

LINEAR STRUCTURAL PATTERNS  
OF SETTLEMENT

by

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(1959)

SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE  
DEGREE OF MASTER IN  
CITY PLANNING

at the

MASSACHUSETTS INSTITUTE OF  
TECHNOLOGY

June, 1963

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LINEAR STRUCTURAL PATTERNS OF SETTLEMENT

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Abstract of a thesis submitted to the Department of City and Regional Planning, Massachusetts Institute of Technology, for the Master's Degree, May 1963

This thesis presents a study of the forces influencing the location of human settlements by investigating the development of a unique pattern of settlement: the linear system of cities. Five particular cases are studied, and their courses of establishment, growth, and evolution are followed historically. They are the settlements of Egypt, the St. Lawrence system, Siberia, Venezuela, and the Mississippi River Basin. From these studies the following conclusions are reached:

Linear patterns of settlement are originated by structural elements of obvious linear character, such as natural features, political boundaries, or man-made transportation lines. Although the appearance of a linear settlement may revolve about a single linear element, the existence of more than one element seems to be needed to maintain the original pattern.

Linear forms of settlement are maintained through time when there are strong environmental constraints to expansion beyond the original line of settlement and when reinforcing patterns of interaction along this line are built up. Economic change and technological advance enhance the relative positions of some centers, and the pattern of organization of the linear system emerges from the interplay of market forces and original pattern of settlement.

Thesis supervisor: John Friedmann

It is with pleasure that the author acknowledges the advice and encouragement of Professor John Friedmann. The author also wishes to thank the members of the Department of City and Regional Planning for making these two years both stimulating and rewarding.

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## PATTERNS OF HUMAN SETTLEMENT

The location of human settlements has long been a subject of interest to geographers, economists and regional scientists. A first framework for the study of the location of cities was given by Walter Christaller.<sup>1</sup> His theory in essence says that a certain amount of productive land supports an urban center; the center exists because services must be performed for a surrounding area. The size of the city depends on its tributary area, and thus centers will exist of varying size, according to the area in which they are located. Each city-size would perform a number of services; the services to be provided become more complex as the tributary area is composed of the service areas of many smaller towns. Services performed primarily for the surrounding area are termed "central functions" by Christaller and the settlements performing them, "central places." In isolation, each central place would have a circular tributary area, but these are modified to become hexagons, a form which can completely fill an area. Empirical work done by Christaller in southern Germany indicated the existence of typically-sized settlements. He computed their average population, distance among them and the size and population of the tributary areas in accordance with his hexagonal theory.

Studies done in southwestern Wisconsin and southern England by Brush and Bracey sustained Christaller's hypothesis.<sup>2</sup> These cases indicated that the ideal is closely reached in largely self-contained areas of farming population.

Harris and Ullman in a theoretical study generalized on the original hypothesis of Christaller. Their ideas can be summarized in this statement: "Cities [are] central places performing comprehensive services

for a surrounding area. Such cities tend to be evenly spaced throughout productive territory. For the moment this may be considered the "norm" subject to variation primarily in response to the ensuing factors."<sup>3</sup>

From the first model of Christaller other theoretical works have been derived to introduce more clearly the role of market forces in shaping the pattern of settlements. For instance, among these is Lösch's study.<sup>4</sup> He begins with these assumptions:

- a) the area is considered a homogeneous plain with uniform transport features and with an even distribution of resources;
- b) the area has a uniform distribution of population with a set of undifferentiated tastes and preferences;
- c) production opportunities are available to all, and technical knowledge is disseminated through the plain;
- d) all external economic forces are excluded.

With these assumptions, Lösch postulates that the economic forces of competition among the farmers will define the market areas and transform the original circular shape of the market area into a hexagon. The hexagon is then the ideal economic form of a market area because it will exhaust any area under consideration and minimize the transport expenditures in supplying a given demand.

Thus, according to these theories, a plain is dissected into a honeycomb of hexagonal market areas and these areas are grouped according to the size of their respective market units. Isard builds from these preceding schemes another theory.<sup>5</sup> He finds Lösch's model highly simplified and static, essentially because the assumptions chosen by Lösch only operate at equilibrium.<sup>6</sup>

Isard's scheme takes account of higher levels of market activities related to the city's industrial development and large labor force. At the city's core there is a high population density, high business and manufacturing intensity and a high value to the goods exchanged. In contrast these factors decrease with distance away from the center and as a result the pattern of honeycombs is distorted and the market areas, the hexagons, increase in size.<sup>7</sup>

The schemes of Christaller, Lösch and Isard resemble one another although they differ somewhat in their treatment of the shaping forces. They all begin with the same basic hypothesis, the uniformity of the plain, and proceed considering the economic forces as the chief determinants of the pattern. However these authors have recognized, as is quite obvious, that other patterns of centers exist besides the hexagonal one, but assume, more or less tacitly, that these forms are the consequence of slightly different first assumptions, but still the result of the shaping market forces.

For instance, Ullman indicates in reference to these schemes that the topography, productivity of the soil, type of agriculture and type of government organization, together with industrial concentrations, determined in response to resources and transportation, will produce alterations in the central place locations.<sup>8</sup> As an example he observes that "in many cases central places are strung at short intervals along an important transport route, and their tributary areas do not approximate the ideal circular or hexagonal shape but are elongated at right angles to the main transport line."<sup>9</sup> Furthermore, Harris and Ullman pointed out in referring to the functions of cities and their distribution: "Transport cities performing break-of-bulk and allied services



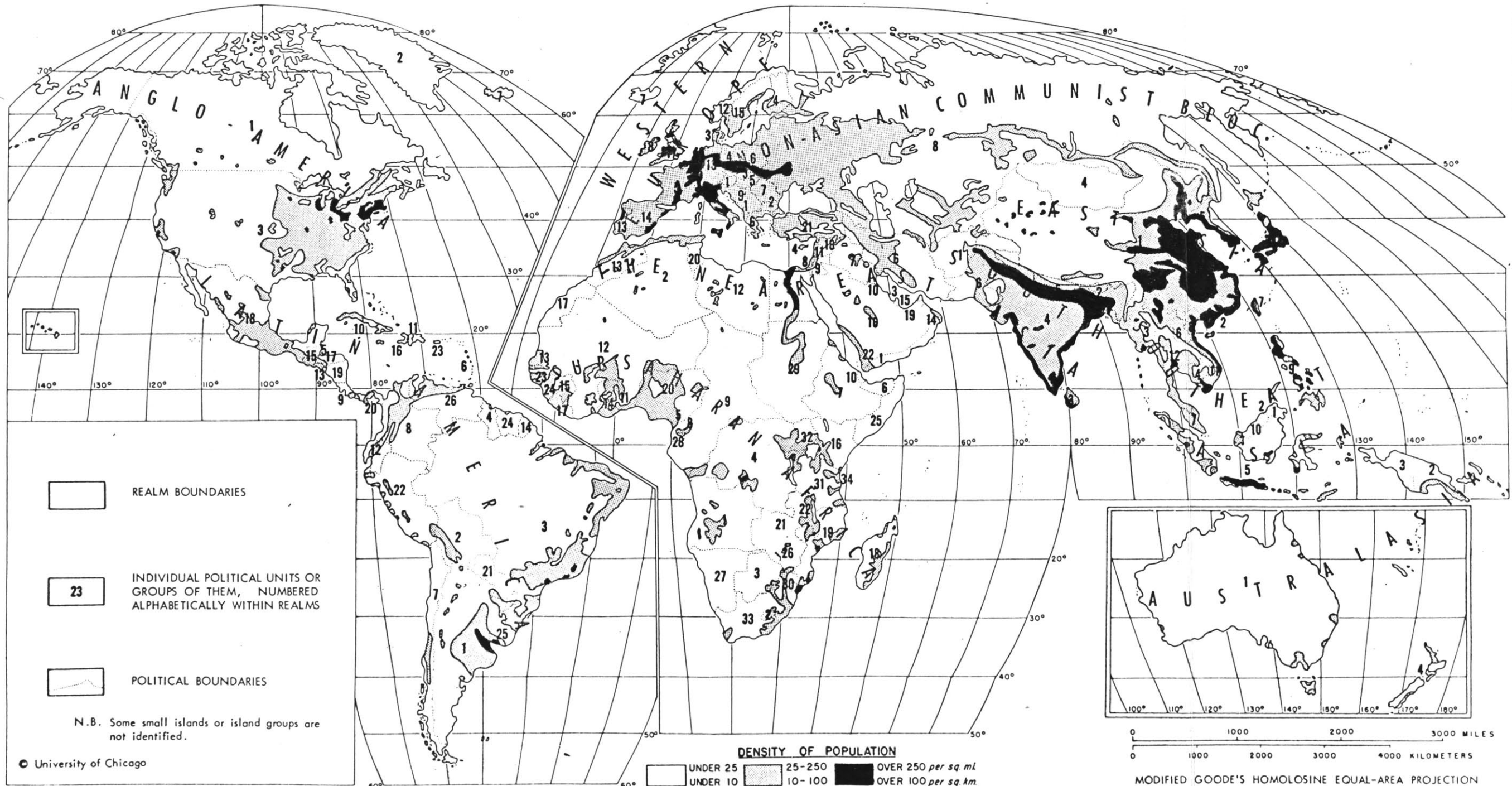
along transport routes, supported by areas which may be remote in distance but close in connection because of the city's strategic location on transport channels ... tend to be arranged in linear patterns along rail lines or at coasts."<sup>10</sup> From these remarks it is clear that other factors beyond those of market force are active in shaping the locations of centers.

Cities are not usually located in uniform environments and these circumstances give rise to systems of cities that are not evenly distributed. Thus, the present work intends to investigate a particular structure where forces other than the economic are at play. One such arrangement, that has been cited by different authors,<sup>11</sup> is the linear structure. This type is clearly related to the geographical features of the land in which a strong linear element influences the arrangement of settlement; thus mountain ridges, river basins and coastal lines are basic physical determinants of linearity. Man-made introductions in the environment, major routes and railroad lines, may provide similar functions as shaping elements.

It is possible to say that a linear structural pattern of cities is an array of interdependent centers arranged in a linear order. Such systems need not form a straight line or a continuum but must form an extended or elongated structure.

A rapid look at any atlas showing population densities will show the wide prevalence of linear patterns. Figure 1 is such a population map.<sup>12</sup> From a survey of the areas with densities over 250 persons per sq. mile the linearities that emerge are:

# COUNTRY UNITS AND MAJOR WORLD REALMS



1. In the Near East: Egypt, along the Nile.
2. India: along the Ganges River and along the sea coast.
3. East Asia: Korea - China - Vietnam, along the coast.
4. Europe: across France and from the Netherlands across Germany, Poland into Russia.
5. United States: along the Atlantic Coast, and around the Great Lakes.
6. Argentina: along the Parana and Plata rivers.

