

DIFFERENCES
IN THE SPATIAL STRUCTURE
OF THE POPULATION
BETWEEN
FINLAND AND SWEDEN
IN 1995



Tilastokeskus
Statistikcentralen
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BETWEEN FINLAND AND SWEDEN IN
1995 – a GIS viewpoint



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Foreword

This report forms part of a co-operation project with the purpose to study the processing methods and implementation potential of statistical grid data. The parties to this co-operation are Statistics Finland, Statistics Sweden and the Department of Geography, University of Oulu.

The researchers of the Department of Geography at the University of Oulu were supplied with grid statistics constructed from the 1995 population data. With the help of these data the regional differences in the spatial structure of the population of Sweden and Finland were analysed and compared (Contract TK-26-1314-95).

By grid materials are meant statistical data where the areal unit is a regular square. The grids generally measure 1 x 1 km and their locations are defined by map co-ordinates. The statistical offices of Finland and Sweden produce grid materials mainly for commissions from outside clients. These datasets are unique both in Europe and the entire world.

A team of experts consisting of Professor Arvo Naukkarinen, Docent Jarmo Rusanen, Ph. D. Toivo Muilu and Phil.Lic. Alfred Colpaert from the Department of Geography of the University of Oulu were responsible for the geographical and statistical analyses. On behalf of Statistics Finland, the project was co-ordinated by Marja Tammilehto-Luode and on behalf of the Statistics Sweden, by Sten-Åke Hallén. In addition, several experts from Statistics Finland and Sweden contributed to the project. We wish to express our warmest thanks to all of them.

Helsinki – Stockholm – Oulu, December 1996

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Abstract

Differences in the Spatial Structure of the Population between Finland and Sweden in 1995 – a GIS viewpoint

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Statistics Finland, Research Reports 221, Helsinki 1997*

The principal aim of the project is to employ a small number of variables extracted from the Finnish and Swedish georeferenced data records to determine the viability of joint use of these data and, purely as a matter of research interest, to analyse similarities and differences in spatial structure between the two countries. The comparisons have been made mostly at the macro-level. One important goal has been the production of cartographic printouts of various classifications covering both countries. A further subsidiary aim has been to identify spatial phenomena that can be described only in terms of coordinate-based grid cell data, i.e. which cannot be revealed using areal units of an administrative kind.

The material consisted of georeferenced data for 1 x 1 km grid cells produced by the statistical offices of Finland and Sweden. All in all, there were a total of 103 036 grid cells in Finland and 117 905 in Sweden inhabited by at least one person on 1.1.1995. The methods employed here are statistical analysis, GIS techniques, cartographic methods and a rank size model.

Both countries are to a substantial extent sparsely populated, having distinctly more uninhabited grid cells than inhabited ones, and the attraction of lakes, rivers and coasts for settlement continues to be reflected in the spatial distribution of population, the major cities being principally located on the coast. Another feature

that they have in common is that the focus of population is towards the south and the northern areas are sparsely populated. The greater distances to the nearest centre with services recorded for Sweden may be attributed to the smaller number of communes and their greater area.

Sweden is a markedly more urbanized country than Finland, and the boundaries between urban and rural areas would seem to be more sharply defined. No definite reason can be suggested for this on the basis of the present material.

The demographic structure as a whole may be regarded as better balanced between the levels in the spatial structure in Sweden than in Finland, although the two countries have many structural problems in common. Examples of these would be the predominance of the older age groups and the male sex in the rural areas and the predominance of females and low proportion of children in the centres of the urban areas.

Keywords:

- *grid cell*
- *coordinate based data*
- *georeferenced data*
- *GIS*
- *regional structure*
- *settlement structure*
- *Finland and Sweden*

Tiivistelmä

Väestörakenteen alueelliset erot Suomessa ja Ruotsissa vuonna 1995 – paikkatietonäkökulma

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Tilastokeskus, Tutkimuksia 221, Helsinki 1997*

Tutkimuksen päätavoitteena on ollut selvittää Suomen ja Ruotsin ruuduttaisten väestötietojen yhteiskäyttömahdollisuuksia ja samalla analysoida molempien maiden aluerakenteessa ilmeneviä eroja ja samankaltaisuuksia. Vertailut on tehty pääasiassa makrotasolla. Yhtenä tärkeänä tavoitteena on ollut tuottaa erilaisilla luokituksilla molemmat maat kattavia teemakarttoja.

Niinikään tavoitteena on ollut nostaa esille sellaisia alueellisia ilmiöitä, joiden selvittäminen on mahdollista vain koordinaattipohjaisten ruututietojen avulla ja joita ei saada näkyviin hallinnollisia alueyksiköitä käytettäessä. Tällaisiin ilmiöihin kuuluvat esimerkiksi väentihyden alueellinen vaihtelu ja siinä erityisesti harvan asutuksen ruudut ja niiden valtakunnallinen yleisyys.

Tutkimusaineistona on käytetty Suomen ja Ruotsin Tilastokeskusten tuottamaa paikkatietoaineistoa, jossa havaintoyksikkönä on 1 x 1 km:n ruutu. Ruutuja, joihin oli rekisteröity yksi tai useampi ihminen, oli 1.1.1995 Suomessa yhteensä 103 036 ja Ruotsissa vastaavasti 117 905. Tutkimusmenetelminä on käytetty tilastollisia analyyskejä, GIS-tekniikkaa, kartografisia menetelmiä ja rank-size -mallia.

Molemmat maat kuuluvat selkeästi harvaanasuttuihin alueisiin, joissa asumattomien alueiden määrä on asuttuja selvästi suurempi. Kummassakin maassa erityisesti meren rannikoiden ja vesistöjen vetovoima asutuksen

suhteen näkyy yhä asutusrakenteessa suurimpien kaupunkien sijaitessa pääasiassa rannikoilla. Yhtäläistä on myös se, että asutuksen painopiste on maan eteläisissä osissa ja harva asutus pohjoisessa. Toisaalta kuntien pienemmän lukumäärän ja suuremman pinta-alan vuoksi Ruotsin kuntakeskuspalvelut sijaitsevat kauempana kuin Suomessa.

Ruotsi on selkeästi Suomea urbanisoituneempi. Myös kaupungin ja maaseudun välinen raja näyttää Ruotsissa olevan jyrkempi. Käytävissä olevan aineiston perusteella tähän ei voida sanoa selvää syytä.

Ruotsin väestörakennetta voidaan pitää kokonaisuudessaan aluerakenteen eri tasoissa tasapainoisempana kuin Suomessa, vaikkakin molemmille maille yhteisiä rakenteellisia ongelmia on löydettävissä. Esimerkkeinä voidaan mainita maaseutualueiden väestön ikääntyminen ja miesvaltaisuus sekä ydinkeskustojen voimakas naisvaltaisuus ja lasten vähäinen osuus.

- Avainsanat:**
- ruutu
 - koordinaattipohjaiset ruututiedot
 - GIS
 - paikkatiedot
 - aluerakenne
 - asutusrakenne
 - Suomi ja Ruotsi

1. Introduction

Work has been going on at the Department of Geography of the University of Oulu since 1987 on a long-term analysis of the properties and dynamics of the spatial structure in Finland based on georeferenced data supplied by the official statistical agency, Statistics Finland. At the initial stage, the project involved the three northernmost regional planning boards in the country, which also financed the acquisition of the initial data, the aim being to test the properties of the georeferenced material, assess possible sources of error and consider the suitability of the resulting information for use in areal research and planning. This phase may be regarded as having come to an end in spring 1990. The second phase, involving use of the georeferenced data, began in October of the same year, when the staff engaged on the project changed and Prof. Arvo Naukkarinen was joined by Alfred Colpaert and Jarmo Rusanen and later Toivo Muilu. In the meantime, of course, technical advances had taken place in both software and hardware, so that the material was transferred from the GIMMS software to Arc/Info and the system operated in a UNIX instead of a VMS environment. This represents the state of affairs at the present moment as far as the technical implementation is concerned. The developments in software and the extension of the research group have both served to introduce greater depth into the work.

Collaboration with the Statistics Finland georeferenced data project in the person of Marja Tammilehto-Luode began in 1991 and has continued uninterrupted up to the present time. Within the general theme of the properties and dynamics of the spatial structure in Finland, the main individual topics have been changes in population, occupation and employment structure at different levels in the spatial system, dependence ratios, rural areas and their delimitation, regionalization and urban studies. One of

the challenges of the work has been to develop new methodologies for studying these topics, with the aim of enabling coordinate-based data to be used more widely and more efficiently in a variety of research, planning and decision-making situations. The second phase of the work may be said to have reached its culmination in September 1994, when the Department of Geography was asked to present a paper at the meeting of European statistical offices at Voorburg in the Netherlands setting out the main results achieved to date in the analysis of georeferenced data.

The third stage in the work may be regarded as having begun at this same conference, and it is this stage which is still in progress and with which the work reported here is connected. Discussions with Sten-Åke Hallén of Statistics Sweden held at the conference led to cooperation between the statistical offices of the two countries in which the Department of Geography in Oulu has a role of its own connected with data analysis, use and development. Other members of the staff of Statistics Sweden who have participated are Stig Olsson and Mats Haglund. A monitoring group was established for the project, consisting of Marja Tammilehto-Luode, Sten-Åke Hallén and Stig Olsson, who thereby influenced its content and the problems which it set out to resolve.

2. Aims of the research

The principal aim of the project is to employ a small number of variables extracted from the Finnish and Swedish georeferenced data records to determine the viability of joint use of these data and, purely as a matter of research interest, to analyse similarities and differences in spatial structure between the two countries. The comparisons have been made mostly at the macro-level. One important goal has been the production

of cartographic printouts of various classifications covering both countries.

A further subsidiary aim has been to identify spatial phenomena that can be described only in terms of coordinate-based grid cell data, i.e. which cannot be revealed using areal units of an administrative kind. These include areal variations in population density, and in particular sparsely populated grid cells and their distribution on a national scale. Especially interesting in view of the social problems involved are grid squares or areas inhabited only by old people, or only by men or by women, or squares in which the households have no children, as these themes are often linked to questions of the accessibility of public and commercial services.

3. Material, combination of the data and methods

The material consisted of georeferenced data for 1 x 1 km grid cells produced by the statistical offices of Finland and Sweden. All in all, there were a total of 103 036 grid cells in Finland and 117 905 in Sweden inhabited by at least one person on 1.1.1995. For the purposes of the present experimentation it was agreed that the data should concern:

- 1 population in 1995
- 2 age structure of the population in classes 0–6, 7–15, 16–44, 45–64 and 65 years and above
- 3 sex ratio data
- 4 location of the grid cells to an accuracy of 1 x 1 km.

The data sets differed in that the Finnish material was supplied separately by communes, which meant that a square on the border between two communes was counted twice if it had population in each. Such cases make up 2.7% of the material,

and they will be used only in statistical analysis. This problem does not affect the cartographic presentations, of course, where the values have been summed. Corresponding cases in Sweden were resolved differently, the data having been initially assigned to the commune with more observations. These discrepancies could cause difficulties in micro-level interpretation, but they are unlikely to affect the macro level. A second difference between the two sets of material lies in the fact that the coordinates used to define the location of population represent the centre point of the building in Finland but the point for most central building of the whole property in Sweden.

Research projects involving organizations from different countries often experience problems in comparing data and results, and it is interesting to ask whether the potential available in GIS (Geographic Information System) could be used to resolve these problems. The ability to capture and manipulate geographical information makes GIS a very suitable means for storing research data in different formats and/or using different coordinate systems. It is common for map systems in neighbouring countries to have different coordinate systems, and this makes it difficult to share geographical data. GIS programs can be used to change coordinate systems from one projection to another, and this feature enables us to re-format data to conform to a common coordinate system, e.g. the Universal Transverse Mercator Projection.

Research projects spanning international borders and GIS applications related to these call for a high degree of standardization. It is obvious, of course, that measurement techniques and inventory methods used for data collection should be standardized, but a GIS also places demands of its own on the standardization of data collection, the coordinate system, the data model to be used, storage formats etc. Before a homogeneous, error-free, accurate database can

be constructed, all the details concerning the data have to be reviewed and fitted to a common data model.

The grid data available for both Finland and Sweden consist of 1 km² grid cells containing information on population. As the two data sets are based on synthetic areal units of the same size, no problems arise in comparing and analyzing the data. Physically, the representation is in the form of point x,y data, where x,y is the origin of the lower left-hand corner of the grid cell. The file structure is sequential ASCII, and is therefore easy to transfer from one system to another. The exchange medium can be a 3.5" diskette, CD-ROM, CCT tape or a computer network. The point data were read with SAS statistical software and re-shaped into an ASCII matrix suitable for Arc/Info input using the command ASCIIGRID (see Arc/Info manual, version 7.01). The resulting Arc/Info register is a raster file with a resolution of 1 km in which each cell contains one value, e.g. the population of that cell.

Sweden and Finland use national grid networks, the coordinates of which are similar but not compatible. The major problem here was to find the correct parameters for each coordinate system and to select a suitable projection for mapping both countries simultaneously. The eventual choice for this purpose was the Lambert Conformal Conic Projection with two standard parallels, e.g. 60° and 68°N, and one central meridian, 20°E. See the Arc/Info manual for more details on this projection.

Further data were added to enhance the cartographic appeal of the maps, chiefly the national boundaries, sea areas and major lakes. These are public domain data obtainable from a digital chart of the world in Arc / Info format on CD-ROM.

The other methods employed here are statistical analysis, GIS techniques, cartographic methods and a rank size model. In the case of Finland the treatment is filled out with certain

time series (c.f. Openshaw 1995: 399–400), and recourse has been had to earlier findings for interpretation purposes.

4. Classification as a research problem

The traditional approach in geography is to analyse the spatial distribution of population in terms of areal units based on administration divisions, most commonly local government districts, or municipalities, historical or administrative provinces and more recently various regional units in the NUTS (Nomenclature des Unites Territoriales Statistiques) classification. Municipality-based analyses perhaps lend themselves best to cartographic presentation, as people other than professional geographers are able to read and interpret spatial information produced at this level. Similarly, the classificatory methods required for analysing and presenting areal units of an administrative nature are well established and in widespread use.

In the case of grid data the situation is a new one, and no principles of classification have yet had time to emerge (see Rusanen et al. 1995a; Openshaw & Wymer 1995). On the other hand, we know that classification may be used to manipulate the information obtained in cases involving large bodies of data, i.e. the classes can be adjusted according to what one wishes the results to show. In addition, the grid data regarding the distribution of population are already highly skewed, in that there are a large number of squares with very few inhabitants and a small number with very many inhabitants. It is quite common for sets of geographical data to fail to observe a normal distribution, but this tendency is exaggerated further when using relative small grid cells. It may be appropriate at this point, therefore, to introduce a few problem situations and suggestions for solving them.

