Journal of Official Statistics
Vol. 4, No. 1, 1988, pp. 35–46

Statistics for Regional and Local Planning in Sweden[1]

Hans Ansén, Sten-Åke Hallén, and Hans Ylander[2]

Abstract: We give some applications of new techniques for collecting and presenting statistics for urban and regional planning and for managing natural resources. Maps, aerial photos, and to some extent satellite data have been used in recent years as sources for land-use statistics. For urban areas large-scale maps from the 1960–1980 censuses have been combined with other maps and aerial photos to provide different types of statistics, a) areas of urban expansion into agricultural land, b) "areas of common access"[3] for recreation that surround larger urban areas, and c) land-use statistics. Our small-area statistics for local planning are based on censuses and national administrative registers equipped with adequate identifiers. The basic registers are: central population register, central business register, and central real property register. The most common geographical divisions in our statistics are county and municipality. A "key-code system" was designed in 1968 to produce small-area statistics and has gradually expanded since then. Geocoding can also be done via the coordinates of every real-estate unit.

Key words: Maps as data sources; urban expansion; areas for recreation; urban land-use; small-area statistics; integration of national registers; key-code system; coordinates.

1. Introduction

The production of statistics employs a wide range of disciplines, related on the one hand to the substantive matter in question – national income, population, land-use and so on – and on the other to the technical tools of production, e.g., sampling, computer systems, and presentation. In this brief article, we deal with statistics for regional and local planning and statistical applications in which new technology – in a broad sense – is a vital element. We do not cover all statistics for planning or all new techniques in the production of statistics. We discuss:

1. Maps, aerial photos, and satellite information as data sources for land-use statistics
2. Small-area (submunicipal) statistics – especially the integration of administrative registers
3. Regional divisions, geocoding, and the use of coordinates
4. Distribution techniques

[1] An earlier version of this article appeared in Land-Use Information in Sweden D2:1987, pp. 32 – 44, published by the Swedish Council for Building Research, Stockholm.

[2] Senior Statisticians, Departments of Area Statistics and Statistical Services, Statistics Sweden, S-115 81 Stockholm, Sweden.

[3] "Common Access" is a privilege granted by Swedish law that permits individuals to enter privately owned lands except for cultivated fields and private grounds near dwellings.

1.1. *Statistics production in Sweden*

Statistics Sweden (SCB) is the main producer of official statistics in Sweden. Many of these statistics are for regional subdivisions. About 80% of Statistics Sweden's budget comes from state funds, but the remaining 20% comes from the sale of statistical services, e.g., to municipalities. Normally, the state sponsors the production of statistics down to and including the municipal level, while users must purchase statistics for submunicipal areas.

There are several reasons why Statistics Sweden has come to play a dominant role in the Swedish statistical system. The large mainframe computers that became essential for statistics in the 1960s and 1970s required centralized production in a small country like Sweden. There are also advantages to centralized production, for instance, in the coordination and use of administrative registers kept by other authorities. With the spread of computers, the conditions originally leading to centralization have changed, but regional and local authorities still produce only a small portion of the basic statistics. Instead, these authorities put their efforts into handling the statistical material: selecting vital statistics for current problems and doing analyses, projections, and forecasts.

1.2. *Regional and local planning authorities*

Regional and local authorities in Sweden are responsible for planning and administrating over a wide range of areas. Consequently they are important and frequent users of statistical information.

The national government is represented on the regional level by the county administrative board (länsstyrelse) and other regional agencies dealing with physical and economic planning, conservation of natural resources, employment, roads, surveying, forestry, agriculture, and other matters. Medical services are provided for by the county council (landsting), a body elected at the regional level.

Local government – the municipality (kommun) – has increasingly been assigned new planning and administrative duties, especially over the past twenty years. Its most important duties are: child-care facilities, education, social welfare, planning and building, local roads and traffic, recreation, water and energy supply, and sewage treatment. Although, in theory, all municipalities have the same duties, in practice their variation in size (from 3 000 to 650 000 inhabitants) means that they differ greatly in their need for and ability to handle statistical information. This can be seen, for instance, in the use of small-area divisions for planning purposes and in the use of computers, where innovations are started by the largest municipalities and filters down to the smaller ones perhaps ten years later.

