHAPTER 2

Exhibit 8-4. PORTION OF CREW LEADER'S REFERENCE MANUAL

Chapter 2. PRELIMINARY OPERATIONS (Part)

1. Content of training

You will receive detailed instructions during your training on all the preliminary operations. These operations are covered in this chapter except for the recruitment and selection of enumerators, which will be discussed in chapter 3. The following summary covers the preliminary operations described in this chapter:

(1) Checking EA's and EA boundaries
(2) Prelisting of sample of HU's
(3) Indicating enumerator's starting place in each EA
(4) Splitting of large EA's
(5) Preparation for recruitment, selection, and training of enumerators
(6) Checking supplies
(7) Preparation of enumerator assignments
(8) Preparation for enumerator training
(9) Preparation for H-T night enumeration (for homeless and transient persons)
(10) Preparation for enumeration of Special EA's

2. Checking EA's and EA boundaries

One of your most important duties between now and the time you train your enumerators will be to inspect each enumeration area (EA) that is assigned to you.

a. Reasons for checking EA's

Several important reasons for checking EA's are:

(1) To verify that the map of the EA is correct and that the map boundaries and landmarks correspond with the actual physical features of the area. The map should be such that the enumerator can use it and find his way around his area easily. Keep in mind that your main objective in checking EA's is to discover ahead of time the problems the enumerator may run into, and to instruct enumerators in advance how to handle possible problem areas.

(2) To notify the field office of any map discrepancies which must be officially corrected before the start of enumeration.

(3) To locate and report any large (over 100 persons) Special Dwelling Places (institutions, hotels, convents, military barracks, etc.) which were not made Special EA's by the NSO.

(4) To estimate the approximate number of housing units in each EA and determine whether any are too large for one enumerator and should be split into two or more enumerator assignments.

(5) To perform other required preliminary duties in each EA as described in this and other chapters of the manual.

b. Checking procedures

As you travel in and around each EA, make the following checks:

(1) Boundary check

Locate each boundary of the EA as shown on the maps. If you find that any physical features of the boundaries have changed, make a sketch illustrating the boundary changes or write a description of the differences. Turn in the sketch or description, properly identified by EA number and your name and CL area number, to the field office as soon as possible.

Prompt action in informing the NSO of boundary changes is necessary as any <u>official</u> changes in map boundaries must be authorized by the NSO before the enumeration starts. You are never to make any boundary changes unless instructed to do so by the NSO.

Exhibit 8-4. PORTION OF CREW LEADER'S REFERENCE MANUAL--Continued

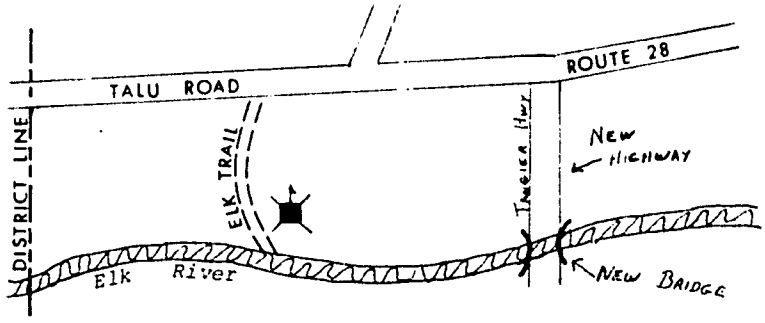
(a) Imaginary lines

Most EA boundaries will be clearly visible features such as streets, roads, rivers, and streams. You may find, however, that some boundaries are not visible on the ground because they are imaginary lines. For example, a boundary could be a proposed street shown on a map but not yet cut through, or the boundary of an administrative division such as a district or barrio.

Imaginary boundaries may cause problems for enumerators, so make notations about nearby landmarks (telephone poles, schools or other buildings, etc.) which will help the enumerator identify and locate the imaginary boundary. Later on you should enter these notes on the cover of the EA book or make a sketch of the area which will help the enumerator during enumeration. Be sure to explain the situation to the enumerator when you make the assignment.

(b) Changes in street names or new streets

Check carefully for street name changes, new streets and roads, or other changes in physical characteristics as you travel through an EA. If you determine that such changes have occurred, correct your map and later make the same corrections on the EA map. At an early opportunity you should also report such changes to the field office so that office maps can be brought up-to-date. Use an "X" to show deletion of features.



The example shows the addition of a new highway and bridge and the deletion of a school building that no longer exists. All such map corrections should be explained to the enumerator assigned to that EA.

(c) Unidentified hamlets or urban places

Although the NSO made every effort during the map preparation period to identify all settlements of 500 or more population (75 to 100 housing units) on the census maps, it is possible that a few may have been missed. This probably will not happen often, but you should be alert to the possibility.

In case you find any unidentified hamlets or urban places, draw the approximate boundaries of the settlement on your maps and print the name of the settlement as near the boundary as possible. Report any additional hamlets or urban places you find to the field office as soon as possible. Then follow the instructions below in making such places separate EA's; be sure to identify these additional hamlets and urban places on the enumerator's map.

