The emerging Great Lakes Megalopolis

The text that follows is a slightly edited version of a document by C.A. Doxiadis extracted from Proceedings of the IEEE – The Institute of Electrical and Electronics Engineers, *vol. 56, no. 4, April 1968, pp. 402-424.*

Preface

WE COMPLAIN about our cities – and justifiably so. For in spite of the much higher incomes and the much more developed technology which the present generation has in relation to those who lived before the eighteenth century, our present cities have not been able to serve us as well as did the cities of the past. Our admiration for the cities of the past is partly because of the better way of living they represented.

Although we complain about the cities of the present, we continue to build in the image of existing cities, and to produce mere expansions of them. Instead of solving any problems, we create situations which worsen with every day that passes. The reason is that we do not have the ability to look ahead and see the cities in which we will live in the future which in reality are the cities we are building today.

In order to escape this impasse of building the cities of the future, which in reality are the cities we are building today, ability to foresee the types of cities in which we shall have to live and try to do our best for them. This requires a twofold approach. First, we must realistically determine those basic characteristics of the cities to come which will be inevitable; and second, we must invent the type of life we want to carry out inside these cities and form the cities accordingly.

The first part of this approach is based on the idea that there are forces beyond man's control, at least in the short term of a generation or two, such as the demographic forces. No policy on population control will have so great impact as to change the basic dimensions of population growth in the next few years. Neither can we control the forces leading towards greater development of resources and greater productivity. These forces are leading, as they have throughout history, to the creation of greater and greater urban concentrations, greater and greater human settlements.

In order to be able to create a better city for the future, we must first try to understand where the inevitable forces of development and evolution are taking the human settlements and then see how we can build better settlements within the frame which is being created. We must study those settlements which are to come, which we may not be able to see yet, but whose foundations have already been laid. Such settlements are the forthcoming megalopolises, the urban concentrations which comprise within them several metropolitan areas and several other minor settlements interconnected in a system which is beginning to operate as one.

Such megalopolises are necessarily inevitable, not only because of a growing population, but also by the new means of transportation which will allow people who, two centuries ago, commuted on foot only for ten minutes a day in each direction, one century ago commuted by train for as much as half an hour a day in each direction, and today commute as much as one hour in each direction by several means of transportation over a distance of 40 or 50 miles, to commute in the future beyond the 100-mile radius. New means of transportation will make this possible in no more than one hour. If we project the increasing speeds properly, we shall see that the dimensions of our settlement reach from the one-mile diameter common before the eighteenth century to several miles in the nineteenth, several tens of miles in the twentieth century, and probably several hundreds of miles at the beginning of the twenty-first century.

The large megalopolises of the future will differ from the cities we now know in many other ways besides size: there will be a much greater complexity of interrelations between their constituent parts, a very different conception of function and life within them and a different conception of spatial configuration and use of land, and so forth. All this will be made possible by greatly increased income and economic potentialities, by new technologies, greatly expanded automation and communications, and the availability of information, and by much more efficient overall planning technologies. Within this whole picture, however, transportation aspects will undoubtedly retain a central position, conditioning the structure and operation of these large future megalopolises to a very high degree.

Introduction

The concept of megalopolis

The second third of our century will probably be regarded as an important period in the history of the evolution of human settlements because it saw, for the first time, the emergence of a new type of settlement, the megalopolis. This new type of settlement is characterized by its large size in area and population, its high regional densities, the inclusion in it of several large centers strongly interacting with each other and with the surrounding region, and also the introduction of new and more complex patterns of life. The characteristics of the megalopolis, however, are not yet sufficiently well defined and considerable further research will be needed before they can be properly identified.

A study by the Athens Center of Ekistics, Athens Technological Institute, called the City of the Future Research Project, has already provided some global data on this new form of human settlements. This study has shown that megalopolises may be expected to grow, in number as well as in size and complexity, at an increasing rate in the near future.

According to the population projections worked out by the Athens Center of Ekistics, during a period somewhere in the first half of the twenty-first century, most probably towards the end of the first quarter of the twenty-first century, the proportion

of the earth's population residing in megalopolises is expected to reach its maximum, almost half of the earth's population then constituting megalopolitan population. The importance of megalopolises will have grown to such a degree as to justify for this period the term "the Era of the Megalopolis."

At the same time, however, larger units, such as urbanized regions, urbanized continents and, finally, the universal city or Ecumenopolis, will start emerging and will gradually replace the current type of megalopolis. Megalopolises will continue growing both in size and in number but, because of space limitations on the earth and the necessity of interconnection between megalopolises, more and more of them will start merging into each other giving birth to larger complexes of a higher order, consisting of several interconnected megalopolises. Because of this merging the number and importance of "plain megalopolises" will start diminishing after the previously mentioned maximum is reached.

Possible alternative definitions of megalopolises

Because of their complexity and variety, megalopolises lend themselves to the development of a considerable range of alternative definitions, each based on a different type of criterion. Whether in the end one would have to choose just one of these alternative simple definitions and establish it as the main one or combine several simple definitions into a multiple one remains to be seen from the development of our knowledge about megalopolises. Possible definitions can be classified as follows:

- **Simple definitions:** These are definitions using one single criterion.
  - *Structural definitions:* The criterion in this case refers to the structure of the area. It might for example be the range for the population size, the area, the density or other defined variable or a more complex criterion, such as the connectivity between major centers, that can be regarded as a function of the size and distance of the corresponding centers.
  - *Functional definitions:* The criterion on which such definitions are based is related to the functions within the area. Among the more characteristic criteria of this type are the overlapping movements (transportation), various types of interactions, economic activities, administrative aspects, and so forth.
  - *Growth definitions:* The criterion for such definitions is chosen among the rates of growth given for various phenomena, such as population, urban land, and others.
- **Multiple definitions:** These are definitions using several criteria jointly.

Because megalopolises are still in the very early stages of their formation and we are not in a position to observe them in any fully "mature" form, and because studies about them are still very scanty and, for the most part, of a preliminary nature, it is still difficult to arrive at a satisfactory definition. The Athens Center of Ekistics has made certain first attempts in this direction which can be classified according to the above scheme. These have helped in obtaining a first approximate delineation of a number of megalopolises of the present and the near future, and in obtaining some rough comparative data about them.

Other, more sophisticated definitions may be developed as our knowledge about megalopolises increases. These may have to be used either independently or in combination with some of the definitions mentioned above.

Studies on megalopolises

The first systematic study of a modern megalopolis and the definition of the term megalopolis was made by Gottmann in his

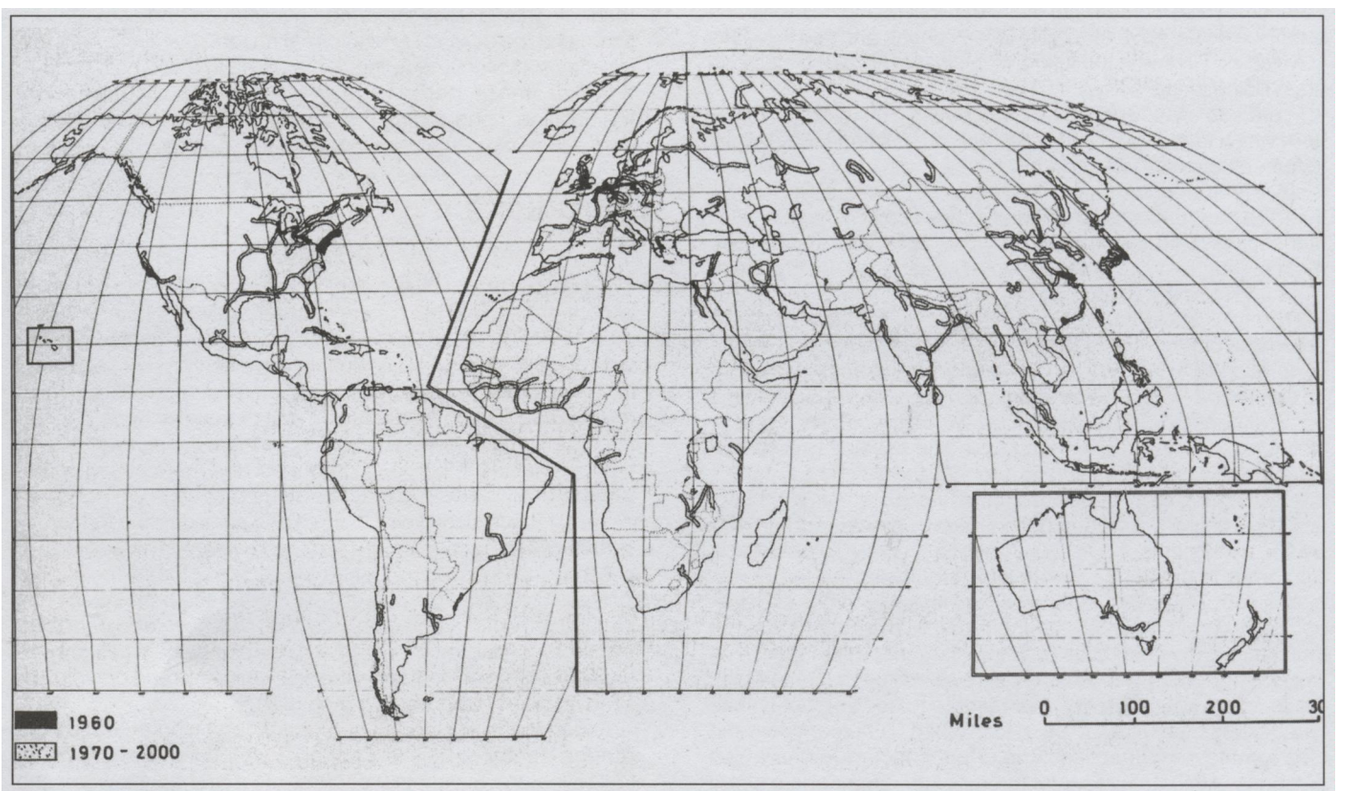


Fig. 1a: Megalopolises AD 1960 to 2000.

study of the East Coast megalopolis of the United States ranging from Boston to Washington.[1]

The Athens Center of Ekistics started working systematically in this field in 1960 when the first tentative studies about major settlements were made under the research project named the City of the Future Research Project. These studies were gradually intensified and the whole project is beginning to comprise a greater number of examples of megalopolises in several parts of the world (in England, Central Europe, the United States, Greece, and, more recently, in Japan, South America, and so forth). Based on these partial studies and on some more general considerations, tentative projections were made for the world as a whole for the year 2000 (fig. 1a).

In 1965 a more detailed study of the Great Lakes megalopolis in the United States was started, and carried out in successive "waves" of increasing extent and depth, within the frame of the Developing Urban Detroit Area Research Project, undertaken as a joint effort by the Detroit Edison Company, Wayne State University, and Doxiadis Associates.[2] This study is still proceeding.

Some historical remarks

It seems useful to situate the concept of megalopolis in historical perspective, although it refers to a phenomenon emerging in the present and expected to evolve mainly in the future.

Permanent rural settlements may have appeared 12,000 to 15,000 years ago, and the first dated ones go almost as far back as 8000 B.C. The first urban settlements may have appeared already within the 7th millennium B.C. (Catal Huyuk, Jericho), but larger and better organized urban life and corresponding settlements are usually regarded as having emerged at the beginning of the 4th millennium B.C. in Mesopotamia. They grew quickly, so that about a millennium later the first metropolis (Ur) appeared, with a population of the order of 100 000. Another two millennia passed before settlements reached populations of almost 1 million (Babylon), and almost another passed before the 1 million mark was exceeded (Rome). During the Middle Ages the 1 million mark was approached for short periods in such places as Constantinople (6th to 9th centuries) and China (Hangchow and Peking); even Aztec Mexico may have approached 1 million, according to one estimate. One had to wait till about 1800 to see a first modern western city (London) exceed 1 million; thereafter the development of contemporary metropolises, the three largest of which exceed 10 million (New York, Tokyo, London), is well known. These, however, are rare and exceptional achievements in the history of human settlements. In the past the bulk of the earth's population resided in small rural settlements; the percentage of urban population, from inconspicuous levels, rose abruptly to reach 45 percent in 1960 and 50 percent in 1966; it is expected to reach 60 percent in 1976 and just over 75 percent in A.D. 2000. The percentage of population living in cities with over 100 000 inhabitants reached 23.7 percent in 1960, and it is anticipated that this will grow to 38.5 percent in 1975,59 percent in A.D. 2000, and 74 percent in A.D. 2030; the percentage living in cities with over 1 million inhabitants is expected to rise from 12.5 percent in 1960 to 21 percent in 1975, 38 percent in A.D. 2000, and 51 percent in A.D. 2030. It is in this picture of abruptly rising urbanization that the megalopolis emerged, probably somewhere in the 1940's, in a first primitive form. Within a generation, it grew considerably to reach, for the first time now, appreciable proportions, although its character remains primitive in comparison with patterns expected for A.D. 2000.

In present times, the leap from the metropolis to the megalopolis has been spectacular. From being represented on a normal map as mere points, settlements suddenly started appearing as large regions with very concrete dimensions and shape; from diameters of some tens of kilometers at the most for the largest metropolises, they have now reached diameters of several hundred kilometers (and we are on the verge of exceeding 1,000 km) for the larger megalopolises; and from a maximum area of a few hundred square kilometers for the largest metropolises, we now leap to areas over 100,000 square kilometers with megalopolises, meaning a multiplication by almost 1000.

The anticipated very rapid growth until "the Era of the Megalopolis" has already been referred to. We may only mention that with a leap in population sizes from about 15 million (the present largest metropolises) to 60 to 70 million (the present largest megalopolises) new orders of population size are achieved, and sizes of the order of 200 to 300 million may become a reality around A.D. 2000, with 1 to 1.5 billion expected later in the twenty-first century. This increase in population alone suffices to suggest what novelty and complexity of structure and function may accompany these new scales in urban settlements.