The densities of 25 to 250 persons per sq. mile show the following linear patterns:

1. Morocco - Algeria - Tunisia, along the Mediterranean Sea; and Saudi Arabia - Yemen on the Red Sea.
2. Russian Siberia: along the Trans-Siberian Railroad.
3. South America: from Venezuela to Ecuador, along the mountains, and Peru and Chile, along the coast; Brazil along the Atlantic Coast.
4. United States: Seattle - Portland, and Los Angeles - San Francisco.
5. Canada: along the St. Lawrence - Great Lakes.

This rapid look at linearities existing over the world indicates a wide distribution of these patterns. But this survey overlooks other cases existing at lower densities, of which many exist.

The purpose of this study is to formulate some hypothesis concerning the origin, evolution and persistence of linear structural patterns of settlement through the detailed study of the development of a few such cases. The wide prevalence of linear patterns suggests that there must be some common underlying characteristics.

The questions put forward are then: how and when were these structural patterns established, and what has contributed to their growth and persistence? Thus, this investigation attempts to follow from the very beginnings the chains of growth and transformation of linear patterns in respect to time and the technological events taking place.

The cases chosen for this study include: Egypt, the St. Lawrence system (Canada), Siberia (U.S.S.R.), Venezuela, and the Mississippi River towns (U.S.A.). These were taken because of the clarity of their linear structure, because they developed in different environments and during different periods of technological advance.

Because of the study's concern with the evolution of the linear structural patterns of human settlements, a major emphasis is put on the nature of the shaping forces. Thus the present study underlines the action of forces upon the structures considered with their subsequent effects on the linear patterns.

The main hypotheses under which the cases studied will be presented in the following section are:

1. Systems of settlement assume linear form in response to a strong element of linearity in the environment which favors accessibility and/or permanent occupance.
2. Linear forms of settlement are maintained through time when there are strong environmental constraints to expansion beyond the original line of settlement and when reinforcing patterns of interaction along this line are built up.
3. In the absence of environmental constraints, however, the linearity of settlements will tend to be modified and may ultimately give way to

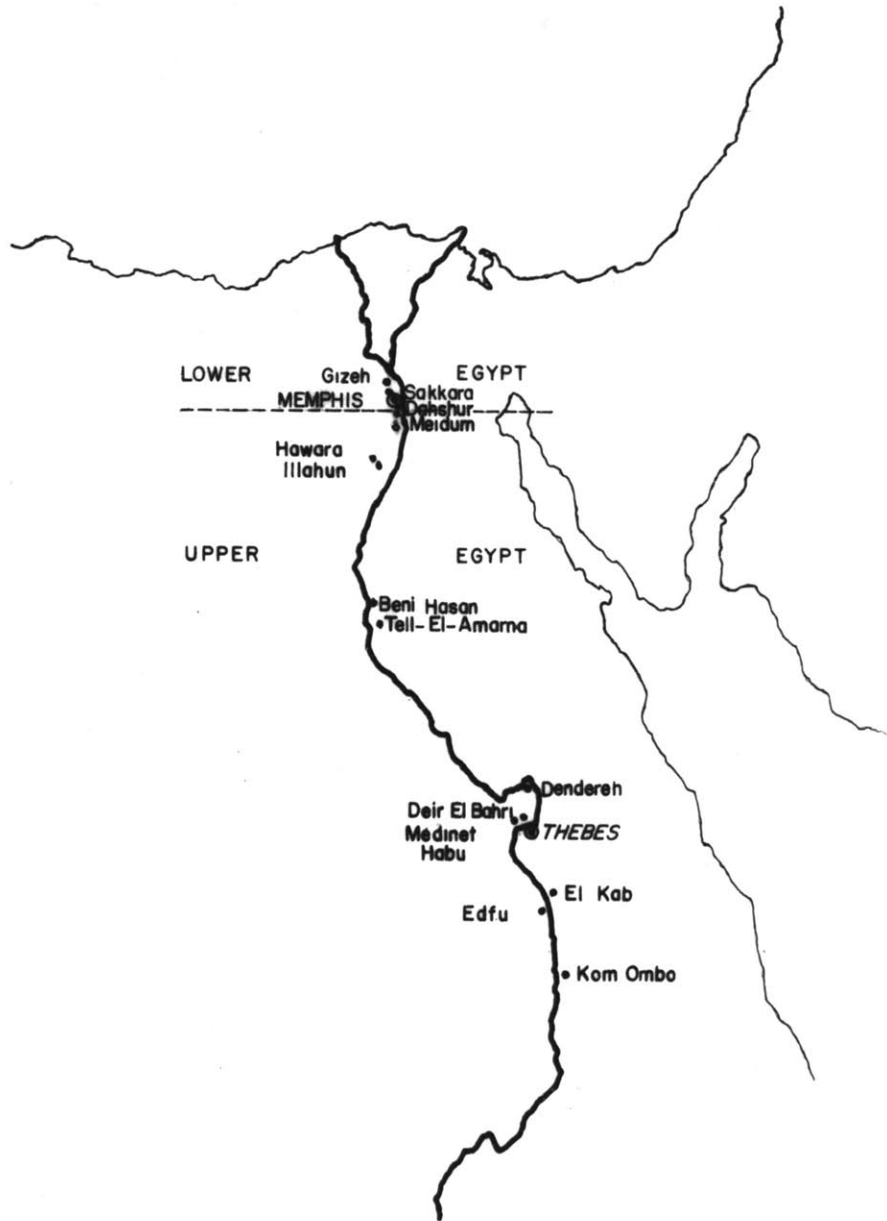
more complex "field" structures.

In attempting to clarify these hypotheses the study-cases will be presented individually with their own characteristics as well as those factors otherwise common to them. Finally the hypotheses will be treated again in expanded form and examples taken from the cases used to substantiate them.

Of the five cases chosen for the study, Egypt and the St. Lawrence - Lower Great Lakes systems are classical cases of linearity; the first having developed one center, the latter, two centers. Siberia and Venezuela are linear systems in transition to more complex patterns. The Mississippi basin is a case in which modifications occurred at early times, the present pattern being that of post-transition. These examples, representing persistence, transition, and post-transition, will be presented in this order.

#### EGYPT

The first case, the cities of Egypt located along the Nile, had its origin at the earliest times of urban civilization (Figure 2). This linear pattern of settlement has persisted along the Nile to the present day (Figures 2, 3, and 4). The river provided for the fertility of the land in an otherwise arid area and for transportation to the cities located along its course. The Nile irrigated the land with its annual inundations and thus provided for the mainstay of the economy. Small self-sufficient farming villages appeared along the valley which finally united under Menes (3000 B.C.), bringing together Upper Egypt, in the Valley, and Lower Egypt in the Delta. With this Kingdom begins the history of Egypt under a strong central rule.<sup>13</sup>



OLD KINGDOM (dynasties III-VI) 2700-2200 B.C  
 capital Memphis

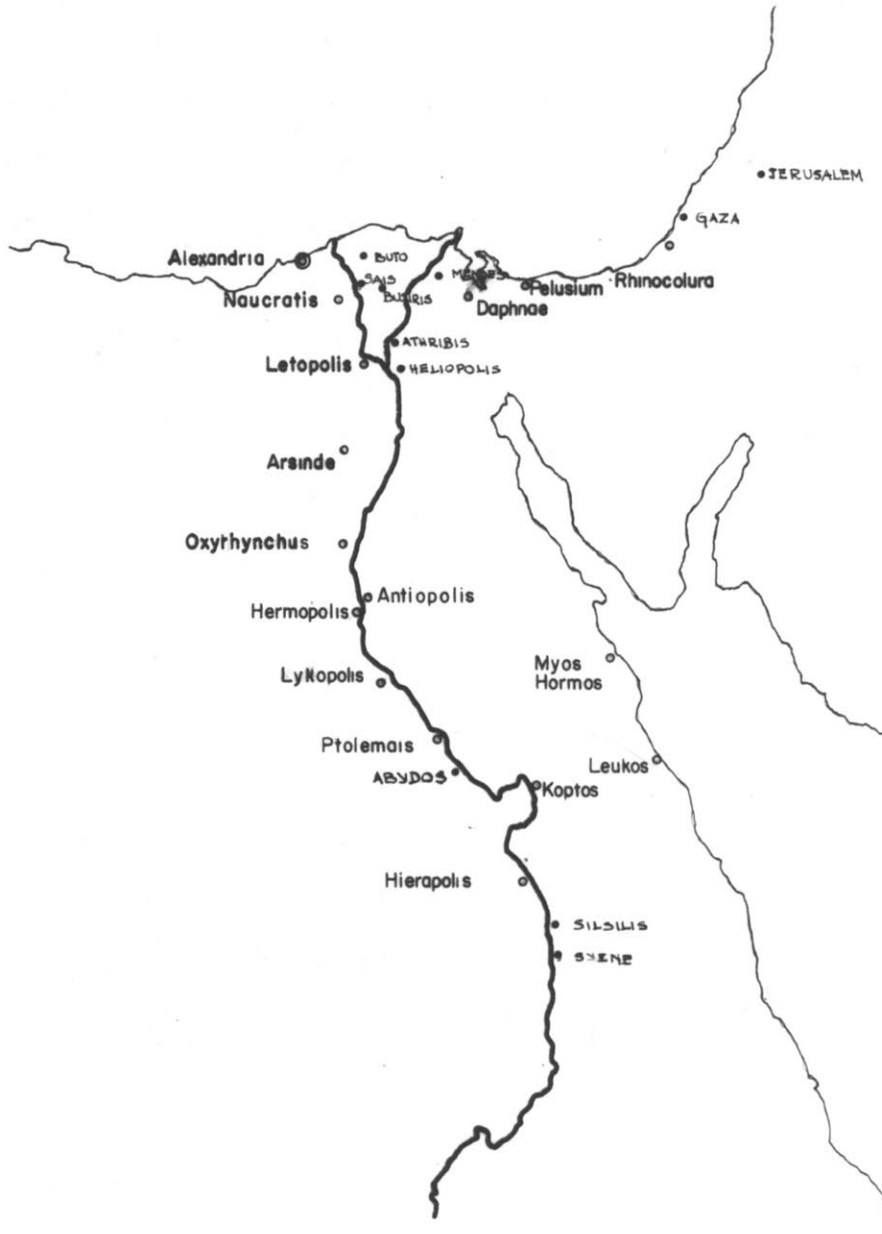
MIDDLE KINGDOM (dynasty XII) 2000-1800 B.C.  
 capital Thebes