2. Maps, Aerial Photographs, and Satellite Data as Sources for Land-Use Statistics

2.1. *Use of maps and aerial photographs*

We describe here the use of maps and aerial photographs in producing statistics. The examples are taken mainly from Statistics Sweden's land-use statistics, and in most cases are based on the use of urban-area maps (economic maps and corresponding aerial photographs) produced in conjunction with the population and housing census to demarcate and present urban agglomerations. This is a new use of Statistics Sweden's urban-area maps from the period 1960–1980, and it is also an improvement in its use of new combinations of maps and aerial photos.

Since most of the applications and experiments use Statistics Sweden's demarcations of urban areas as a point of departure, we briefly describe these maps in the context of the census. Starting with the 1960 census, all

of the country's urban areas were demarcated on large-scale maps. The plotting was done by Statistics Sweden in close cooperation with the land-survey organization and using the National Land Survey's real-estate maps. The maps produced were used in the census to locate dwellings in urban and rural areas and to illustrate commuting patterns. The urban-area maps have also been used to measure the amount of "urbanized area" in the country, and from them it has been possible to trace changes in the amount of urbanized area in five-year periods from 1960 to 1980.

To ensure comparability, the same definition of "urban agglomeration" has been applied over the entire country and in all of the censuses. In practice, when demarcating urban areas there are often different interpretations of urban agglomeration, and rightly so. A completely strict application of the definition could produce unrealistic demarcations, for instance, registering a town's industrial districts and port facilities as rural land. The new real-property coordinates have been useful in coding and processing the data.

While work was in process on Sweden's National Physical Plan in the 1970s and 1980s, great importance was attached to the urbanization of agricultural land, especially since this often involved the best agricultural land. Statistics Sweden was able to produce data about this process by using the urban-area maps in combination with other maps using the same scale (1:10 000); the amount

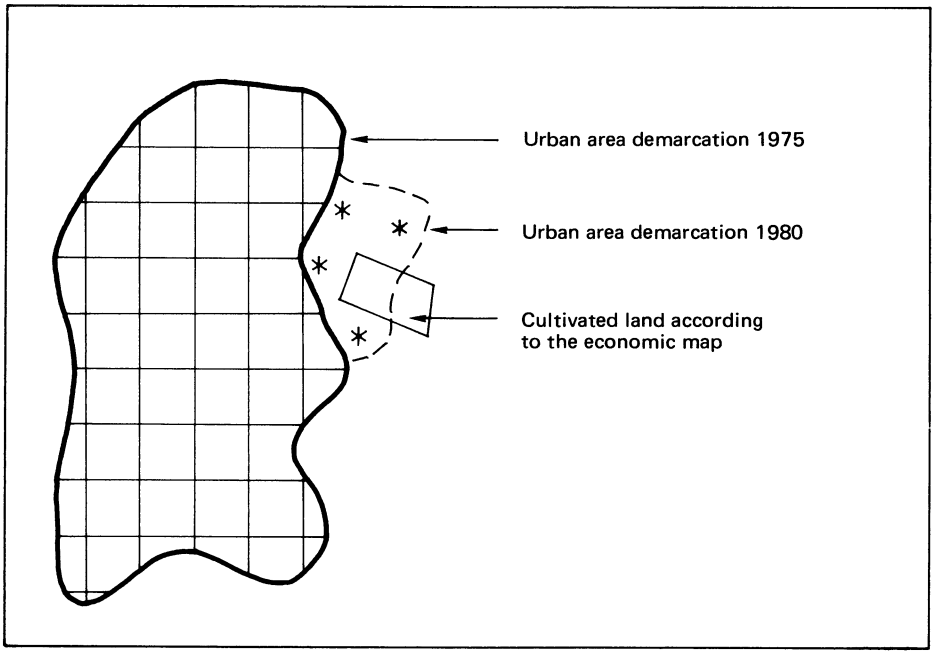

Fig. 1 **The cross-hatched area (solid outline) was demarcated in 1975 as an urban agglomeration. The broken line outlines the expansion observed in the demarcation of 1980, based on then-current property maps. The economic map, which provides information on land use and is somewhat older, shows the area within the broken line as consisting of forests and cultivated fields. The parts of the fields falling within the 1980 demarcation line are urbanized agricultural land.**