(d) Map out-of-date

In checking an EA you may discover that a map is completely out-of-date because so many changes have occurred since the map was made. In such cases try to obtain several copies of an up-to-date map from some local government official--for the enumerator, yourself, and the field office. Draw the EA boundaries on the new maps but give the enumerator the original map to use as well as the new one. Be sure to get both maps back from the enumerator. If you are unable to obtain up-to-date maps, draw a crude sketch showing the changes in the EA; provide one for the enumerator and another for the field office.

CONTINUE WITH INSTRUCTIONS ON PRELISTING

Exhibit 8-5. PORTION OF ENUMERATOR'S REFERENCE MANUAL

Chapter 3. CANVASSING AND LISTING (Part)

6. Canvassing your EA

Canvassing your EA means covering it systematically--searching every block, street, road, or lane for all places where people live or could live. A complete and systematic canvass of your EA is essential to make certain that you locate every housing unit in your EA. As you canvass, you will, of course, list and enumerate each housing unit you find. In fact, canvassing and listing are combined operations.

a. General canvassing and listing rules

Certain canvassing and listing rules have general applications to all types of areas and must be carefully followed by all enumerators.

(1) Start at designated starting point

Always begin your canvass of the EA at the starting point designated by your crew leader. He will mark "X" or "Start" on your map at the point he selected and he will also indicate the direction of travel from that point with directional arrows (→). He may not plan the entire route, however. From the starting point, you will plan a systematic canvassing route through the rest of the EA.

(2) List housing units/collective quarters in order

As you canvass, you must list each housing unit or collective quarters in order as you come to it, whether or not anyone is at home, and whether the unit is occupied or vacant. Of course, you will have to make inquiries at nearby units to find out the best time to call back or any other available information about not-at-home and vacant units.

(3) Show path of travel by directional arrows

As you canvass your EA, enter directional arrows (→) on the map to show your path of travel. Also when you have completely covered a block or a road, enter a checkmark (✓) on your map to show that this portion of the EA is complete. These devices are very useful to help you make certain you have canvassed all of your EA.

(4) Canvass each floor separately in multi-unit structures

In multi-unit structures with housing units on more than one floor, canvass and list each floor separately, beginning with the basement. Numbered apartments should be listed in numerical order; unnumbered apartments should be listed by location, proceeding from front to back and/or right to left, according to the arrangement of the apartments; for example: basement, rear; first floor, right front; second floor, left rear; etc.

(5) Look for out-of-the-way housing units

Look for housing units (apartments and housekeeping rooms) above or in the rear of stores, garages, other places of business, partially built or abandoned buildings, improvised living quarters, and houses hidden from the road.

To help you locate out-of-the-way or hidden housing units you should be on the look-out for various clues: for example, mailboxes, lead-in electrical wires, milk cans or produce crates stacked near the road, outside stairways, etc.

(6) Be alert for all types of collective quarters

Be alert as you canvass for all the various types of collective quarters--institutions, convents, hotels, boarding and lodging houses, etc., that were not designated as special EA's.

b. Rules for canvassing specific types of areas

There are specific canvassing rules to follow depending on whether you are assigned to an urban or rural EA, and also specific instructions for canvassing certain types of structures. Follow the instructions below which are applicable to your particular EA.

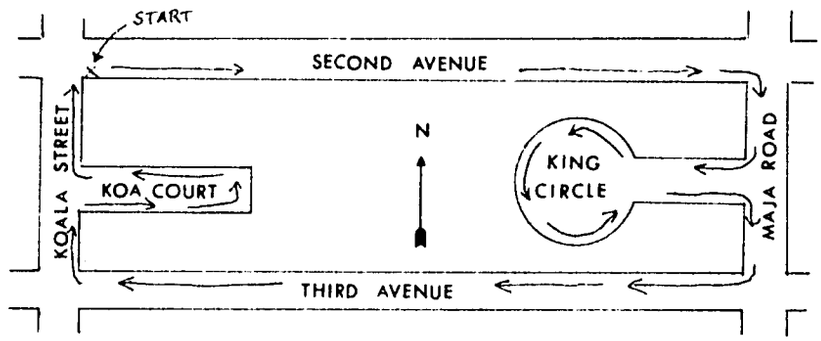
(1) Urban areas and hamlets with blocks

If you are assigned an urban EA which is divided into blocks or squares (areas bounded on all sides by streets), canvass one block or square at a time. Do not go back and forth across streets. Begin each block at a convenient corner (usually the northwest corner) and proceed clockwise around the block until you reach your starting point. As you canvass in a clockwise direction, you should list and enumerate

Exhibit 8-5. PORTION OF ENUMERATOR'S REFERENCE MANUAL--Continued

the housing units on your right. Check every alley, court, or passageway you come to in the block. You must canvass not only around but through the entire block to find all housing units, before going on to the next block.

As you canvass through your EA, remember to check (✓) off each completed block on your map. Also remember to enter directional arrows (→) on your map to show your path of travel through each block in the EA, as illustrated below:



(2) Urban places or hamlets without blocks

If your EA is an urban place or hamlet that is not laid out in blocks, you will have to canvass street by street and road by road, looking for all housing units where people live or could live. In such areas, you should interrupt the canvassing of a main street or road to turn off and canvass any side streets as you come to them. You might miss some of the side streets if you wait until later to come back.