NEW KINGDOM (XVIII-XX) 1570-1100 B.C

EGYPT  
 DYNASTIES

0 \_\_\_\_\_ 100 miles

FIGURE 2



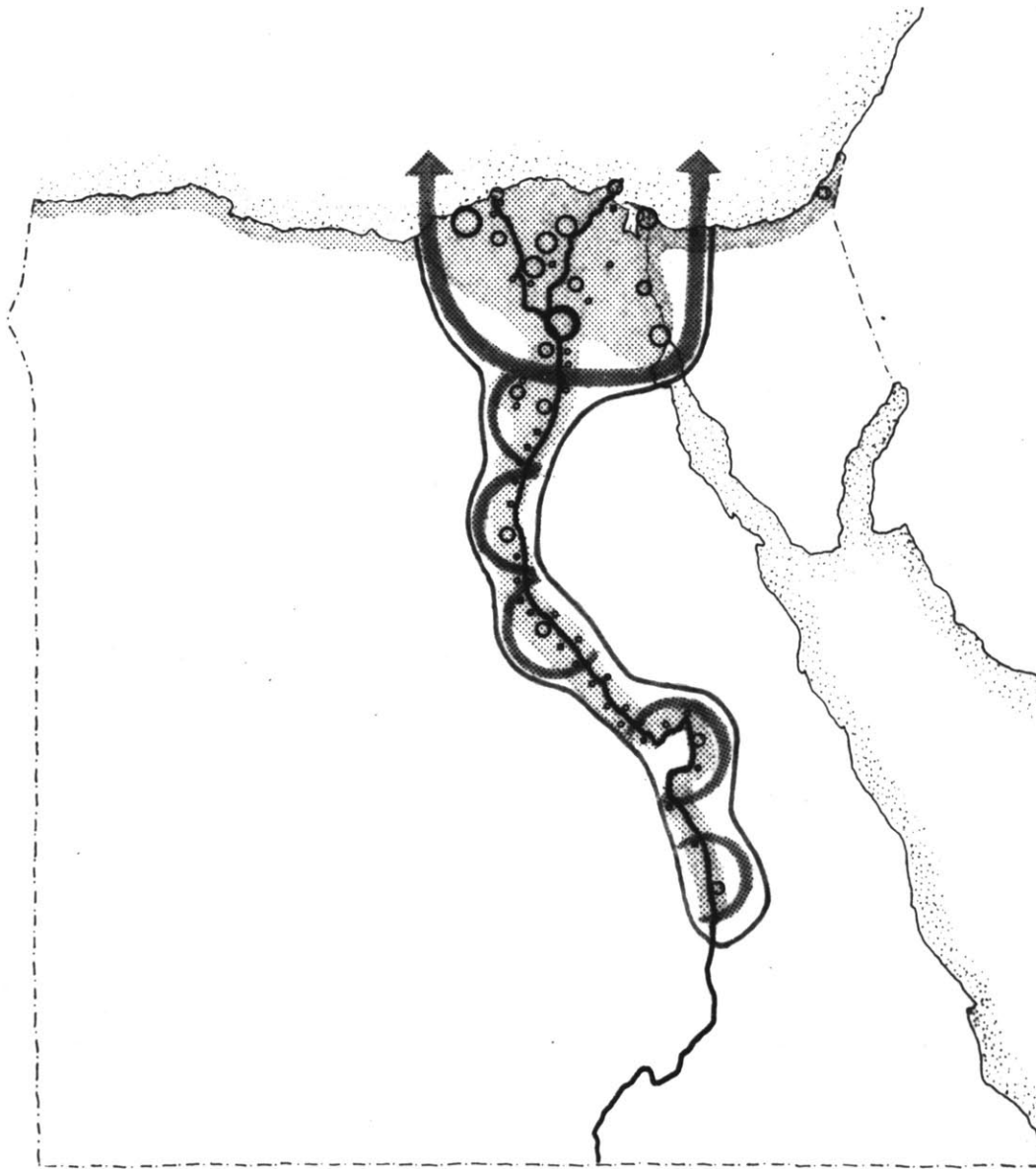
PTOLEMAIC PERIOD - 323 - 30 B.C.  
 Capital Alexandria, other centers: ○

ROMAN AND BYZANTINE - 30 - 639 A.D.  
 the centers: ●

EGYPT

0 ————— 100 miles

FIGURE 3



CITY - SIZE DISTRIBUTION 1955

○ Over 1,000,000	○ 50,000 - 100,000
○ 500,000 - 1,000,000	○ 25,000 - 50,000
○ 100,000 - 500,000	○ 15,000 - 25,000
▨ Extent of area settled	⤵ indicates the pattern of organization

EGYPT

0 100miles

FIGURE 4



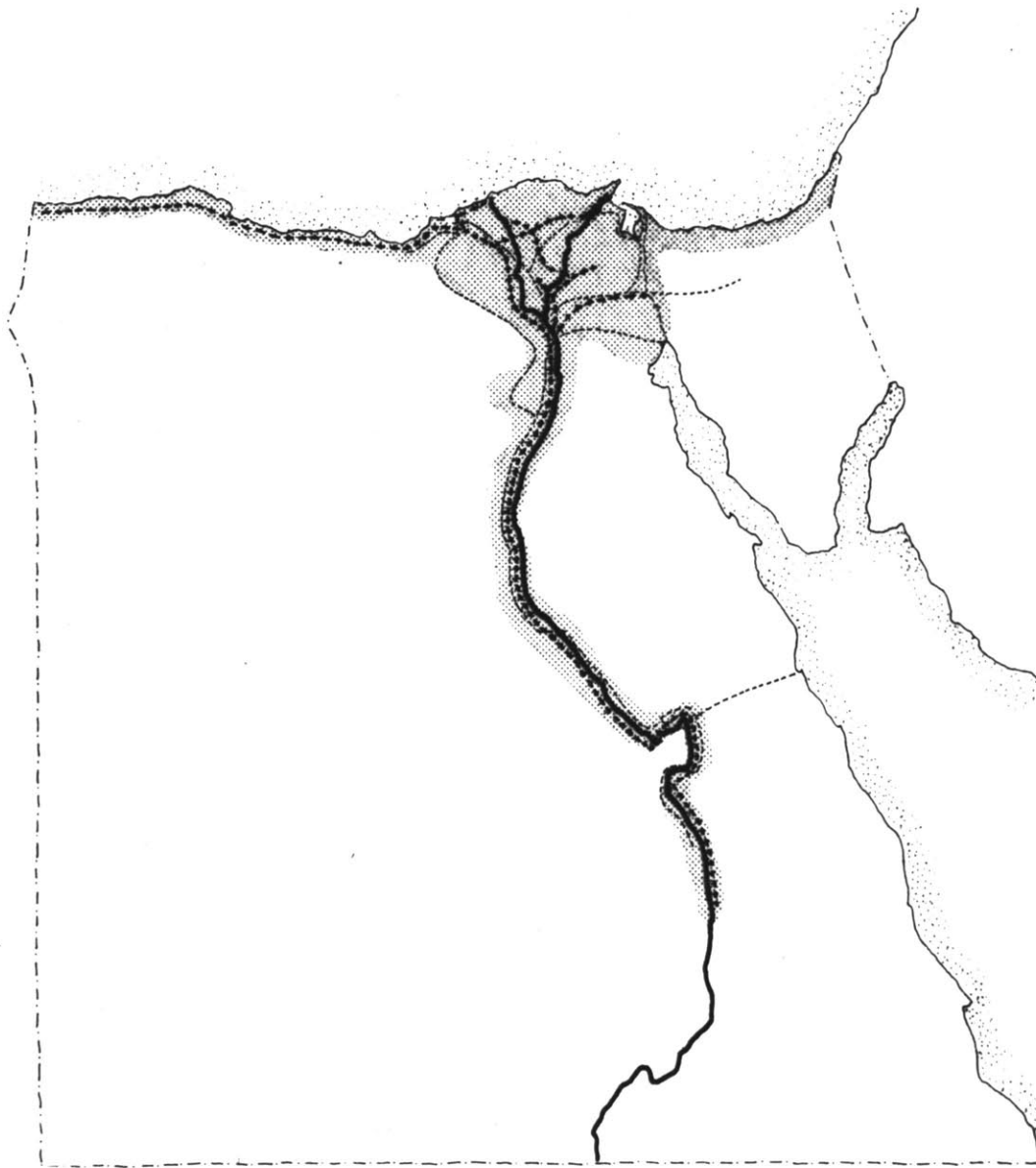
The capital was the place of concentration of economic surplus and this center was usually the largest, but few large cities developed because of the practise in early dynastic Egypt of changing the site of the capital with the ascendancy of a new pharaoh. Besides the capital which had a significant concentration of activity, the larger communities were little more than marketing centers for the rural hinterland.<sup>14</sup>

The river as a transport artery not only allowed communication among the centers but permitted access to the Mediterranean Sea and thus to basic raw materials not available along the Nile.<sup>15</sup>

In Egypt natural conditions were the greatest force in molding the linear structure as it developed and as it appears today. The inhabited area is a narrow strip along the Nile River and the Delta.<sup>16</sup> The fertile Nile valley is flanked at both sides by the desert; there was no other possible way of settlement but along the river.

The same conditions have influenced the development of supplementary transportation lines; railroads and roads were laid out for the most part in the same linear fashion; they run along alternate sides of the river, crossing it to follow the most fertile and densely settled areas (Figure 5). The three parallel lines, water, railroads and roads, compete with one another; during the last two decades roads have increased as freight carriers but the water route is still important.<sup>17</sup>

The terminus of the linear system is at the Delta where connections are made to the Mediterranean Sea and the rest of the world. Thus Cairo operates as the main funnel of external movement, and it is therefore the largest city (Figure 4). The second largest city is Alexandria, the important seaport with its own hinterland to the west and south. Other main centers are located at the Delta on canals and are further



LINES OF TRANSPORTATION

EGYPT

- \*\*\* Railroad lines
- Main roads
- Extent of area settled

0 100 miles

FIGURE 5

linked by railroads to Cairo; only roads offer possibilities of movement across the Delta area.

Cairo has performed a dominating function almost since the date of its founding in 969 A.D., because of its location at the strategic point of convergence of both up- and downstream traffic.

The major urban concentrations of the country occur in the Delta area; the rural population is denser in the Upper Nile Valley.<sup>18</sup> The seven cities of more than 100,000 population are located in Lower Egypt;<sup>19</sup> manufacturing industry is also concentrated in the Delta,<sup>20</sup> in correspondence with the market and trade concentrations at the points of easy exterior accessibility.