of agricultural land urbanized during each five-year period was thus measured with a planimeter, see Fig. 1 (Statistics Sweden (1982)). The investigation showed that the expansion was greatest during the periods 1965–70 and 1970–75, declining by approximately one-half during the period 1975–80.

In a similar study done in cooperation with the National Environmental Protection Board, Statistics Sweden used urban-area maps in conjunction with economic maps to measure the amount of land available for recreation and outdoor activities around the larger (more than 10 000 inhabitants) urban agglomerations (Statistics Sweden (1985a)). "Areas of common access" are thus forests and undeveloped land not used for agriculture. As Fig. 2 shows, land was surveyed in kilometer-wide zones around urban agglomerations. This method of assessment employs a grid with observations made at points 100 meters apart. Water and coastal zones are treated as special classes according to their suitability for recreational use. The results show which urban areas have ample accessible land and which do not. Those areas having

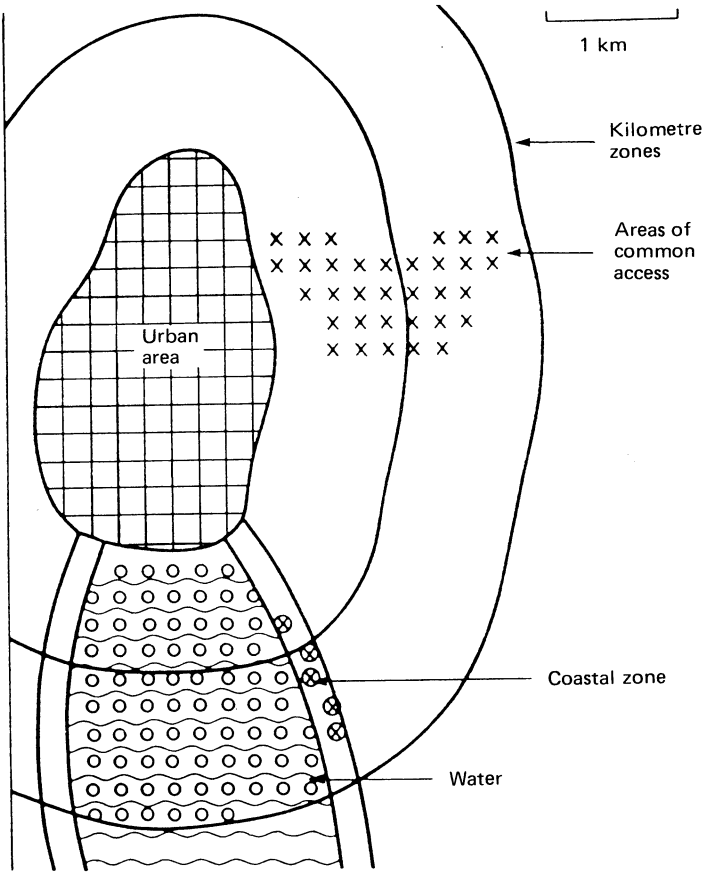

Fig. 2 Diagram of the cartographic survey method. The cross-hatched area is an urban agglomeration, around which two 1-km-wide zones are traced. Within these zones, every cross drawn over green areas on the economic map represents four hectares of common access land. Corresponding water areas are indicated by small circles. The various areas are totaled and presented in tables.

scarce available land have particular reason to protect this land from development interests.