Identification of a great lakes megalopolis

General

It is anticipated that one of the more important megalopolitan formations will develop in the Great Lakes area of the United States. Quite apart from the City of the Future Research Project, and independently of each other, many authors and administrative authorities seem to be taking into account the possibility of the emergence of something like a Great Lakes megalopolis and a large proportion of the inhabitants of this area seem to feel that such a megalopolis is coming, if it has not already reached its early stages of development.

How far are we already entitled to speak of a Great Lakes megalopolis? There do not seem to be sufficiently detailed studies to give an answer to this problem so far. Doxiadis Associates and the Athens Center of Ekistics felt that a preliminary study which would merely aim at posing this problem would be in place. It should of course be understood that much more thorough and detailed studies would be necessary before a final answer to this problem, either positive or negative, could be given.

As a first approach, the study was oriented toward defining and identifying the area within which this megalopolis was suspected to be emerging. Second, it attempted a comparison with the eastern megalopolis to determine whether the present suspected Great Lakes megalopolis could be compared with the eastern megalopolis at some earlier stage in its evolution, in which case it would be interesting to introduce the concept of a time lag between the two megalopolises for each variable considered.

Method of analysis

One of the primary objectives was to define the area within which the Great Lakes megalopolis was supposed to be emerging; the method followed was to make successive approximations based on the study of various phenomena by counties.

Three major clusters were isolated as constituting the main elements of the Great Lakes megalopolis: one centered on Chicago and Milwaukee, another centered on Detroit, and a third one centered on Cleveland and Pittsburgh. Also considered was the possibility of a northeastern extension into Canada as well as the connection with other adjacent urban clusters, such as one around Cincinnati in the south, or a branch extending south of Lakes Erie and Ontario, east through the Mohawk Valley, and forming a link between the Great Lakes megalopolis and the eastern megalopolis.

A correct study of the megalopolis concept should take into

account that inherent to the megalopolis is its growth through time, and its boundaries are constantly changing. This is well illustrated in Gottmann's *Megalopolis, The Urbanized Northeastern Seaboard of the United States* where two different areas, one for 1950 and another, larger one for 1960, are shown.[1] Consequently, if a Great Lakes megalopolis already exists it would have boundaries covering a larger area today than before, and would be expected to cover a still larger area as it grows in the future.

Since an examination of this growth in area would complicate matters considerably at the present stage, two constant areas have been defined for the purposes of comparison; in the eastern megalopolis (EM) it is the 1960 megalopolis after Gottmann which is usually taken into consideration; for the Great Lakes megalopolis (GLM) a preliminary definition, the result of the present study, has been adopted (figs. 1b and 1c, and also figs. 4 and 5).

The phenomena considered in the definition of the Great Lakes megalopolis are the following:

- Total urban population (Great Lakes megalopolis 1840, 1850, 1870, 1960, eastern megalopolis 1790, 1810, 1830,1930)
- Total population of metropolitan areas (Great Lakes megalopolis 1960, eastern megalopolis 1930)
- Population densities, 1910, 1930, 1950, 1960
- Population changes by Standard Metropolitan Statistical Areas (SMSA) for 1940-1950, 1950-1960
- Population trends by counties 1940-1960
- Percent population change by counties 1950-1960
- Population size by SMSA's 1960

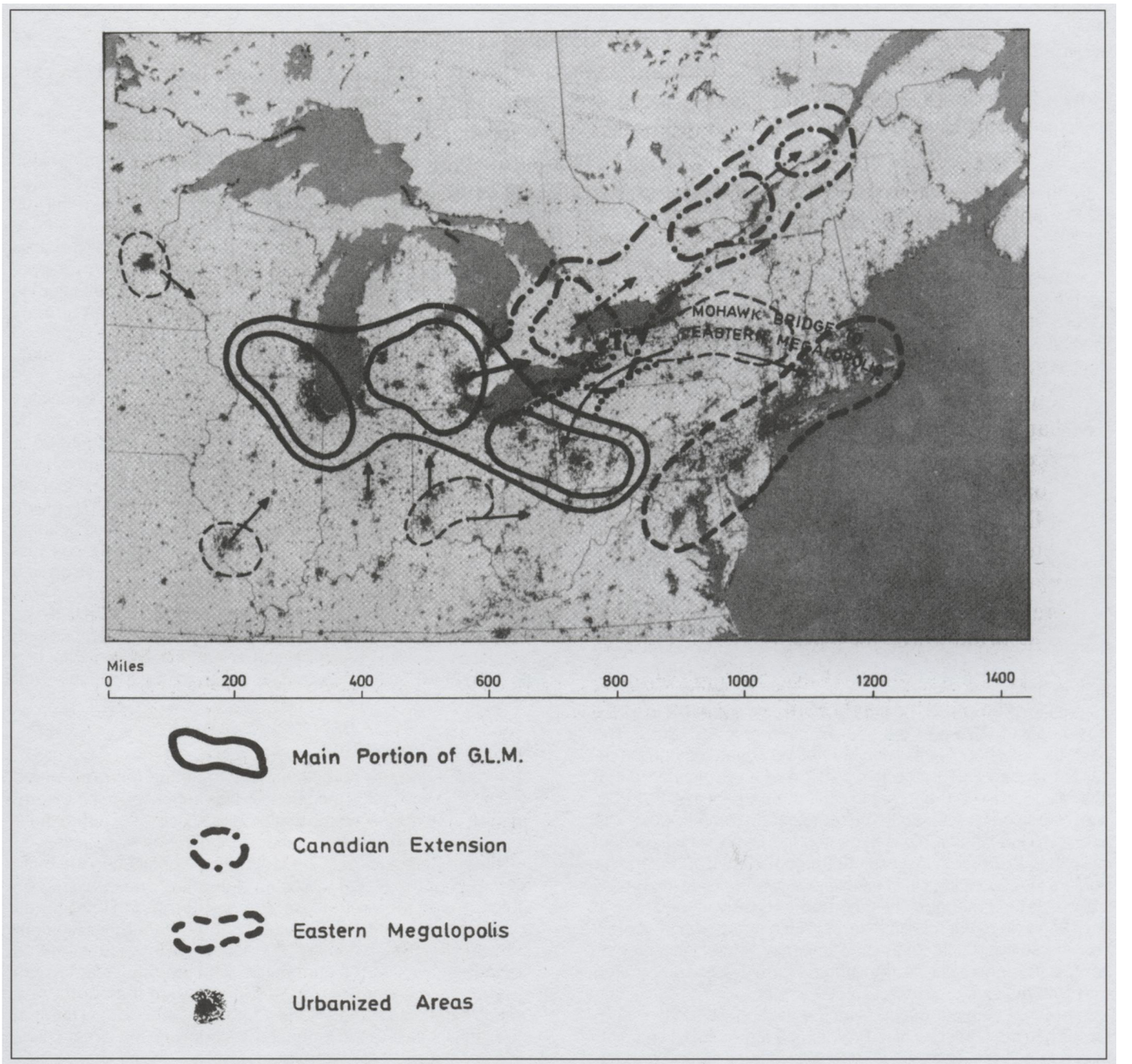


Fig. 1b: A preliminary definition of the Great Lakes megalopolis.

- Population size order by SMSA's and urban counties 1960
- Percentage of urban population by counties 1960
- Percentage of white population by SMSA's
- Median family incomes by SMSA's 1959
- Percentage of families earning more than $5,000 by counties 1949-1950
- Percentage of families earning more than $10,000 by counties 1960
- Aggregate income by SMSA's for 1960
- Percentage of employed population in manufacturing by SMSA's 1960
- Counties with metropolitan-type economies
- Value added by manufacturing in 1958 by SMSA's
- Change of commerce of U.S. ports
- Urbanized areas in 1960
- Median value of owner occupied houses by SMSA's 1960
- Major highway network 1964
- Rerouting of the rail traffic on the new "Penn Central" railway system.

The analysis of the above phenomena helped in understanding the character of the area within which the Great Lakes megalopolis is supposed to be emerging and further in assessing the relative degree of development of the Great Lakes and the eastern megalopolises. By comparing the results of overlapping between the maps representing the phenomena earlier enumerated, a first definition of the boundaries for the suspected megalopolis was arrived at, and a number of its characteristics could be analyzed and understood in a first approximation.

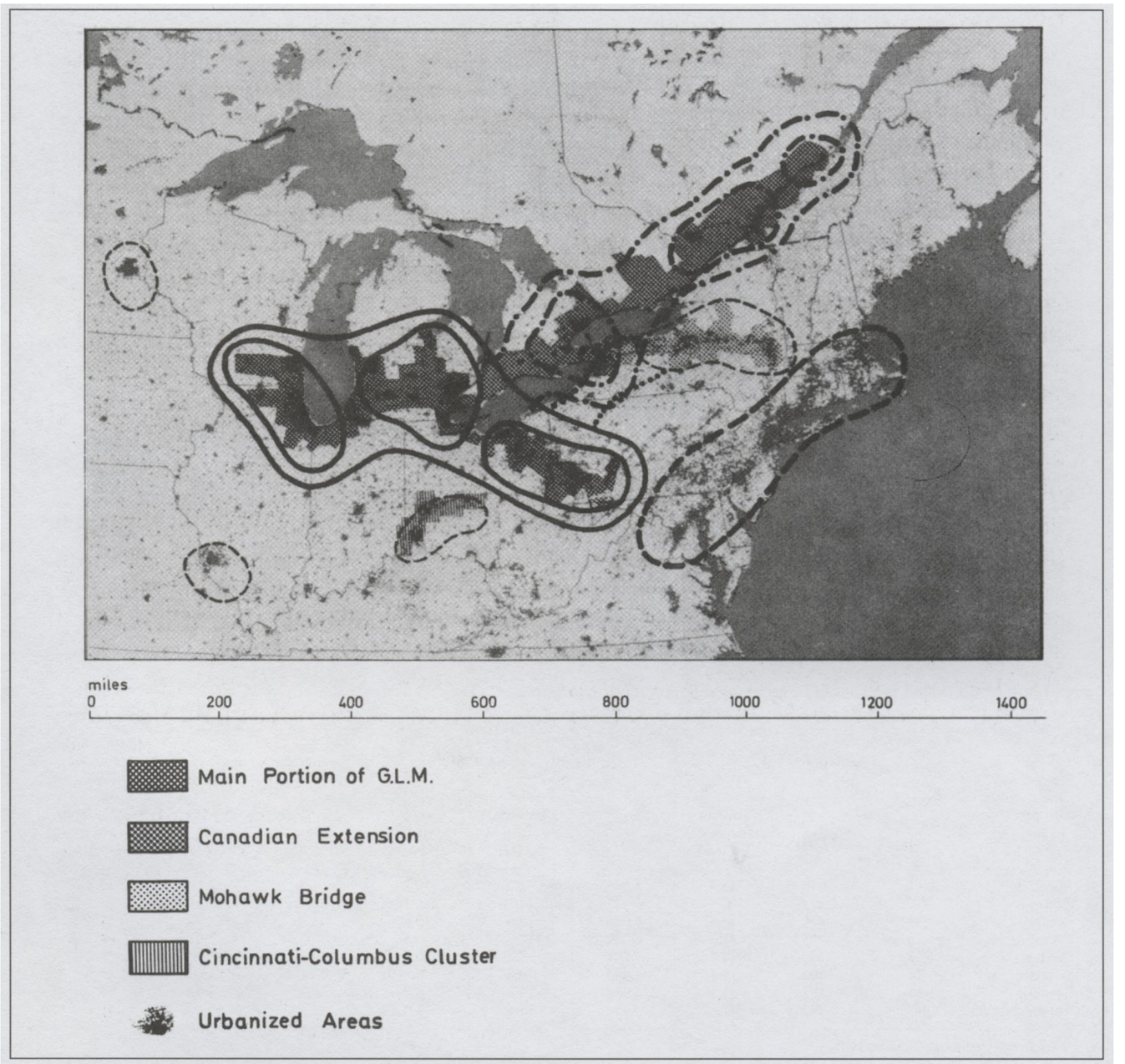


Fig. 1c: Tentative boundaries of the Great Lakes megalopolis and its probable extensions.

A comparative analysis of urbanized areas

Furthermore, in view of the wealth of statistical material available for "urbanized areas" in the United States, as defined by the U. S. Bureau of the Census, a tabulation of the more characteristic data by urbanized areas was compiled and is reproduced here. For comparison, table 1 shows data for 1960 for the seven most populated urbanized areas of the Great Lakes and eastern megalopolis regions.

The seven largest urbanized areas in the Canadian extension of the Great Lakes megalopolis are listed in table 2. For Canada we used the nearest equivalent-census metropolitan areas.

A study of figure 2 and tables 1 and 2 permits the following conclusions:

● **Land Area:** The eastern megalopolis is 7.3 percent larger primarily due to the very large area of the New York-northeastern New Jersey urbanized area.