The centers strung along the Nile Valley are fourth or fifth order centers, performing limited central place functions for their respective hinterlands (Figure 4). The larger of them also exercise administrative functions as capitals of *muridias* (provinces). In general, the spacing of cities is in proportion to the density of settlement; the centers are farther apart where population thins out (Figure 4).

In this case of classical linearity, a natural linear element, the river, gave origin to the system which continued to persist by the existence of strong natural constraints. A secondary reinforcement of the basic linear pattern by modern means of communication maintained the structure and accentuated the role of the capital city at the point of high interior-exterior accessibility.

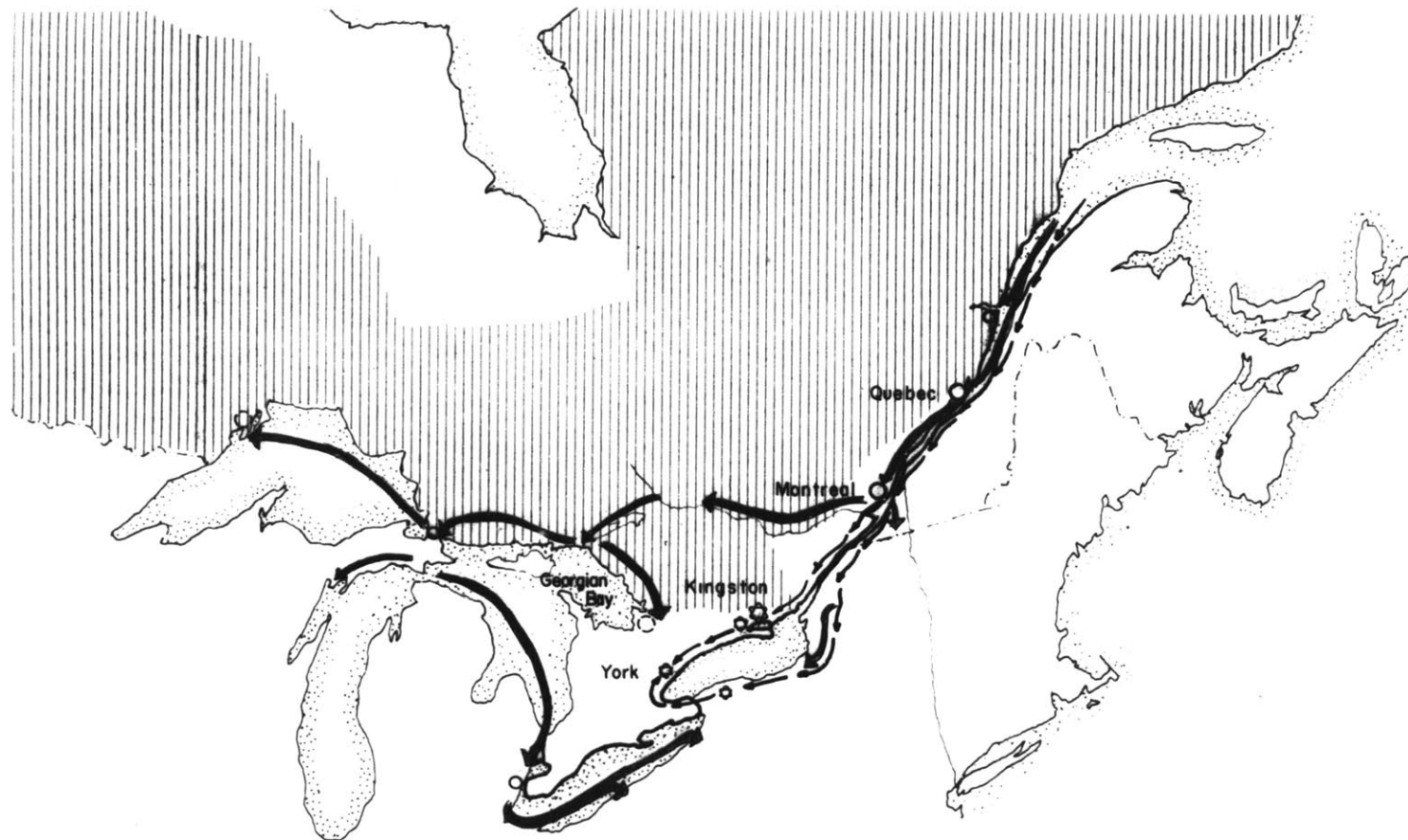
#### THE ST. LAWRENCE RIVER - GREAT LAKES SETTLEMENTS

The St. Lawrence River was the line of French penetration into Canada, with the first settlements, Quebec and Montreal, made along this route

between 1550 and 1600. The French reached Georgian Bay by a northern route along the Ottawa River and Lake Nipissing and then turned to the south to reach Lake Ontario in 1615; not until 1657 was a southern route to Lake Ontario along the St. Lawrence opened by the French.<sup>21</sup> These first settlements in southern Ontario did not survive and the first stable towns were founded in this area by British and "Loyalists" migrating from America. In this period, from 1780 to 1800, appeared Kingston near the Bay de Quinte and York, the future Toronto, on the shore of Lake Ontario.<sup>22</sup> Figure 6 shows the early French penetration and subsequent British settlements. The next 20 years (1800-1820) were characterized by the spread of new settlements further inland along routes opened from these first towns. Accessibility was the main determinant for the general pattern as it developed up to 1820. The northern hinterlands were developed as new routes, over land or water, were opened, while movement to the south was restricted by the establishment of a political line separating the British settlements from the newly independent states.

The pattern of settlement was characterized by the sparseness of population; the first towns, Quebec, Montreal, and Kingston and its surrounding areas, were the most densely populated, and these centers were the only ones providing urban services. The economy was chiefly of self-sufficient farming; trade developed very slowly, since the overall communication was poor. The link among districts was weak; although roads were opened the difficulties of transit were great, and trade was carried almost entirely by the St. Lawrence River.<sup>23</sup>

During the next 20 years (1820-1840) new immigrants arrived from Britain and Ireland. These migrants were received by the oldest settled



EARLY FRENCH PENETRATION AND SUBSEQUENT BRITISH SETTLEMENTS

- French routes (1530-1763) ... ○ ○ settlements, ○ forts
- British routes (1780-1800) ... ☆ ☆ settlements
- Canadian Shield

EASTERN CANADA

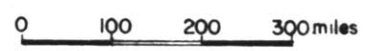


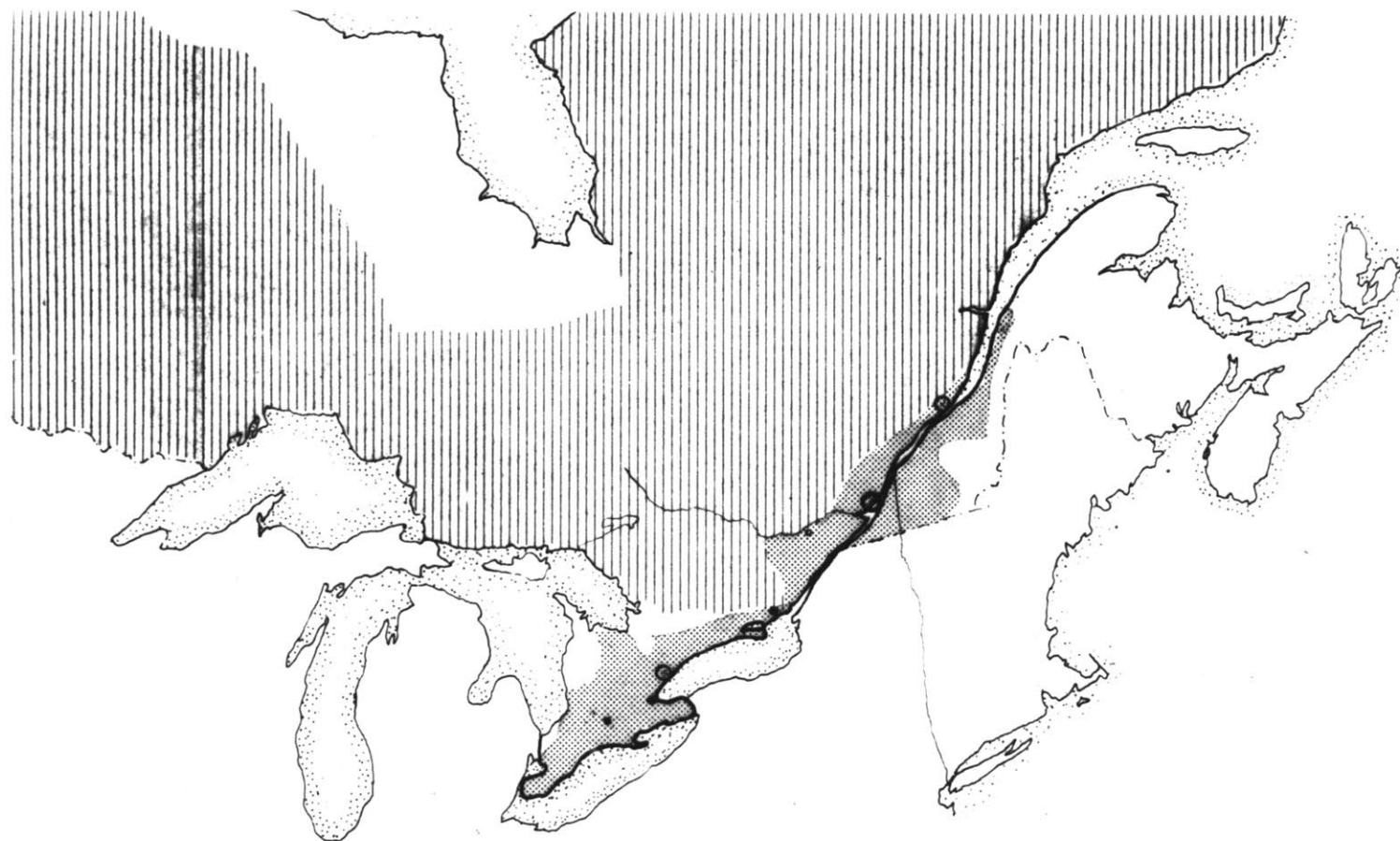
FIGURE 6

parts of the region, from where some of them penetrated into new areas.<sup>24</sup> This period is characterized by the opening of canals that allowed further connections to the north of the already settled area, and also to the south to reach the American frontier. The opening of the Welland Canal is of especial importance for the development of the area of Ontario. The canal provided a new trade route between Toronto and New York and in this way, Toronto gained independence from Montreal. Trade and finance underwent considerable change on account of the easy access to the American market; the period of the self-sufficient economy was drawing rapidly to a close.<sup>25</sup>

By 1850 (just before the railroads developed) the urban pattern had grown in close relation to the main artery and already had been extended to the southern limits of the Canadian Shield.(Figure 7). The ports exhibited the larger urban concentrations: Montreal 57,700 inhabitants; Toronto 30,700; Quebec 30,000; Hamilton 14,000; Kingston 11,500; Ottawa 7,760. The only inland city of importance was London with 7,000. Other ports ranged between 2,000 to 5,000 inhabitants, and the inland centers were in the order of 500 to 2000 inhabitants.