The classifications that are traditionally used in connection with administrative areas are perhaps the easiest point of departure and the one that springs to mind first, but the method does not necessarily work with grid cells. Quite different results are obtained for the density of settlement, for instance, depending on whether one uses aggregated municipality data or grid cell data, which come close to the true situation, being concerned only with the inhabited area. Assessed in the traditional way, the density of settlement in Finland is 16 inh/km² (Statistical Yearbook of Finland 1995) and that in Sweden 21 inh/km² (Statistical Yearbook of Sweden 1996), whereas the corresponding figures for the grid square analysis are 49 and 75 inh/km² (see Table 1). The difference is about 3-fold in the case of Finland and 3.5-fold in that of Sweden.

A second basis for classification consists of objective methods, i.e. the use of classifications constructed by reference to certain scientific criteria. Every user can classify the material in the same way and reach the same result, although researchers may differ in the interpretation they give to the situation represented by the point of departure. The example most commonly employed in the present work is fractile classification, in which the areal material is divided into parts of equal size in terms of population. A decile classification, for example, enables structural differences to be perceived on the urban – rural dimension, while consideration of the three or four highest deciles will allow an examination of the properties of the internal structure of core urban areas and differences between them.

A third means of classification consists of arbitrary classes which divide the continuum into equal parts, e.g. 1–99, 100–199, 200–299 etc. These are clear and easy to interpret, but their use is problematical in the sense that they do not imply any notion or theory regarding the existence of a certain

Table 1.
Background data on Finland and Sweden
(Statistical Yearbook of Finland, 1995; Statistical Yearbook of Sweden, 1996).

	Finland 1995	Sweden 1995
Total area (km ²)	338 145	449 964
Land area (km ²)	304 593	410 934
Population, Statistical Yearbook . .	5 098 754	8 816 381
Population, coordinate data	5 034 805	8 786 000
Difference (%) between statistics and coordinate data.	-1.26	-0.35
Inhabited grid cells	103 036	117 905
Inhabited grid cells as a % of total area	30.5	26.2
Inhabited grid cells as a % of land area	33.8	28.7
Inhabitants per km ² land area.	16	21
Inhabitants per inhabited km ²	49	75
Grid cells (%) less than 100 inhabi- tants.	94.7	92.3
Population (%) in grid cells less than 100 inhabitants	23.4	17.0
% of settlement in localities (1995)	81.1	83.9

phenomenon, let alone a search for it. Such class boundaries may be appropriate for analytical purposes at the stage where one has no idea how the phenomenon in question can be demonstrated, but they are an end in themselves, so to speak, and become the determining factor in the analysis. Classes of this kind will not be used at all in the present work.

The fourth and most recent of the methods is exploratory data analysis, in which an attempt is made on the basis of a theory or conjectural model to determine experimentally a set of class boundaries that will best permit statistical analysis or cartographical visualization of the information which is most essential to the research. This is represented in the present work by the classification devised by Stig Olsson (see The Population of Sweden 1994/95) for recognizing the parts of an areal structure, e.g. scattered settlement, urban centres, etc. Exploratory data analysis is particularly well suited to large bodies of data, for even in this case numerous

maps can be constructed using different classifications in order to reveal the phenomenon in question and its spatial distribution as well as possible.

The above comments on classification apply particularly to the macro-level, i.e. analyses covering the whole country, whereas such macro-level classifications do not apply at the micro-level, e.g. at that of the municipality, region or province. It has been shown in the case of Finland, for instance, that there are some municipalities where over 95% of the inhabited grid squares are in the most sparsely populated class of all.

All the above types of classification have been used in the course of the present project, but only results obtained by the most objective methods and by exploratory data analysis are included in this paper.

5. Comparison between Finland and Sweden

A comparison between the official statistics for Finland and Sweden and those obtained from the grid data is presented in, which also contains certain indices relevant to themes to be analyzed below.

The mean population densities calculated for the grid squares, 49 for Finland and 75 for

Sweden, serve to indicate that the population of Sweden lives in far denser groups than that of Finland, even though the average population densities for the two countries do not differ greatly. This in turn naturally means a greater concentration of settlement. The change that has taken place in Finland in recent decades may be appreciated by taking for comparison the situation in 1970, when the population density in inhabited grid squares was 40, since which time the number of inhabited squares has decreased steadily in spite of the growth in population (Naukkarinen et al. 1995).

One surprising feature is that the two countries have very similar numbers of grid squares inhabited by 1–4 and 5–19 persons, and these account for a very similar total population. In proportional terms, on the other hand, all classes of grid square in Sweden represent a smaller percentage of the total number of inhabited squares up to a density of 1000 inh/km². As far as dense settlement is concerned, the differences between the two countries are greatest in the class 2000–5000 inh/km², whereas the number of squares representing the highest densities of all is not so much greater in Sweden as one might expect (Fig. 1).

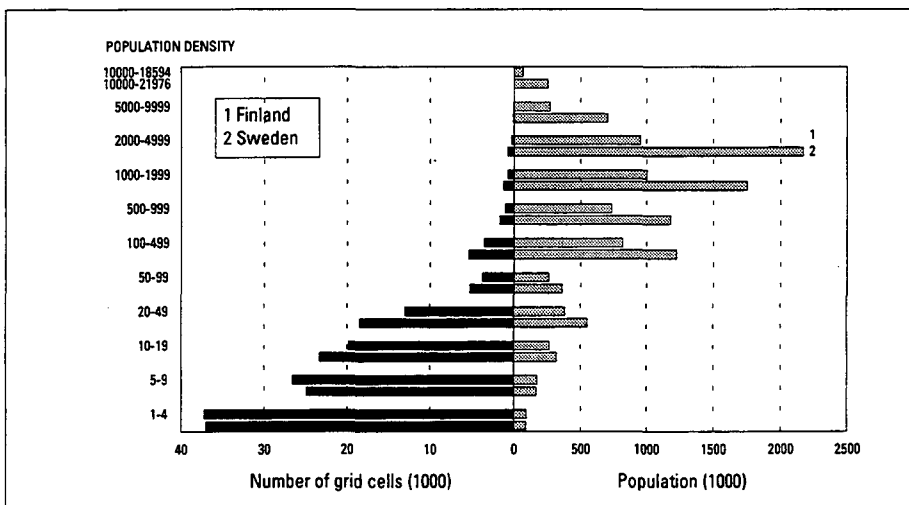


Fig. 1. Distribution of population and grid cells in Finland and Sweden by population density in 1995 (inh/km²).

6. Spatial structure of population

Spatial distribution using different classifications

The first task undertaken was the construction of population density maps for Finland and Sweden based on 1 km² grid cells and experimenting with a number of classification schemes and colour combinations. The classification (Fig. 2, p. 17) eventually selected as the basis for the work was that obtained by Stig Olsson (The Population of Sweden 1994/95) as a result of analysing the relations of population density to settlement and functional structure in Sweden. The functional associations are the following:

Population density

1-4	forest, approx. 1 family per square kilometre
5-29	'normal' agricultural districts
30-149	agricultural districts with urban elements
150-4999	predominantly urban areas
5000-21976	urban areas with high-rise residential blocks

The spatial structure of the population in Finland has been analyzed in something of the same man-

ner by Rusanen et al. (1995b) and Räisänen et al. (1996), who refer to the lowest category as 'scattered settlement', the class 5-29 inh/km², as typical countryside, and the middle class, 30-149 inh, as a transition between rural and localities. An attempt was made to define this concept more precisely in another investigation, but it would certainly seem that densities of 149 inh/km² are associated with settlement of an urban character, at least in Finland, so that the upper boundary of the transitional class could well be somewhat lower, perhaps 90-130 inh/km². In any case, values in excess of 150 inh/km² point to distinct signs of urban settlement, even though it should be noted that this same figure is used by the EU as a criterion for rural areas. In both Finland and Sweden the classes 150-4999 and over 5000 inhabitants/km² clearly represent urban settlement.

In spite of the fact that the total population of Sweden in absolute terms is about 1.75 times that of Finland (Table 2), the number of people living in the least densely populated areas, with 1-4 inhabitants per square kilometre, is very similar in both countries, and even the numbers in the next class, 5-29 inhabitants do not differ by as much as one might expect. This implies, of course, that the countryside of Finland has a much higher population relative to the total than does that of Sweden (see also Fig. 3). Similarly

Table 2.
Distribution of the population of Finland and Sweden in 1995 among grid cells of different population density.

Population density (inh/km ²)	Population		Sweden		Number of grid cells			
	Finland	%	Sweden	%	Finland	%	Sweden	%
1-4	93 095	1.83	88 262	1.00	37 751	35.10	36 963	31.35
5-29	612 508	12.35	731 675	8.33	53 081	50.67	58 326	49.47
30-149	608 121	12.16	878 137	9.99	10 549	9.97	15 190	12.88
150-4999	3 382 416	67.29	6 129 310	69.76	4 468	4.21	7 299	6.19
5000-21967	338 665	6.38	958 618	10.91	48	0.04	127	0.11
Total	5 034 805	100.00	8 786 000	100.00	105 897	100.00	117 905	100.00

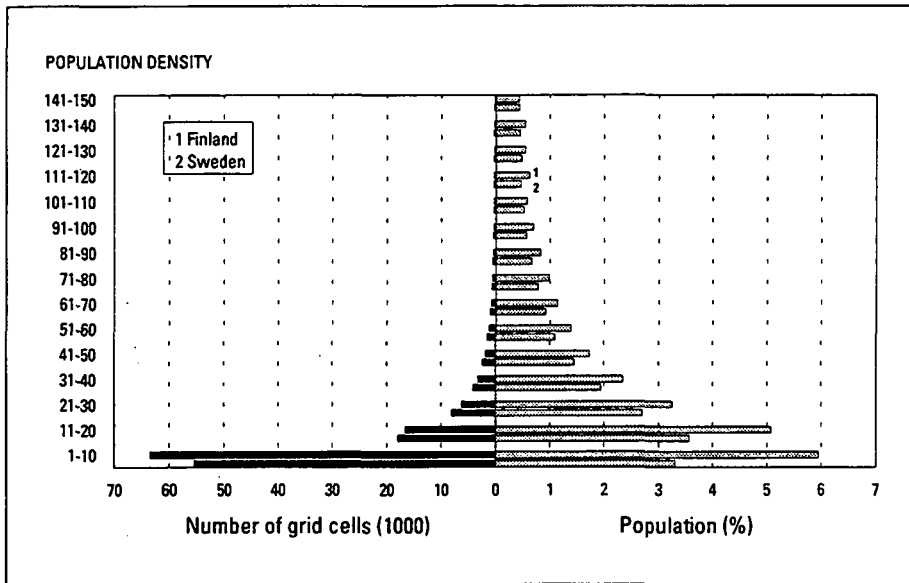


Fig. 3. Distribution of population and grid cells in 'rural' areas in Finland and Sweden by population density in 1995 (inh/km²).

the 'transition zone' between rural and urban settlement, represented by the class 30–149 inh/km², is narrower in relative terms in Sweden than in Finland.

The smaller amount of sparse settlement to be found in Sweden than in Finland means that the proportion and amount of urban settlement is correspondingly greater there. This typical concentration is not visible in the smaller localities of private houses, terraced houses and suburban dwellings with densities of 150–4999 inh/km², but is evident above all in the highly populous areas of apartment blocks. Thus the population of Sweden living in the most

densely settled areas is in absolute terms more or less three times that found in Finland.

The absolute number of grid cells in the most sparsely populated class is more or less the same in the two countries, and the same is true of the population accounted for by this class, but in relative terms both the number of squares and their population account for about a 5% higher proportion of the total in Finland than in Sweden, a difference which may be regarded as significant. The greater concentration of population in Sweden is reflected in relative terms in all the density classes above 30 inhabitants per square kilometre.

Table 3. Population in Finland and in Sweden in 1995 using OECD-classification criteria and thresholds (see Malinen et al. 1994).

Population density (inh/km ²) and description	% of population		% of grid cells	
	Finland	Sweden	Finland	Sweden
1–150 predominantly rural areas	26.1	19.4	95.7	93.7
151–500 significantly rural areas	13.6	11.6	2.2	3.1
500+ predominantly urbanized areas	60.3	69.0	2.0	3.2
Total	100.0	100.0	100.0	100.0

In addition to the above discussion concerning the delimitation of rural and urban areas and differences between the two countries in this respect, it is useful to compare the grid data with internationally accepted criteria as well, the principal definitions of interest being those employed by the OECD (see Malinen et al. 1994: 16–19; Copus & Crabtree 1996: 42–43; Throughton 1995: 295–296). It should be remembered, however, that these criteria were derived in the traditional manner, i.e. by relating the population of a certain district to its surface area, whereas the grid data are more precisely focused, specifically on the inhabited areas. This means that they are not directly comparable to the traditional figures but come somewhat closer to those conventionally presented for densely populated areas. The results are also affected by this difference in the basis for calculation (see Rusanen et al. 1993).

Use of the OECD criteria yields clear differences between the two countries that support the earlier observation of a greater concentration of the population in Sweden, in that almost 40% of the Finnish population is shown to live in rural areas or areas classifiable as highly rural in character, as opposed to 31% of the Swedish population. This figures are higher

than the ones arrived at using the official classification of localities for each country.

Distribution by age groups

The structure as far as the most sparsely populated cells are concerned (1–4 inh/km²) is the same in both countries (Table 4), with less people on average in the age groups below 45 years and a high proportion of people over 65 years, an age group which is in any case particularly large in Finland. All in all, the age structure of the sparsest settlement may be said to be an unhealthy one in both countries, but one degree worse in Finland than in Sweden.

The 'normal' agricultural districts, with a population density of 5–29 inh/km², have proportions of both age groups of children that are close to the average, and even slightly higher in Sweden. The problem in these areas is the lower than average proportion of people in the young working age category, 16–44 years.

The transitional population density class of 30–149 inh/km² typically has above average proportions of children in both countries. It is areas of this kind that tend to attract young people of working age. The same is also true of the actual urban areas, 150–4999 inh/km², with the difference that here the latter age group, 16–

Table 4.
Distribution of age groups (%) in Finland and Sweden in 1995 among grid cells of different population density.

Population density (inh/km ²)	Age structure											
	0–6 (%)		7–15 (%)		16–44 (%)		45–64 (%)		65– (%)		Average	
	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE
1–4.....	0.62	0.44	0.71	0.38	1.28	0.68	2.81	1.44	3.61	1.83	2.11	1.00
5–29.....	11.98	8.96	13.62	9.59	10.67	7.49	12.82	8.71	14.42	8.59	13.09	8.33
30–149.....	13.24	11.50	14.66	12.03	11.21	9.34	11.92	10.16	12.07	9.19	12.64	9.99
150–4 999.....	69.28	70.11	67.22	71.00	69.25	69.69	65.82	70.53	61.95	67.94	66.01	69.76
5 000–21 976.....	4.87	9.00	3.79	7.01	7.60	12.80	6.63	9.16	7.95	12.45	6.15	10.91

44 years, is also greater than average. The proportion of those over 65 years of age is lower than average in these areas, especially in Finland. The other main difference between the two countries in this category is that the age classes are fairly evenly represented in Sweden whereas the differences between them are more pronounced in Finland.

The mean differences between the two countries are greatest, however, in the urban core areas. Here the proportion of children aged 7–15 years is well below the average and that of old people above average.