Table 1
Comparison of Great Lakes and eastern urbanized areas by selected characteristics

URBANIZED AREAS*	Area	Population, 1960						Family income, 1959			Other selected socioeconomic characteristics					Housing units, 1960		Occupied housing units			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Land Area (Sq. Miles)	U. S. Rank	Total (1,000)	Per Sq. Mile	% Increase, 1950–1960	% Nonwhite	Median Age Years	Median Income ($)	% Under $3,000	% $10,000 And Over	Aggregate Income In 1959 Of Population, 1960 ($ Million)	Median School Years Completed 25 Years Old And Over, 1960	% Unemployment Of Civilian Labor Force, 1960	% Of Total Employment In Mfg., 1960	% Of Total Mfg. Employment In Durable Goods Industries, 1960	% In One Unit Structures	% In Structures Built In 1950 Or Later	% With Air Conditioning	% With Automobile	Median Value Of Owner Occupied Units ($)	Median Gross Rent Of Renter Occupied Units ($ Monthly)
GREAT LAKES																					
Chicago–Northwestern Indiana	959.8	3	5,959	6,209	21.1	16.1	31.3	7,292	10.7	25.7	14,572	10.8	4.4	35.2	63.7	43.1	22.1	14.7	70.4	18,600	89
Detroit	731.9	5	3,538	4,834	28.6	15.8	29.6	6,838	13.6	22.0	7,621	10.8	7.9	40.7	82.4	74.3	28.9	6.8	82.1	13,300	79
Pittsburgh	525.0	9	1,804	3,437	17.7	8.1	32.4	6,106	13.8	17.1	3,667	10.8	6.8	35.9	80.6	71.7	20.5	6.8	74.1	12,900	69
Cleveland	586.7	10	1,785	3,042	29.0	14.7	31.4	6,967	11,4	22.4	4,154	11.1	5.3	39.4	72.8	62.6	25.2	8.9	79.8	17,700	84
Milwaukee	392.0	14	1,150	2,934	38.6	5.8	30.1	7,036	9.4	21.0	2,636	11.2	3.9	40.8	73.1	54.7	28.4	7.8	77.9	16,500	89
Buffalo	160.2	16	1,054	6,582	17.7	8.1	31.2	6,394	12.6	16.8	2,148	10.4	6.9	38.4	64.0	49.3	20.6	5.1	76.3	14,800	74
Cincinnati	242.3	17	994	4,101	22.2	13.0	30.5	6,317	15.1	18.4	2,108	10.3	4.7	32.9	56.3	54.0	21.0	10.0	72.6	15,500	68
Total/Average	3,597.9		16,284	4,526	24.0	13.6	30.9	6,889†	12.0	22.2	36,906	10.6	5.7	37.3	69.8	56.8	24.0	10.1	75.3	16,000	83
EAST COAST																					
New York–Northeastern New Jersey	1,891.5	1	14,115	7,462	14.8	11.3	33.9	6,675	12.4	22.7	34,139	10.6	4.7	29.2	43.1	31.8	19.5	15.0	58.6	17,800	76
Philadelphia	596.7	4	3,635	6,092	24.4	17.5	32.0	6,437	13.2	19.2	7,632	10.4	5.2	35.0	49.1	79.5	21.8	18.9	68.7	10,700	69
Boston	515.8	7	2,413	4,679	8.0	3.5	32.3	6,622	11.3	20.6	5,365	12.1	3.8	28.8	52.9	43.9	14.0	5.8	71.7	15,800	82
Washington	340.7	8	1,808	5,308	40.5	25.9	29.4	7,603	10.3	30.7	4,615	12.3	2.9	7.6	36.7	56.5	35.6	25.7	73.5	17,100	88
Baltimore	220.3	12	1,419	6,441	22.1	24.4	30.1	6,319	14.3	17.2	2,805	9.5	5.6	31.5	63.0	75.9	26.0	12.5	69.0	10,500	77
Providence–Pawtucket R.I.–Mass.	188.0	26	660	3,508	13.1	2.2	33.2	5.688	15.7	12.4	1,229	10.1	5.1	40.9	60.2	49.0	16.5	4.8	78.6	12,300	62
Norfolk–Portsmouth, Va.	108.6	36	508	4,676	31.9	26.5	24.7	5,075	27.1	11.1	835	10.6	5.1	16.2	64.6	72.2	35.6	14.1	73.5	11,000	72
Total/Average	3,861.6		24,558	6,360	17.7	13.4	32.7	6,624†	12.6	21.7	56,620	10.5	4.6	26.5	50.7	45.1	21.0	14.9	65.1	15,200	76

Source: U. S. Dept. of Commerce, Bureau of the Census, *County and City Data Book, 1962.*
* Only the seven largest U.S. urbanized areas of each included.
† Average family incomes ($): Great Lakes 8,887; East Coast 8,959. Per capita income ($): Great Lakes 2,266; East Coast 2,306.

Table 2
Comparison of Canadian metropolitan areas by selected characteristics

Census metropolitan areas*	Population, 1961			Family income, 1961			Occupied dwellings, 1961		Manufacturing employment, 1961
	Canadian rank	Total (1,000)	Percent increase 1951–61	Average income ($)	Percent under $3,000	Percent $10,000 and over	Percent single detached	Percent with automobile	Percent labor force in manufacturing
Montreal	1	2,110	43.3	6,046	17.2	10.9	19.5	54.1	32.4
Toronto	2	1,824	50.7	6,542	14.1	12.1	55.7	72.9	32.3
Ottawa	5	430	46.9	6,643	12.6	13.0	48.3	72.9	13.2
Hamilton	6	395	41.0	6,030	14.7	8.5	73.0	77.0	46.3
Quebec	7	358	29.4	5,801	19.2	10.2	29.2	55:2	20.7
Windsor	10	193	18.2	5,384	20.6	6.7	75.2	73.6	43.1
London	12	181	40.6	5,985	14.4	8.5	66.9	76.3	27.7
Total/Average		5,491	43.6	6,189	15.7	11.0	42.1	65.1	31.4

Source: Census of Canada, 1961.
* Based on areas defined for the 1961 Census; only the seven largest areas in the Great Lakes vicinity included.

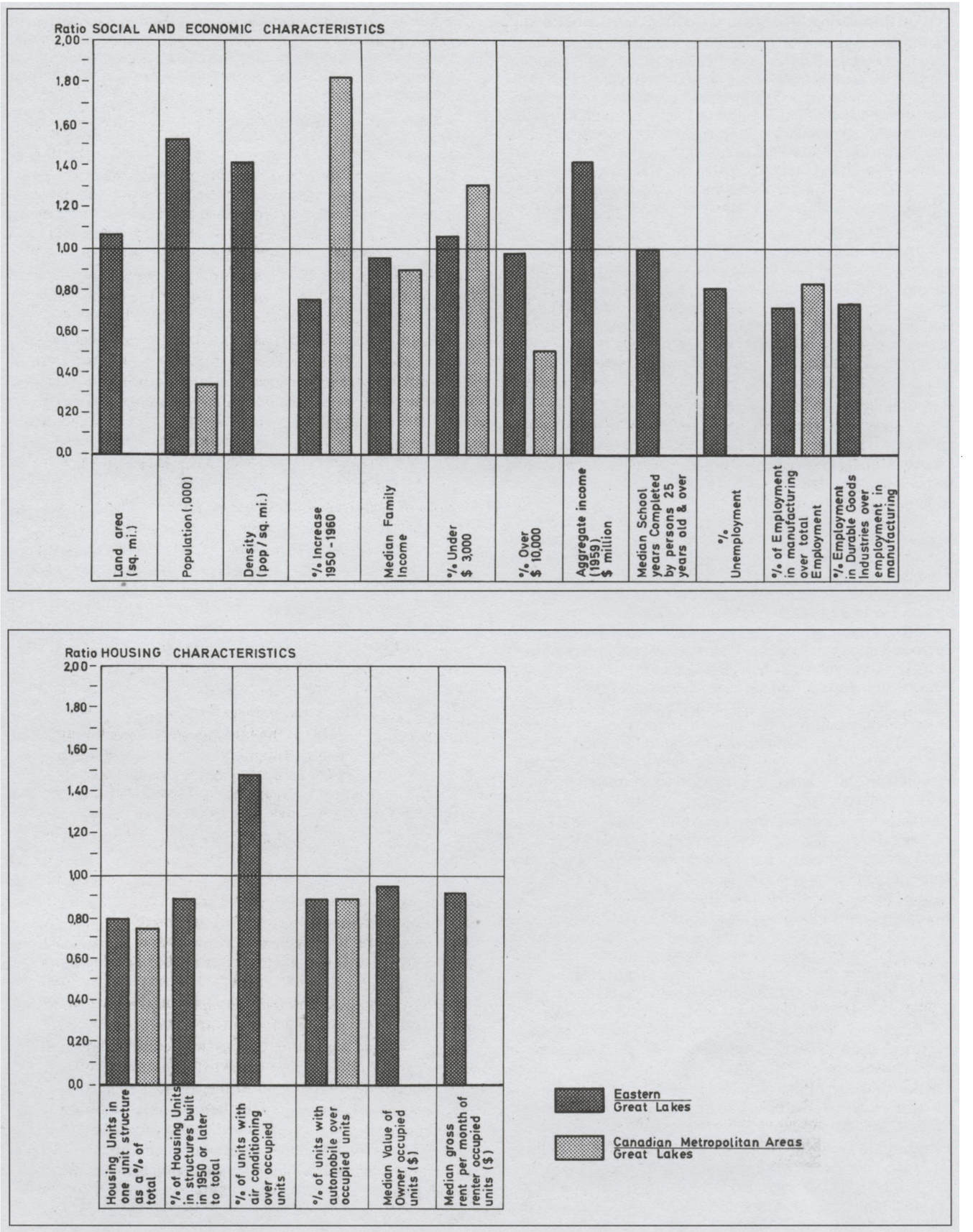


Fig. 2: Comparison of selected social, ecological and housing chracteristics among major urbanized areas.

● **Total Population:** The eastern megalopolis is considerably more populous, having 24.9 million inhabitants compared to 16.3 million in the Great Lakes megalopolis, which in turn has three times the population of its Canadian extension. The distribution of population among urbanized areas is much more uneven in the eastern megalopolis; here New York surpasses the rest and the second largest city, Philadelphia, is one-third its size. Within the Great Lakes megalopolis, Detroit is only 40 percent smaller than Chicago. Within the Canadian extension Montreal is only 17 percent larger than Toronto but inequalities between these cities and the remaining census metropolitan areas are very great.

● **Population Density:** Densities are higher in the eastern megalopolis, exceeding those of the Great Lakes by about 40 percent (6,360 inhabitants per square mile as compared with 4,526, respectively). Density differs among the various urbanized areas, especially in the Great Lakes megalopolis where it differs considerably. Buffalo, with the highest density in the Great Lakes megalopolis, comes second to New York, which has the highest density of all.

● **Population Growth 1950-1960:** A considerably more rapid overall population increase is noticed in the Great Lakes megalopolis, 24.0 percent versus 17.7 percent for the eastern megalopolis. More uniform figures are found in the Great Lakes megalopolis, whereas the spread in the eastern megalopolis is larger. The largest figure, 40.5 percent, is found in Washington; the lowest, 8.0 percent, in Boston – both in the eastern megalopolis. In the Great Lakes megalopolis the highest percentage increase, that for Milwaukee, is only slightly lower than that for Washington; the next highest, those for Cleveland and Detroit, are higher than all eastern megalopolis rates of growth except those for Washington and Norfolk. Since Milwaukee can be regarded as a fringe area of the Chicago complex, this means that Cleveland and Detroit are the fastest growing urbanized areas of the Great Lakes megalopolis. It may be characteristic that the two *urbanized* areas with the lowest increase, Pittsburgh and Buffalo, show a percentage of increase exactly equal to the average for the eastern megalopolis. In other words, the lowest percentages of increase in the Great Lakes megalopolis (Buffalo and Pittsburgh) are higher than those of New York, Providence, and Boston, or the entire northern section of the eastern megalopolis.

Canadian increases surpass even those of the Great Lakes megalopolis. The highest (50.7 percent) is in Toronto, a fact of particular importance for the future development of the Canadian extension. Only Windsor, across the river from Detroit, displays a relatively low rate of growth in population.

● **Median family income:** This is approximately on the same level in both megalopolitan areas, being only slightly higher in the Great Lakes. Average family and per capita incomes, however, are higher on the east coast. The distribution among the various urbanized areas of the eastern megalopolis has a greater spread of values than occurs in the Great Lakes megalopolis. Milwaukee and Detroit, with the second and third highest median family incomes after Chicago, surpass all urbanized areas of the east coast except Washington.

In the Canadian extension, average family incomes are lower but evenly distributed among census metropolitan areas, as in the Great Lakes megalopolis.

● **Aggregate income:** Taking into consideration that family or per capita incomes are roughly on the same level although population is considerably higher in the eastern megalopolis, it follows that aggregate income is considerably higher there – by about 55 percent. New York has almost as much aggregate income as all seven urbanized areas of the Great Lakes.

● **Median school years:** Median exposure to education is at about the same level in both areas. There are no important differences among the various urbanized areas, except that Baltimore is considerably lower and Boston and Washington considerably higher than the eastern megalopolis average.

● **Employment structure and unemployment:** In 1960, unemployment in the Great Lakes was more than 20 percent higher, with the highest percentage in Detroit, followed by Buffalo and Pittsburgh. All exceeded Baltimore, which has the highest rate for the eastern megalopolis. This may be related to the considerably higher percentage of manufacturing employment, particularly in durable goods, which is found in the Great Lakes area. Such activities are more vulnerable to recession and other structural changes such as automation.

However, the correlation is less apparent when individual urbanized areas are examined because of special factors influencing each case.

Employment in manufacturing is considerably higher in the Great Lakes megalopolis (37.3 percent) than in the eastern megalopolis (26.5 percent). Of this, 69.3 percent in the Great Lakes and 50.7 percent on the East Coast is in durable goods. Detroit has the highest percentage of manufacturing employment in durable goods (82.4 percent) while Washington has only 7.6 percent of total employment in manufacturing.

Canadian figures, which refer only to percentage of employment in manufacturing (31.4 percent) fall between those for the Great Lakes and the East Coast. The highest percentages are in Hamilton and Windsor, near Detroit.

● **Housing Units:** In view of population changes during recent decades, it is only natural that the percentage of new houses is higher in the Great Lakes than in the eastern megalopolis. Differences between urbanized areas are not marked in the Great Lakes, where Detroit and Milwaukee head the list, but are pronounced on the East Coast, where Boston has only 14 percent of new houses compared to 35.6 percent for Washington. There is a close relationship between age of housing and rates of population increase.

The percentage of single-unit detached houses, an index of the suburban type of urban development, is considerably higher in the Great Lakes megalopolis than in the East (56.8 percent and 45.1 percent, respectively), and lowest (42.1 percent) in the Canadian extension. Nevertheless, the urbanized areas with highest percentages of single-unit detached houses are found in the eastern megalopolis (Philadelphia 79.5 percent, Baltimore 75.9 percent). Detroit is the highest (74.3 percent) in the Great Lakes. The Canadian census metropolitan areas display great divergences, ranging from 19.5 percent (Montreal) to 75.2 percent (Windsor).

● **Occupied units with air conditioning:** The percentage of occupied housing units with air conditioning is appreciably higher in the East (14.9 percent compared to 10.1 percent for the Great Lakes). Within each megalopolis, the percentage for each urbanized area appears to be directly dependent on climatic conditions and income distribution. Divergencies within the eastern megalopolis are greater than on the Great Lakes.