The geographic location of Toronto in respect to New York and Montreal and its setting as administrative center and gateway to a large hinterland enabled this center to grow from 3,000 inhabitants in 1830 to 30,700 in 1851, while Kingston with 4,000 in 1831 only grew to 11,300 by 1851.<sup>26</sup>

The linear pattern that developed prior to 1850 was under the influence of natural elements: the river - Lakes system and the fertile lands that extended up to the Canadian Shield and marked the northern boundary of the settlements.



LINEAR PATTERN OF SETTLEMENT - 1851

- |   |  |
|---|--|
| <p>  Extent of area settled.<br/>  Canadian Shield         </p> | <p>  over 50,000<br/>  25,000-50,000<br/>  10,000-25,000<br/>  5,000-10,000         </p> |
|---|--|

EASTERN CANADA

0 100 200 300 miles

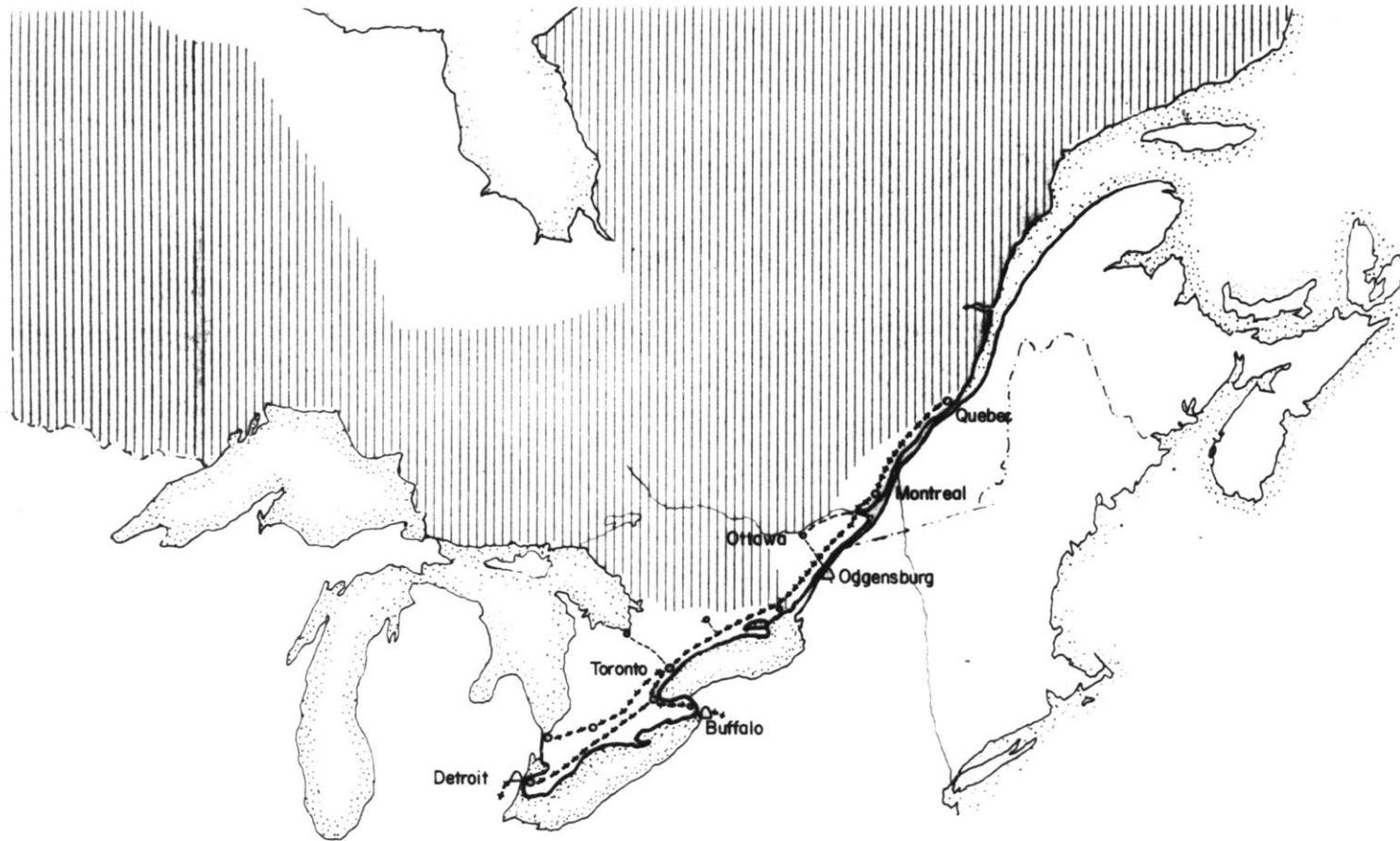
FIGURE 7

When new means of communication were laid out, they followed the line of centers already existing, creating for them an overland route. The principal line of railroads (Figure 8) joined Toronto with Montreal and continued to the southwest, reaching the American boundary at Windsor-Detroit. Other lines appeared radiating from the existing major centers.

Although the linear system was reinforced by the parallel layout of main railroad lines and the river, some modifications were introduced. In essence the new lines followed a pattern similar to the waterway routes; thus direct connections were made to the American railroads at the border: Hamilton-Niagara-Buffalo; Windsor-Detroit; Ottawa-Prescott-Ogdensburg. In addition feeder lines were extended from inland centers to the main line running from Toronto to Montreal. The construction of these lines had a profound effect on the growth of urban centers. Toronto benefited largely by this enterprise and it expanded to a population of around 100,000 by 1880, while Montreal reached 107,000 by 1871. Kingston, the earlier rival of Toronto, lost most of its importance as a trade and shipping center, while Hamilton, at a focal point of the railroads, became a center of about 20,000. Other inland centers, Guelph, Lindsay, and Peterborough, were served by railroads and grew to centers of 5,000 to 10,000.

There was a multiplication of centers but, even more important, there began a differentiation in the functions these centers performed. Although a number of them remained only central places for their contiguous hinterlands, others engaged in specialized manufacturing or in trade and communications for a larger system; all of this last type were located along the new routes of communication.





RAILROAD NETWORK 1851-1880

- Main railway lines
- Secondary railway lines
- ||||| Canadian Shield
- o Canadian centers
- △ American centers

EASTERN CANADA

0 100 200 300 miles

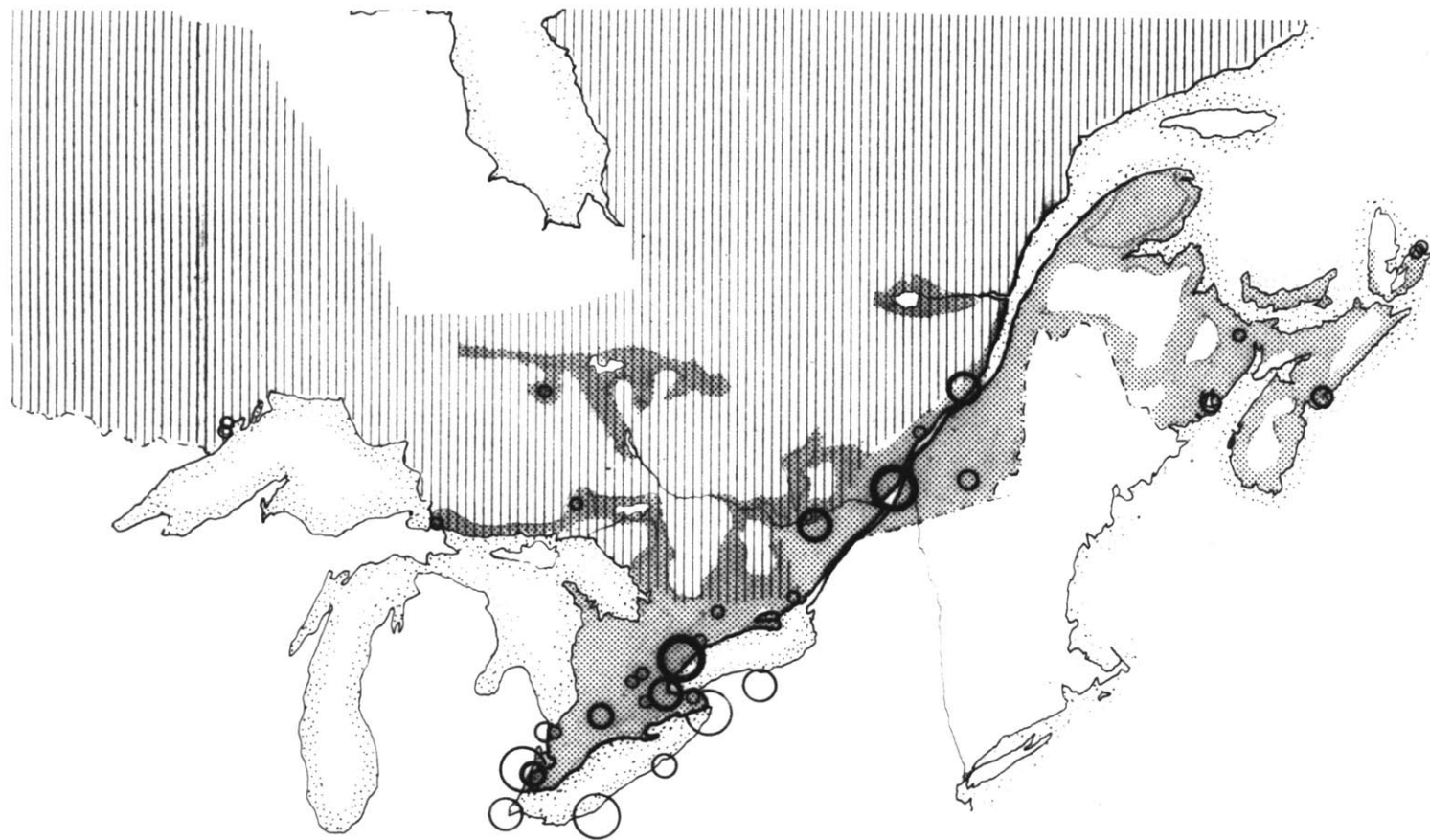
FIGURE 8

The struggle between Toronto and Montreal for supremacy on the St. Lawrence system continued when, during the 1900's, both wanted an extension of lines across the country. Montreal won in this conflict and the Central Pacific Railroad was built to Vancouver, giving to Montreal a larger area of dependence. Later Toronto joined this line at North Bay, and opened for itself the rich mineral lands of northern Ontario.