Spatial distribution of population

The two countries are largely similar in settlement structure at the macro-level (Fig. 2, p. 17), and, as is well known, both have their population concentrated to some extent in the south and south-west, with the northern limit of this densely populated part of Sweden located at approximately the same latitude as the south coast of Finland. The northern parts of both countries are extremely sparsely inhabited, and are characterized most of all by a distribution of population that even nowadays reflects the influence of the history of settlement in the valleys of the great rivers flowing into the Gulf of Bothnia. On the other hand, the process of urbanization all over the two countries has introduced a relatively new, constantly changing element into the spatial structure, the increasing prominence of large, rapidly developing centres and their peripheral belts of settlement.

The classes analysed above are presented as separate elements in Figures 4a–4d (pp. 21–24), enabling the picture of the behaviour of each to be filled out further. The principal conclusion to be drawn is that extensive tracts of sparsely populated land are a typical element in the settlement structure of both countries, as are scattered settlements and small village settlements, both of which play a major role in the 'normal' concept

of countryside. The future of the functional structure of rural areas depends to a great extent on developments in these classes of settlement.

The class 30–149 inh/km² is again analysed as a transitional one between rural and urban land use types, although the spatial analysis suggests that the situation is not quite as simple as that, especially in the case of Finland, where a large number of the data points in this class concern ribbon-like river valley settlement, which cannot in any sense be interpreted as urban. This class also covers many of the village centres in the north of Finland, and also some radial settlement patterns that are beginning to emerge in Central Finland, which could be interpreted as the initial stages of an urbanized form of development in country districts. Without any more far-reaching familiarity with the local situation one might be tempted to liken these to the situation in Sweden, particularly the cases of relatively dense village settlement in Southern Sweden.

By contrast, the population density class 150–21 976 inh/km² identifies the centres of large towns and the settlement patterns radiating outwards from these, and also the network of main villages in the rural districts. This is true of both Finland and Sweden, although in the case of Sweden particular mention should perhaps be made of the relatively dense ribbon development along the main thoroughfares of the southern part of the country, which would appear to have no counterpart in Finland outside the Helsinki conurbation.

Hierarchical structure

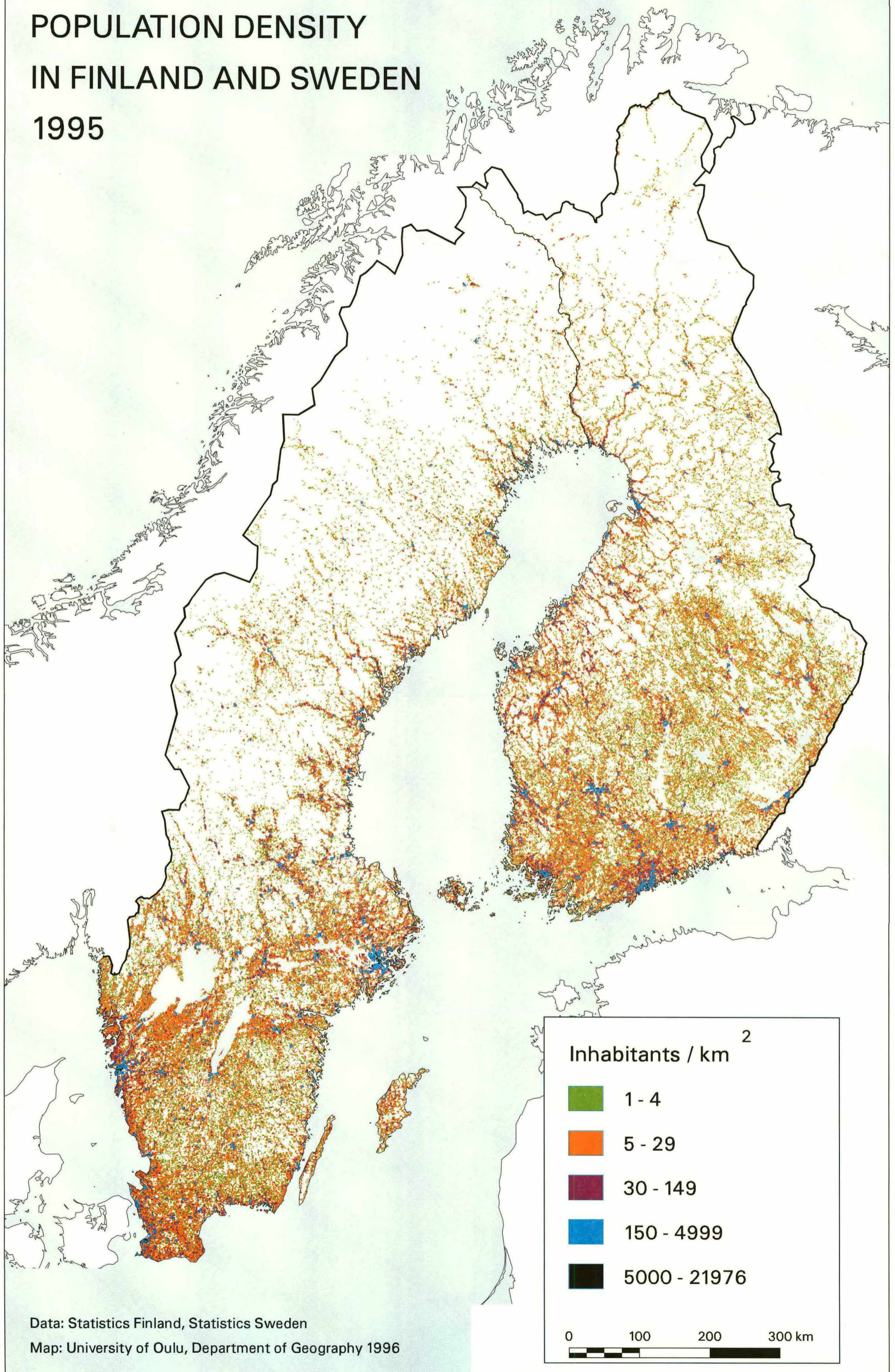
Concentration of population

The classification used above is valid for comparisons between these two countries, as it is applicable to both without alteration. Another means of examining differences in settlement is

Texts of Figures in pages 17–20

- Fig. 2.** Population density in Finland and Sweden in 1995 (p. 17).
- Fig. 9.** Age structure in Finland and Sweden in 1995 (p. 18).
- Fig. 11.** Population of Finland and Sweden in 1995 by distance from a commune centre (p. 19).
- Fig. 12.** Population within a radius of 10 kilometers in Finland and Sweden in 1995, determined by the focal sum method using a circle of radius 10 km. (p. 20).

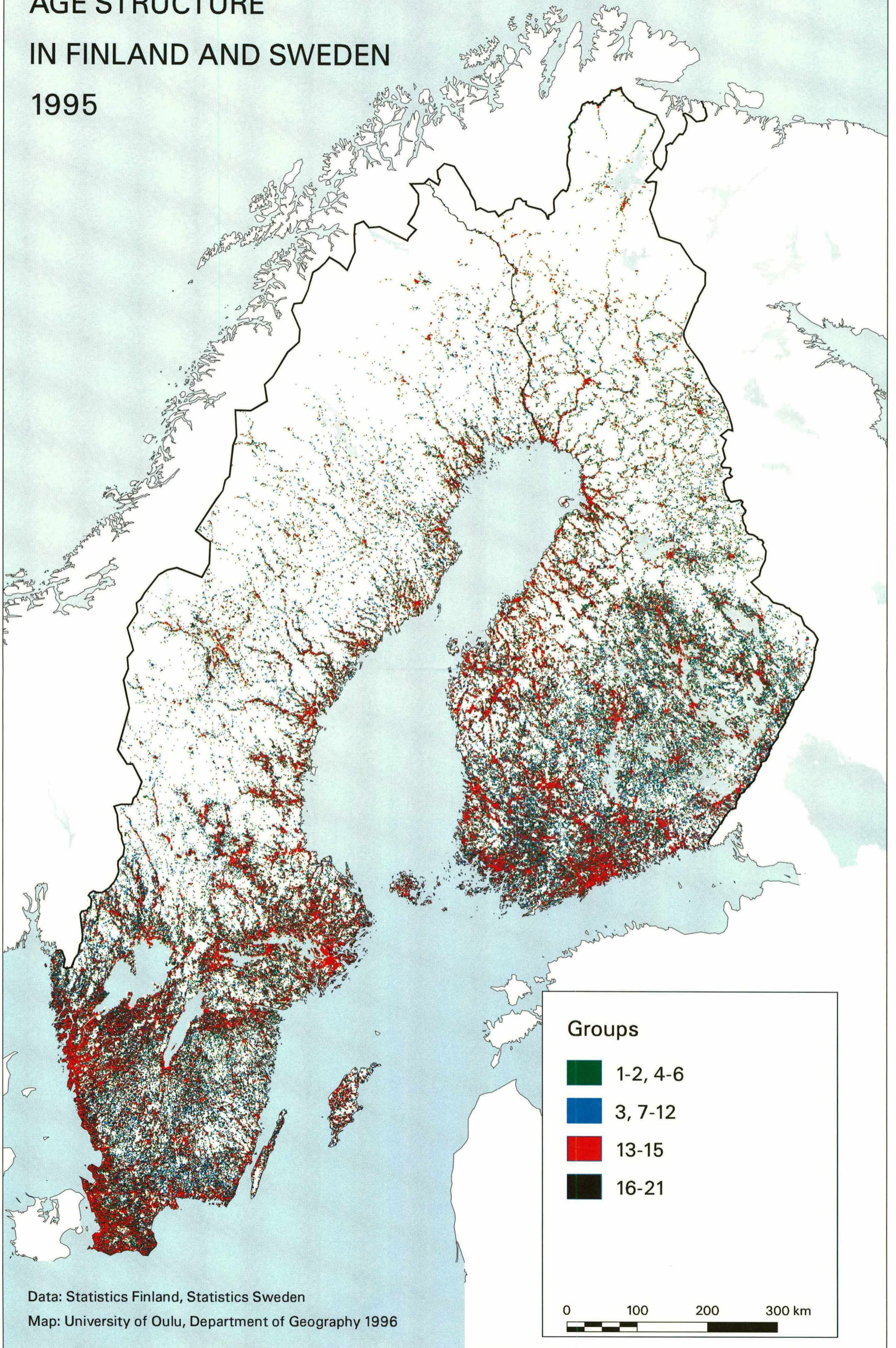
POPULATION DENSITY IN FINLAND AND SWEDEN 1995



Data: Statistics Finland, Statistics Sweden
Map: University of Oulu, Department of Geography 1996

Fig. 2.

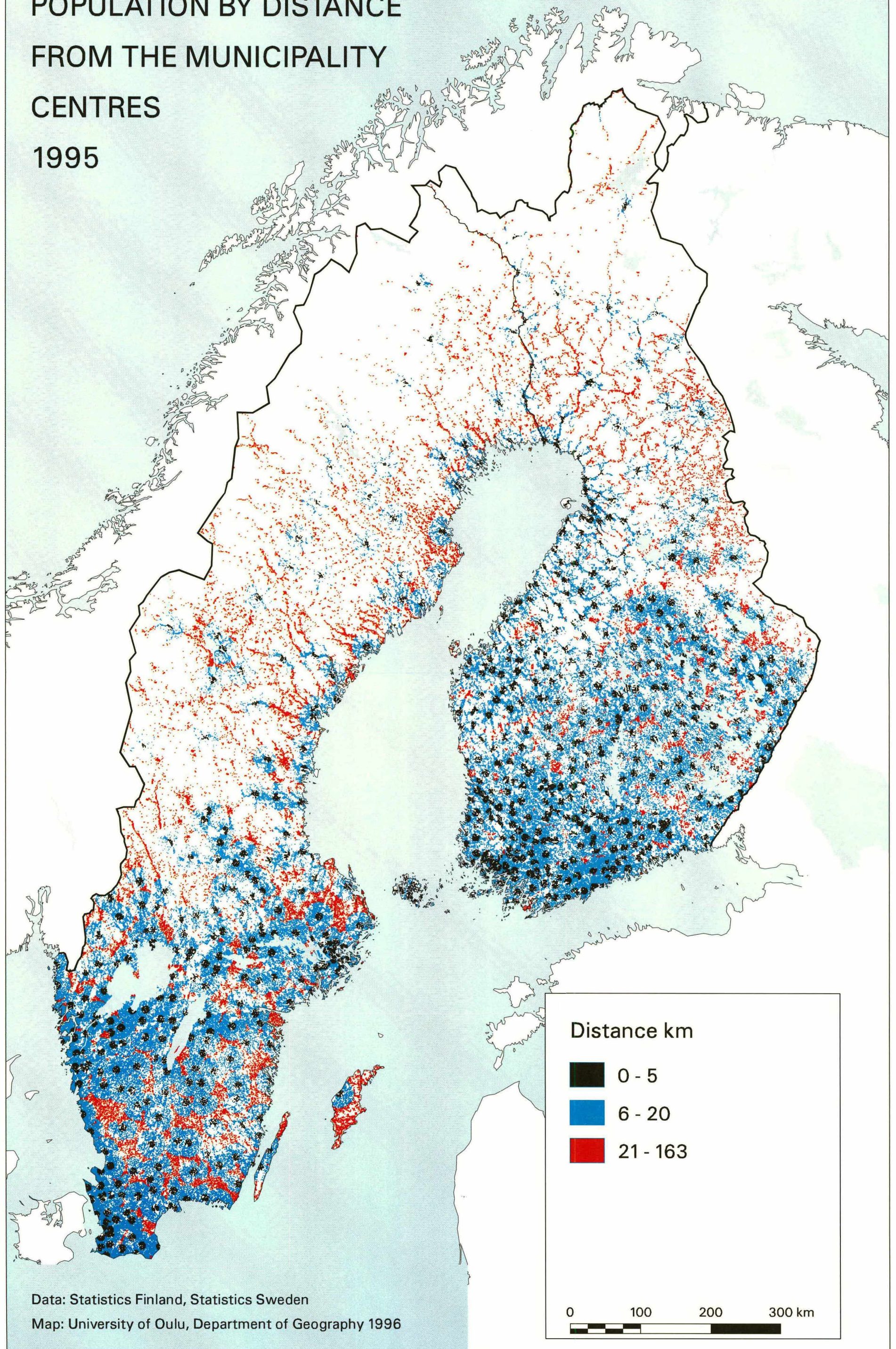
AGE STRUCTURE IN FINLAND AND SWEDEN 1995



Data: Statistics Finland, Statistics Sweden
Map: University of Oulu, Department of Geography 1996

Fig. 9.