(3) Rural areas

If you have been assigned a rural EA, you will have to canvass road by road. Generally, you should cover both sides of a road as you go, except for EA boundary roads where, of course, you will canvass only the side that is in your EA.

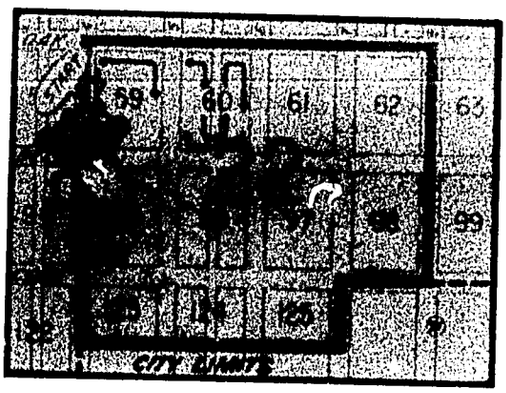
Although you will begin canvassing at the starting point and in the direction indicated by your crew leader on your map, you should study your map carefully before starting out and make a preliminary plan for your path of travel. This will help you make sure you cover every part of the EA. Occasionally you may find it convenient to go completely around small built-up sections, just as you would in block-type urban EA's.

Your objective is to canvass every road in your EA. You should turn off from main roads to canvass every side road, path, lane, and trail as you come to them, as such roads may lead you to places where people live. The directional arrows you enter on your map to show your path of travel should clearly indicate where you turn off from a main road to canvass a side road before completing the canvass of the main road.

In rural areas there are many houses which cannot be seen from the road, and there may be no visible clues to indicate their location. Therefore in rural areas make it a practice to always ask at each housing unit about neighbors, and find out exactly where they live. Ask the respondent to point out on your map the approximate locations of his closest neighbors. Some rural maps will show the location of housing units, and other buildings such as schools and churches, which serve as landmarks. Obtaining information from the local residents will help you ensure complete coverage of your EA.

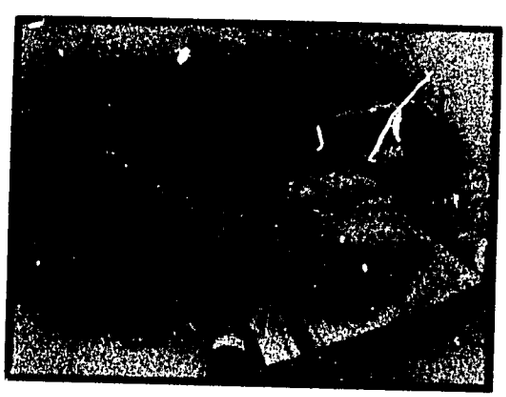
CONTINUE WITH INSTRUCTIONS ON CANVASSING

Exhibit 8-6. PORTION OF FILMSTRIP AND SCRIPT ON CANVASSING PROCEDURES
(Eight frames are shown here to illustrate format and content)



6. Every EA has an identification code. The one shown here is the EA number without administrative area codes. The EA you see is EA 22. Note that the blocks are numbered also. The EA boundaries are outlined with a heavy solid line, usually in orange or some other bright color. Your crew leader has indicated the starting point in the northwestern part of the EA. You should return to the starting point of one block before going to the next.

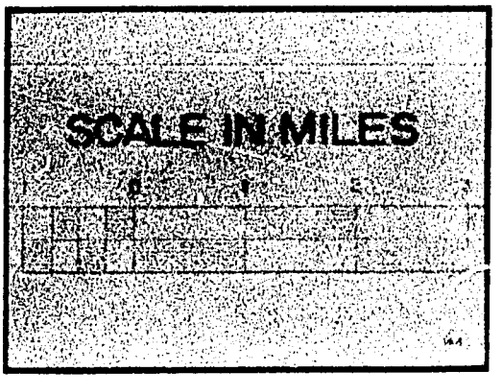
7. The EA boundary line is like a fence around your own private territory. Work inside it. If you enumerate outside the fence, you will be entering some other enumerator's territory.



14. As you work, turn your map so that the street or road on the map is lined up with the ground and pointing in the same direction as you are heading. Line up your map this way as you travel around each part of the EA. As you walk clockwise around the blocks or sections, the houses you are to enumerate will always be on your right.

15. Maps become outdated rather quickly. You should make any corrections necessary to bring your map up-to-date. If you find new streets, roads, trails, or paths, draw them in. In this example, a new street named "Grant Court" has been added. Delete any that no longer exist by crossing them out. In this example, a street in the southwestern part of the EA was crossed out.

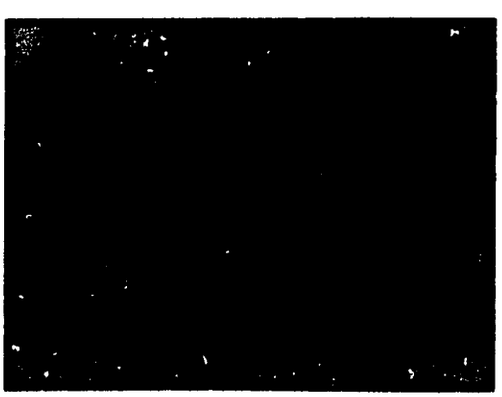
Exhibit 8-6. PORTION OF FILMSTRIP AND SCRIPT ON CANVASSING PROCEDURES--Continued



19. Another useful feature of maps is a scale. Scales can represent miles or kilometers. The part of the scale to the left of the zero mark is usually divided into parts of a mile or parts of a kilometer, such as fourths or tenths. The scale can help you find the distance between two visible points or locate an invisible boundary in relationship to a visible landmark.