The basic pattern did not change although the two great centers, Montreal and Toronto, had increased their hinterlands and continued to grow at a higher rate than the other centers. In southern Ontario new centers grew along the new lines, and engaged in trade and transportation, a function previously performed only by the ports.

Figure 9 of the St. Lawrence system of cities illustrates the growth experienced by Montreal and Toronto during the first half of this century. Since the first decade of the 20th century, both Toronto and Montreal have had opened for them the rich mineral lands of northern Ontario and central Quebec. Both have engaged in manufacturing, using imports to supplement their own raw materials. (In 1911 Toronto employed 70% of the manufacturing labor force in south-central Ontario; in 1951 this grew to 83%. This manufacturing is highly diversified, with iron and steel products employing 17.7% of total manufacturing labor force.)




The dominating role of Toronto and Montreal is based on their central location in the transportation net (Figure 10). Through this they serve as market place for their provinces -- their locations insuperable for the distribution of finished products. This great concentration of populations and functions operates as a magnet for the further increase



**LINEAR PATTERN OF SETTLEMENT - 1951**

-  Extent of area settled
-  Canadian Shield
-  The american cities at the border

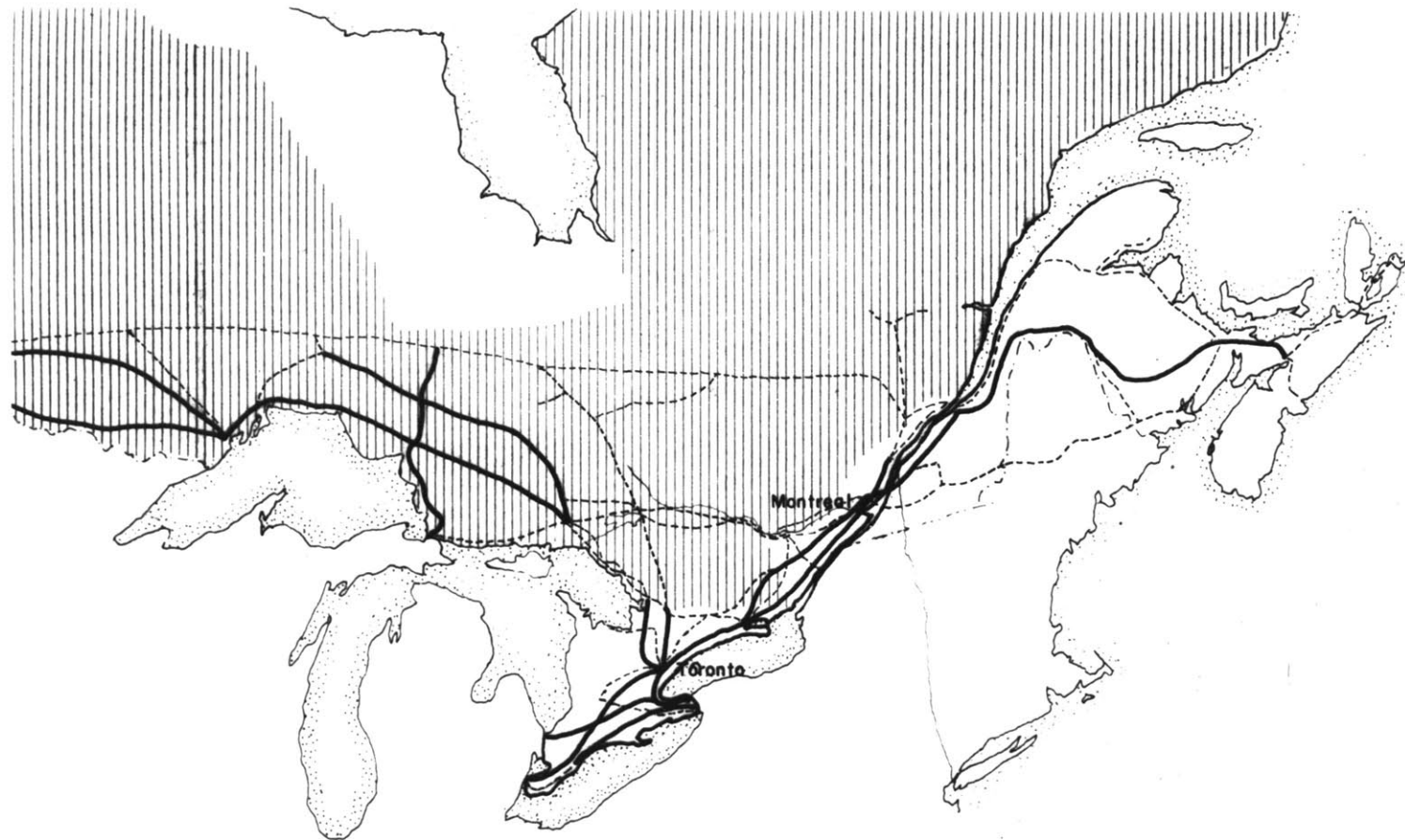
-  Over 1,000,000
-  250,000-500,000

-  100,000-250,000
-  50,000-100,000
-  25,000- 50,000

**EASTERN CANADA**

0 100 200 300 miles

**FIGURE 9**



RAILWAY FREIGHT TRAFFIC (1954)  
 Thousands of net-tons per mile of road operated

- 2000 to 7000 and over
- - - - 100 to 2000
- ||||| Canadian Shield

EASTERN CANADA

0 100 200 300 miles

FIGURE 10

of industries, attracting also larger populations. Now these centers have grown in their peripheries to almost join nearby cities. Hamilton and Toronto already form a solid line along the Lake Ontario shore.

This self-propelling quality of centers became a characteristic of the larger centers once they had established their dominance over a large area. The ease of communications made the service of larger regions possible by these centers, and the smaller centers tended to disappear or their rates of growth were diminished.

The pattern of today is still fairly consistent with that created 170 years ago. New centers have appeared and the total density of population in the area has been multiplied many times, but what was born along the river still remains and tends to perpetuate the linear pattern by the strength created over a long period of time.

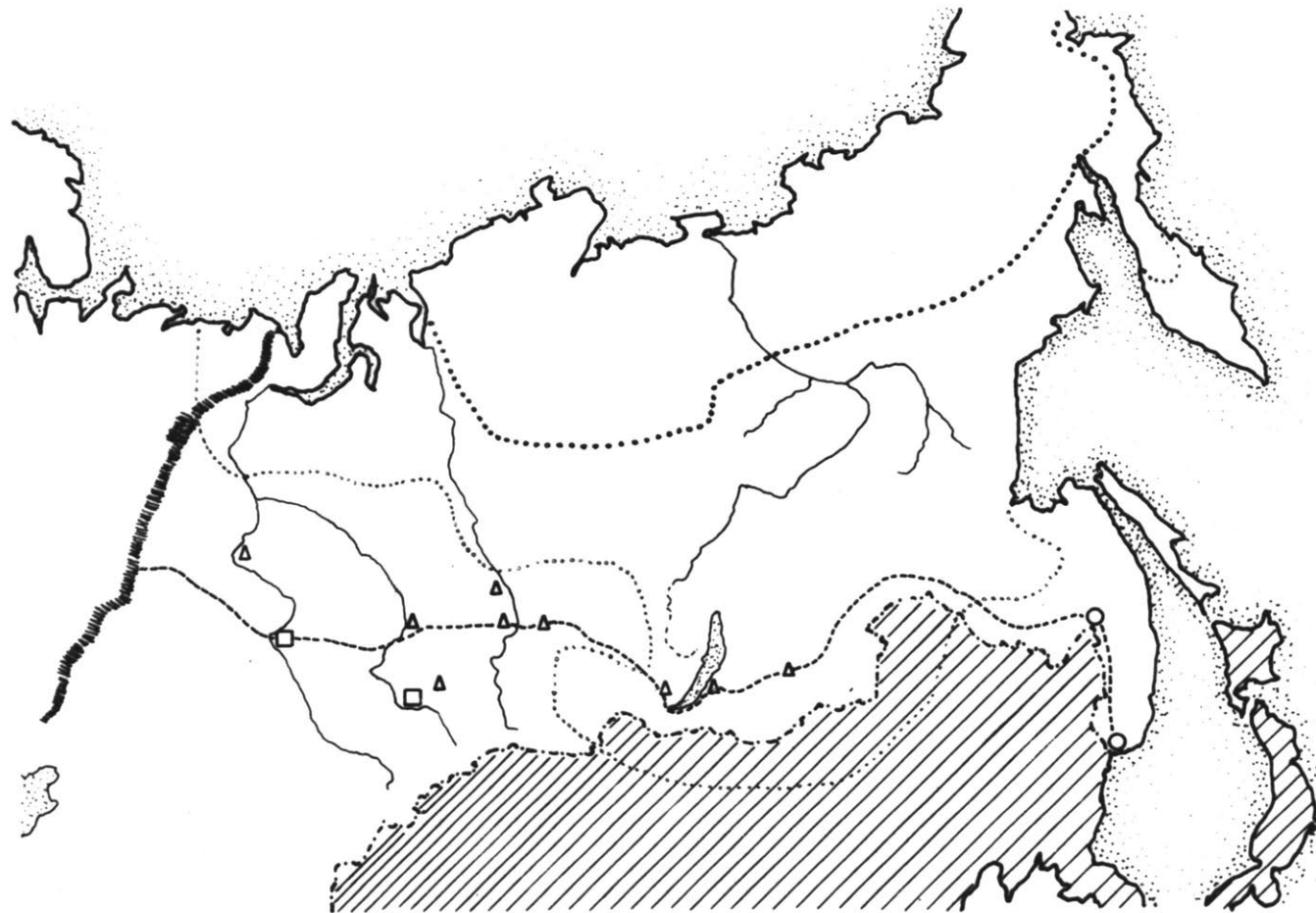
This second case of classical linearity developed its linear form in the first settlements along the river - lakes system. The original structural element of linearity was accompanied by the natural constraints of the Canadian Shield and the political boundary with the United States. The original trade routes along the river - lakes line were reinforced by new means of communication and at the same time the accessibility of markets across the border favored the location of major centers. From this interaction two major centers, Toronto and Montreal, outgrew from the system.