POPULATION BY DISTANCE FROM THE MUNICIPALITY CENTRES 1995



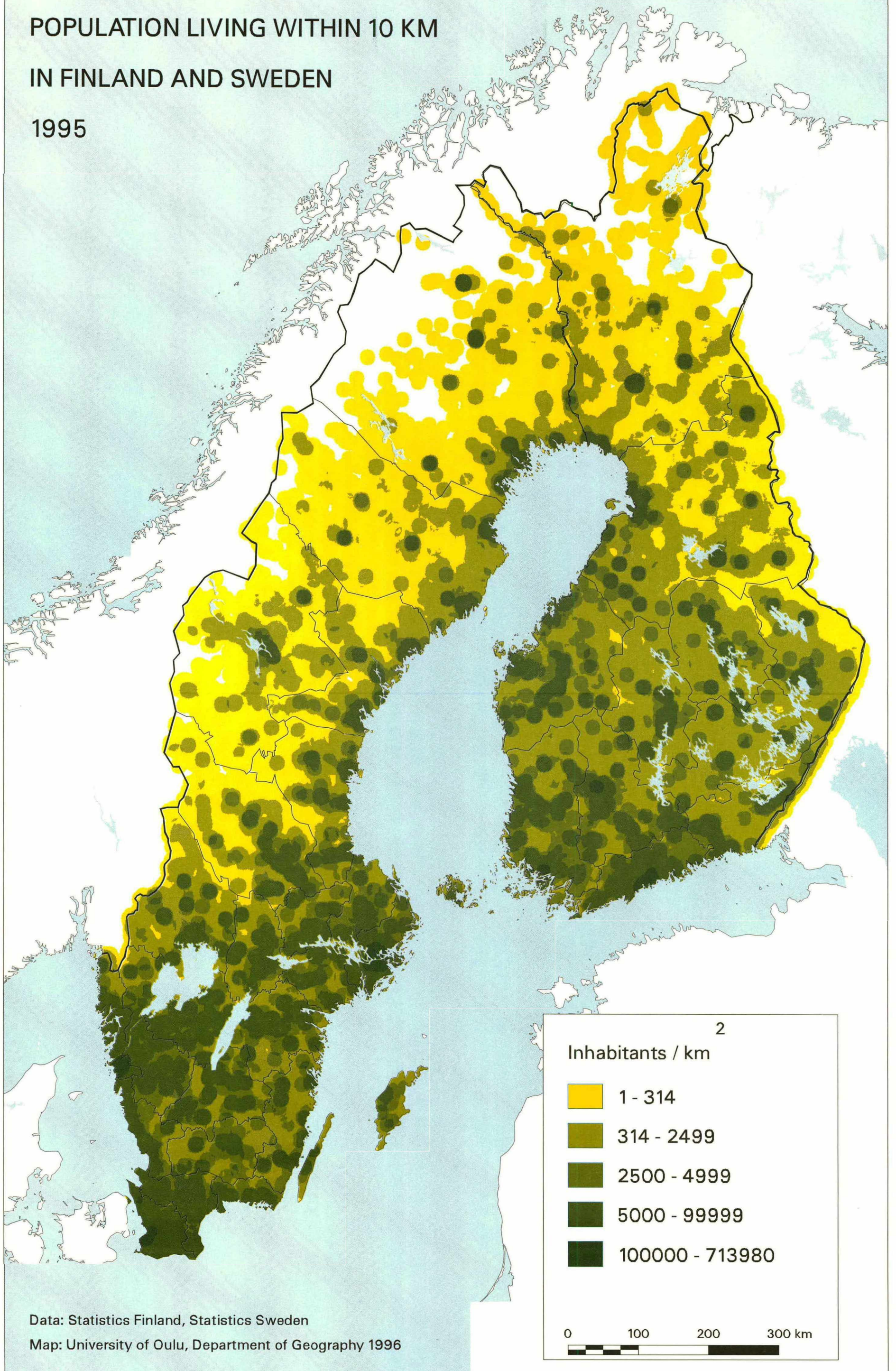
Data: Statistics Finland, Statistics Sweden
Map: University of Oulu, Department of Geography 1996

Fig. 11.

POPULATION LIVING WITHIN 10 KM

IN FINLAND AND SWEDEN

1995

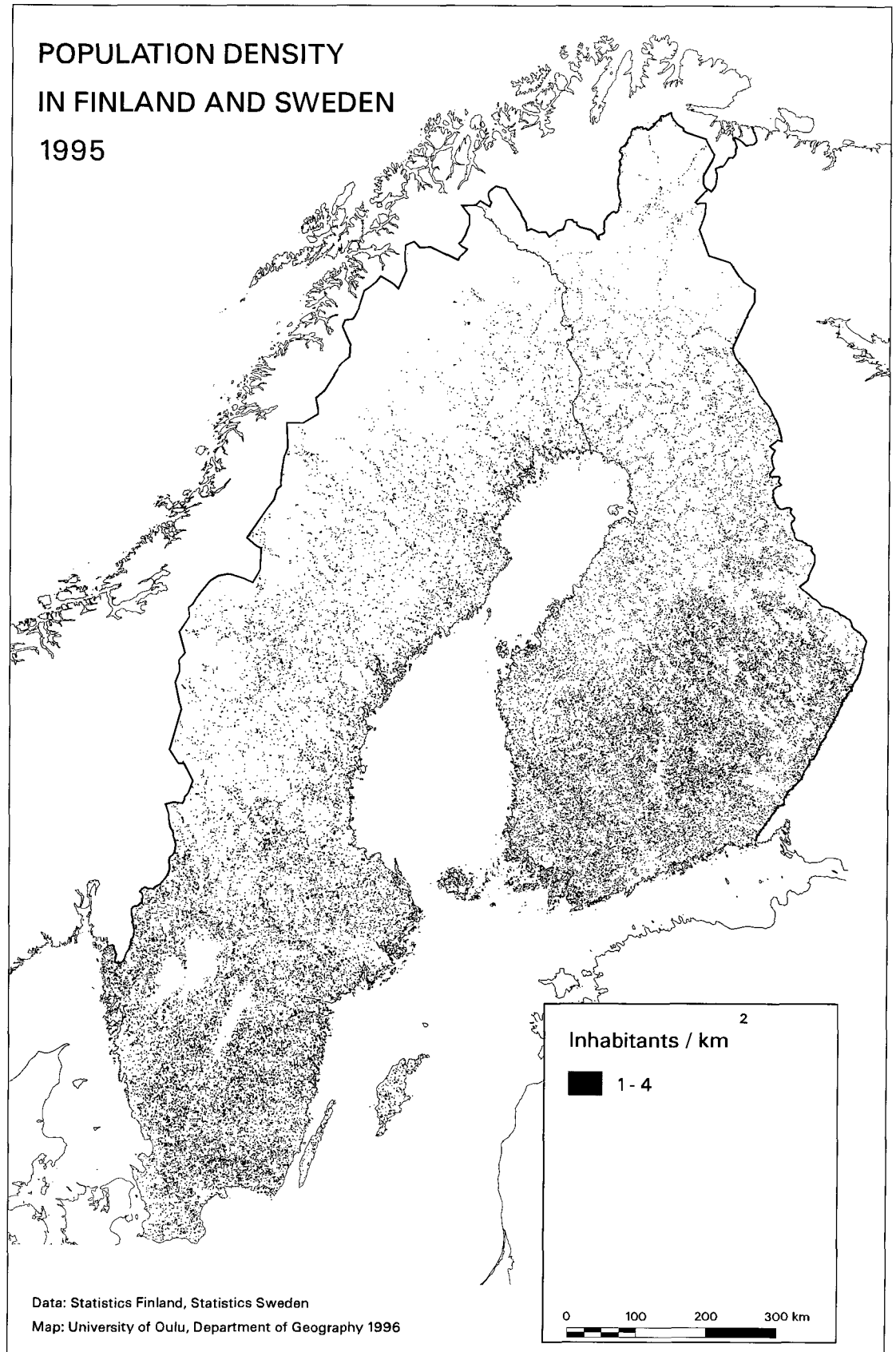


Data: Statistics Finland, Statistics Sweden

Map: University of Oulu, Department of Geography 1996

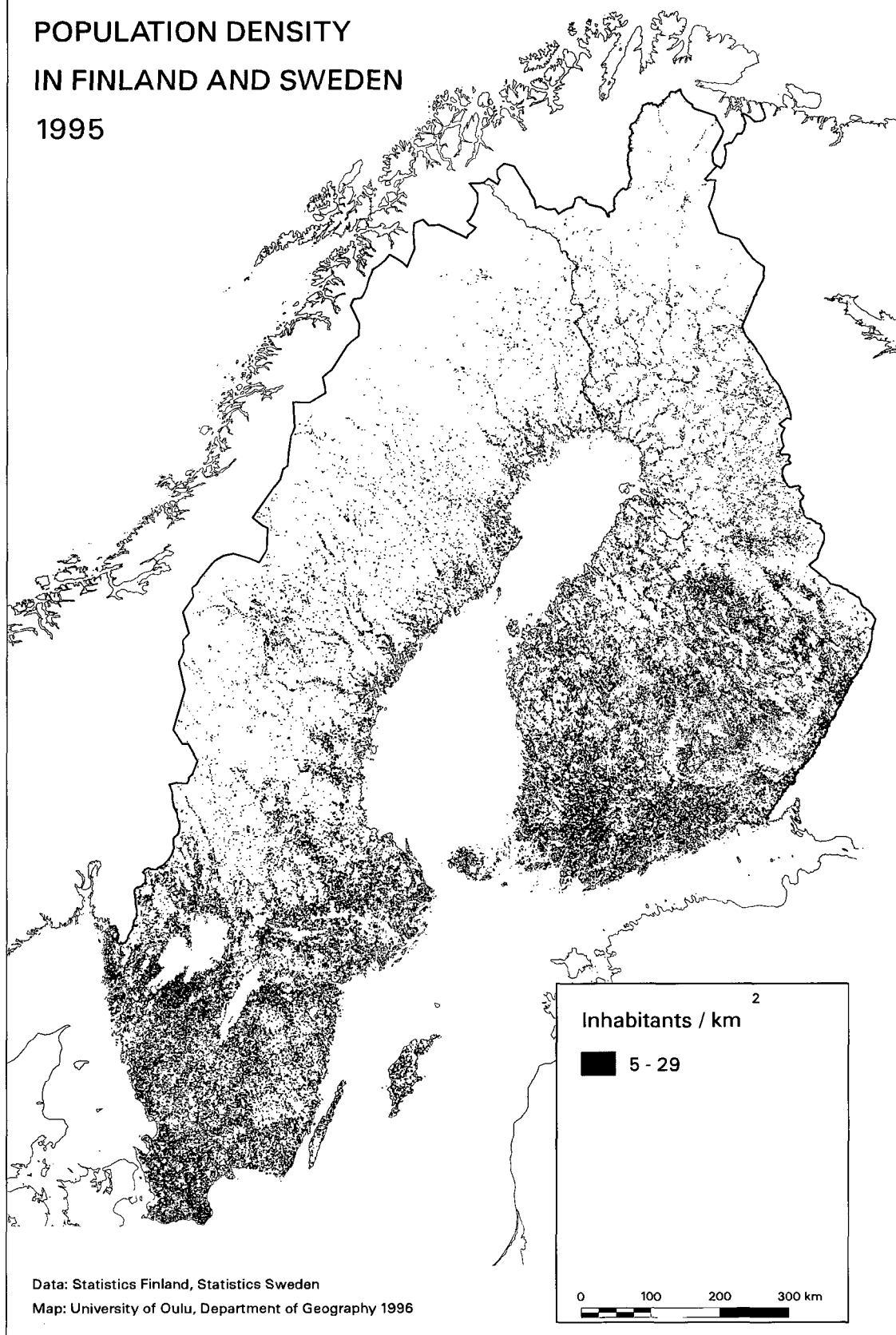
Fig. 12.

**POPULATION DENSITY
IN FINLAND AND SWEDEN
1995**



Figures 4a-4d.
Elements of the regional structure of Finland and Sweden in 1995 in terms of population density.

**POPULATION DENSITY
IN FINLAND AND SWEDEN
1995**



Data: Statistics Finland, Statistics Sweden
Map: University of Oulu, Department of Geography 1996

Fig. 4b.