20. Suppose you want to find the invisible boundary at Point A. First mark the distance from the nearest crossroad B to Point A on a piece of paper. Then measure the distance you marked against your map scale to get the ground distance. In this instance, the distance is 2¼ miles. Point A can be located quite closely by driving down the road from Point B, using your car or bicycle odometer to measure the 2¼ miles. However, you still should verify the location of the boundary by asking the residents.

23. In urban areas you should enumerate completely around one block before starting the next. Do not go back and forth across a street.



29. In rural areas, canvass your EA in an orderly manner. One way is to divide it into parts--something like blocks in a city. Another is to divide it into subareas. However, it is not always possible to find trails or paths to do that. In that case, you can canvass by road sections. Starting in the northwest corner of the EA, note the sections numbered 1, 2, 3, and so on and the arrows pointing to 4, 5, and 6. When you list the HU's, be sure to include the section number in the address. One more point--be sure to ask about houses back from the road even if you do not see paths or trails leading to them.

GLOSSARY

A

ADMINISTRATIVE AREA: Area (or division) of a country delineated by the government for purposes of administration. Administrative divisions may be large, intermediate, or small in size and are referred to as 1st order (such as provinces), 2nd order (such as districts), and 3rd order (such as villages or barrios). Some countries have more than three divisions. Urban areas may be 2nd, 3rd, or 4th order divisions.

ADMINISTRATIVE AREA MAP INDEX: An inset map in outline form showing a shaded area and a number of adjoining administrative areas. The shaded area is the particular administrative area that is covered by the detailed map.

AERIAL PHOTOGRAPHY: Form of imagery that records reflected light energy on light-sensitive film through a camera-lens system. Photos are usually taken from an airplane or helicopter.

AGGLOMERATION: See *settlement.*

AIR PHOTO: See *aerial photography.*

AIR PHOTO INDEX: Sheet(s) identifying air photos and showing coverage of an area; used to locate air photos; may serve as a crude mosaic.

AIR PHOTO MOSAIC: Composite of air photos to produce coverage of a large area.

AREA IDENTIFICATION MAP: Map which shows the names and boundaries of an administrative or statistical area for which data are published.

AREA SAMPLE: Sample in which the selected sites are defined land areas with identifiable boundaries.

AUTOMATED CARTOGRAPHY: Production of maps using such equipment as computers, automatic drafting equipment, or microfilm systems.

AZIMUTH: Direction of a line on the Earth's surface, usually measured by means of a compass. Starting with north as 0°, the system moves in a clockwise direction through 360° and returns to north at 0° (or 360°).

B

BACKSIGHT: Reading at the end of a traverse leg to determine the accuracy of a compass reading which was taken at the beginning of the traverse leg. The compass reading at the end of the leg should differ from the reading at the start of the leg by 180°.

BACKTRACKING: During field enumeration, going back over the same roads or streets.

BAR GRAPH: Graph on which values are shown by means of vertical or horizontal bars. The lengths of the bars are proportional to the size of the value represented.

BASE MAP: Map to be used in the delineation of EA's; may be used as the base for publication maps.

BASE MAP PACKAGE: Assembled materials consisting of primary source map, reference maps, air photos, and instructions, which are sent to the drafting unit for preparation of base maps.

BEARING: Compass reading using cardinal points North East, South, and West to establish direction. Fo example, N.30°W. corresponds to 330° azimuth.

BLOCK: Small geographic area; can be used as a statistical area. It is usually bounded by streets or natural features.

BOUNDARY: Line which serves to delimit an administrative division, statistical area, EA, etc.

BOUNDARY FILE PROCESSING: Conversion of digital description of area boundaries into graphic images.

CADASTRAL MAP: Map which shows property lines and ownership.

CANVASS: Systematic enumeration of an EA or other area.

CARTOGRAPHER: Person who constructs maps.

CARTOGRAPHY: Science, technique, and art of map making.

CATHODE RAY TUBE (CRT): Screen (similar to a television screen) on which information from a computer can be displayed.

CENSUS AREA IDENTIFICATION MAP: Publication map showing boundaries and names or numbers of administrative divisions.

CENSUS SECTOR: See *census tract.*

CENSUS TRACTS: Small statistical areas into which large cities and their surrounding areas are divided for statistical purposes; called "sectors" in some countries.

CHOROPLETH MAP: Shaded map that presents several classes of statistical data for an administrative or statistical area.

CLASS INTERVAL: Group in which statistical data are classified; for example, 0 to 9, 10 to 14, 15 to 19, 20 to 29, etc.

CLOSED TRAVERSE: See *traverse.*

COLLECTIVE QUARTERS: See *Special Dwelling Place.*

COMPASS BEARING: See *bearing.*

COMPILING: Selecting source materials and preparing instructions for constructing base maps.

COMPOSITE NEGATIVE: Several negatives combined into one for ease of making a plate for printing; usually accomplished by using positive acting duplicating film.