#### SIBERIA

The picture of the origin of settlement in Siberia is quite distinct from the ones already considered. In the cases considered up to now a natural element served as a guide for settlement. But for the expansion

of the Russian territory in the 16th century there was no natural route to carry on the conquest of neighboring tribes. The motive for the settlement of the eastern part of Russia was the conquest of other lands and peoples, and the colonization was a military operation by which the Russians absorbed the subjugated tribes into their expanding territory. The process was surprisingly rapid; in less than a century the Pacific Ocean was reached. In this expanding process the object was to establish a number of fortified centers at strategic locations, in most cases at the river crossing points.<sup>27</sup> A look at the map shown in Figure 11 will indicate the locations of these forts. These fortified places, founded during the first half of the 17th century, were the guards of the new frontier. Thus this linear element was not a natural one but a political line. It was not until the 18th century that Siberia began to be populated. By the beginning of the 19th century there were already 600,000 inhabitants in Siberia, mostly in the western parts, where agricultural land was available. It was not until the last decade of the 19th century that the eastern part of Siberia was settled. The agent of colonization then was the Trans-Siberian Railroad, which by 1871 had reached the Pacific Coast. The purpose of its construction was the protection of the border districts through colonization against their eastern neighbors. Now a linear element had appeared in the form of a man-made route. Figure 12 shows the line of the railroad, along the forts and the southern border; where it enters the area of permafrost it lies close to the boundary line.

The lack of a route of penetration slowed down the process of development, but when the railroad was built, it functioned like a natural element. It is worth mentioning in addition that this region of Siberia



FORTS AND EARLY SETTLEMENTS

△ 1600 - □ 1700 - ○ 1800

----- Trans-Siberian railroad at the beginnings of the 20<sup>th</sup> century

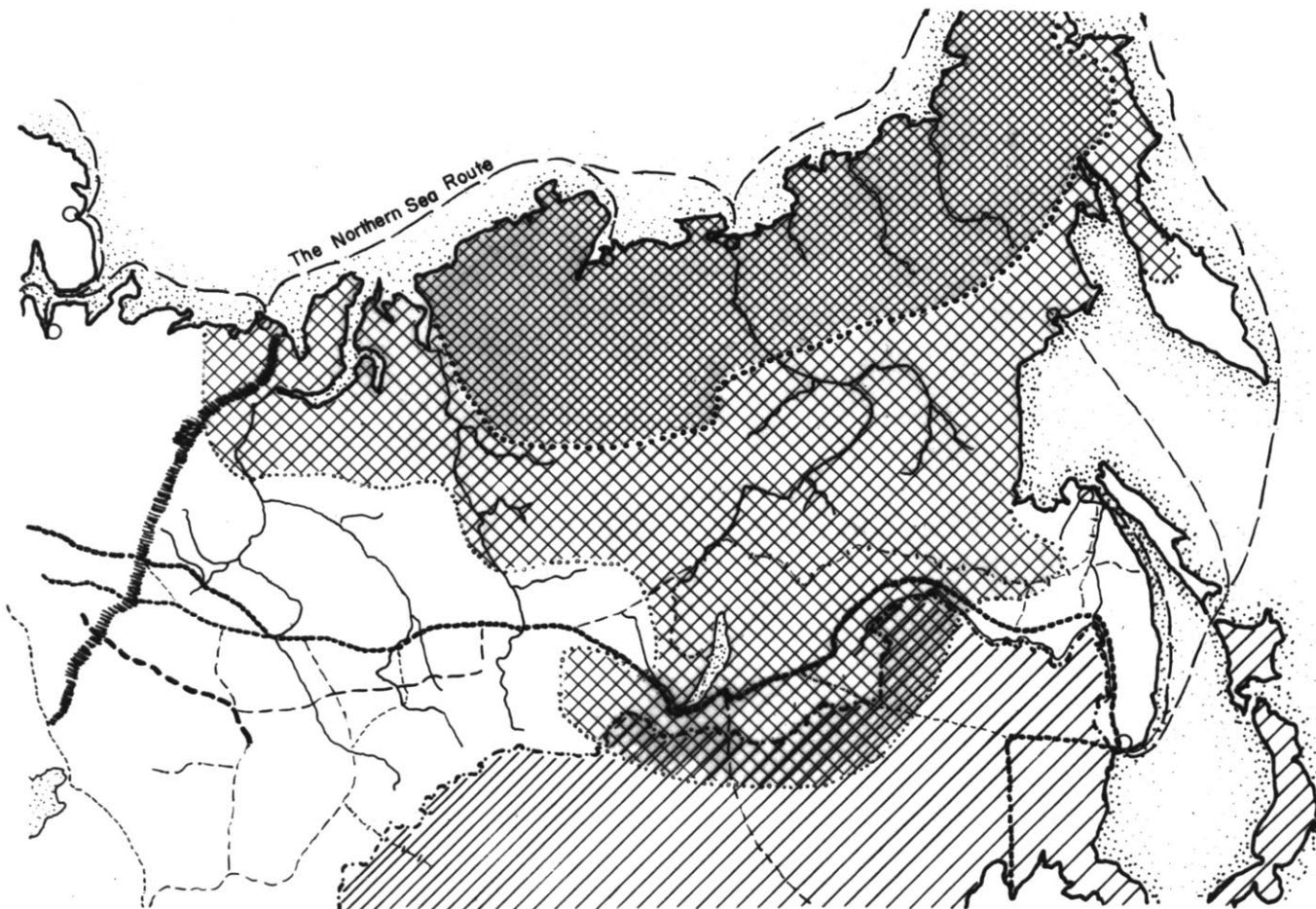
..... Southern limit of intensive permafrost

..... Southern limit of greatest extent of permafrost.

SIBERIA

0 500 miles

FIGURE II



**WATERWAYS AND RAILWAYS**

Railroads built before 1917	multiple track	single track
Railroads built since 1917	— — — —	— — — —
Seaways	— — — —	and navigable rivers
.....	Southern limit of intensive permafrost	
.....	Southern limit of greatest extent of permafrost.	

Projected lines — — — —  
 Ports ○

**SIBERIA**

0 ————— 500 miles  
**FIGURE 12**



is crossed by a number of large rivers. However, since the rivers run in the north-south direction they contributed very little to the original settlement in which the major movements were in the east-west direction. When this cross line was established then the rivers began to act as secondary agents for further penetration and settlement.

Although settlement along the Trans-Siberian Railroad progressed and the agricultural population expanded into new areas, the centers continued to be located along the major line.<sup>28</sup> Industries developed in accord with the resource availability of each area, and soon an active commerce developed exerting a steadily growing influence on the Siberian towns.<sup>29</sup>

In 1917, with the Russian revolution, a change took place. A new emphasis was placed on active commerce, industry and exploitation of natural resources. Thus the creation of new lines, the Turkish-Siberian Railroad and the line to China from Ulan-Ude brought accelerated growth to the old centers (for instance, Omsk and Novosibirsk).

In Siberia the extension of a communication network did not mean the parallel development of new routes in respect to pre-existing ones, but rather these came to complement the pattern already there. Thus, the rivers now were used for north-south traffic and railroads were extended to connect territories further south of the main line (Figure 12). Omsk and Novosibirsk, centers of western Siberia since early times, grew to attain regional dominance over vast territories and to serve as connecting points to the already existing complexes in the Urals and central Eurasia.

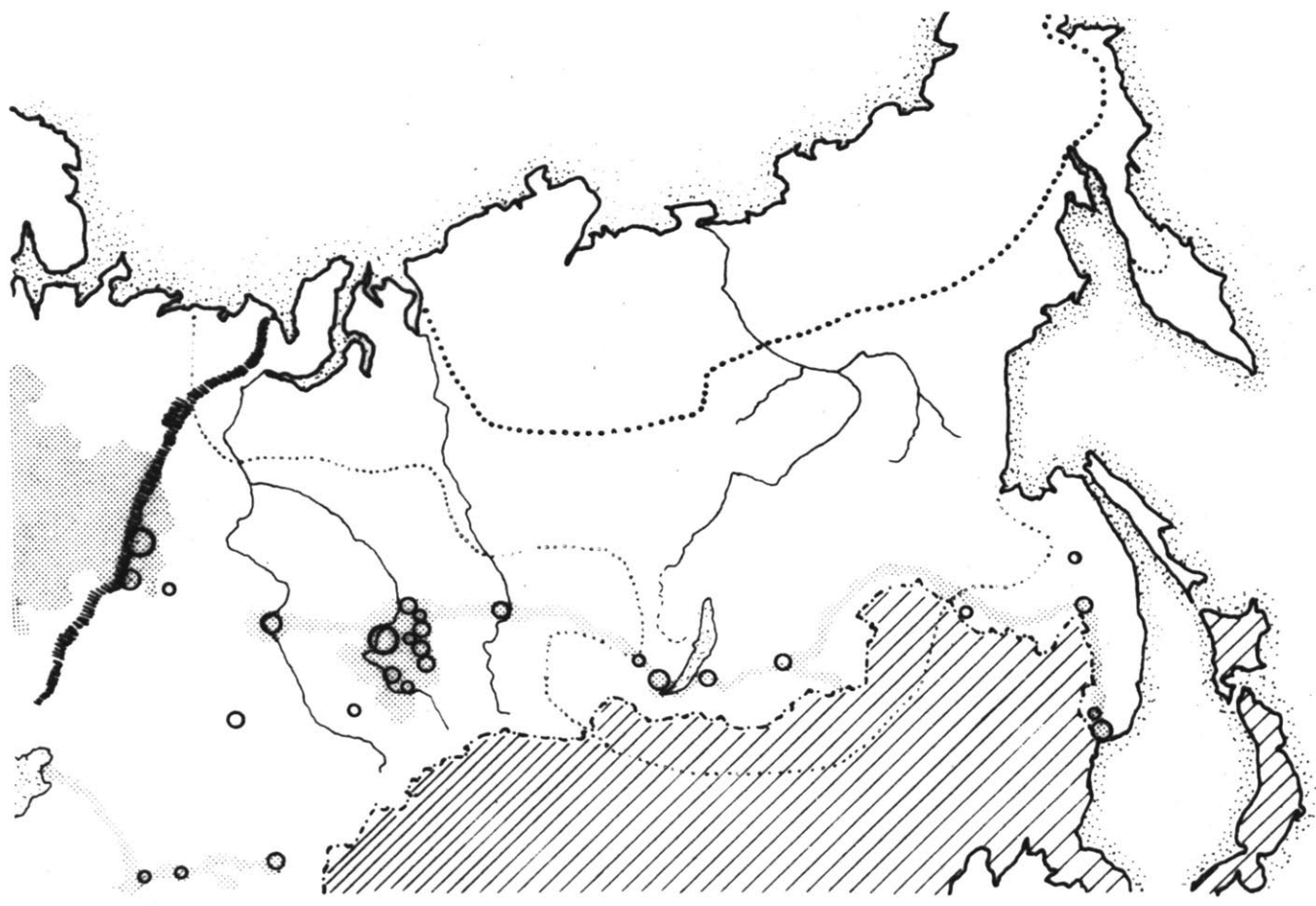
The pattern developed by the growth of new centers was closely related to the resource availability. From 1926 on, a number of industrial centers appeared in the Kusbas Industrial District (near

Novosibirsk), where coal was available as the source of fuel and iron ore could readily be brought from the Urals.<sup>30</sup> These centers formed a line perpendicular to the Trans-Siberian Railroad; although industrial centers, they have not overpassed the trade centers already established, which now in turn have engaged in complementary manufacturing (Figure 13). Figures 13 and 14, where the distribution of population is shown for the years 1939 and 1959, indicate some of the modifications appearing in the system. Although the centers along the line have continued to grow there are now a number of centers outside the line also. The development of an extensive system of highways has brought these cities into communication with the railroad (Figure 15).