POPULATION DENSITY
IN FINLAND AND SWEDEN
1995

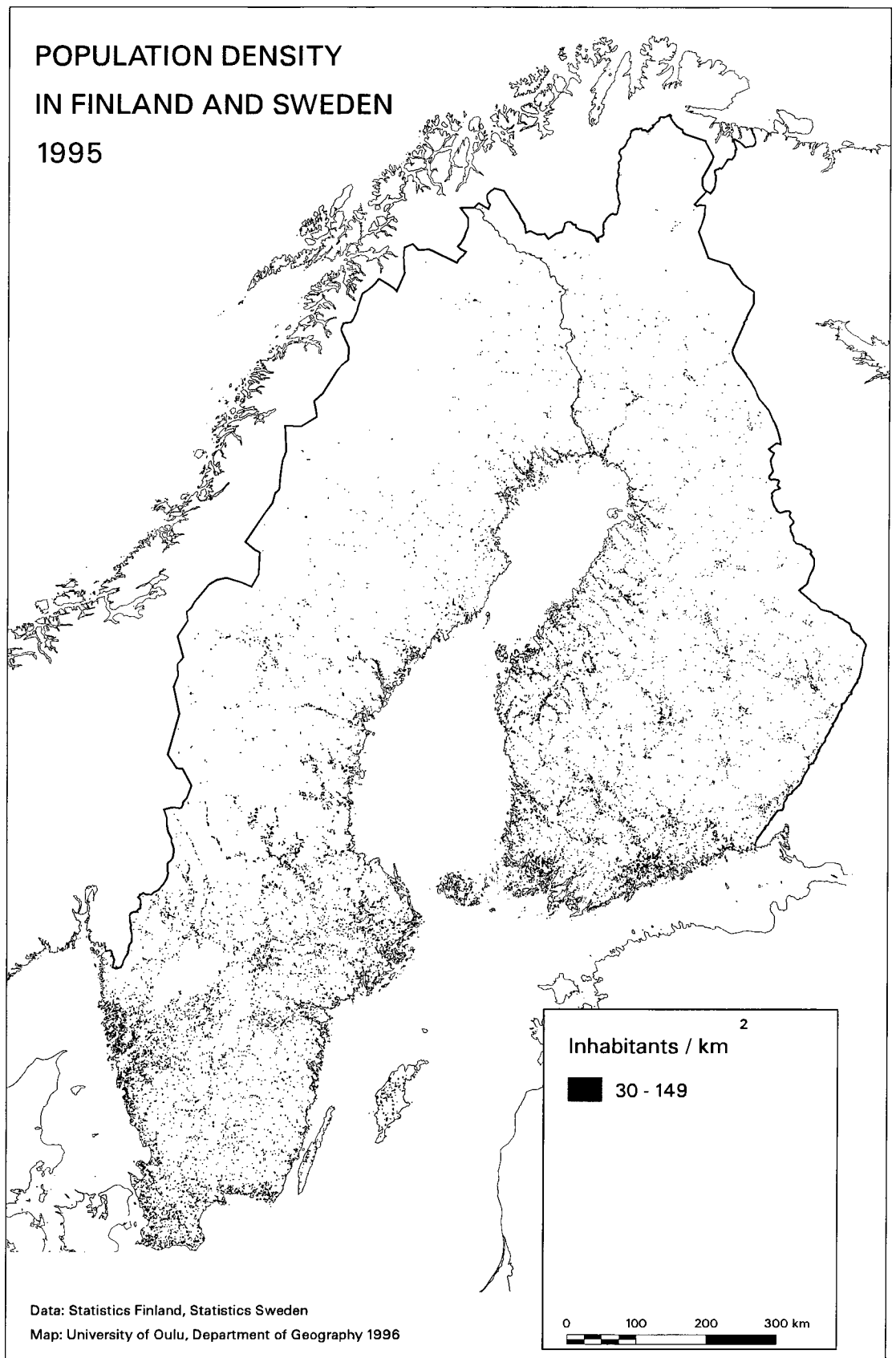
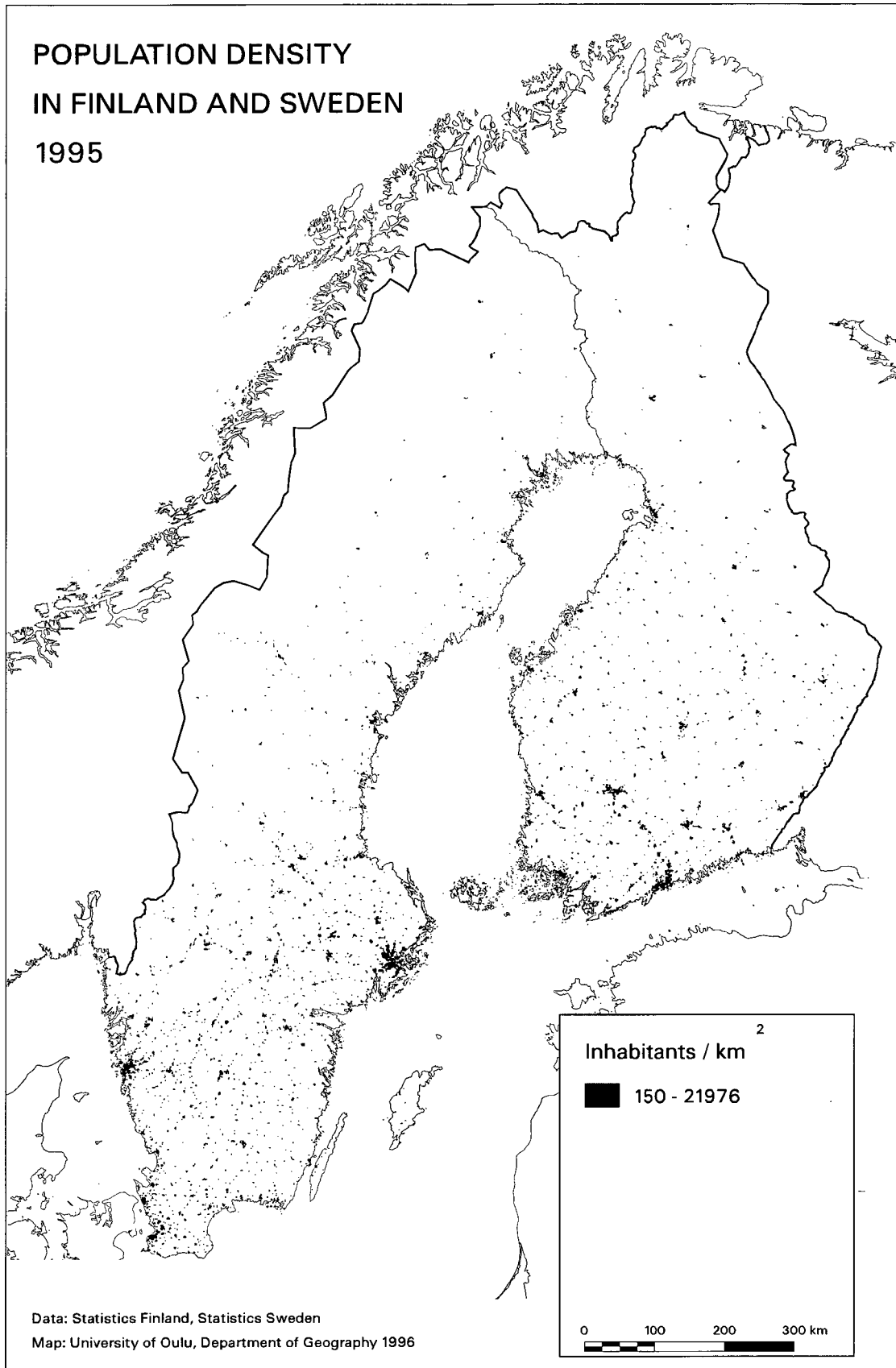


Fig. 4c.

**POPULATION DENSITY
IN FINLAND AND SWEDEN
1995**



Data: Statistics Finland, Statistics Sweden
Map: University of Oulu, Department of Geography 1996

Fig. 4d.

fractile analysis, as described above. This technique involves dividing the parameter under discussion into 10 parts, or deciles, accounting for equal proportions of the population. This allows comparison to be made between the boundaries of the resulting classes and the degrees of concentration. If the parameter, e.g. age structure, were equally distributed throughout the spatial structure, an equal number of data points, 10% of the total, would occur in each decile. Conversely, any deviation from this situation means that some age groups are overrepresented or underrepresented. This method will be used below chiefly to identify differences in macrostructure between the two countries in terms of distribution by age and sex.

The decile boundaries are higher in Sweden than in Finland throughout, on account of the larger total population (Table 5), and all the more so where higher population densities are concerned. Also, there are proportionally more data points in the first decile in the Swedish than in the Finnish material and correspondingly less in the second. The two lowermost de-

ciles in both countries clearly indicate that rural land use types are of critical importance for the preservation of settlement.

Data from the statistical yearbooks indicate that the inhabitants of localities accounted for 81.1% of the population of Finland in 1995 and 83.9% of that of Sweden. Expressed in decile terms, this means that the dividing line between rural and urban settlement runs very close to the boundary between the second and third deciles. The fact that the population density at which this occurs is very much higher in Sweden than in Finland, 161 inh/km² vs. 61 inh/km², again points to a much steeper distinction between town and countryside in Sweden than in Finland.

As far as the spatial concentration of population is concerned, it may be noted that a half of the inhabitants of Finland live in an area comprising 1342 km², representing 1.27% of the inhabited grid squares, while the concentration is not quite so pronounced in Sweden, where the area concerned is 1677 km², or 1.42%.

Table 5.
Distribution of the population of Finland and Sweden in 1995 by deciles.

Decile	Finland		Sweden			
	Number of grid cells	%	Population / grid square	Number of grid cells	%	Population / grid square
1. (sparsest)	82.539	77.94	1-18	97 207	82.45	1-32
2.	15 541	14.68	19-61	13 660	11.59	33-168
3.	4 330	4.09	62-240	3 077	2.61	169-470
4.	1 392	1.32	241-501	1 417	1.20	471-815
5.	758	0.72	502-833	867	0.73	816-1 242
6.	496	0.47	834-1 211	600	0.51	1 243-1 745
7.	351	0.33	1 212-1 707	434	0.37	1 746-2 366
8.	244	0.23	1 708-2 478	318	0.27	2 367-3 307
9.	164	0.15	2 479-3 882	215	0.18	3 308-5 245
10. (densest)	85	0.08	3 883-19 594	110	0.09	5 246-21 976
Total	105 897	100.00		117 905	100.00	
Average				49		75
Population	5 014 784			8 786 000		

Concentration of population by age groups

The two countries differ greatly in the spatial concentration of families with children (Table 6, see also Fig. 5a–5e). The number of children in the population in Finland is lowest in the centres of the major towns and cities, represented by the 10th decile, and at the other extreme in the spatial structure, the most sparsely populated areas, and highest in absolute and proportional terms in the fourth decile, decreasing steadily towards more urban environments. In Sweden, on the other hand, the overall situation is a more balanced one. Again the number is lowest in the urban centres, but there are higher proportions of children in the sparsely populated country districts than in Finland. Examination of the pattern by deciles suggests that the highest proportions of children in the population in Sweden are to be found in rural environments, whereas the main domiciles for families with children in Finland are the new localities that have emerged rapidly in recent decades.

A balanced age structure in the population, and particularly a sufficient number of children, is regarded as a critical criterion in the evaluation of regional development prospects, especially where rural areas are concerned. Judging

from the numbers in the younger age classes and their distribution, the future would seem less promising at the moment for the sparsely populated rural areas in Finland than for those in Sweden.

The distributions of 7–15-year-olds amongst the population density deciles in the two countries follow the above pattern to a great extent, except that in both countries the differences between the deciles are more pronounced. The numbers of children of this age in the urban centres are extremely small, and the highest proportions are to be found in deciles 3–5 in both countries. It is indeed this age group that is most conspicuously absent from the centres of the town and cities, and in this sense the somewhat higher numbers of children in the young age bracket may be an indication that these central areas serve as a source of first homes for young families or that the campaigns to revive the city centres have appealed to such families.

The distribution of young people and adults of age 16–44 among the deciles differs markedly from that of children. The trend is very much the same in both countries, namely that these young people of working age are least commonly found in the sparsely populated areas

Table 6.
Distribution of age groups in Finland and Sweden in 1995 by deciles (see also Figures 5a–5e).

Decile	0–6 years (%)		7–15 years (%)		16–44 years (%)		45–64 years (%)		over 64 years (%)	
	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE
1 (sparsest)	8.55	10.19	9.80	10.78	8.52	8.79	11.80	10.83	13.86	11.05
2	10.56	11.49	11.81	12.04	8.91	9.37	9.77	10.23	10.35	9.18
3	11.23	11.20	12.05	12.11	9.61	9.55	9.74	10.50	9.39	8.27
4	11.34	10.68	11.40	11.55	10.10	9.63	9.44	10.73	8.70	8.54
5	10.70	10.47	10.97	11.10	10.10	9.68	9.67	10.51	8.69	9.08
6	10.48	10.28	10.54	10.58	10.29	9.91	9.80	10.37	8.69	9.24
7	10.13	9.49	9.79	9.39	10.47	10.04	9.97	10.01	9.10	10.52
8	9.80	9.35	9.26	8.70	10.48	10.41	10.02	9.48	9.23	11.17
9	9.53	8.71	8.26	7.44	10.51	10.96	9.93	9.00	10.16	11.62
10 (densest)	7.67	8.14	6.13	6.31	11.01	11.66	9.87	8.35	11.83	11.34

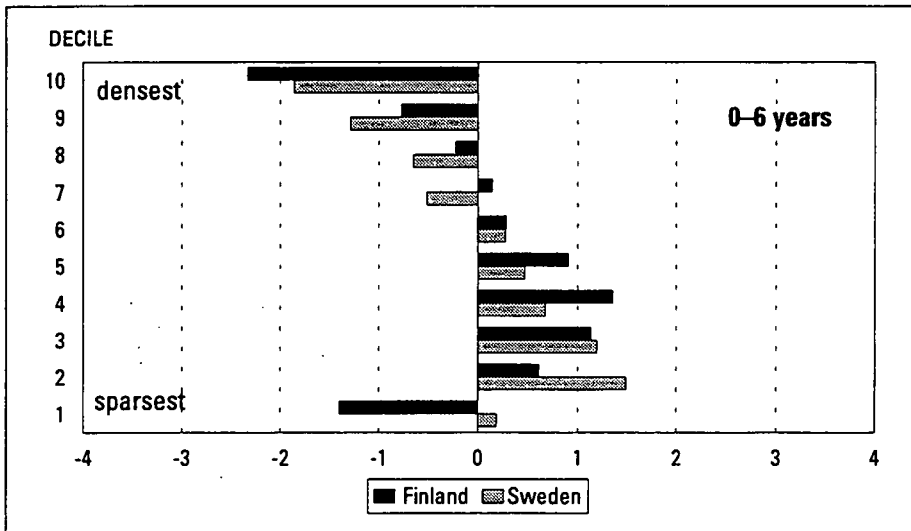


Fig. 5a-5e.
Distribution of age groups
in Finland and Sweden in
1995 by deciles.

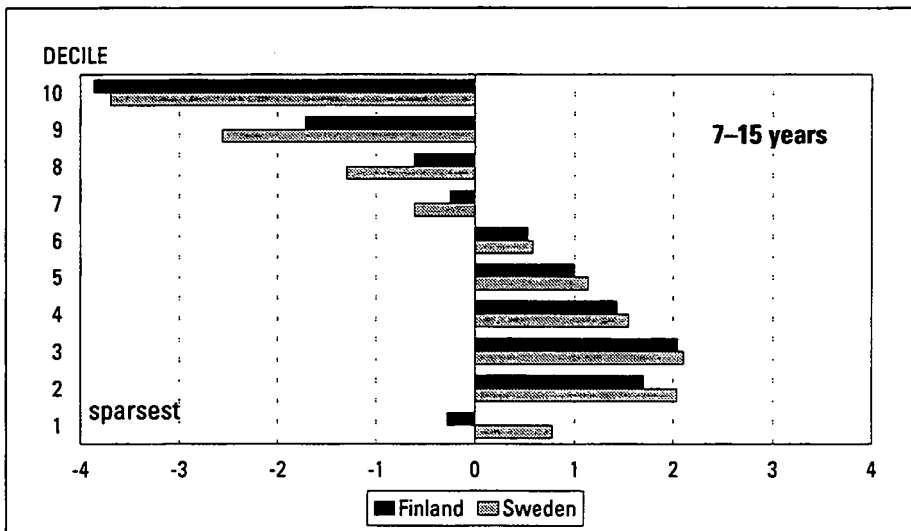


Fig. 5b.

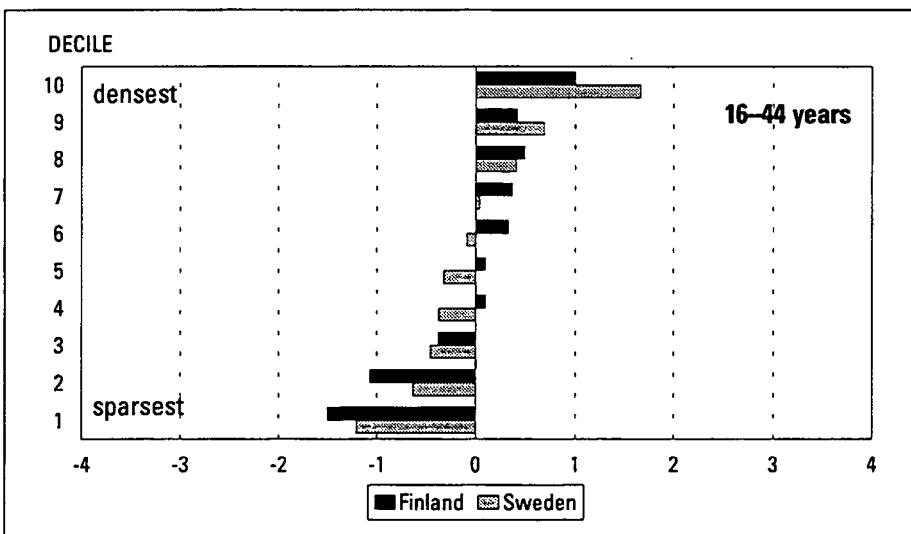


Fig. 5c.