Statistics on land-use in urban areas and their immediate vicinity have been prepared by using map-aided plotting from aerial photograph (Matérn (1986), Saebø (1983), Statistics Sweden (1985b)). A random sample of 60 urban areas, mainly larger towns, was drawn from the country's 1 820 urban agglomerations. The total area of the urban agglomerations in the sample was 25% of the country's total urban area; in 1980, 38% of the urban population resided in these agglomerations.

Land-use in the urban areas sampled was determined via selective plotting from aerial photographs. Data from urban-area maps and economic maps were used extensively to supplement the photos. The plotting was done on light tables from prints of black-and-white aerial photos taken on a scale of approximately 1:10 000. The photographs were taken in 1980 or thereabouts. A transparent plastic film with an etched 1-cm grid was placed over the photo, and the 1980 urban-area demarcation lines were drawn onto the film. Outside these demarcation lines, new boundaries were drafted showing the outer limit of the zone of accessibility (defined as a real distance of 500 meters for agglomerations with up to 50 000 inhabitants and 1 000 meters for those with more than 50 000 inhabitants). Points were then plotted corresponding to a real distance of 50, 100 or 200 meters (depending on the size of the agglomeration).

The classification system used was developed from studies of municipal plans and from the information contained in the maps and aerial photographs. It was also related to a system developed by the Nordic bureaus of statistics, the "Standard Nordic Classification of Land" (Nordic Committee for Environmental Statistics (1985)). The system employed about 25 categories with ten major classes, and the type of land-use was indicated by a code marked directly on the plastic film.

Altogether 70 600 points were plotted in urban areas and 60 400 in accessible zones. The location codes for these points were recorded, certain mechanical verifications were made and the data were processed. The results have been presented on the national level with the data distributed among three sorts of urban areas classified according to size. The same method has also been used to study gross changes in land-use within urban areas and their immediate vicinity for the period 1970–1980.

2.2. *Experiments with satellite data*

Statistics Sweden is experimenting with satellite data to see if they can replace some investigation methods or yield new types of statistical data. The subjects being considered are land-use and agricultural statistics.

The first earth resource satellite, the 1972 Landsat, had a ground resolution of 80 × 80 meters, too low for our applications. Considerable improvement was made by 1984 with Landsat 5, which had a resolution of 30 × 30 meters for data measured in seven spectral bands, and by 1986 with SPOT, which had a resolution of 20 × 20 meters in three-band mode and 10 × 10 meters in one-band mode (black and white data).

For agricultural applications, Sweden's cloudy weather – skies are clear only one day in five – is a severe handicap: satellite data are relatively unpredictable, since the satellites pass over the same earth location at intervals of about two weeks. Another difficulty is the relatively low accuracy of classifying crop type; errors of 10–40% are common. Thus, satellite data must be used in conjunction with ground investigations. A frequently used technique is regression estimates with ground data as the exact variable and satellite data as the auxiliary variable.

For land-use statistics in urban areas, satellites cannot yield as detailed classification schemes as that used with aerial photographs. However, our tests indicate that satellite data can be used for statistics on green areas around urban areas, since it is fairly easy to distinguish water, forests, and agricultural fields. Note, however, that defining the border of the urban area itself is somewhat more difficult, especially for small houses in wooded regions. SPOT data with a 10-meter resolution does not display each individual house with certainty.

3. Small-area Statistics Based on Administrative Registers

3.1. *General remarks*

In order to produce statistics for a large number of small areas, input must be obtained from "all-inclusive investigations" or "comprehensive registers" of the populations to be described. Sample surveys cannot be used for the thousands of areas with an average population of about 100 people. For this reason, our small-area statistics are based on either national administrative registers or censuses of population and housing. To reduce the cost of data collection, our censuses are now partly based on administrative registers.

In many cases, using administrative registers to produce statistics means relying on data gathered by other authorities for other purposes. It becomes necessary for the national statistical office to cooperate with and to influence other authorities concerning data collecting and setting up registers. Statistics Sweden has the responsibility of coordinating codes, standards and classifications, and has been rather successful. But standardization often takes time and effort. For instance, it was only a few years ago that we in Sweden were able to use a single basic identity code for real property.