● **Occupied units with automobile:** The Great Lakes account for a higher percentage of occupied units with automobile than the eastern megalopolis (75.3 percent compared to 65.1 percent), Detroit being first with 82.0 percent, the highest in the United States. The highest percentage on the East Coast is in Providence. Although the location of the automobile industry seems to have affected these percentages in the various urbanized areas, especially in the Great Lakes megalopolis, other differences may be due to variables such as the existence of rapid transit systems and the suburban character of each.

The Canadian extension of the Great Lakes megalopolis has

the same percentage as the eastern megalopolis (65.1 percent), but metropolitan areas nearer the Great Lakes display percentages very close to the Great Lakes average.

- **Value and rents of housing units:** In both of these variables the Great Lakes megalopolis exceeds the East Coast by a small margin. As far as the distribution among the various urbanized areas is concerned, there appears to be a fair amount of correlation between the two variables. However, there are important exceptions probably due to the supply and demand situation or other special factors. Overall, there is a greater spread in the eastern megalopolis than in the Great Lakes.
- **Change in population densities 1950-1960:** As figure 3 shows, densities within the two megalopolitan areas are falling, a phenomenon which has been ascertained in a number of other studies. The decrease in population densities is considerably faster in the eastern megalopolis," which has the highest overall density. Apparently an equalization process is taking place.

The above-mentioned comparisons of urbanized areas within the Great Lakes megalopolis and the eastern megalopolis support the view that the Great Lakes megalopolis is in a less "advanced" state of development than the eastern megalopolis, but is growing more rapidly in a way likely to considerably reduce the gap between them in the near future.

Preliminary definition

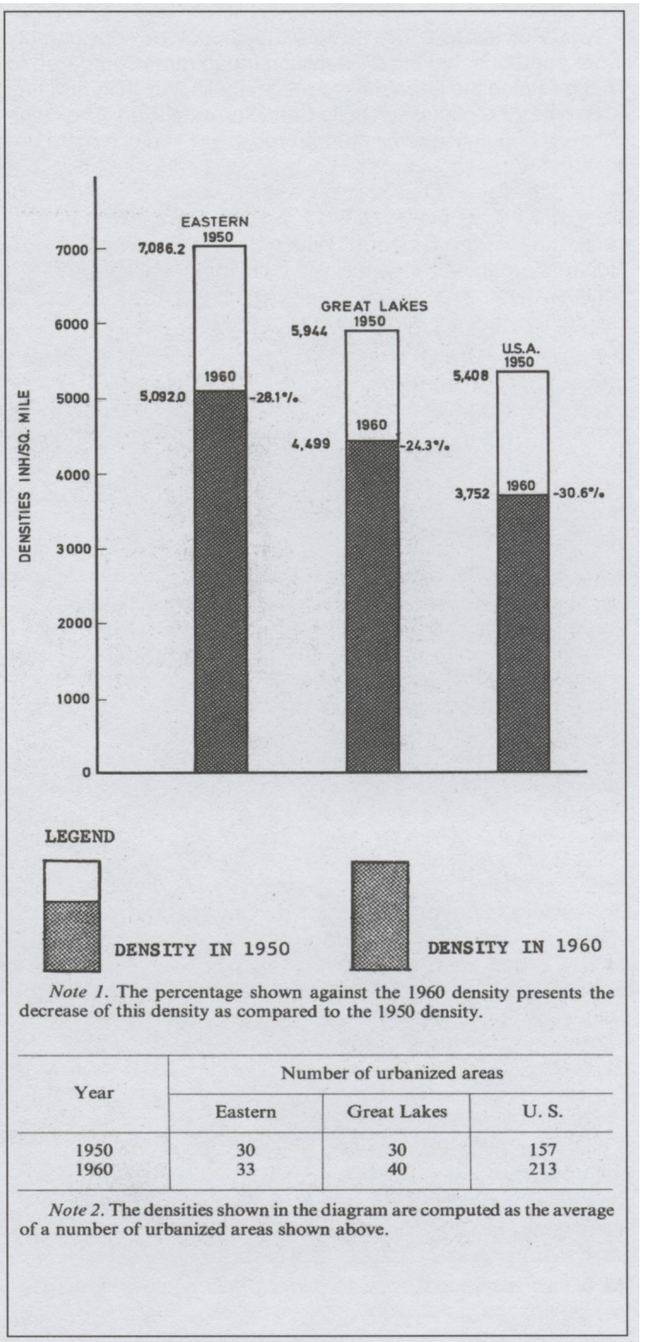
A comparison of the various phenomena considered shows the formation of certain clusters within the Great Lakes megalopolis, with three major clusters centered around Chicago-Milwaukee, Detroit, and Cleveland-Pittsburgh. These three major clusters are considered as forming the main portion of the Great Lakes megalopolis.

Those phenomena for which we have data for Canada consistently show a Canadian extension of the main portion of the Great Lakes megalopolis north of the Great Lakes, via London (Ontario), toward the Toronto, Montreal-Ottawa, and Quebec clusters.

A number of clusters to the south, southwest, and west of the Great Lakes megalopolis appear more or less frequently on a number of maps representing the phenomena considered; of these, the Cincinnati-Dayton-Columbus cluster appears more consistently and more prominently. It has been shown as a cluster related to the Great Lakes megalopolis, although it is not possible to predict whether this cluster, which is growing faster than the three clusters within the main portion of the Great Lakes megalopolis, will be directly connected.

The Mohawk "bridge" appears prominently on a number of maps. In view of the expected rapid development of both the eastern megalopolis and the Great Lakes megalopolis, at least one bridge connecting these two areas is likely to develop: a connection south of Lake Erie from Cleveland to Buffalo, Albany, Massachusetts, and Connecticut. This link will probably be strengthened by the increasing importance of the Canadian extension of the Great Lakes megalopolis, especially in the rapidly growing Toronto-Hamilton-Buffalo cluster. The Buffalo-Albany arc, therefore, will offer two different connections westward, one toward Toronto into Canada north of the lakes and another one south of the lakes toward Cleveland and the main portion of the Great Lakes megalopolis (fig. 4).

The exact delimitations of the areas to be included in the Great Lakes megalopolis and its extensions cannot be determined at this point. Many more detailed studies will be needed before such a precise delimitation could be reached. Still, to permit statistical comparisons, a provisional delimitation has been attempted (fig. 5).



Note 1. The percentage shown against the 1960 density presents the decrease of this density as compared to the 1950 density.

Year	Number of urbanized areas		
	Eastern	Great Lakes	U. S.
1950	30	30	157
1960	33	40	213

Note 2. The densities shown in the diagram are computed as the average of a number of urbanized areas shown above.

Fig. 3: Change in densities of urbanized areas 1950 to 1960.

Comparative analysis of growth patterns

The relative growth during the last 50 years of the main clusters that form the Great Lakes and eastern megalopolises is shown in table 3.

The Great Lakes megalopolis has grown at a much more rapid pace (2.15 percent) than the eastern megalopolis for which the average yearly growth rate is 1.52 percent; in other words, the population of the Great Lakes megalopolis has trebled in half a century while that of the eastern megalopolis has slightly more than doubled.

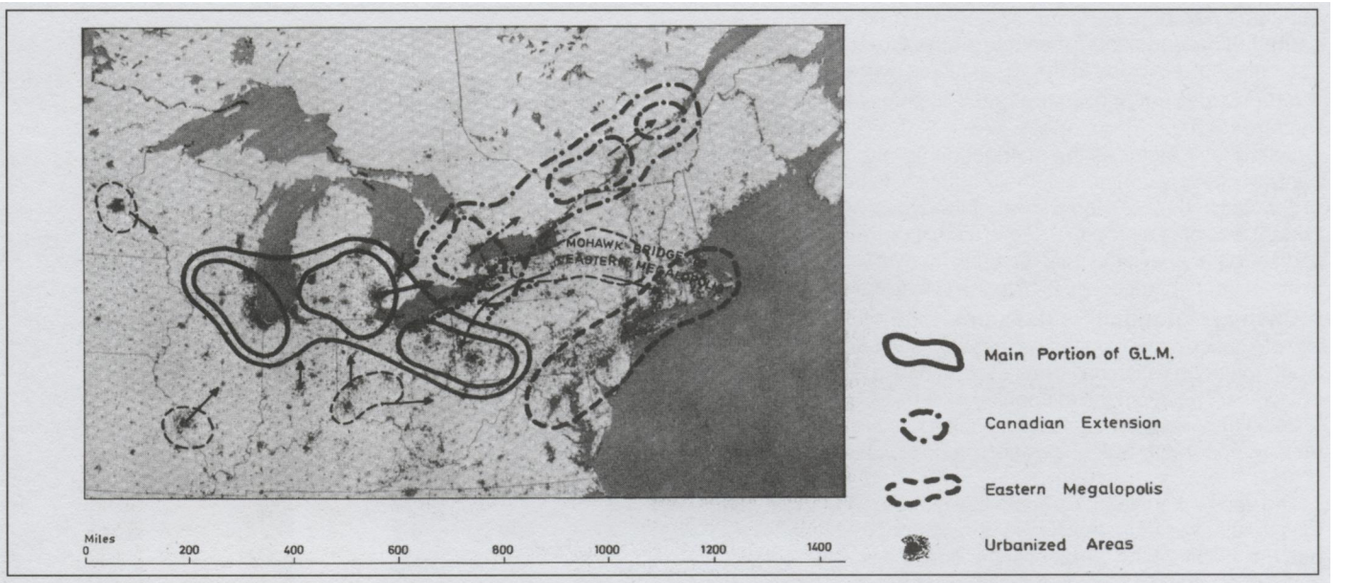


Fig. 4: A preliminary definition of the Great Lakes megalopolis.

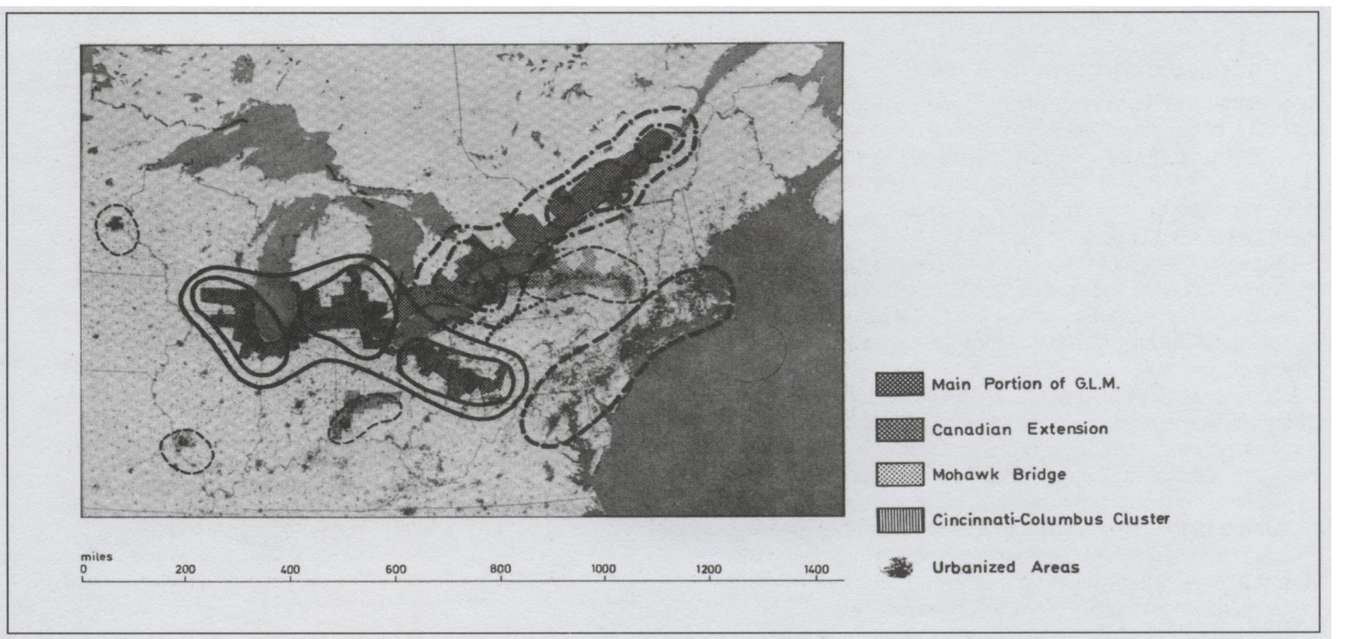


Fig. 5: Tentative boundaries of the Great Lakes megalopolis and its probable extensions.

Table 3
Comparison of populaton growth between the Great Lakes and Eastern Megalopolises, 1910-1960

	1910	1920	1930	1940	1950	1960
Chicago area	3,463	4,494	6,053	6,293	7,254	8,903
Detroit area	1,304	2,263	3,674	3,973	4,983	6,232
Cleveland–Pittsburgh area	2,737	3,710	5,073	5,211	5,722	6,558
Great Lakes	7,504	10,467	14,800	15,477	17,959	21,693
Boston area	3,106	3,561	4,047	4,316	4,679	5,064
New York area	7,701	9,375	11,947	12,991	14,488	16,725
Washington–Philadelphia area	4,378	5,266	6,528	7,132	8,594	10,493
East Coast	15,185	18,202	22,522	24,439	27,761	32,282

Source: U.S. Department of Commerce, Bureau of the Census.