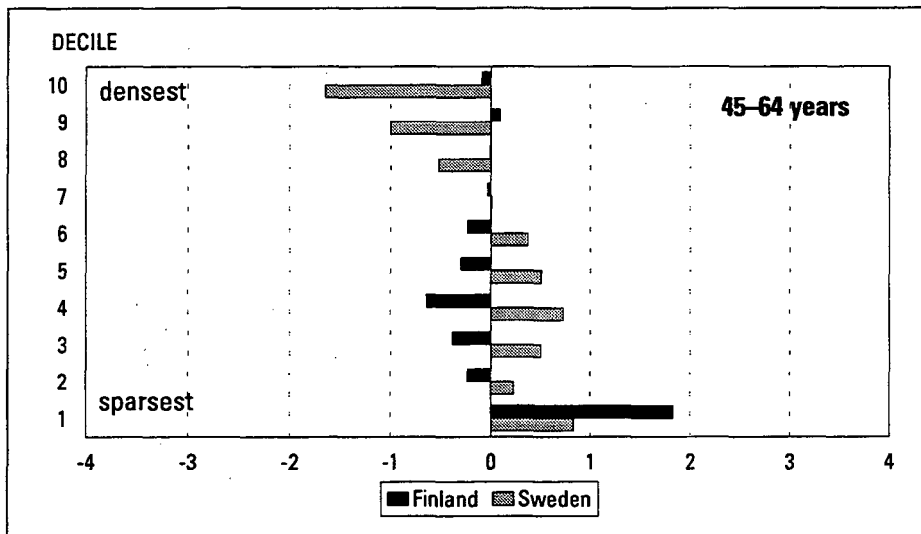


Fig. 5d.

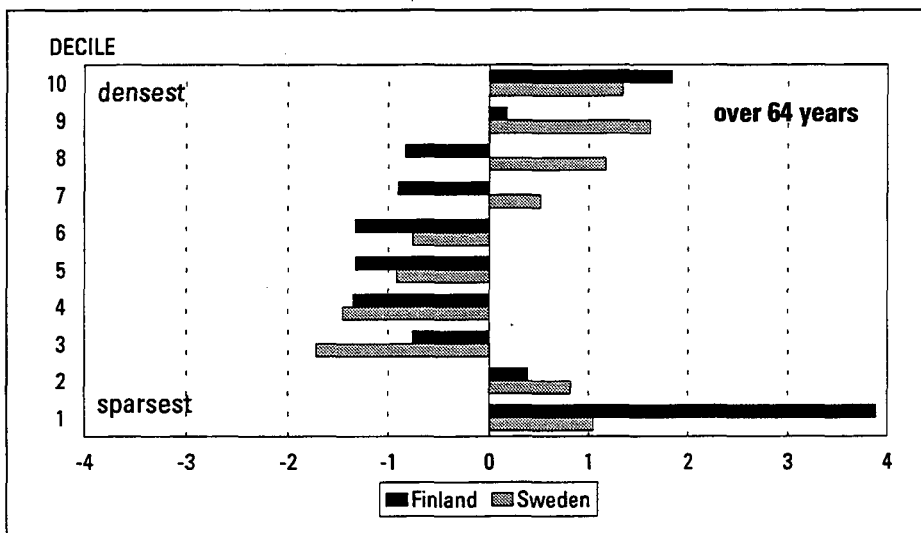


Fig. 5e.

and increase in number more or less steadily with increasing population density. Thus this age group is largest in the densely populated city centres. If anything, this trend is slightly more marked in Sweden than in Finland, but it is certainly the case that this age group is underrepresented in the rural areas of both countries.

In the age group 45-64 years the difference between Sweden and Finland is quite pronounced, with the former having a lower proportion of this age group in deciles 8-10 than one might expect, especially in the areas representing the highest population densities of all,

although otherwise the proportion decreases from the countryside towards the towns. In Finland this age group is clearly largest in the sparsely populated rural areas and more or less equally underrepresented in all the other deciles.

One feature common to the distribution of the elderly population in both countries is the relative overrepresentation of the two extremes of the decile scale, the densest agglomerations and the depths of the countryside. In the case of Finland, one finds an extremely skewed age structure in the rural population, the first signs of which are already visible in the previous age

group, so that the over 64s in this decile in Finland form by far the most overrepresented age group to be found anywhere.

Concentration by sex

Where the analysis in terms of age structure revealed both common features and distinct differences between the two countries and on the rural – urban axis, a further division of the data by sex (Table 7, see also Fig. 6a–6b) introduces additional elements into the spatial pattern. The proportion of females is lowest in the most sparsely populated rural areas in both countries and increases more or less steadily towards the urban centres, its peak coinciding with that in population density, while the pattern for males is exactly the opposite. The situation in Sweden is slightly more evenly balanced.

An examination of the sex distribution in terms of a three-fold division of the population by age serves to fill out the impression conveyed above of the skewed nature of the demographic structure in different parts of the spatial system (Table 8). Examination of the child population by sex merely serves to indicate that they are evenly distributed by sex in every decile, but a distinct trend is to be observed in the

distribution of women of age 16–64 years among the deciles, in the sense that several decades of selective migration (higher rates of migration for women than for men), motivated by various socioeconomic considerations, has had the effect of depriving the rural districts of many of their women. This trend is similar in both countries but it is less marked in terms of the decile structure in Sweden than it is in Finland. The figures for men in this age group fluctuate fairly evenly around the mean.

The sharpest deviations between the deciles are to be observed in the age group over 64 years, where the proportion of men in the sparsely populated country districts of Finland is extremely high. The situation is similar in Sweden, but not so exaggerated. Some accumulation of women of this age in the countryside is also detectable in Finland, while a particularly high concentration of women of this age in Sweden is to be found in the urban centres.

Settlement structure as represented by a rank size model

The rank size model has been used in geography to examine the hierarchical nature of the system of urban areas (see Bradford & Kent 1977; Popu-

Table 7.
Distribution of the female and male population (%) of Finland and Sweden in 1995 by deciles (see also Figures 6a–6b).

Decile	Female (%)		Male (%)	
	FIN	SWE	FIN	SWE
1 (sparsest)	9.30	9.32	11.15	10.71
2	9.28	9.62	10.35	10.43
3	9.74	9.78	10.35	10.18
4	9.92	9.92	10.10	10.08
5	9.95	10.00	9.95	9.99
6	10.09	10.09	9.90	9.92
7	10.23	10.20	9.86	9.79
8	10.23	10.32	9.74	9.76
9	10.46	10.35	9.46	9.69
10 (densest)	10.79	10.39	9.13	9.44

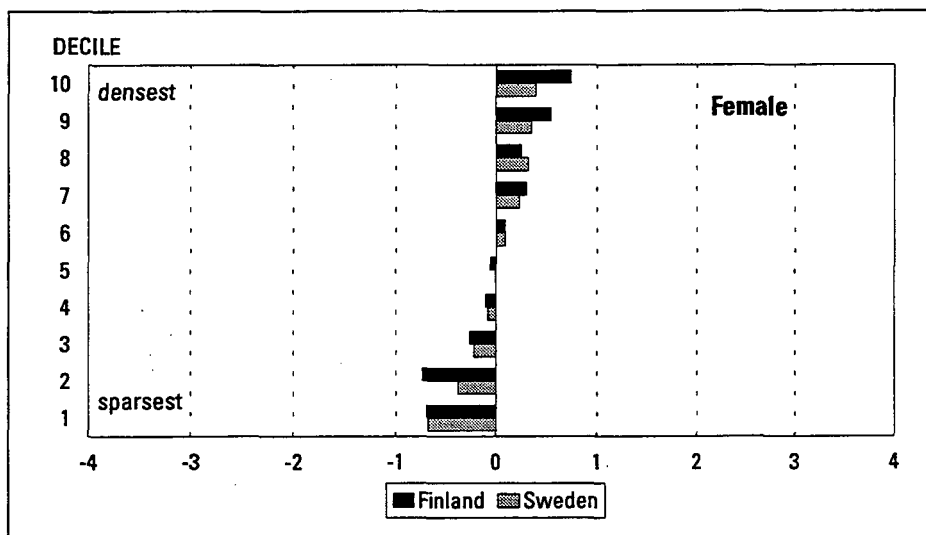


Fig. 6a-6b. Distribution of the female and male populations of Finland and Sweden in 1995 by deciles.

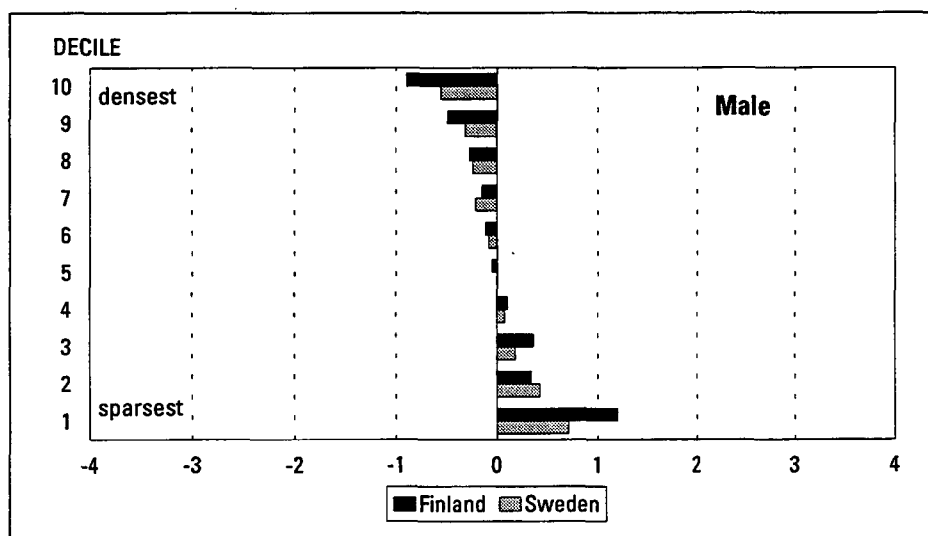


Fig. 6b.

lation, National Atlas of Sweden 1991: 56-57; Das & Dutt 1993). The method is a very simple one. The material is sorted in order of size with respect to a certain variable and the results presented in either mathematical or graphical form. The method is best adapted to cross-sectional analyses, and thus it is particularly useful for examining changes taking place over long

periods of time. It has been used with grid square data for modelling the structure of settlement, for example, and for describing transitional zones between rural and urban settlement. This has been done at the national level in the case of both Finland and Sweden.

The curves obtained for the two countries are very similar, indicating that no appreciable

Table 8.
Distribution of the female and male population of Finland and Sweden in 1995 by age groups and deciles
 (see also Figures 7a-7f).

Decile	Female					
	0-15 years		16-64 years		over 64	
	FIN	SWE	FIN	SWE	FIN	SWE
1 (sparsest)	9.17	10.53	8.55	8.99	12.28	9.16
2	11.24	11.77	8.64	9.41	9.42	8.16
3	11.61	11.65	9.38	9.82	8.92	7.87
4	11.37	11.07	9.81	10.07	8.67	8.36
5	10.83	10.77	10.00	10.07	8.78	9.03
6	10.56	10.42	10.27	10.23	8.87	9.35
7	9.97	9.46	10.53	10.19	9.49	10.95
8	9.56	9.03	10.60	10.22	9.59	11.86
9	8.83	8.08	10.86	10.34	10.85	12.60
10 (densest)	6.86	7.23	11.37	10.66	13.18	12.67

Decile	Male					
	0-15 years		16-64 years		over 64	
	FIN	SWE	FIN	SWE	FIN	SWE
1 (sparsest)	9.33	10.47	10.90	10.12	16.52	13.60
2	11.28	11.79	9.82	9.97	11.92	10.55
3	11.76	11.70	9.93	10.00	10.17	8.81
4	11.38	11.19	9.91	10.02	8.76	8.78
5	10.87	10.83	9.88	9.91	8.53	9.15
6	10.47	10.46	9.95	9.94	8.38	9.09
7	9.90	9.42	10.04	9.88	8.56	9.93
8	9.44	8.99	10.01	9.90	8.63	10.24
9	8.81	8.01	9.73	10.10	8.99	10.30
10 (densest)	6.77	7.13	9.82	10.16	9.55	9.54

differences in settlement structure exist at the macro-level (Fig. 8, see also Figures 7a-7f). The differences in the case of scattered settlements and somewhat denser village settlements are negligible, and it would seem to be only in the areas with the densest settlement of all that there are proportionally more data points in the graph for Finland than in that for Sweden. Comparison with the corresponding graphs for 1970 shows very clearly the sharp decline in

population density that has taken place in the urban centres in Finland, by as much as a third, and the decline in the rural population, at the same time as an accumulation has taken place in the suburban areas and other localities. It is interesting to note in this sense that there were some grid cells in the centre of Helsinki in 1970 that had a higher density than anywhere in Stockholm in 1995.

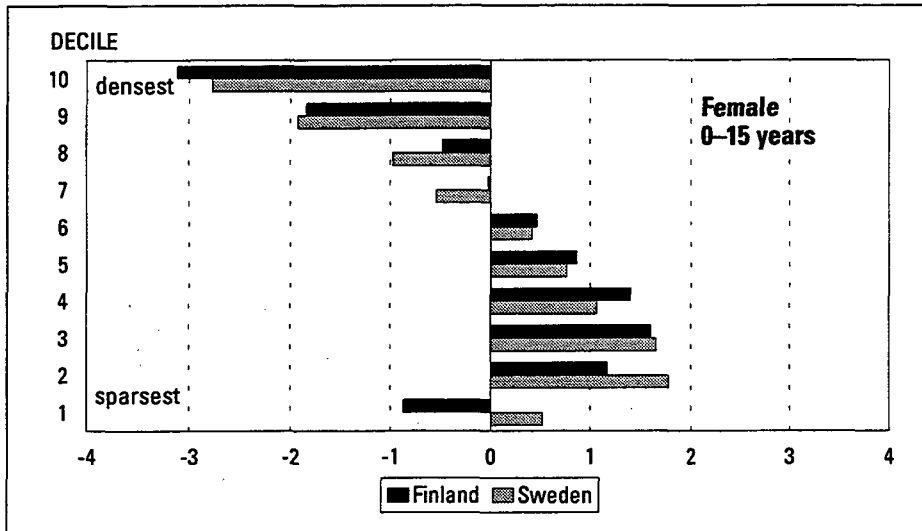


Fig. 7a-7f.
Distribution of the female and male populations of Finland and Sweden in 1995 by age groups and deciles.

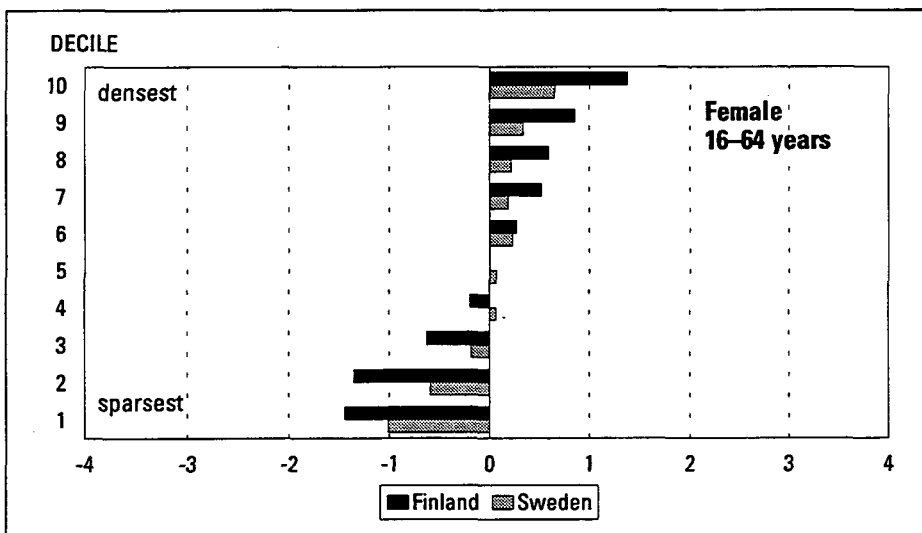


Fig. 7b.