COMPUTER OUTPUT ON MICROFILM (COM): Use of a light beam to plot lines or dots on microfilm.

CONFORMALITY: Characteristic of certain types of map projections showing true shapes of areas on the Earth's surface (not true size).

CONTINUING SURVEY: Survey conducted over time (annually, semi-annually, quarterly, monthly), primarily to produce current data and estimates of change. Continuing surveys usually cover the same core items each time the survey is conducted.

CONTINUOUS TONE: Smooth and continuous transition from shades of black to gray to white, as on an ordinary photograph.

CONTOUR: Line on a topographic map in which each point has the same elevation above sea level or some other base level.

CONTOUR INTERVAL: Difference in elevation between successive contour lines.

COVERAGE ERROR: Error in an estimate that results from (a) failure to include in a census or a survey all eligible units or (b) inclusion of some units erroneously.

CREW LEADER (CL): Supervisor in charge of a small group of enumerators.

CROSSHATCHING: Parallel-line pattern drawn over a specific area of a map. It is used to indicate a statistical value or to differentiate one area from another.

CULTURAL FEATURES: Man-made features of the landscape.

D

DELIMIT: Establish boundaries for a certain area, such as an EA.

DELINEATION: Process of dividing an area into EA's, statistical areas, etc.

DIAZO PROCESS: Type of reproduction, involving a direct contact positive, light, and ammonia fumes.

DIGITIZE: Convert location of map features into numerical values for automated cartography.

DIMENSIONAL STABILITY: Degree to which a material remains the same size or does not expand or contract more in one direction than in another.

DIVIDED CIRCLE: See *pie chart.*

DIVIDES: Watersheds which separate drainage areas. The term is sometimes used to refer to ridge lines.

DOT MAP: See *point symbol map.*

E

EARTH GRID SYSTEM: Imaginary east-west and north-south lines (latitude and longitude) which cover the Earth and which are used to locate features on the Earth's surface.

EDGING: Method of protecting the edges of a map by applying drafting or masking tape on the under side so that the map will not tear easily.

ELECTRO-MAGNETIC SPECTRUM (EMS): Range of radiation, including visible to invisible wavelength bands, recorded by sensors in remote sensing imagery.

ELEVATION: Height above sea level or other base level.

EMULSION: Light-sensitive coating on the surface of paper, film, etc., to reproduce an image.

ENCLAVE: Portion of an administrative area enclosed within another administrative area.

ENGRAVER (SCRIBER): Tool for scribing; also a person who uses a graver.

ENUMERATION AREA (EA): Area to be covered by one enumerator; must have identifiable boundaries and lie wholly within an administrative or statistical area.

EQUAL AREA (EQUIVALENT) PROJECTION: Map projection in which area size is not distorted. A map reader can compare the sizes of areas.

EQUIVALENCE: See *equal area projection.*

ERROR OF CLOSURE: Gap or opening between the beginning and ending points of a closed traverse when a sketch map is plotted.

ETCHING: Removing part of the surface coat by cutting or by dissolving with acid, alcohol, ammonia, or other solution.

EXCLAVE: Portion of an administrative area which is physically separated from the body of the area.

EXTENDED LINE: Imaginary line which connects visible features and which is used as part of an EA boundary.

F

FIELD SPLIT: Division of a large EA into two or more work assignments by field staff. See also *split EA.*

FLOW MAP: Map showing movement of people or commodities.

FOCAL LENGTH: Distance from the focal center of the lens of a camera to the film.

FUNCTIONAL INTEGRATION PRINCIPLE: Concept that involves the way in which a statistical area may be defined. The area comprises a nucleus and surrounding areas that are integrated through communication or movement.

GBF: Geographic Base File.

GENERALIZATION: Simplification of features on a map so that less detail is shown. This is often done to make maps easier to read.

GEO-CODE: See *geographic coding.*

GEOGRAPHER: Person concerned with land features, population distribution, spatial or locational aspects of physical (natural) and cultural (man-made) phenomena, and the processes that result in these distributions.

GEOGRAPHIC BASE FILE: Reference tape of geographic codes. The tape is used for automated address coding, matching of data from different files, and data analysis.

GEOGRAPHIC CODING: System by which each area used for census and survey purposes is assigned a unique number.

GEOGRAPHIC COORDINATE: Location on the Earth's surface expressed in terms of a grid, usually latitude and longitude.

GEOLOGIC MAP: Map showing the materials and structure of the Earth's crust.

GRADUATED CIRCLES: Circles of varying sizes used to represent statistical values (or class intervals

GRAPHIC SCALE: Type of map scale which shows ground distance by means of a bar or line divided into units of measure such as kilometers, miles, meters, or feet.

GRAVER (ENGRAVER): Tool for scribing.

GRID: See *locational grid.*

GROUND TRUTH: Information used to verify interpretation of air photos or satellite images, obtained by on-the-ground inspection or inspection of larger-scale or more detailed photography. Ground truth is usually obtained on a sample basis.

HACHURES: Short lines on maps used to indicate slope; not commonly used on modern maps.

HALFTONE: A photographic screen of closely spaced dots or lines that converts continuous tone to varying sized dots or line widths; necessary for the reproduction of continuous tone material through a printing process.

HAMLET: Rural population settlement.