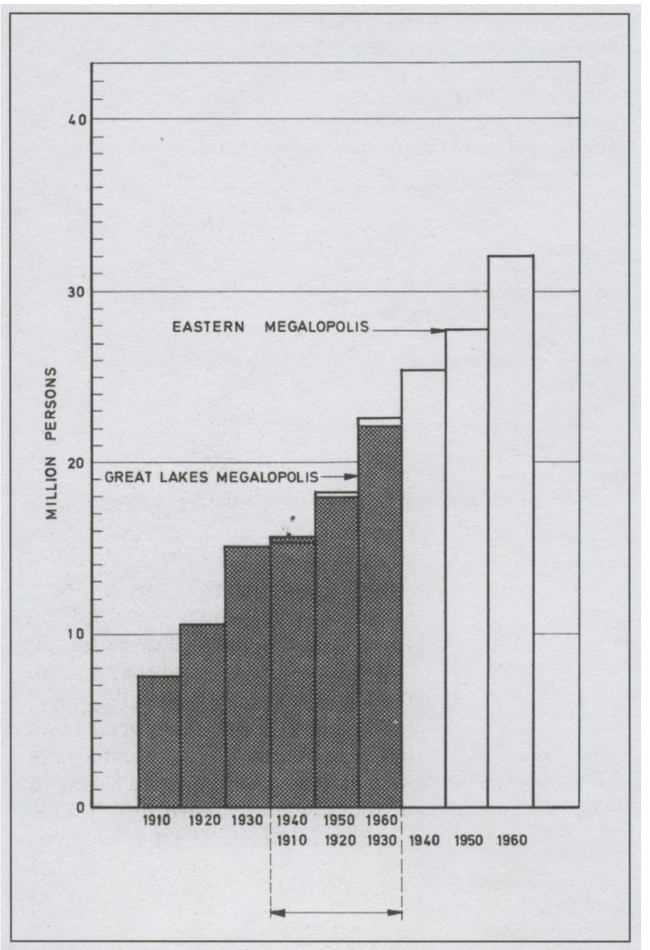


Fig. 6: Thirty-year time lag.

These statistics (fig. 6) also shows the similarity of figures for the Great Lakes megalopolis and eastern megalopolis taking into consideration the 30-year time lag which the analysis has shown (fig. 7). The time lag hypothesis, therefore, is positively confirmed by these as far as the variable "population" is concerned.

If growth rates are studied in more detail, it will be seen that the Great Lakes megalopolis has grown faster than the eastern one in every decade except 1930-1940, the depression decade. Among its three main clusters the one with the highest increase during the two last decades is that around Detroit. In the eastern megalopolis the corresponding position is occupied by the Washington-Philadelphia cluster in 1940-1950 and the New York cluster in 1950-1960.

The analysis has also shown that the time lag between comparable phenomena for the two areas has been considerably greater in the remote past. Initially it must have been greater than 50 years, then it progressively decreased to its present lag of about 30 years for most variables. In general, the Great Lakes megalopolis constitutes a younger version of the eastern megalopolis which, however, is growing more quickly than the eastern megalopolis.

The younger age of the Great Lakes megalopolis can be seen in the comparatively long distances separating its three main clusters. The more advanced eastern megalopolis consists of much closer clusters, so that the distances between them either disappear for certain variables or, for others, are quite small. As the Great Lakes megalopolis grows, its clusters will spread outward from their nuclei and their links will join as in the case of the eastern megalopolis.

This decrease of the time lag in the future is also anticipated by other studies, including the projections for the main regions of the United States made by the U. S. Bureau of the Census and various authors. According to them, the population of the Great Lakes area is expected to catch up with the mid-Atlantic region (covering the eastern megalopolis) by the end of this century or earlier.

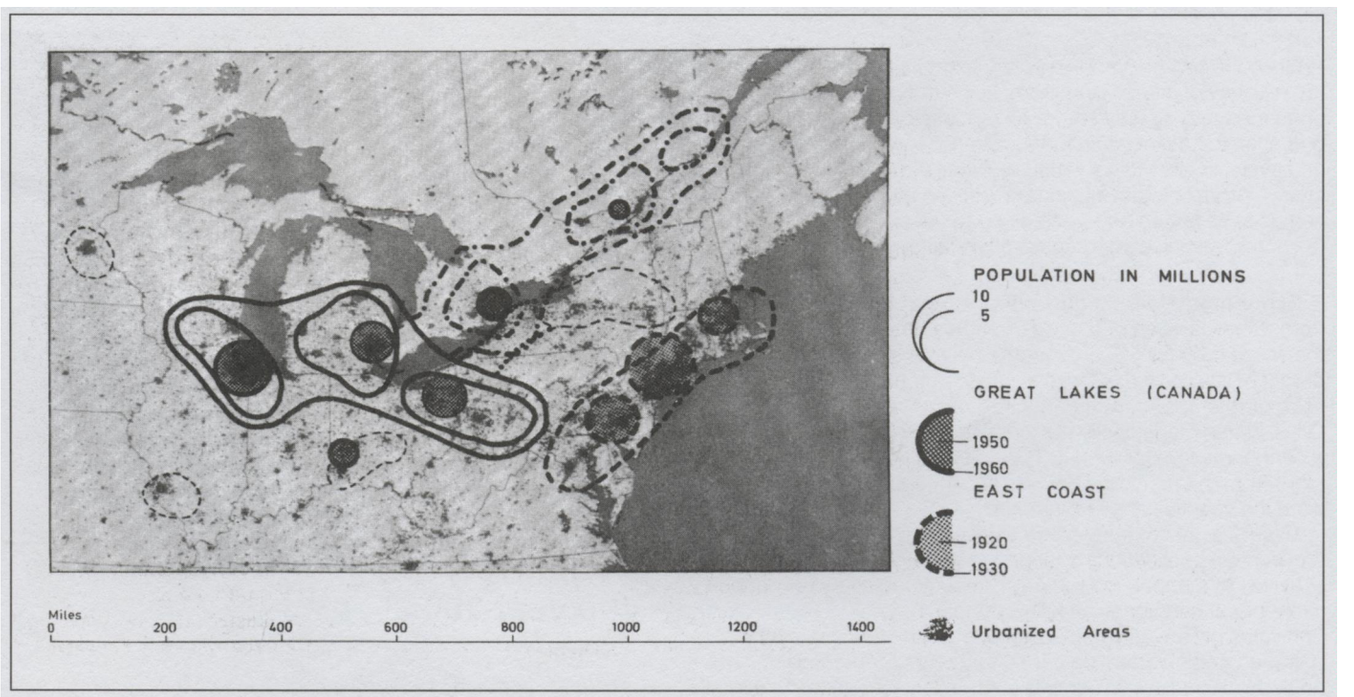


Fig. 7: Population by major metropolitan clusters: Great Lakes 1950-1960; Canadian 1941-1961; Eastern 1920-1930.

Towards a final definition of the Great Lakes Megalopolis

● **Methodology used:** Following the preliminary definition of the boundaries of the Great Lakes megalopolis referred to above, work is continuing to establish a final definition of the Great Lakes megalopolis at its present stage of development.

The method that was judged most appropriate for this purpose was the formal statistical technique known as Principal Component Analysis, a powerful statistical tool suitable for multivariate situations, that is, for cases where a large number of characteristics (i.e., variables) describe the units of an aggregate. The main advantage of this method consists in reducing the number of variables available to a limited number of components (or basic factors) capable of replacing all variables considered in describing the total phenomenon.

Each of these components contains, so to speak, that part of each variable which is common to all variables; conversely seen, this common part is due to the existence of the component. Moreover, each component accounts for a different part of each variable and has the important property of being orthogonal to, i.e., completely independent from, the others.

Each component is a linear function of all variables considered, each variable entering the equation with a different coefficient; the coefficients, different for each component, are also estimated by the analysis and can be viewed as weights assigned to the original variables to produce the components.

The extraction of the components is done so that the first component extracted accounts for the largest possible amount of total variation contained in the original variables, the second component accounts for the second largest amount of total variation, and so on in descending order so that in practice in most applications a few components are extracted, say 3, 4, or 6, and retained if together they account for a large part of total variation, say 60 percent, 70 percent, or more, while a good many others are ignored since each of the remainder accounts for only a negligible proportion of the total variation. In this way, from the mass of data contained in as many variables as 30 or 50 or even more, we end up with a manageable small number of basic components which adequately represent the whole body of original data.

Once the basic components are extracted, one is faced with the difficulty of interpreting them, since they do not have a concrete meaning as they stand. As a guide for their interpretation one uses the association that exists between each component and every single original variable. Those variables which show a strong correlation with the component considered give an indication as to its nature and enable one to describe its sociological, economic, social, demographic, physical, or other meaning.

● **Experimental application of principal Component Analysis:** For purposes of testing both the computer program and the whole process of Component Analysis, an experimental application was carried out with a limited number of variables. The area of this application consisted of the main portion of the Great Lakes megalopolis (as tentatively defined in figure 8) and a peripheral zone around it. The units that were judged convenient from the point of view of both scale and data availability were the counties; their number in this area totalled 246.

Twenty-eight variables were selected from the 1960 population census publications covering many aspects of the life and activities of a populated region. These variables were grouped into broader categories as follows (table 4):

The values of the 28 variables for each of the 246 counties were gathered and punched on cards, for computer processing. The analysis yielded seven components, which accounted for a total of 82 percent of the total variance contained in the original 28 variables. The first three components accounted for two-thirds of the total variance as follows (table 5):

Table 4
Variables grouped into broader categories

Category	Number of variables
Population size and structure	8
Population change	4
Socioeconomic level of population	4
Housing conditions	4
Employment characteristics	3
Education	2
Land	3

Table 5
Cumulative percent explained by component of variance

Component	Percent of variance explained by component	Cumulative percent of variance
I	39.6	39.6
II	17.1	56.7
III	9.6	66.3

Through examination of the variables with which every component was more strongly correlated, it was possible to identify the nature of the components and attach a particular meaning to them.

Thus, Component I was strongly correlated with variables indicative of size, with indices of economic level, and with urban structure characteristics; it was, therefore, tentatively identified as an *index of urban concentration.*

Component II was mostly associated with population age and change, with unemployment, with availability of land, and with percent of persons employed outside their county of residence; it seemed to be, in fact, an *index of suburban development.*

Component III was related to farmland and changes thereof. It seemed, therefore, that it reflected agricultural activities of the counties and could, therefore, be identified as an *index of agricultural character.*

Further study of the results of this experimental application of Component Analysis is continuing, and component values computed for each county on the basis of the values for the 28 original variables are being used for cartographic work.

In addition, investigation is being carried out for the use of a technique such as cluster or similarity analysis which would result in a classification of counties into homogeneous groups with respect to the three components.

Simultaneously, the design of the final application of Component Analysis is proceeding. This involves a much greater region and a much larger number of original variables ; it is expected that, among other things, the results of this application will enable us to arrive at a much more reliable definition of the Great Lakes megalopolis.

Tentative population projections for the year 2000

General

The first approach to the problem of the Great Lakes megalopolis produced some material which has been used as a basis for

a first series of entirely tentative population projections to A.D. 2000.

The area covered by these projections was first the main portion of the Great Lakes megalopolis and then its possible extensions (figs. 4 and 5). For reasons of comparison, similar projections were shown for the eastern megalopolis.

Furthermore, projections started with the above areas but also involved possible extensions, beyond the area of the megalopolitan formations (figs. 4 and 5), extensions which are expected to come about by the year 2000.

It should be stressed that these projections are of an entirely preliminary and tentative character. Several other methods of arriving at plausible population projections for A.D. 2000 (and also for the still more remote future) can be devised; still, the method delineated here is regarded as a first attempt to give orders of magnitude for the urban population in this area in A.D. 2000.

Methodology

The method used for arriving at population projections for the year 2000 started from projections for the initial central areas. These areas have been designated A for the main portion of the Great Lakes megalopolis, B for its Canadian extension, C for the Mohawk bridge, and D for the Cincinnati-Columbus cluster, and are here referred to as Case 1) (fig. 8). Following this, three types of successive extensions in the areas concerned were considered and corresponding population projections for these extensions were calculated and added to those of the initial "central" areas.

- **Population projections for the initial central areas:** Two main findings of the analysis have been used as starting points for the population projections for the initial central areas. These are as follows:

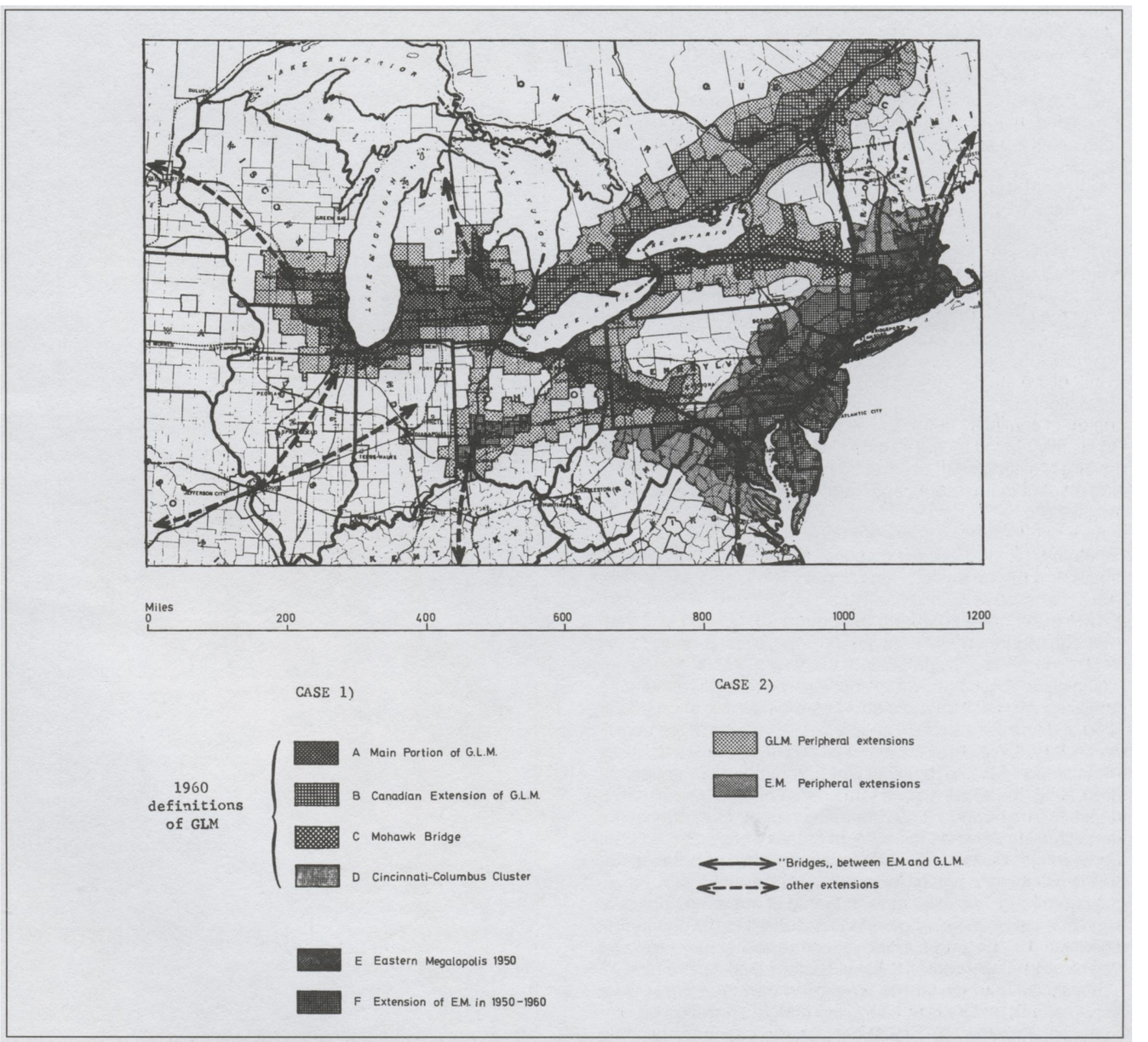


Fig. 8: Great Lakes and eastern megalopolises: 1960 definitions (Case 1) and peripheral extensions by the year 2000 (Case 2).