Protecting privacy and personal integrity is an urgent matter for the producer of statistics, especially when using administrative registers to produce small-area statistics. This is not the proper place to discuss these matters in detail, but we can note that Sweden has a special Data Act regulating the use of registers on individuals and secrecy rules exclusively concerning the handling and presentation of statistical data. Nevertheless, discussions are underway about increasing security still more by crypting the identity codes in registers.

3.2. *Keys for integrating registers*

Since the production of small-area statistics is based upon the integration of many registers, adequate identifiers and adequate integration keys are essential. By "adequate" we mean: unique, stable over time, up to date and referring to the same date, frequently used, and easy to handle.

From the user's (planner's) point of view, adequate identifiers must be provided for the most important objects. Any analysis in urban and regional planning will end up with three such objects: the individual, the firm, and the real property unit. In Sweden we are fortunate to have adequate identifiers for these objects:

- individual – a 10-digit civil registration number
- firm – numerical codes for the firm and its locations
- real property – an alphanumeric code

We lack permanent identifiers for buildings or dwellings. In the census, however, a provisional dwelling identification number is used.

3.3. *Administrative registers and their integration*

In the production of statistics we use copies of registers from many authorities, agencies, and organizations. The basic registers are:

- central population register – kept by National Tax Board
- central business register – kept by Statistics Sweden
- central real property register – kept by National Tax Board and the Central Board for Real Estate Data

Secondary registers with important data items are those for population change, income, pensions and other allowances, car owners, unemployed (more correctly, those seeking employment), and since 1986, those employed. Fig. 3 shows the linking among various registers of the three most important identifiers.

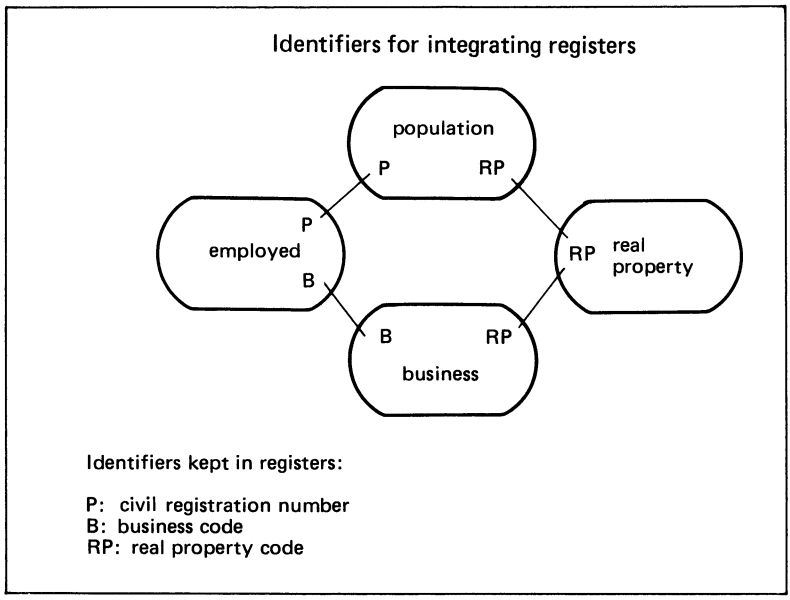

Fig. 3 The identifiers present in some of the more important registers and how they are used to link the registers.

To get good statistical output from matching administrative registers it is, as noted, vital that the integration keys be of high quality. That, in turn, depends on many factors, but in our experience it is most important that the identifiers be used primarily for administrative purposes, so that the authorities responsible for them have an interest in keeping a high standard. The situation is less favorable for the statistical agency if the identifiers or other data items are added to administrative files for statistical purposes only.