HOMOGENEITY PRINCIPLE: Concept involving the way in which a statistical area may be delineated. Areas with similar characteristics are grouped together. See also *stratification.*

I

IDENTIFICATION MAP: Map showing boundaries and the names or other identification of areas for which statistics are published.

IMAGE MOSAIC: Composite of satellite images or air photos to show coverage of an area.

IMAGERY: Any portrayal of the Earth made by recording light or other forms of energy radiated or reflected by the Earth. It is usually recorded by equipment aboard aircraft or satellites.

INDEX MAP: Outline map showing areas covered by larger-scale individual maps or air photos.

INFRARED: Portion of the electro-magnetic spectrum with longer wavelengths of energy than those that are seen by the naked eye. Color infrared photography makes parts of the infrared spectrum visible of film. In the printing process, colors are changed; for example, green vegetation is shown as red.

INSET MAP: Usually a larger-scale detailed map for part of an area; placed in a corner of the map.

INTERMITTENT STREAM: Stream which flows part of the time.

INTERVIEWER: Person who collects information from a respondent; term interchangeable with "enumerator."

INVENTORY CARD: Card listing the information about the maps or air photos available for census or survey areas.

ISOLINE MAP: Map using a series of lines to connect points of equal value.

ISOPLETH MAP: Type of isoline map; shows the distribution of statistical data (ratios or percentages) by a series of lines, each of which connects points of equal value.

KNEADED ERASER: Eraser made of synthetic rubber or plastic that can be pressed or molded into any shape.

L

LAND COVER: Entire collection of features that cover the surface of the Earth.

LANDSAT: Unmanned satellite(s) orbiting the Earth on a polar orbit, designed to record all the features of the Earth on a continuing basis.

LARGE-SCALE MAP: Map which covers a comparatively small land area with great detail. An EA map is an example of a large-scale map.

LAYER TINTING: Technique which shows elevation zones by use of different colors. For example, elevations between 0 and 1,000 meters might be colored green and those between 1,000 and 2,000 meters might be colored brown.

LEG: Part of an open or closed traverse between two points at which measurements are taken. Both points must be within sight of each other, so that compass readings can be taken in both directions.

LEGEND: List of map symbols and their meanings. The type of projection, dates of compilation and publication, and authorship also are often included.

LETTERPRESS: See *photo engraving*.

LINE GRAPH: Diagram on grid paper showing a line connecting a series of points that represent values.

LINEWEIGHT: Width or thickness of lines on a map.

LIST SAMPLE: Sample of units selected from a list, such as a list of villages, a list of households, a list of agricultural holdings, etc. Previous censuses may provide such a list which can be updated; or a list can be compiled through a listing operation.

LISTING: Recording each unit (housing unit, agricultural holding, establishment) in a sample segment. Listing is usually conducted at the same time as sample units are enumerated.

LITHOGRAPHY: Method of printing in which the image is transferred (offset) from the press plate onto a rubber cylinder and from the rubber to the paper.

LOCATIONAL GRID: Vertical and horizontal lines used to identify or locate features on a map quickly and easily. The grid divides the area into squares or rectangles.

M

MANNED SATELLITE: Space vehicle orbiting the Earth, carrying human beings (for example, Skylab).

MANUSCRIPT MAP: Map on which the original map work is done.

MAP ACQUISITION: Task which involves the collecting of map materials from various government agencies and other sources.

MAP DISTORTION: Inaccuracies on a map resulting from the fact that features on the curved surface of the Earth cannot be reproduced exactly on a flat surface or map.

MAP ORIENTATION: Aligning the features on the map with the same features on the ground, thereby positioning the map and establishing location.

MAP PROJECTION: Transformation of the spherical surface of the Earth to a flat surface (plane).

MAP SCALE: Relationship of the distance between features on a map and the actual distance between the same features on the ground.

MAP SKETCHING: Using a compass for measuring direction, and pacing or using a tape, odometer, chain, or wheel for measuring distance. See also *traverse*.

MARGINALIA: Information which appears along the margins of a map (legend, date, north arrow).

MERIDIANS (LONGITUDE): Imaginary north-south lines on the Earth from which east-west distance (longitude) can be measured in degrees.

MOSAIC: See *air photo mosaic* or *image mosaic*.

MULTI-SPECTRAL SENSING (MSS): System for simultaneously sensing the same ground area in different parts of the electro-magnetic spectrum.

MULTI-STAGE SAMPLING: A procedure in which the elementary (or listing) units are selected through two or more stages of sample selection. For example, to select a sample of housing units in a country that is administratively divided into provinces, districts, and barrios, one can first select a sample of districts within provinces (first stage), then select a sample of barrios within selected districts (second stage), and finally select a sample of housing units within selected barrios (third stage). The housing unit would be the final sampling unit.

N

NADIR POINT: Point directly below the camera or sensor; approximately center of photo or image.

NAME-FINDER INDEX: Alphabetical list of areas, places, and surface features, and a key which can be used to locate them on a map; also known as a gazetteer.

NEGATIVE: Image in which color or tones are reversed so that light objects appear dark and dark objects appear light.

NEGATIVE STRIPPING: Revising or changing negatives by cutting and taping in other negatives.

NIB: Point of a pen.