• A time lag of the order of 30 years seems to prevail for certain variables between the eastern megalopolis and the Great Lakes megalopolis. One should remember that these are mainly population variables (which are of interest precisely for the projections of the present report), whereas for other categories of variables the time lag is considerably shorter, if not nil or even negative. Therefore, dealing exclusively with population projections, the 30-year time lag has been taken as a basis for the years 1930 and 1960, respectively, for the eastern megalopolis and the Great Lakes megalopolis.

• In general, megalopolitan formations (or other highly urbanized formations showing certain megalopolitan characteristics) tend to show higher growth rates during their earlier phases of development whereas these growth rates tend to decrease as they approach later development stages. In this way, for example, the older eastern megalopolis grew in population at an average annual rate of 1.54 percent during 1950-1960, whereas the younger Great Lakes megalopolis grew by 2.09 percent annually during the same period; although not entirely comparable figures are available for the Canadian extension of the Great Lakes megalopolis (portion B), it seems that this still younger urbanized area is growing at a still faster rate, of the order of 2.6 or 2.7 percent annually.

On the basis of these considerations, the time lag between the eastern megalopolis and the Great Lakes megalopolis has been projected into the future, taking into account that this time lag was of the order of 50 years at the beginning of the nineteenth century; then decreased to approximately 40 years around the middle of the nineteenth century; and then further decreased, although at a slower rate, to reach the 30-year time lag for the years 1930-1960. If this concave decreasing curve is projected towards the year 2000 by plain extrapolation, it is seen to yield a time lag of the order of 25 years just before the end of the twentieth century. This means that, from the population point of view, the Great Lakes megalopolis is likely to reach, around 1985, a degree of development or maturity comparable to that of the eastern megalopolis in 1960. This refers mainly to population size and densities and does not forcibly apply to the degree of continuity between adjoining urban areas which may lag slightly behind for the Great Lakes megalopolis because of the larger distances of separation between these urban areas with respect to the more concentrated urban areas of eastern megalopolis.

As a result of these considerations, a series of curves was constructed for the various portions of the Great Lakes megalopolis and for the eastern megalopolis taken as a whole (see table 6 and fig. 9). These curves started with the average growth rate observed during the period 1950-1960 and then their subsequent evolution was determined according to the aforementioned considerations; in this way a monotonously declining curve is assumed for the eastern megalopolis whereas a curve, equally declining, but showing a maximum shortly after 1960 and an inflection point shortly before the end of the twentieth century, is assumed for the main portion of the Great Lakes megalopolis (A) in such a way as to reach, during the decade 1980-1990, the same growth rate as that of the eastern megalopolis for the period 1950-1960. This means that roughly the same time lag between the eastern megalopolis and the Great Lakes megalopolis which was shown for plain population figures is assumed to prevail for population growth rates.

A curve roughly similar in form to that of the main portion of the Great Lakes megalopolis (A) is assumed for the Canadian extension (B); this curve, however, starts at a higher level and then moves roughly parallel to the curve for A (see fig. 9, Graph 1).

In a similar manner, curves have been drawn for the smaller units C and D; that for C (the Mohawk bridge) shows an expected maximum in the 1970-1980 decade, illustrating the fact that this accretion between the two megalopolises is expected to in-

Table 6
Annual population growth rates (in percent) for the four portions of the Great Lakes megalopolis and for the eastern megalopolis: middle assumption

Areas	Averages by decade				
	Actual	Projected			
	1950–1960	1960–1970	1970–1980	1980–1990	1990–2000
GLM Portions					
A (main)	2.09	2.05	1.84	1.54	1.41
B (Canadian)	—	2.62	2.54	2.22	2.09
C (Mohawk)	1.75	2.01	2.17	1.925	1.80
D (Cincinnati)	2.46	2.38	2.17	1.88	1.54
EM	1.54	1.41	1.32	1.23	1.14

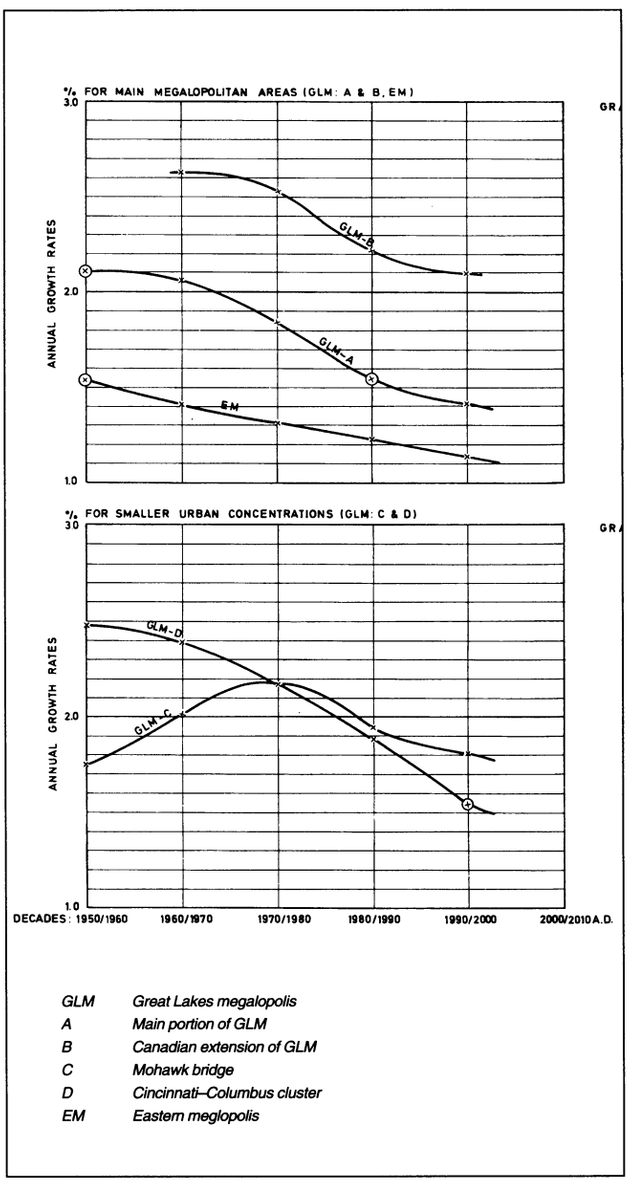


Fig. 9: Curves adopted for annual population growth rates (average by decades).

crease in importance in the near future, whereas later the curve starts declining at a pace parallel to that assumed for the other portions of the Great Lakes megalopolis. For D (the Cincinnati-Columbus cluster), a curve halfway between those for portions A and B has been assumed which reaches the 1950-1960 levels of growth rate for the eastern megalopolis during the last decade of the twentieth century.

It is on the basis of these curves for growth rates that population projections for the four portions of the Great Lakes megalopolis and for the eastern megalopolis in its entirety have been calculated by decades until the year 2000 (see table 6).

● **Peripheral extensions of the initial areas:** From Gottmann's study it becomes apparent that the eastern megalopolis has grown considerably in area in the period between 1950 and 1960 (see E and F in fig. 8). On the basis of this observation it has been assumed that the various portions of the Great Lakes megalopolis are also likely to grow further in area with time.

Based on a time lag of approximately 25 years by the end of this century as discussed above, it has been assumed, for the purposes of the present paper, that the extent of the four Great Lakes megalopolis portions (A-D in fig. 8) will represent the true extension of megalopolitan formations in the Great Lakes megalopolis area around 1985. During the period from 1985 to the year 2000, the four portions of the Great Lakes megalopolis are then assumed to grow peripherally in a way roughly similar to that observed for the eastern megalopolis 1950-1960 period. Because, however, the distances between the main clusters or urban areas in the Great Lakes megalopolis area are larger than those of the eastern megalopolis, it has been assumed that these extensions will proceed at a slightly slower rate.

These extensions (as far as area is concerned) are shown in figure 8 and are referred to here as Case 2). As far as the corresponding population is concerned, the figures for the eastern megalopolis in the 1950-1960 period have been taken as a basis. The figures for the eastern megalopolis show that in 1950 the population in the peripheral area of growth F (see fig. 8) was 10.0 percent that of the inner area E, whereas in 1960 it was 10.6 percent that of the inner area E.

On the basis of these percentages and certain considerations about differential growth rates by regions, figures ranging between 8 and 15 percent for the population increase in these peripheral areas have been assumed for the various portions of the Great Lakes megalopolis and figures ranging between 5.5 and 13 percent have been assumed for the peripheral areas of the eastern megalopolis for their corresponding growth in the period 1985-2000. This yielded corresponding population figures for these peripheral areas as shown in table 7.

● **Further extension by accretion:** Generally speaking, it has been assumed that the previous peripheral extensions will take the form of a zone of roughly uniform width around the initial 1960 definition of the four portions of the Great Lakes megalopolis and the possibility that other outlying major urban centers will be connected to these formations has not been considered. Since this, however, is rather likely, a further step in the population projections of the present study assumes that such outlying areas will be initially connected by rather thin "bridges" of urbanization, which will gradually increase in importance so that finally a considerably larger area may become more or less continuously connected to the Great Lakes megalopolis.

Since this process of extension by accretion, i.e., the connecting of smaller neighboring clusters to areas of the Great Lakes megalopolis as previously defined, is very difficult to esti-

Table 7
Population projections, year 2000, for the four portions of the Great Lakes megalopolis and for the eastern megalopolis for three assumptions: H (High), M (Middle), and L (Low), and for four cases of area extension

Areas	1960 (actual	In Million Inhabitants											
		2000 A.D. (projected)											
		Case 1) Central areas			Case 2) With peripheral extensions			Case 3) With further extensions by accretion					
								a) Narrow extensions			b) Wide extensions		
		H	M	L	H	M	L	H	M	L	H	M	L
GLM Portions													
A (main)	22.7	52.3	44.8	38.6	60.1	49.7	42.1	72.0	60.1	50.9	83.8	70.4	59.6
B (Canadian)	9.5	27.5	24.1	20.7	32.0	26.7	22.4	38.8	32.7	27.6	43.2	36.6	31.0
C (Mohawk)	2.5	6.3	5.5	4.7	7.3	6.1	5.1	7.8	6.4	5.3	7.8	6.4	5.3
D (Cincinnati)	2.8	7.1	6.2	5.3	8.2	6.9	5.7	8.2	6.9	5.7	8.2	6.9	5.7
GLM Total	37.5	93.2	80.6	69.3	107.6	89.4	75.3	126.8	106.1	89.5	143.0	120.3	101.6
EM Total	37.15	69.0	61.2	53.9	78.0	66.1	56.9	85.9	73.1	63.0	105.4	89.5	76.5

mate, two stages in this development have been assumed: in the first stage (Case 3a; see table 7 and fig. 10) only urban clusters lying rather close to the previous definitions of the Great Lakes megalopolis and eastern megalopolis have been assumed to become connected by accretion. These clusters are usually within 100 to 120 miles of the boundary defined for the Case 2) peripheral extensions. To give an example, they are assumed to reach as far as Indianapolis, Springfield, Peoria, and Rock Island, south and west of Chicago, for the Great Lakes megalopolis; or to Portland, Maine, or Norfolk and Richmond in Virginia, for the eastern megalopolis.

If this process of extension by accretion is assumed to take place at a faster rate, then clusters at greater distances may also become connected to the Great Lakes megalopolis and eastern megalopolis by the year 2000. This is shown in table 7 and figure 10 and is here called Case 3b. To give an idea of the extent of this wider zone, it may be mentioned that for the Great Lakes megalopolis it assumes that Minneapolis-St. Paul, St. Louis, Louisville, Huntington, and Charleston will become connected. For the eastern megalopolis it assumes an extension northwards into Maine and probably even into the eastern Canadian coast of the Atlantic, and an extension southwards into both North and South Carolina which will occur along two lines, one along the coast and the other near the foothills of the Appalachians leaving the agricultural plains inbetween relatively free from urbanization. This push towards the south, as indicated in the Ecumenopolis studies by the Athens Center of Ekistics under the City of the Future Research Project, points to a meeting of this southern extension of the eastern megalopolis with the northern extension of the Florida megalopolis (which a number of authors assume will have already taken shape by 1980) somewhere in the southern coastal area of South Carolina.

Population figures for these two cases of extension by accretion (Cases 3a and 3b), have been calculated as shown in table 7. The figures were obtained on the basis of assumptions as to

Fig. 10: Further extensions of Great Lakes megalopolis and eastern megalopolis by accretion by the year 2000 (Cases 3a and 3b).

the form of the curves for population growth rates, similar to those assumed for the initial areas of the Great Lakes megalopolis and eastern megalopolis.