An example of a favorable situation is the use of property codes to link population to small statistical areas. Normally more than 95% of the population in municipalities can be located in that way, and good results largely depend on the fact that properties are the basis of civil registration. We are now, on the other hand, facing an unfavorable situation in our attempt to use a code for "place of activity," to be reported by employers to the tax authority and used by Statistics Sweden to locate the working population within the 1985 census. This code is novel to employers and in many cases is unnecessary for their wage- and tax-paying routines. Nor is the code of major interest to the tax authority,

which cares most about firms in the legal sense and somewhat less about their geographical distribution. We see the consequences when we try to distribute employment statistics geographically within municipalities. In some cases we are missing as much as 25% of the data, which is unacceptable and must be remedied by complementary data collection.

3.4. *Statistical output*

The registers and their variables and values can be combined in many ways. To provide the statistics most commonly required in local and regional planning, however, the production of small-area statistics has been standardized in a system where tables are issued at predetermined intervals. Today we produce about 100 standard tables distributed among ten "statistical packages" on various topics like "population," "income," etc. County and municipal planners have catalogues at their offices and can order tables for specified areas, points in time, and periods of time. This system makes it possible for us to use computer-aided methods for handling orders, bill's, and production, and thereby reduce costs and save time. With these tools we handle about 2 000 orders every year. In addition to this standardized production, we deliver about 100 "tailor-made" products annually. The basic packages are presented in Table 1.

Table 1. Basic packages of small-area statistics

Statistical package	Frequency of production	Since
Population	3/year	1968
Income	annual	1969
Population change	annual	1974
Car owners	annual	1975
Real property	annual	1983
Unemployed	semiannual	1984
Employment	annual	1987
Census	every 5 years	1970

4. Regional Divisions, Geocoding, Coordinates

4.1. *Regional divisions*

Naturally, the most common geographic divisions in our statistics reflect Sweden's administrative structure: the hierarchy of 24 counties, 284 municipalities and 2 565 parishes (the parishes are not often used in statistical presentations nowadays). Most statistics on population, housing, industry, education, agriculture, and so on are aggregated by county and municipality.

Another division important for planning purposes is that between urban areas (agglomerations with 200 or more people) and sparsely populated areas. Urban areas were previously demarcated in connection with censuses. To reduce costs, however, this was not done in the 1985 census.

4.2. *The key-code system for submunicipal statistical units*

We remarked above that the real-property register is an important source of small-area statistics and that the real-property code is a vital link between different registers. However, the most important function of the real-property code is to locate statistical data spatially. Units of real property are the finest geographical division in Sweden. With the names or codes for county, municipality, parish, and real-property unit (e.g., 01 80 22 Lion 14), a piece of land can be located on a surveyor's map. This is the primary reason that real property has come to play a dominant role in Swedish geodata systems. Other reasons are that, as mentioned, a great deal of information can be linked to real property, and that Sweden lacks a well-standardized address system.

In 1968, Statistics Sweden designed what is called the key-code system to produce small-area statistics. Key codes (six-digit codes

designating areas on a map) constitute an "external index" for this simple geodata system. It has been widely used over the years, and at present 278 of the 284 municipalities (comprising 99% of the population) are affiliated with the system. The finest subdivision contains about 85 000 areas.

To become affiliated with this system, the local authority drafts a subdivision of its territory and lists the real-property units that constitute each sub-area. Subdivisions can be updated once a year. Statistics Sweden has compiled routines and aids to facilitate initiating and updating the system. We charge a fee for initial implementation and updating, the amount of which depends on the population of the municipality.

The configuration of the sub-areas is dictated by local conditions such as the size and structure of the municipality. The subdivision should, however, be designed to ensure that sub-areas can be used as building blocks in the different subdivisions used by the different municipal departments.

The key-code system is hierarchically structured; the smallest sub-areas formed from one or more units of real property can be aggregated to areas of increasing size. In this way, the local authority can obtain statistics at a level appropriate for their planning needs. Areas may also be selected at will and aggregated to form new areas.