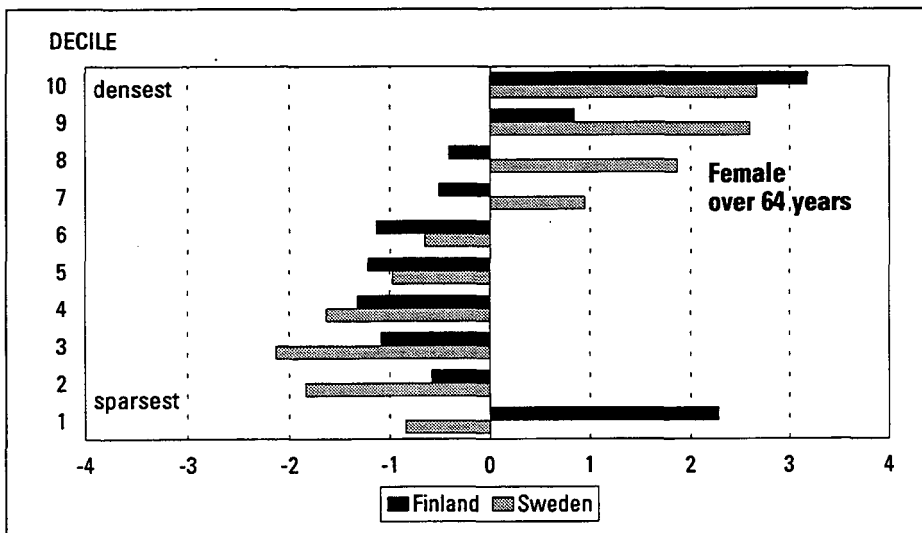


Fig. 7c.

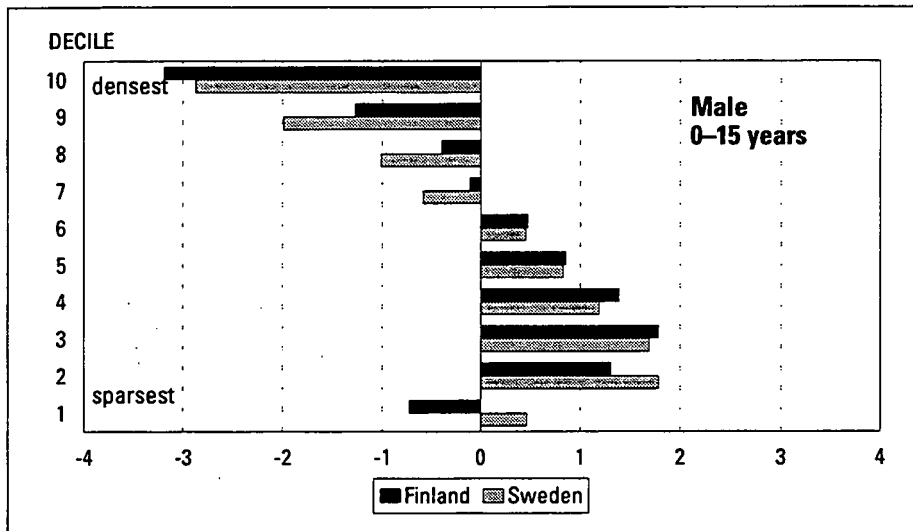


Fig. 7d.

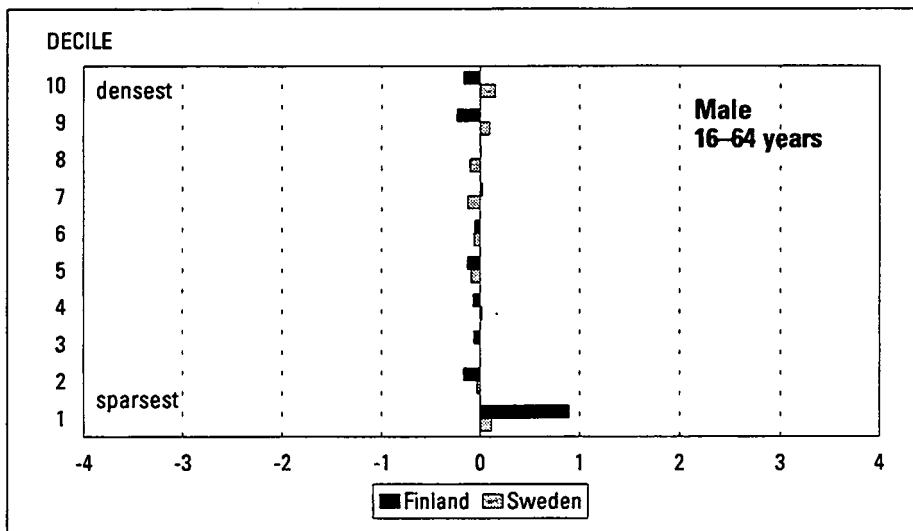


Fig. 7e.

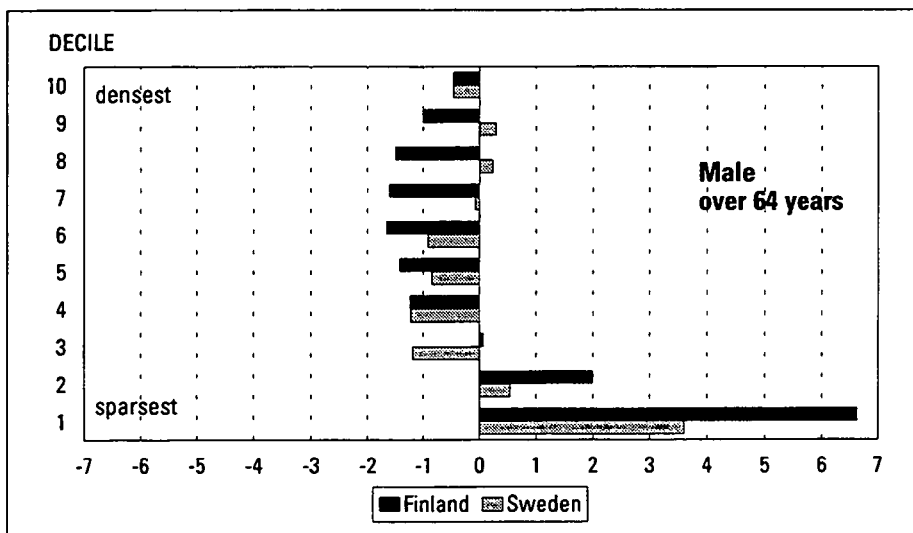


Fig. 7f.

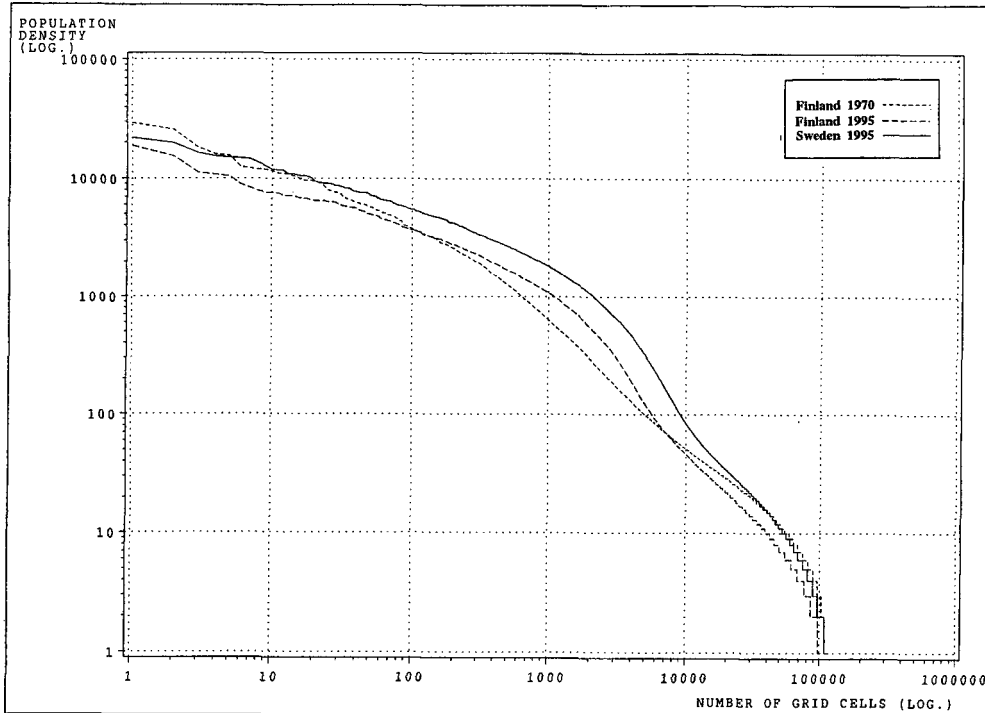


Fig. 8.
Rank size distributions of the population of Finland in 1970 and 1995 and of Sweden in 1995.

7. Grid cell analysis in the search of demographical problem areas

The coordinate-based material can be used to generate spatial information of a kind that cannot be observed at all when using traditional administrative units. It is possible, for instance, to identify cells which contain only old people, or areas where there are only working age people but no children. Spatially definable extreme cases of this kind are encountered mainly in the sparsely populated areas, but they can often act as clues to the existence of local problems or reflect future demographic problems and provide valuable information for planners and administrators for the targeting of appropriate intervention measures. We will look below at a few examples of cells with an exceptional demographic structure.

The spatial distribution of grid cells of the above kind is amazingly similar in the two countries, amounting to more than one fifth of the total. Sweden has both in absolute and relative terms more cells inhabited only by old people, and Finland more with only working age people (see age distribution types 1 and 3 in Table 9). The numbers of people involved,

however, are by no means as great as the areal extent of the cells might at first suggest, because they tend to be concentrated in the sparsely populated rural areas. Although the examples are related to the extreme cases and their areal distribution, they show that the grid cell analysis can be used in finding many kinds of socioeconomically relevant groups in our societies.

Particularly the rapid ageing of the population and the pronounced increase in unemployment have raised the general question in recent times of the ability of society in the future to attend to the security and welfare of its citizens. The principle of full employment and the responsibility of society for ensuring that this comes about, which are central features of the Nordic concept of welfare, have attracted criticism on account of the ever increasing public debt, and various dependency indices have been proposed, based on the ratio between the active and passive sectors of the population, for assessing demographic structure, welfare needs and future trends in these (Muilu et al. 1996; Naukkarinen et al. 1995).

At the national level, according to the generally used age classification, Finland and Sweden both belong to type 13 (see Table 9), in which the number of inhabitants of working age is greater than that of the passive group (children and the elderly) while within the latter the children are more numerous than the elderly. Admittedly Sweden is on the point of moving

into type 15, in which the number of old people is greater than that of children but their combined total still smaller than the working age population, a situation now represented only by Italy among the European countries (Statistical Yearbook of Finland 1995:542)

The accompanying map (Fig. 9, p 18) depicts those areas which deviate markedly from the

Table 9.
The types of age distribution, their spatial occurrence and the amount of population in each type according to the grid data in Finland and in Sweden in 1995.

Age distribution types	Number of grid cells				Population			
	Abs.		%		Abs.		%	
	FIN	SWE	FIN	SWE	FIN	SWE	FIN	SWE
1. A = age 15 – 64.....	17 988	15 673	17.0	13.3	47 555	39 648	0.9	0.5
2. B = age 0 – 14.....	2	13	0.0	0.0	4	16	0.0	0.0
3. C = age 64 +.....	6 716	9 238	6.3	7.8	10 793	15 831	0.2	0.2
A + B.....	17 112	17 301	16.2	14.7	155 166	155 624	3.1	1.8
4. A > B.....	12 290	12 367	11.6	10.5	125 021	126 331	2.5	1.4
5. A = B.....	2 751	2 964	2.6	2.5	14 350	15 416	0.3	0.2
6. A < B.....	2 071	1 970	2.0	1.7	15 795	13 877	0.3	0.2
A + C.....	20 154	18 448	19.0	15.6	109 104	106 189	2.2	1.2
7. A > C.....	11 466	9 655	10.8	8.2	76 261	67 489	1.5	0.8
8. A = C.....	5 173	4 651	4.9	3.9	16 014	15 762	0.3	0.2
9. A < C.....	3 515	4 142	3.3	3.5	16 829	22 938	0.3	0.3
B + C.....	2	8	0.0	0.0	4	27	0.0	0.0
10. B > C.....	0	0	0.0	0.0	0	0	0.0	0.0
11. B = C.....	2	5	0.0	0.0	4	14	0.0	0.0
12. B < C.....	0	3	0.0	0.0	0	13	0.0	0.0
A + B + C								
A > (B + C).....	32 407	41 351	30.6	35.0	4 533 848	8 109 234	90.0	92.3
13. and B > C.....	19 584	25 059	18.5	21.2	3 113 809	4 680 542	61.8	53.3
14. and B = C.....	4 611	4 793	4.4	4.1	74 811	99 166	1.5	1.1
15. and B < C.....	8 212	11 499	7.8	9.7	1 345 228	3 329 526	26.7	37.9
A = (B + C).....	3 604	4 234	3.4	3.6	44 158	65 078	0.9	0.7
16. and B > C.....	1 767	2 120	1.7	1.8	24 400	33 652	0.5	0.4
17. and B = C.....	779	806	0.7	0.7	6 176	7 216	0.1	0.1
18. and B < C.....	1 058	1 308	1.0	1.1	13 582	24 210	0.3	0.3
A (B + C).....	7 912	11 776	7.5	10.0	134 173	294 353	2.7	3.3
19. and B > C.....	4 208	5 342	4.0	4.5	68 691	97 548	1.4	1.1
20. and B = C.....	1 170	1 669	1.1	1.4	10 955	17 081	0.2	0.2
21. and B < C.....	2 534	4 765	2.4	4.0	54 527	179 724	1.1	2.0
Total.....	105 897	118 042	100.0	100.0	5 034 805	8 786 000	100.0	100.0

mean demographic structure consisting age distribution types 13-15 and which areal distribution in the map is indicated by red color. The first group comprises grid cells containing only people of working age or working age people with children. These amount to about 33 % of the inhabited grid cells in Finland and about 28 % in Sweden (cf. Table 9), although in spite of their great areal extent, they account for only about 4 % of the population in Finland and a half of this in Sweden. These instances are mostly located in remote, sparsely populated rural regions, so that the greatest problems encountered in everyday life are concerned with access to services.