● **High, middle, and low assumptions:** The calculations and figures mentioned so far refer to middle assumptions as to the pace of population growth. In view of the great margins of uncertainty connected with these projections, it has been thought wise to present three types of projections, termed "high," "middle," and "low."

A similar type of reasoning has been assumed for the high and low projections. To give an example of the ranges involved between high and low, it could be mentioned that for the main portion of the Great Lakes megalopolis high projections result in figures approximately 15 percent higher than for the middle assumptions and low projections approximately 15 percent lower than middle assumptions.

Results

The results of the projections made according to the method previously described are shown in table 7. These results are given for the three assumptions, high (H), middle (M), and low (L), and also for the four cases of area extension, i.e., Case 1 for the initial central areas only; Case 2 for their peripheral extensions; and Cases 3a and 3b, for narrower or wider extensions by accretion.

What will be the extent of the Great Lakes megalopolis by the year 2000? The answer to this question is not a simple one. Between the minimum proposed (Case 1) and low assumptions and the maximum proposed (Case 3b) and high assumptions, a wide range of intermediate possibilities can be interpolated. Theoretically, there are eight possibilities of combination of the various portions of the Great Lakes megalopolis: A, A + B, A + C, A + D, A + B + C, A + B + D, A + C + D, and A + B + C + D. Assuming the four cases of extension to apply homogeneously to all portions of the Great Lakes megalopolis, one gets 32 possibilities by multiplying the eight previous combinations by the four cases. Further, assuming high, middle, and low assumptions to apply uniformly to all areas, one obtains 96 possibilities of defining the extent of the Great Lakes megalopolis by the year 2000. Needless to say, if one assumed a differentiation in these combinations, as for example, high assumptions for a given area and low for another, the number of possible combinations would grow beyond control.

In the spirit of what has been said previously on methodology, one could assume as most likely that the true megalopolis by the year 2000 in this area will reach beyond Cases 1 and 2 and be identified with either case 3a or 3b or some intermediate case between 3a and 3b. It is therefore proposed to look at the figures given for 3a and 3b for all three assumptions, high, middle, and low, of which middle is regarded as the most probable. As far as the four portions of the Great Lakes megalopolis are concerned, the most likely assumption is that all four of them will have become firmly connected into one unified urban complex by the year 2000 with a fully megalopolitan character throughout all four portions in the sense of the megalopolis definition for the eastern megalopolis in 1960; it is even probable that many portions of the Great Lakes megalopolis will be in a much more advanced stage of development by the year 2000 than that of the 1960 eastern megalopolis.

Although quite a range of possible definitions of the extent of the Great Lakes megalopolis by the year 2000 is conceivable, the most probable definitions seem to range between Cases 3a) and 3b) for the middle assumption for the "total Great Lakes megalopolis"; the corresponding more probable populations for this probable area definition of the Great Lakes megalopolis are likely to be somewhere in the range between 106.1 and 120.3 million inhabitants versus a corresponding eastern megalopolis population somewhere between 73.1 and 89.5 million inhabitants.

The corresponding gross densities in 1960, expressed in inhabitants per hectare, were 2.64 for the eastern megalopolis and 1.60 for the total of all four portions of the Great Lakes megalopolis, with A (main portion) and D (Cincinnati-Columbus cluster) exhibiting the highest densities, i.e., 2.38 and 2.80, respectively, whereas B (Canada) and C (Mohawk) exhibited much lower densities, i.e., 0.95 and 0.87, respectively, for Case 1.

Again for Case 1 the year 2000 densities, according to middle assumptions, will roughly double (in some cases they will be slightly less than double and in some others slightly more); thus the eastern megalopolis will become 4.36, the total Great Lakes megalopolis 3.44, with 4.68 for A, 2.41 for B, 1.91 for C, and 6.20 for D. This means that these central portions of the Great Lakes megalopolis, taken as a total, will reach considerably higher densities by the year 2000 than the eastern megalopolis of 1960; actually the main portion A, which was of a slightly lower density than the eastern megalopolis in 1960, will exceed the density of the eastern megalopolis by the year 2000; it will also be seen that the "less developed" portions B and C will still show smaller densities by the year 2000 than the eastern megalopolis in 1960.

If one moves from Case 1 to Cases 2, 3a, and 3b, then the overall densities will naturally diminish. Precise density calculations are not being given in the present report because of the uncertainty of the exact area definition, especially for Cases 3a and 3b. For these cases the reduction of densities for the year 2000 with respect to Case 1 is likely to be, as a rule, of the order of 30 to 40 percent, i.e., densities for Cases 3a and 3b are likely to be roughly two-thirds those given above for Case 1.

Accordingly, the main portion A of the Great Lakes megalopolis in all four cases will show, by the year 2000, considerably higher densities than the eastern megalopolis for the year 1960. If, however, the total of the Great Lakes megalopolis (all four portions) is considered, then densities by the year 2000 are likely to be of the same order or slightly lower than those of the eastern megalopolis for 1960.

It will be seen, in figures 8 and 10, that the boundary between the generalized Great Lakes megalopolis and the generalized eastern megalopolis area is assumed to be provided by the relatively more mountainous portion of the Appalachians. The main "bridges" between this generalized definition of the Great Lakes megalopolis and the eastern megalopolis are expected to proceed along three lines: it is believed that the earliest firm connection between the two will start being formed along the Mohawk Valley; later on, another connection between the Montreal-Ottawa portion of the Canadian megalopolis and the eastern megalopolis is expected to take place along the valley of the Hudson River and Lake Champlain; a third connection is expected to take place over the relatively less mountainous portion of the Appalachians, roughly from Washington to Pittsburgh.

Also in figures 8 and 10, some possible future extensions of both the Great Lakes megalopolis and the eastern megalopolis have been shown by arrows. These can be seen either as extensions of the assumed megalopolitan areas into neighboring areas of markedly less urbanized character, such as the extension of the eastern megalopolis westwards, or as connections between the Great Lakes megalopolis or eastern megalopolis on the one hand, and other megalopolitan formations expected to take shape in the United States on the other, such as the Florida megalopolis or the formations south of Cincinnati and Louisville. Beyond providing an indication of possible future extension of the Great Lakes megalopolis and the eastern megalopolis after the year 2000, these arrows may represent already for the year 2000 some further extensions beyond Case 3b as assumed in the present paper, since in certain cases urban-

ization may proceed at a still faster rate than that corresponding to Case 3b.

Finally it should be stressed that, in the successive extensions of the initial central Great Lakes megalopolis (Case 1 through 2, 3a, and 3b), it is still the Great Lakes megalopolis of Case 1 that retains the main weight of the total population, because of the much higher densities prevailing in this central area; if one looks only at orders of magnitude, therefore, substituting one boundary for the next adjoining one, e.g., 3a for 2, or 3b for 3a, the resulting changes in population are rather small when compared with the large corresponding changes in area.

Subdivision of the Great Lakes megalopolis into urban areas

General

The understanding of major megalopolitan structures will be greatly enhanced if meaningful subdivisions into smaller areas centered around the main urban poles of attraction can be identified within them; actually, it may even be preferable to define larger areas around each major center of urban attraction representing the sphere of influence of each of them in such a way that adjacent areas would not overlap but would either remain in contact or show a separation through an intermediate "neutral zone."

Such an area has been defined with Detroit as a center and has been studied in considerable detail so far[2]; this area has been termed the Urban Detroit Area (UDA) and represents the area of direct influence around Detroit. It is believed that it will be particularly useful to try and define similar urban areas around the main urban centers of the Great Lakes megalopolis so as to understand better their interrelation as well as their relation to the various metropolitan segments.

An attempt has been made to start with such a definition, in a preliminary way, for two more urban areas, comparable to the Urban Detroit Area: one centered around Chicago-Milwaukee, to be called the Urban Chicago-Milwaukee Area (UCMA), and another centered around Cleveland-Pittsburgh, to be called the Urban Cleveland-Pittsburgh Area (UCPA). An attempt has also been made to correlate these three urban areas with the main portion of the Great Lakes megalopolis (part A of fig. 8); this was done only for this main portion of those initial central areas of the Great Lakes megalopolis which have been called Case 1).

Methodology

● **Definition of Urban Areas:** In order to arrive at a first identification of the above-mentioned three urban areas, the maps considered in the analysis part of the study, showing the most characteristic phenomena in the Great Lakes area, were examined. It immediately became apparent that no uniform definition of an urban area around Chicago-Milwaukee could be arrived at easily; for a considerable number of variables, the contours seem to gather very near each other just outside of the boundary of the main portion of the Great Lakes megalopolis in the Chicago-Milwaukee area, thus defining a rather limited Urban Chicago-Milwaukee Area. For a number of other variables, however, the area defined seemed to extend much further out, usually in two ways. In one category of cases the extension took a radial or tentacular shape along the main roads connecting Chicago-Milwaukee with outlying centers ; in other cases the pattern seemed to be, on the contrary, that of a peripheral interconnection of such outlying areas with weaker links of the ring just formed with the central area around Chicago-Milwaukee.

This led to a dual definition of an Urban Chicago-Milwaukee Area which is particularly strong in the southwest, south, and southeast areas with respect to Chicago-Milwaukee, whereas north, west, and east of Chicago-Milwaukee the two definitions seem to coincide, more or less. This is why, pending a more thorough study, two urban areas have been defined around Chicago-Milwaukee, an inner one ($UCMA_1$) and an outer one ($UCMA_2$), as shown in figure 11.

It will be seen in this same figure that the urban areas thus defined for Chicago-Milwaukee do not touch the Urban Detroit Area; a small area, here called the West Michigan Area (WMA), seems to constitute a "neutral area" between the Urban Detroit Area and the Urban Chicago-Milwaukee Area; whether this neutral area will finally come under the influence of one or the other urban area or whether it will be split between these two urban areas is a problem that will require further study to be properly answered.

It may be mentioned that this discontinuity between the Urban Detroit Area and the Urban Chicago-Milwaukee Area is not only based on observations on the material contained in the Detroit studies by Doxiadis Associates and the Athens Center of Ekistics but also appears on some of the maps of the Michigan Transportation Study and other independent U.S. studies.

On the contrary, the definition of the Urban Cleveland-Pittsburgh Area did not seem to present such great difficulties; on the basis of the maps of the previously mentioned reports, a single outlying area could be determined which happens to come in complete contact with the Urban Detroit Area somewhere halfway between Toledo and Cleveland.

It should be stressed that the Urban Cleveland-Pittsburgh Area and Urban Chicago-Milwaukee Area definitions are of an entirely preliminary and temporary character pending further, more detailed studies for their more precise definition. Still, they can be regarded as a first approximation which may serve to determine orders of magnitude for the populations included in them. It should also be remarked that slight changes in the boundaries of these urban areas are not likely to affect total populations very considerably, since the largest proportion of the population resides in their central areas while the outlying areas are much less populous.

● **Population projections for the year 2000:** The population of the urban areas thus defined has been calculated, on a county basis, for 1950 and 1960. The corresponding average yearly growth rate for this decade has been determined and extrapolated up to the year 2000 according to a slightly decreasing curve, in a way more or less comparable to the population projections made in the preceding section.

● **Comparison with the main portion of the Great Lakes megalopolis, case 1:** Fig. 11 shows that the three urban areas previously defined extend considerably beyond the boundaries of the main portion of the Great Lakes megalopolis, Case 1). In order to facilitate the comparison with it, therefore, the three urban areas have been subdivided into two sections: the first section, "a," is included in the main portion, the second section, "b," represents the rest of the corresponding urban area, i.e., its portion lying outside the main portion of the Great Lakes megalopolis. The difference between the two definitions of the Urban Chicago-Milwaukee Area (i.e. between $UCMA_1$ and $UCMA_2$) is called "c," whereas the Canadian portion of the Urban Detroit Area is called "d," for reasons of easy identification (see table 8 and fig. 11).

Population figures for these two sections of each of the three urban areas have been calculated for 1950 and 1960 and projected for the year 2000 as previously described for the total of the urban areas.