The major drawbacks of the system are: it has as yet no built-in geometry or connectivi-

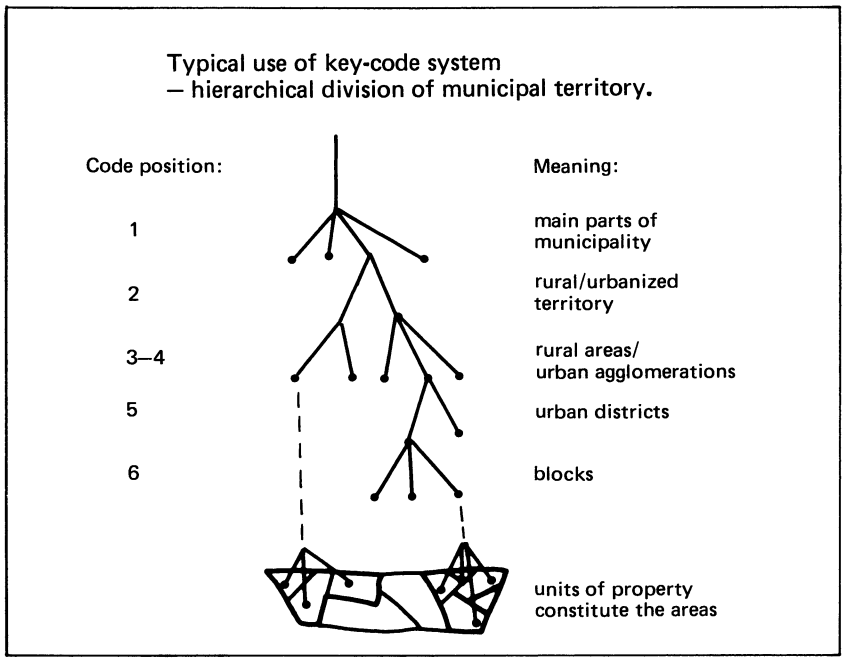

Fig. 4 The structure of a typical subdivision. The key-code system is simple, comprehensible and inexpensive – the yearly update for an average-sized municipality requires one or two days' work and costs the user a fee of about 1 500 SEK.

ty; an external index is needed, either on a map or committed to memory; and the subdivisions are not standardized among municipalities. In spite of this last drawback, key-code areas have recently been used to construct a national subdivision for civil defense purposes. On the county level, the key-code division has been used to plan traffic flow and medical care.

4.3. *Coordinate-based areas and statistics*

The Swedish Central Board for Real Estate Data (CFD) is currently replacing all manual real-property registers by a computerized system; the reform will be completed in about four years from now. When setting up the new registers, CFD also registers coordinates for every real-estate unit. About 70% of all real property in the county has been registered so far.

With this system, data linked to real property can be located for arbitrarily delimited areas, and new ways to handle and present statistics with computer-based spatial analysis and cartographics have become available. When real-estate coordinates are available for the entire country, it will be possible to treat the geographical dimension of statistics more thoroughly, and it is hoped that this will lead to greater use of geographic data. Geographic variables such as density, potentials, and spatial covariation are certainly relevant for statisticians and planners.

These new methods have been utilized for a number of years in a joint venture by CFD (coordinates), Statistics Sweden (data) and the National Land Survey (base maps). The result is computer-produced statistical maps of different types (dot, grid, isarithmic) and scales. Like the statistical packages, these maps are produced on request for regional and local planning. A number of different maps were produced with 1980 census statistics. Population maps are available for every year and maps with real-property information for years after 1983.

5. Distribution of Statistics

5.1. *Paper*

The predominant medium for distributing statistical results is still print – publications or computer printouts – but other media are developing quickly. We distribute about 500 000 pages of small-area statistics yearly. Of course, computer printing has improved greatly over the years. We started with greasy, blue-striped paper in macro format and are currently sending out white laser printouts in standard A4 format – even printed vertically and punched for filing. Microfiche was tried for a couple of years but was not popular with our users.

5.2. *Magnetic tapes*

Tapes have always been used for distribution, though their use has not increased over the years. Tapes go to the large-scale users with their own mainframe computers and to redistributors which also sell application systems – a computer center serving county administrative boards and some others serving municipalities.