O

OBLIQUE PHOTOGRAPHY: Air photo taken with the camera pointed downward at an angle which is not vertical, much as a passenger might take a picture from a window of a plane.

OFFSET: See *lithography*.

OFFSET LINE: Imaginary line connecting two visible features and running parallel to a linear feature, such as a railroad. It can be used as an EA boundary line if no visible feature is available.

OPAQUE: Quality of blocking light. Light rays will not pass through to expose the sensitized surface of film, plates, or other light-sensitive materials.

OPEN TRAVERSE: See *traverse*.

OPEN WINDOW NEGATIVE: Film which indicates the areas to be printed in a particular color or shade by removal of an opaque coating in the areas to be printed.

ORTHOPHOTOMAP: Map that is a composite of several air photos with additional information superimposed.

OUTLINE BASE MAP: See *identification map.*

OVERLAP: Parts of air photos or maps which are also shown on adjoining photos or maps.

OVERLAY: Transparent material which shows certain features, colors, and other detail, and which is placed in its correct position (or registration) on top of another map.

P

PACING: Counting steps to measure distance. Two steps equal one stride.

PANTOGRAPH: Instrument used to manually reproduce a map at different scale (sometimes at same scale).

PAPER STRIP METHOD: Method of measuring distance on a map using a graphic scale and paper.

PARALLEL LINE METHOD: Technique for measuring area on a map.

PARALLELS (LATITUDE): Imaginary east-west lines on the Earth from which north-south distances (latitude) can be measured in degrees.

PERENNIAL STREAM: Stream which flows all the time.

PERIPHERY: Territory beyond the boundaries of an area. It is important that EA maps show peripheral area, so that the enumerator can readily locate the EA.

PHOTO INDEX: See *air photo index.*

PHOTO-ENGRAVING: Method of producing the printing plate for letterpress reproduction. The sensitized surface of the plate is exposed through a negative, and the unexposed emulsion is washed away. The unprotected surface, or cleared area, is then etched with acid.

PICTOGRAPH: Graph showing pictures resembling people or commodities; usually reflect statistical values.

PICTOMAP: Map showing pictures resembling people or commodities; may not reflect statistical values.

PIE CHART: Circle that is divided to show the proportion of the total contained in each category; used on publication maps and charts.

PIN REGISTRATION: Method used to assure proper alignment of base maps and overlays by means of pins inserted in precisely punched holes.

PLANIMETER: Instrument for measuring area by tracing the perimeter.

PLANIMETRIC MAP: Map showing locations on the Earth's surface without reference to elevation.

POINT SYMBOL MAP: Map on which point symbols are used to represent values such as population size, crop production, etc.

POLAR PLANIMETER: Precision instrument that is used to measure areas on a map; operates around a single pole (or pin). It is the most commonly used planimeter.

PRELISTING: Listing operation conducted prior to enumeration. Each unit (housing unit, household, agricultural holding, establishment) is listed by address or other identification to (a) provide a sampling frame for surveys or (b) provide an estimate of the number of units in an area.

PRIMARY SAMPLING UNIT (PSU): Units that make up the sampling frame for the first stage of a multistage sample.

PROPORTIONAL CIRCLE: See *graduated circle.*

Q

QUADRANGLE INDEX MAP: An outline map with grid lines indicating which parts of the area are shown on individual sheets; also contains identification (name or number) of each map sheet being indexed.

QUADRANGLE MAP: Map which shows the part of the Earth's surface that is contained in one quadrangle (rectangle) of a grid.

QUICK COUNT: Process of dividing an EA or other area into sectors with identifiable boundaries and estimating the number of units (housing units, agricultural holdings, establishments, etc.) in each sector. Quick count differs from listing in that an estimate of units is made by observation rather than by recording (listing) each unit separately.

R

RADAR: Device for determining distance and characteristics of various objects through the use of high frequency radio waves. Airborne radar such as SLAR (side-looking airborne radar) can be used to produce photos, from which maps can be made.

RATIO: See *representative fraction.*

RECEIVING STATION: Location on Earth where satellite image data are received.

RELIEF: Difference in elevation within an area.

RELIEF SHADING: See *shading.*

REMOTE SENSING: Collection of information through the use of instruments (such as cameras and scanners) which are sensitive to electro-magnetic energy reflected or radiated from man-made and natural features.

REPRESENTATIVE FRACTION (RF): Map scale expressed as a fraction. It shows the relationship of the distance between two points on the map and the distance between the same two points on the ground. A fraction may also be expressed as a ratio.

RURAL PLACE: Settlement that does not qualify as an urban place.

S

SATELLITE IMAGERY: See *imagery.*

SCALE: Relationship of distances on maps or air photos to real world distances.

SCANNER: Instrument used in a satellite which senses the amount of energy being reflected or radiated from a series of points on the Earth's surface.

SCREEN TINTS: Film containing a specific pattern of lines or dots interposed between a negative and a sensitized surface to produce a pattern. Tints with closely spaced dots or lines produce the illusion of solid gray.

SCRIBING: Technique which permits the map maker to produce a negative on coated polyester film. The draftsman obtains the desired lines by removing the coating from the plastic film.