Because of the consistency in the form of the curves assumed for the extrapolated annual population growth rates, very little adjustment and smoothing proved necessary to achieve com-

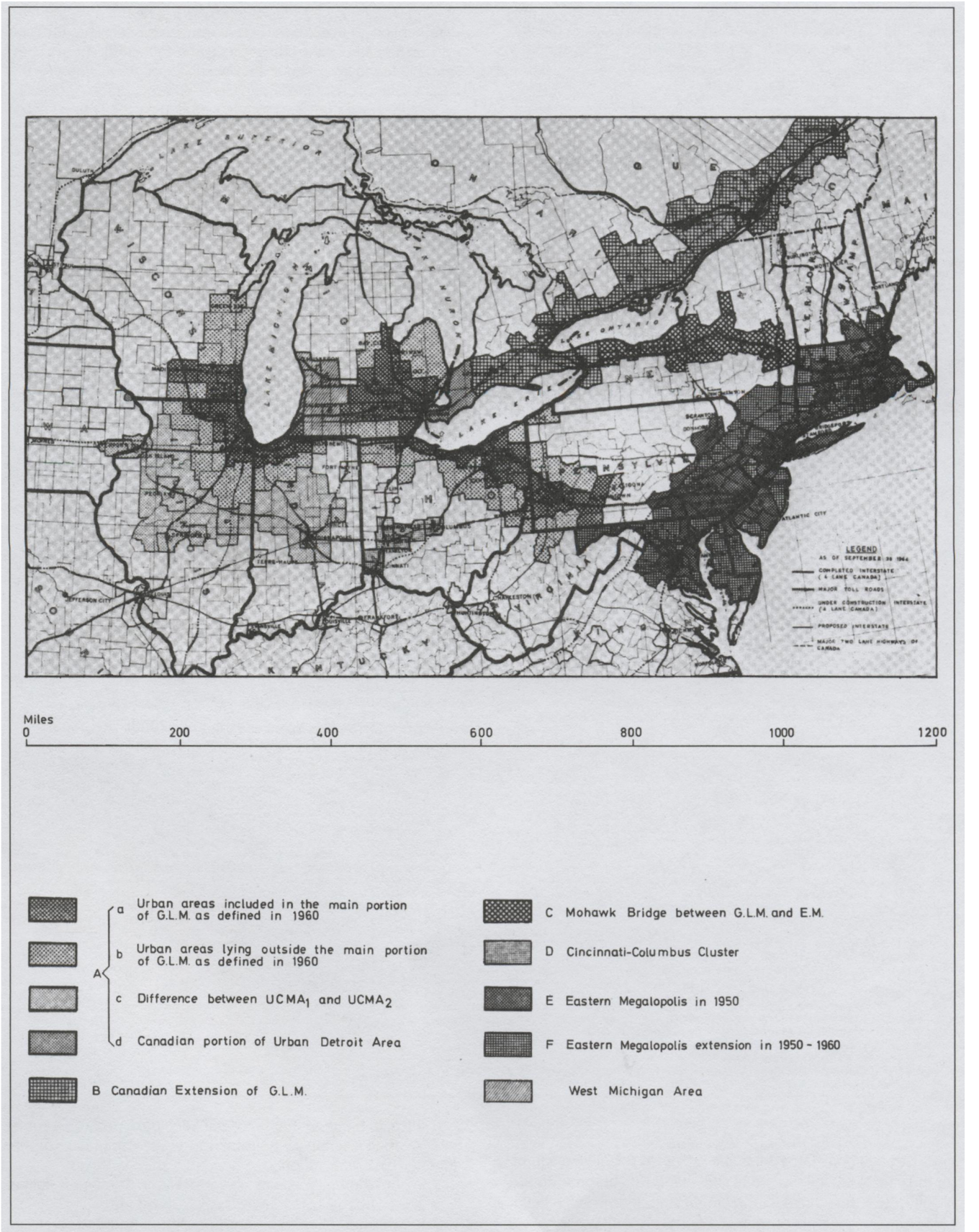


Fig. 11: First definition of urban areas related to the main portion of the Great Lakes megalopolis (area A) in 1960.

plete consistency for the year 2000 population projections: with only slight corrections of the decimals (in this study the population has been expressed in terms of millions of inhabitants), it proved possible to bring into full agreement the year 2000 population figures taken as a basis for the Urban Detroit Area studies (high 16.5, low 13.5) with the corresponding Urban Chicago-Milwaukee Area and Urban Cleveland-Pittsburgh Area figures in such a way that the population of the inner portions of the urban areas, i.e., the three "a" areas, added up to the population projections as calculated in Section III for the main portion of the Great Lakes megalopolis, i.e., for area A, Case 1).

- **High, middle, and Low Curves:** The above-mentioned calculations were made under three different assumptions, high (H), middle (M), and low (L), as shown in table 8. Again it should be stressed that full consistency has been achieved for all three assumptions, between the population projections of the present section, those of the preceding section, and the current population projections of the various studies for the Urban Detroit Area.

for the Urban Chicago-Milwaukee Area is higher than the high assumption for the Urban Detroit Area: on the contrary, the middle assumption for the Urban Cleveland-Pittsburgh Area is comparable to the low one for the Urban Detroit Area, whereas the high assumption for the Urban Cleveland-Pittsburgh Area is only slightly lower than the high assumption for the Urban Detroit Area.

It will be seen that the outlying less dense areas, "b," contain only a relatively small fraction of the total population of the urban areas, roughly 20 percent for the Urban Cleveland-Pittsburgh Area, slightly more than 10 percent for the Urban Detroit Area, and almost 15 percent for the Urban Chicago-Milwaukee Area; this simply stresses the fact to be expected that the bulk of the population of the urban areas will remain concentrated in their central areas, "a," that is, their portion lying within the main portion of the Great Lakes megalopolis as per Case 1.

Table 8
Great Lakes megalopolis population projections, case 1, by urban areas and their subdivisions for three assumptions: H (high), M (Middle), L (low)

Areas	Population in Millions				
	Actual		Projected for the year 2000		
	1950	1960	H	M	L
A. URBAN AREAS OF GLM					
Urban Chicago–Milwaukee Area (UCMA$_1$)					
a.	7.549	9.269	23.900	19.900	16.600
b.	1.222	1.437	3.200	2.800	2.300
Total UCMA$_1$	8.771	10.706	27.100	22.700	18.900
Urban Detroit Area (UDA)					
a.	4.710	5.864	13.400	12.200	11.400
b.	0.676	0.793	1.800	1.500	1.300
Total USA	5.386	6.657	15.200	13.700	12.700
d. (Canada)	—	0.450	1.300	1.000	0.800
Total UDA	—	7.107	16.500	14.700	13.500
Urban Cleveland–Pittsburgh Area (UCPA)					
a.	5.470	6.377	12.800	10.800	9.000
b.	2.103	2.241	3.400	2.900	2.400
Total	7.573	8.618	16.200	13.700	11.400
West Michigan Area (WMA)	0.751	0.957	2.200	1.900	1.600
Total	—	—	62.000	53.000	45.400
Minus UDAd (Canada)			1.300	1.000	0.800
Total USA	—	—	60.700	52.000	44.600
B. TOTAL GREAT LAKES MEGALOPOLIS					
a.*	18.480	22.465	52.300	44.800	38.600
b.	4.001	4.471	8.400	7.200	6.000
Total GLM	22.481	26.936	60.700	52.000	44.600
UCMAc	2.891	3.409	8.000	6.800	5.600
UCMA$_2$ (Overall total of UCMA including areas c)	11.662	14.115	35.100	29.500	24.500

a. inside GLM main portion, Case 1).
b. outside GLM main portion, Case 1).
c. further extension (only for UCMA).
d. Canadian part of UDA.
* Identical with GLM-A, Case 1).

Results

It will be seen from Table 8 that the projected population figures for the year 2000 for the Urban Cleveland-Pittsburgh Area are slightly lower than those for the Urban Detroit Area while those of the Urban Chicago-Milwaukee Area are considerably higher than those of the Urban Detroit Area: even the low assumption

It will also be seen that the West Michigan Area represents only a small fraction of the total aggregate population of the three urban areas, roughly 3.5 percent.

The above-mentioned calculations refer to the "inner" definition of the Urban Chicago-Milwaukee Area; if the "outer" definition is adopted, slightly higher population figures result, as shown in Table 8.

Transportation and the future of the megalopolis

Transportation as a unifying factor

The previous analysis shows clearly that we expect a great growth of population in the Great Lakes megalopolis, reaching the order of a hundred million inhabitants by the year 2000 and many more during the twenty-first century. By the end of the twenty-first century the population in the Great Lakes megalopolis as well as in many parts of the world may level off after having reached a new balance between space and man.

While such a growth is reasonably certain, and while it is certain that this growth will take place mostly around the major urban areas which exist today, we can also be certain that new growth will take place along the major axes of transportation and around major points of access to the transportation system, such as, perhaps, major airports or railway stations. Where future transportation development depends mostly on highways, then the urban development may be linear if the points of access are close together, or it may be in separate centers along one line if the points of access are further apart.

Depending on the form of transportation, we shall have different urban patterns. In any case, however, the transportation systems, their configurations, their speeds, and their operational methods will be the greatest unifying factor in the formation of the Great Lakes megalopolis.

The expanding Ekistic fields

If we want to study how this phenomenon of the unification of urban areas through transportation will take place, we must make use of the kinetic ekistic fields (figs. 12 and 13). How far can man move by the use of different means of transportation within reasonable periods of time, allowing him to commute from place to place during the same day? It is now accepted that many people commute for one hour a day in each direction and there are also large groups of people who commute for two hours in each direction. Whether we will have people commuting for even longer periods of the day and turning themselves into nomads of the urban deserts, or whether we will tend to reduce the commuting time, depends on the goals that humanity will set for its future. It is our hope that commuting time will be reduced.

In any case, the phenomenon we witness today is the phenomenon of expanding ekistic fields caused by increasing speeds of transportation. As we do not tend to reduce the commuting time, but do have higher speeds, a kinetic ekistic field which had a radius of 10 miles two generations ago and 20 miles one generation ago may well today have a radius of the order of 40 miles. If our transportation systems are blended more reasonably within the urban texture this radius might easily expand to 60, 80, and 100 miles by the end of the century.

If the kinetic ekistic fields expand to 100 miles around major urban centers this will mean that the Urban Chicago Area will touch the Urban Detroit Area and the latter will touch the Urban Cleveland Area; the Urban Cleveland Area will overlap the Urban Pittsburgh Area and then the expanding ekistic fields will be interconnected.

This does not mean that people would commute within the same day between Chicago and Detroit or Detroit and Cleveland, because this would mean that they would have to cover two kinetic ekistic fields. It does mean, however, that there will be people living on the fringes of both who will move inside the kinetic ekistic fields of two major cities: Chicago and Detroit, or Detroit and Cleveland. In this way, a new category of people will develop whose interests will no longer be confined to

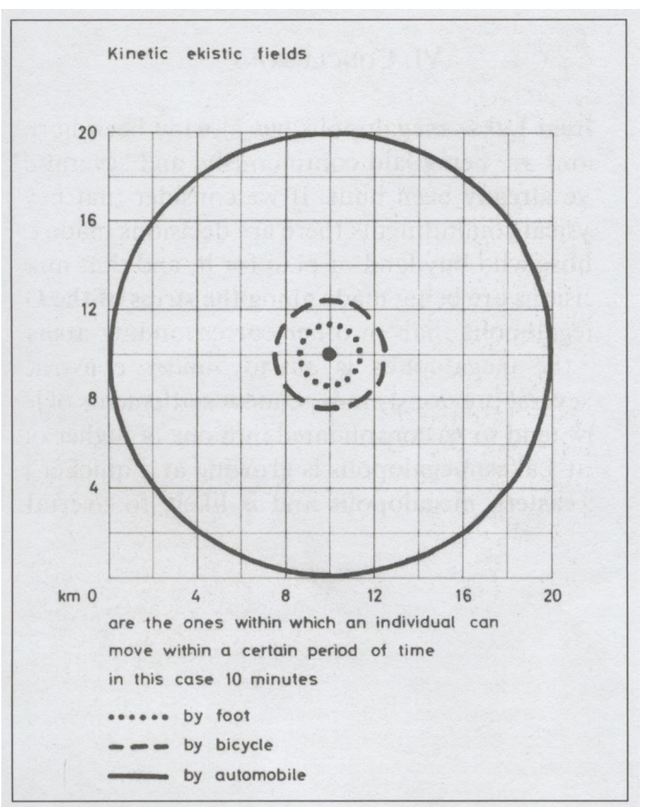


Fig. 12: Kinetic ekistic fields.

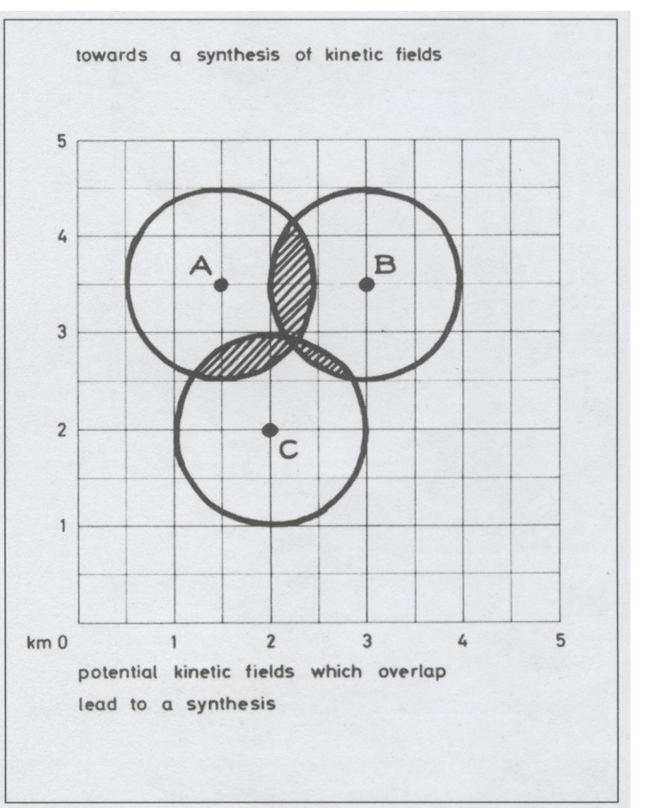


Fig. 13: Towards a synthesis of kinetic fields.

one of the major urban areas as they have been so far, but who will be interested in both; and these people will provide the link which will gradually lead to an even more unified system. The people living on the fringes, the people living on the overlapping areas, are the ones who will act as the connecting elements and lead towards a broader unification of the ekistic fields.

Conclusions

The Great Lakes megalopolis has already been born; its foundations are being laid continuously, and several of its parts have already been built. If we consider that beyond these physical commitments there are decisions made every day by those who buy land or plan for it, and that more of these decisions are being made along the strips of the Great Lakes megalopolis than in other corresponding areas, we see that the megalopolis is already under construction because several previously independent settlements of lower order now tend to be consolidated into one of higher order. The Great Lakes megalopolis is growing at a quicker pace than the eastern megalopolis and is likely to overtake it and even surpass it in many respects before the year 2000. In view of the above, it is time for us to study not only the different settlements along the Great Lakes which already exist and for some parts of which we can do little, but also the forthcoming Great Lakes megalopolis as a system and those of its parts which will be created from now on. We hope that studies such as the present one, whose purpose is the illumination of this ongoing phenomenon and the projection as far as possible of its future evolution, can help us to follow the second of the roads outlined in the Preface, that is, to invent the future and plan for better conditions within this upcoming major human settlement. This is a task to be undertaken. It is not too early for that; in a few years it may even be too late.

Notes

1. J. Gottmann, *Megalopolis, The Urbanized Northeastern Seaboard of the United States* (Cambridge, MA, M. I. T. Press, 1961).
2. C.A. Doxiadis, *Emergence and Growth of an Urban Region, The Developing Urban Detroit Area*, vols. 1 and 2 (Detroit, The Detroit Edison Company, 1966 and 1967).