5.3. *On-line databases*

Traditional presentation and distribution methods will never fully succeed in meeting the numerous and varied demands of users. Standardized tables are compromises. Users of statistics spend many hours searching for statistics, discarding some, aggregating data from tables, doing simple calculations, designing suitable table layouts, etc. For this reason, Statistics Sweden started as early as 1973 to develop an on-line statistical database system. Similar systems have been developed in other countries. The database management system, called AXIS, has been in

regular operation, at a charge to the user, since 1982.

AXIS handles three databases targeted at a variety of user categories. TSDB contains economic-statistical time series, RSDB provides regional statistics for counties, municipalities, and urban areas, and DSDB contains small-area statistics for the key-code divisions. The comparison is difficult, but we estimate that the total contents of the databases today are equivalent to 150 shelfmeters of statistical publications.

RSDB and DSDB are designed for regional and local authorities. RSDB contains, for instance, most of the 1975, 1980, and 1985 census statistics, and DSDB provides basic population statistics. In mid-1988 there are 250 contracted users of the three databases, among them ministries, government bureaus, county councils, county administrative boards, and 20 municipalities.

5.4. Disks for local computers

PCs are now being installed in planning offices. We have been distributing floppy disks on a regular basis since the beginning of 1987, and after one and a half year around 100 municipalities and some other users as well had ordered disks. Program development on PCs for regional and local planning applications has just started.

6. Concluding Remarks

The decentralization of planning responsibilities in Swedish society continues. New laws on comprehensive physical planning and management of natural resources, for instance, give local governments both more power and more duties. We are also witnessing some changes in organization of local and regional bodies as we move from a sectorized administration to a model based on integration within geographical sub-areas. These factors strengthen the demand for statistics with regional divisions in general. Subject-matter areas like environment, health, and local economy are attracting new attention.

The use of administrative registers for statistical purposes will continue and probably increase, due to their potential in spatial subdivision and statistics and also due to the costs of other types of data collection. Work must continue on issues concerning secrecy, methods for matching, and reduction of data loss. The use of geographical coordinates offers new potential in employing arbitrary area divisions in statistics and in the development of more sophisticated methods for description and analysis in the spatial dimension.

The spread of computers means that statistics users have powerful tools to handle data, even the large amounts that come from satellites. It has always been a challenge to statistical agencies to produce relevant information. There is now a new challenge in developing user-friendly systems that can handle our output in a relevant way.

7. References

Matérn, B. (1986): Spatial Variation: Stochastic Models and Their Application to Some Problems in Forest Surveys and Other Sampling Investigations. Second Edition, Lecture Notes in Statistics, Springer-Verlag, Berlin.

Nordic Committee for Environment Statistics (1985): Standard Nordic Classification of Land. (In Swedish.) Nordisk arealklassifikation. Tekniske rapporter 39, Nordiska Statistiska Sekretariatet, Köpenhamn.

Saebø, H.V. (1983): Land Use and Environmental Statistics Obtained by Point Sampling. Bulletin of the International Statistical Institute, Vol. 50, pp. 1317–1340.

Statistics Sweden (1982): Urban Expansion on Agricultural Land 1975–1980. (In Swed-

ish.) Tätortsexpansion på jordbruksmark 1975–1980. Statistiska meddelanden J 1982: 10. Statistiska centralbyrån, Stockholm.

Statistics Sweden (1985a): Areas of Common Access Around Localities With More Than 10 000 Inhabitants. (In Swedish.) Allmänt tillgänglig mark kring tätorter med mer än 10 000 invånare. Statistiska meddelanden. Na 12 SM 8501. Statistiska centralbyrån, Stockholm.

Statistics Sweden (1985b): Land Use in Urban Settlements and Their Surroundings in 1980. (In Swedish.) Markanvändningen inom tätorter och tätorters närområden 1980. Statistiska meddelanden. Na 14 SM 8501. Statistiska centralbyrån, Stockholm.

Received February 1987
Revised October 1987