These problems are not perhaps of quite the same significance for above groups in the population as they are for the next group, which consists of grid cells with only old people, old people and those of working age, or in a few cases old people and children. Cells of this type are relatively numerous, exceeding 25% of all inhabited cells in Finland and almost as many in Sweden, 23.4%, although again accounting for only 2.4% of the population in the former case and approximately a half of that in the latter. A further group can be distinguished in which all components are present but the inhabitants of working age are either equal or in the minority relative to the passive sector. Grid cells of this type are notably more common in Sweden, where they also account for a higher proportion of the total population, although the figures are once more fairly marginal. This example nevertheless serves to demonstrate that grid data of this kind can open up excellent possibilities for addressing many social questions in a manner which can be of relevance for areal and community planning.

Demographically problematic cells and their significance for the spatial structure can also be examined in the framework of a system of ad-

ministrative units, e.g. by municipalities. Table 10, for instance, contains data on the ten municipalities in each country that have the most grid cells with population exclusively of one age group. The proportions of the inhabited areas of the communes affected in this way are in all cases higher in Sweden than they are in Finland.

8. Population by distance

The location of the population in terms of distance from a given point may be determined from grid data either by reference to administrative boundaries or in a manner independent of these. When calculating distances from the centre within communes, no data were available here on the true centre points of the communes, e.g. the market place or main square of the chief town or village, the locus of the principal services or the central nodes of the transport system such as the main railway station, nor were data available on the road network, so that distances had to be measured "as the crow flies". In practice there are many natural barriers that increase these distances considerably. Thus the distances are calculated here by reference to the most densely populated grid cell in each commune, which does not necessarily correspond to the true centre but will serve as a basis for comparison between the two countries.

There are two basic structural differences to be taken into account in the comparison as well. In the first place, Sweden is considerably larger in area than Finland, and in the second place, it has only 288 communes as compared with Finland's 455, so that they are significantly larger in area. Thus it is not surprising that the Swedes live further away from their commune centre on average than do the Finns, 16.9 km vs. 12.1 km, a difference of about a third. There has been much discussion in Finland recently about re-

Table 10.

The ten municipalities of Finland and Sweden having the highest proportions of grid cells with population exclusively in one age group.

FINLAND					
Only 16-44-years		Only 45-64-years		Only over 64-years	
Municipality	% of inhabited area	Municipality	% of inhabited area	Municipality	% of inhabited area
Savukoski.....	8.6	Inari.....	15.9	Velkua.....	27.3
Inari.....	8.3	Houtskari.....	15.7	Särkisalo.....	21.0
Houtskari.....	7.9	Pelkosenniemi.....	15.4	Kustavi.....	20.0
Nurmes.....	6.8	Jaala.....	14.9	Nauvo.....	16.1
Enontekiö.....	6.5	Pertunmaa.....	14.5	Föglö.....	15.9
Humppila.....	6.3	Vårdö.....	14.3	Kökar.....	15.4
Utsjoki.....	6.3	Leivonmäki.....	14.1	Heinola.....	15.1
Hirvensalmi.....	6.0	Heinolan mlk.....	13.9	Kuhmoinen.....	15.0
Siikajoki.....	5.7	Korpilahti.....	13.8	Längelmäki.....	14.9
Liljendal.....	5.7	Savonranta.....	13.8	Houtskari.....	14.6

SWEDEN					
Only 16-44-years		Only 45-64-years		Only over 64-years	
Municipality	% of inhabited area	Municipality	% of inhabited area	Municipality	% of inhabited area
Malung.....	13.3	Arjeplog.....	26.7	Arvidsjaur.....	31.3
Arvidsjaur.....	11.8	Arvidsjaur.....	24.1	Arjeplog.....	31.3
Arjeplog.....	11.7	Hällefors.....	19.4	Norsjö.....	28.0
Laxå.....	11.0	Åsele.....	18.3	Lycksele.....	27.4
Storfors.....	10.1	Ljusnarsberg.....	17.4	Jokkmokk.....	27.0
Hällefors.....	9.9	Storuman.....	17.3	Sorsele.....	26.9
Gällivare.....	9.8	Norsjö.....	16.0	Mora.....	26.5
Boxholm.....	9.5	Norberg.....	15.7	Älvdalen.....	25.9
Kiruna.....	9.2	Dorotea.....	15.6	Dals-Ed.....	25.7
Härjedalen.....	8.5	Mora.....	15.5	Malung.....	25.2

ducing the number of communes by combining some of the existing ones into larger units, which would without doubt increase the distances to the centres to some extent. The maximum distances recorded in the present data were 161 km in Storuman, Sweden, and 139 km in Enontekiö, Finland.

There is no consistent pattern, however, in the spatial distribution of the population relative to the central point of the commune. The central grid cells from which the distances are measured are slightly less populous in Sweden,

but the cumulative proportions of the population accounted for are more or less equal at a radius of 3 km (Fig. 10). A higher proportion of the population is then found in the zone 4–11 km in Finland than in Sweden, while beyond that the Swedes are more numerous in relative terms. A half of both the Finns and Swedes live within 5 km of their commune centre, and 80% within 10 km and 11 km respectively.

It is now possible to analyze and illustrate the question of access to the services provided in commune centres, for which purpose we em-

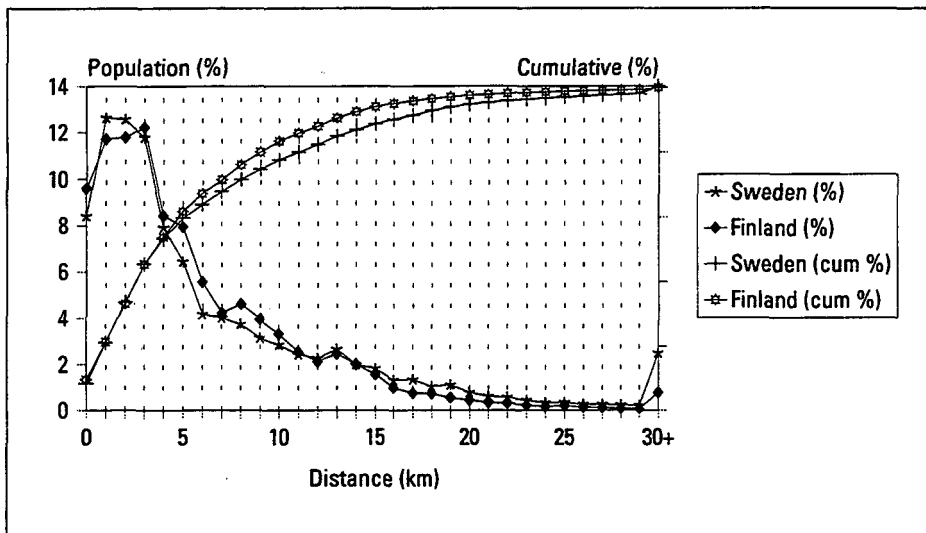


Fig. 10. Population of Finland and Sweden in 1995 by distance from a commune centre.

ploy here distance zones of under 6 km, 6–20 km and over 20 km. No actual theoretical or empirical justifications exist for these particular boundary values, but one may perhaps refer verbally to excellent, good and poor access respectively. This classification would show 61.7% of the Finns to have excellent access to services, 35.4% good access and only 2.9% poor access, while the corresponding figures for the Swedes would be 59.8%, 33.9% and 6.3%.

Access to services in both countries is poorest in the sparsely populated areas, i.e. central and northern Sweden and northern Finland (Fig. 11, p. 19), but the larger size of commune in Sweden means that there are some areas of poor accessibility in the south as well, whereas such situations are comparatively rare in southern Finland. One is thus led to conclude that the services offered by commune centres are on average less readily available to people living in Sweden than to those living in Finland and less easily arranged for them. Such an analysis tells us nothing, however, about how services for those living in more remote areas are actually organized in practice, or about whether the inhabitants feel that access to them is difficult.

One should remember when evaluating the results of such an accessibility analysis, of course, that the situation represented is largely a hypothetical one and does not conform to the true locations of commune centres or the services that they provide.

The grid data can well be used to analyze and illustrate the population base in a given area, and thereby the accessibility of that population, e.g. with a view to marketing campaigns. The accompanying example involves the use of the focal sum method (see Arc/Info manual 7.01, Tomlin 1990) to assess the number of inhabitants within a 10 km radius of each grid cell, i.e. in a circle of area of 314 km² centred on the centre point of the given cell. Classification used in Fig. 12 (p. 20) is based on the criterion of 8 inhabitants per km² laid down for EU Objective 6 regions, i.e. classes of less than one inhabitant per km² within a radius of 10 km, 1–8 inhabitants, and more than 8 inhabitants, corresponding to the best population base, that to be found in the centres of large cities.

Sweden has more extensive and more continuous sparsely populated areas than Finland, and they also extend further south (Fig. 12, p. 20).

9. Conclusions and prospects for future research

The grid data provide excellent coverage of the population and its various components in both countries, although it must be remembered that they differ very slightly in the manner in which the location of the population is recorded and that the data were supplied in slightly different forms. These differences are not likely to affect macro-level interpretations, however. The results naturally cannot be compared with the situation in any country for which no data are available in this form.

Both countries are to a substantial extent sparsely populated, having distinctly more uninhabited grid cells than inhabited ones, and the attraction of lakes, rivers and coasts for settlement continues to be reflected in the spatial distribution of population, the major cities being principally located on the coast. Another feature that they have in common is that the focus of population is towards the south and the northern areas are sparsely populated. The greater distances to the nearest centre with services recorded for Sweden may be attributed to the smaller number of communes and their greater area.

Sweden is a markedly more urbanized country than Finland, and the boundaries between urban and rural areas would seem to be more sharply defined. No definite reason can be suggested for this on the basis of the present material.

The distortions in demographic structure are less marked in Sweden than in Finland, evidently for historical reasons. The population engaged in agriculture and forestry reached its maximum size in the 1880's in Sweden but only in the 1920's in Finland, and the normal structural change experienced in rural areas, a reduction in the number of farms, has been

going on there for longer. Rural settlement in Finland was still expanding in the post-war years, and even up to the late 1960's in the north of the country (Häkkinen 1988:424).

The demographic structure as a whole may be regarded as better balanced between the levels in the spatial structure in Sweden than in Finland, although the two countries have many structural problems in common. Examples of these would be the predominance of the older age groups and the male sex in the rural areas and the predominance of females and low proportion of children in the centres of the urban areas. Many rural areas have based their development campaigns on the achieving of a functional structure and satisfactory population base, but experiences in Finland suggest that a large number of these areas are threatened with a decline in population.

The present research is likely to stimulate further investigations in numerous directions, of which perhaps the most significant are these three:

- 1 Aggregation and visual presentation at the commune level of phenomena analyzed at the grid cell level, especially with a view to the accessibility of services, which could be done on the basis of existing data on the population and its structure by age and sex. One example would be calculations of the population density of communes from the grid data. At least in Finland, the population densities of rural areas differ depending on whether they are calculated relative to total area or to the number of inhabited 1 km² grid cells. The accessibility of services may be analyzed in greater depth at the macro-level by calculating the percentage of the population of each commune living at a given distance from the centre or determining the sum of the distances at which the

people live. Dependency ratios can also be aggregated at the commune level, in the same way as mean distances or distance sums. A further possibility would be commune specific indices reflecting remoteness, accessibility or the dependency ratio.

- 2 The formation of reference areas, e.g. precisely defined areas of equal size in terms of population. Examples of these might be the regions around national capitals or other large Nordic cities such as Turku or Gothenburg, or on the other hand, regions with a biased population structure as shown by dependency analysis, each the provinces in the north of the Nordic Countries. Examples of existing comparisons of this kind include the work of Häkkinen (1990) and Korhonen (1990) on the regions of Kainuu in Finland and Jämtland in Sweden.
- 3 The need for new material in order to analyze spatial structures in greater depth. The main needs at the initial stage would concern the labour force and employment opportunities, which would need to be classified in the same manner in both countries for the

sake of comparability (e.g. the Statistical Yearbook of Sweden 1996, table 197). At a later stage it might be possible to introduce variables that are specified for age, for instance. Fuller data on places of employment would also allow the functional centres of the communes to be defined better than they are here, which would be of use for the analysis of the accessibility of services. As far as occupational structure is concerned, it would be possible to assess whether Finland is still "lagging behind" Sweden in its occupational structure from the viewpoint of the transition theory (see also Heikinheimo 1987:3-9; Korhonen 1990:87-79; Koistinen 1994:19-26).

It is impossible to find fully comparable historical data on changes in population, for instance, in the case of Sweden, even though the first grid square map of that country dates back to 1856 (Population. National Atlas of Sweden 1990: 42-43). Even a difference of two or three years between data sets would allow the analysis of changes in various aspects of the spatial structure.

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Appendix I

Summary of the use of GIS and grid data (in Finland)

The following is a brief summary of the experiences gained so far with the use of grid data (Halme et al. 1996).

Advantages

1. Flexibility. The areal unit used is suitable for any aggregate level from small areas to the macro level, and also for defining new boundaries.
2. Spatially stable. Administrative areas may be merged with time, but grid cells always remain the same.
3. Independent of administrative boundaries.
4. Fits with any boundaries.
5. Provides flexibility in hierarchical analysis. Population density, for example, is basically hierarchical in character.
6. Visualization. Serves as a tool for communicating micro and macro-level findings to decision makers familiar with GIS.
7. Allows merging of several spatial files, which constitutes the basic method of working in GIS.
8. Opens the way to new methods, including a wide variety of buffers and smoothing and classification techniques.
9. Allows the creation of new indices, principally distance from a centre.
10. Complements classical indices, e.g. population density.
11. Accepts new units, e.g. depopulated and newly populated grid cells.
12. Provides a historical dimension, e.g. the period 1970–1995 for which data are available for Finland is long enough for planning purposes.
13. Allows handling and rapid analysis of large databases.
14. Makes it ease to demonstrate a spatial process to decision makers, even beyond the boundaries of their own commune.

15. Enables even subtle changes to be identified.
16. Data generated annually since 1987.
17. Permits detailed analysis of the internal structure of a commune.
18. Allows comparison of the dynamics of areas that are identical in terms of some parameter, e.g. grid cells with 100–200 inh/km² or with over 10000 jobs.

Disadvantages

1. Lack of theory suitable for 'raster' data.
2. The grid cell is an abstract, artificial, somewhat inhuman spatial unit which the inhabitants themselves cannot recognize.
3. It is hard to understand the character of grid cells or to describe it to people unfamiliar with the system.
4. The size of cell is problematic. Even 500 x 500 metres would be too large for urban research, but smaller sizes would be available, e.g. 200 x 200 metres.
5. Errors in the data are difficult to correct.
6. Some of the techniques involved are difficult to describe to non-geographers or non-experts.
7. GIS is an expert system, and the communes will generally have few or no people with any training in its use.
8. Visualization entails some problems related to the scale of the map.
9. A responsible attitude towards cartographic presentation is essential, as this is easy to manipulate.
10. Local authorities generally have no GIS hardware or software.
11. GIS is an expensive system unless full use can be made of its potential.
12. Grid data are not necessary of any additional value in the case of small communes.

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