SECTORS: Small, permanently established, geographic areas into which cities and their environs are divided for statistical purposes; called census tracts in some countries. Sectors may also be subareas for which estimates of housing units are obtained in the quick count operation. See also *quick count.*

SEGMENT: Division of a sector into smaller groups of units; may also be an entire sector.

SERPENTINE FASHION: Numbering of areas on a map by going back and forth, or up and down, across the map.

SETTLEMENT: Cluster of housing units. Commercial and industrial buildings, churches, schools, and other structures may also be included.

SHADING: Cartographic technique that produces a 3-dimensional effect on a map through the use of various light and dark tones. Such shading is particularly effective in showing areas with steep slopes.

SHELF LIFE: Period of time sensitized material can be safely stored without deteriorating.

SIDE-LOOKING AIRBORNE RADAR (SLAR): See *radar.*

SKETCH MAP: Hand-drawn map of an area. See also *map sketching.*

SKETCHING: See *map sketching.*

SKYLAB: Manned satellite orbited in the 1970's designed to carry out a number of experiments, including gathering information about the Earth's surface.

SLASH/BURN AGRICULTURE: Type of nomadic farming in which forested areas are cleared and cultivated and then abandoned after the soil fertility declines. A new area is then cleared for crops.

SMALL-SCALE MAP: Map that shows fairly large areas greatly reduced in size.

SOFTWARE: Programs written to perform specific functions on computers. They are necessary to activate the hardware (computer, printer, plotter, etc.).

SPECIAL DWELLING PLACE: Collective living quarters including such places as orphanages, workers' camps, dormitories, army barracks, monasteries, hospitals, homes for the aged, and prisons.

SPECIAL EA: EA containing a Large Special Dwelling Place.

SPLIT EA: Large EA that has been divided to create more manageable workloads for two or more enumerators.

STABLE-BASE PLASTIC: Plastic film which will not change in dimension. It will remain the same length and width as it ages or as temperature and humidity change.

STATISTICAL AREA: Area defined by the statistical office, generally using criteria relating to social and economic characteristics; differs from an administrative area whose boundaries are defined for administrative purposes.

STEREOSCOPE: Instrument used to view stereoscopic pairs of photos of the same area to give a 3-dimensional view of the area.

STEREOSCOPIC PAIR (STEREOPAIR): Two air photos of the same ground area taken from different camera positions. A stereoscope can be used to obtain a 3-dimensional view of the area involved.

STICK-ON LETTERS: Letters printed on material with an adhesive backing. The letters are cut out and applied to maps.

STRATA: See *stratification.*

STRATIFICATION: Classification of units (administrative divisions or other areas) into strata or groups so that the units within a stratum are similar. The criteria for delineating the strata depend upon the survey objectives and the kinds of information available.

STRIDING: See *pacing.*

STRIP-COATED POLYESTER: Plastic (polyester) film having opaque coating; used for making open-window negatives.

SURVEY: Inquiry of a sample of units (housing units, households, persons, agricultural holdings, establishments) to estimate characteristics of the total.

SYMBOLIZATION: Use of symbols.

SYMBOLS: Designs (dots, circles, squares, etc.) representing natural or man-made features.

T

TEMPLATE (TEMPLET): Pattern guide for drawing symbols; usually made of plastic or metal.

TEXTURE: Variations in tone of features on air photos or satellite images that create a visual impression of relative roughness.

THEMATIC MAP: Map which illustrates a certain type or class of information; often called a statistical map. For example, a thematic map might show climate zones, agricultural production, or population density for a selected area.

TICK MARKS: Short lines used on maps. They are placed on the frames of maps to represent some type of grid system.

TIE LINE (TIE-IN LINE): Line drawn around an area to show that its scale is different from that of the surrounding area. Most tie lines are associated with urban-rural boundaries.

TINT SCREENS: See *screen tints.*

TONE: Relative darkness or lightness of an object on air photos or satellite images.

TOPOGRAPHIC MAP: Map showing surface features of a region, such as landforms, rivers, lakes, roads, and bridges.

TRACT: See *census tract.*

TRANSLUCENT: Able to transmit light, but diffusing it so that objects cannot be seen through it distinctly.

TRANSPARENT: Able to transmit light so that objects may be seen through it distinctly.

TRAVERSE: Walk or ride around or within an area for the purpose of measuring distances and directions. If the traverse ends at the place where it started, it is called a closed traverse; if not, it is an open traverse. See *map sketching.*

TRIANGULATION: Technique for determining the location of a feature by means of compass bearings taken from points of known location.

UNMANNED SATELLITE: Space vehicle orbiting the Earth, not carrying human beings (for example, Landsat).

URBAN PLACE: High density settlement which is designated as being urban. Criteria vary according to country but usually include population density and minimum population size.

URBANIZED AREA: Core city and adjacent built-up area.

V

VELLUM: White or slightly tinted drawing paper. It may be translucent or transparent and is often used for tracing.

VERTICAL PHOTOGRAPH: Air photo that is taken at an angle of 90° to the Earth's surface.

VISIBLE BOUNDARIES: Boundaries following features that can be seen and located on the ground.

W

WORD STATEMENT: Map scale expressed in the form of a statement, such as "one centimeter represents one kilometer."

X

XEROGRAPHIC: Non-printing process of duplicating materials. It is a dry process that reproduces the image by static electricity and heat to fix carbon particles to paper.

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