Siberia underwent a considerable increase in population since 1939, mainly in urban population directed to the further exploitation of natural resources.<sup>31</sup> The mineral resources of the plateau of central Siberia are not completely known but the variety of the deposits already found is impressive: coal, diamonds, graphite, gold, oil, tin, copper, nickel, lead, and zinc.<sup>32</sup>

Although transportation is still a problem the development of the Northern Sea Route has helped to overcome some of the difficulties. This seaway and the network of rivers it joins is open only during a short season (Figure 12). In addition an extensive network of air lines facilitates communications and the transport of light cargo.<sup>33</sup>

The adverse climatic conditions that undoubtedly influenced the layout of the Trans-Siberian Railroad along the southern limits of the permafrost region (Figure 12) seem now overshadowed by the opportunities of rich resources available there. Thus the linear system is in transition to a more complicated and extended distribution of centers. Figure 16 shows



Settled areas - 1939

- Over 10 persons per sq. km.
- ..... Southern limit of intensive permafrost
- . - . - Southern limit of greatest extent of permafrost.

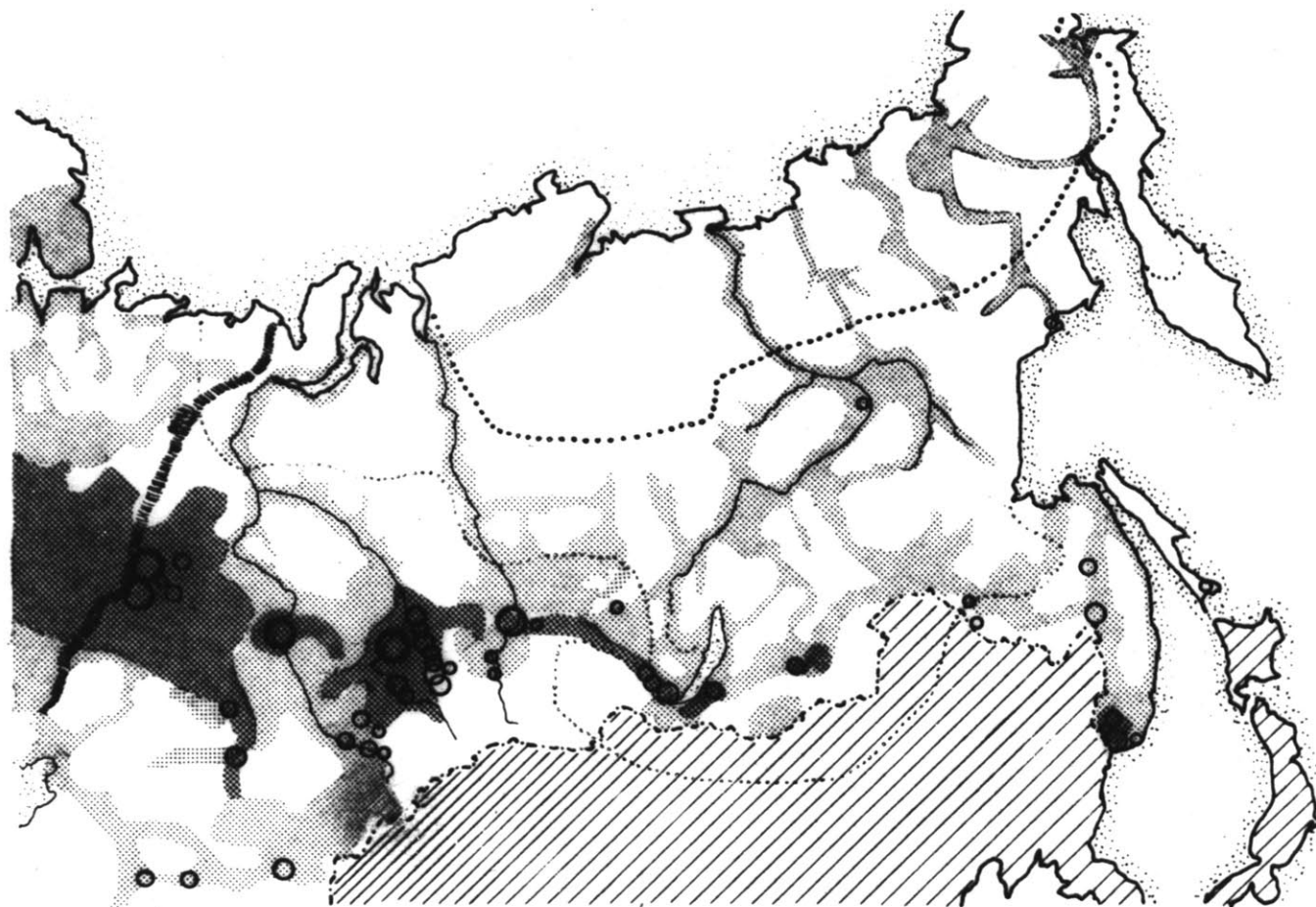
CITY - SIZE DISTRIBUTION

- Over 400,000
- 200,000 - 400,000
- 100,000 - 200,000
- 50,000 - 100,000

SIBERIA

0 500 miles

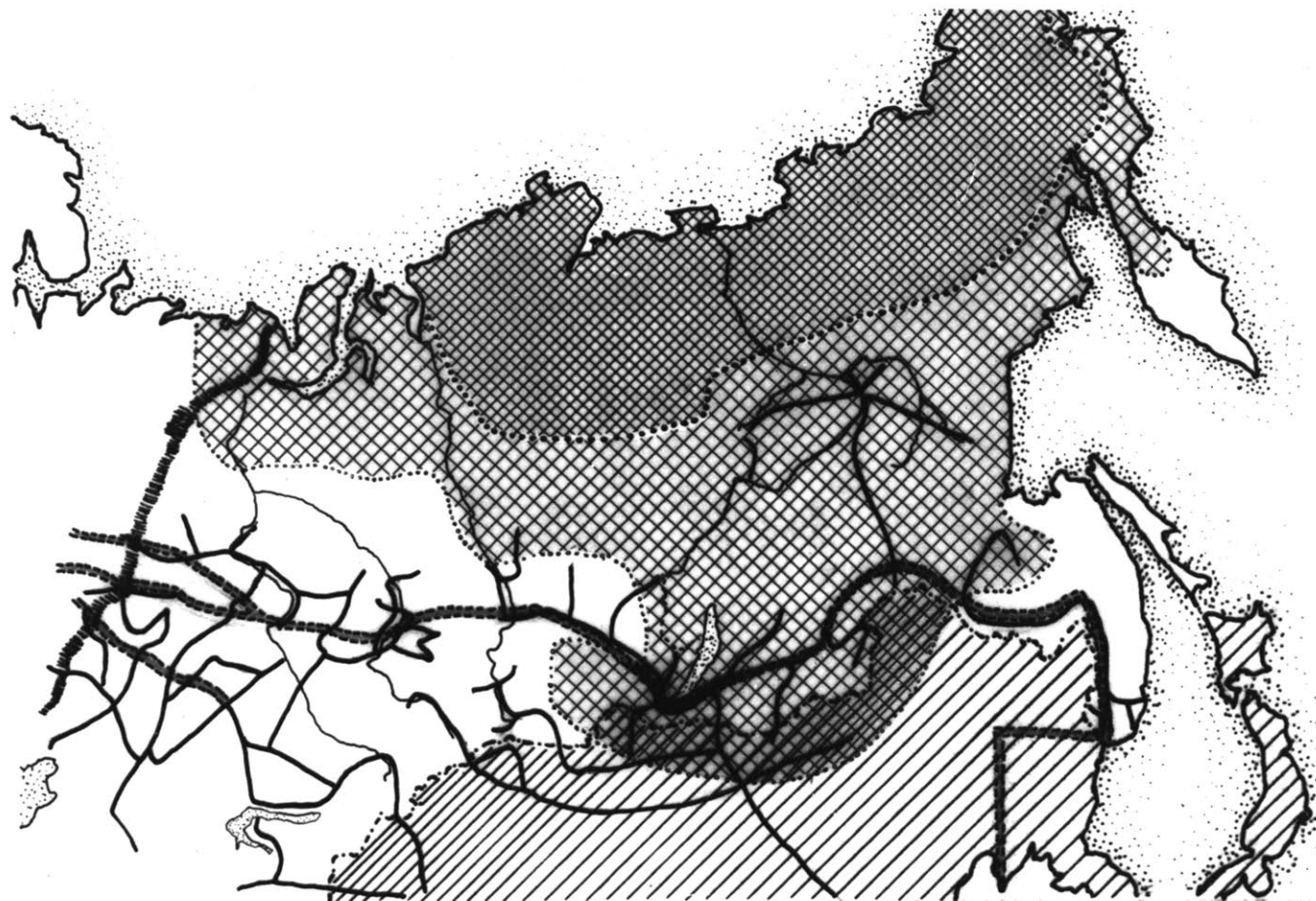
FIGURE 13



Settled areas - 1959  
 ▨ 20-50 persons per sq. km.  
 ▩ 10-20 persons per sq. km.  
 ..... Southern limit of intensive permafrost  
 ..... Southern limit of greatest extent of permafrost.

CITY SIZE DISTRIBUTION  
 ○ Over 750,000  
 ○ 400,000-750,000  
 ○ 200,000-400,000  
 ○ 100,000-200,000  
 ○ 50,000-100,000

SIBERIA  
 0 500 miles  
 FIGURE 14



ROADS  
 — Main roads  
 — Main railroad lines  
 ..... Southern limit of intensive permafrost  
 ..... Southern limit of greatest extent of permafrost.

SIBERIA

0 500 miles

FIGURE 15



LINES OF MOVEMENT AND REGIONS OF INFLUENCE

SIBERIA

graphically the orientation of the centers and the units they affect together with the main lines of movement.

#### VENEZUELA

In the case of Venezuela the first settlements took place along the coast and in the mountainous areas of this tropical region. The choice of the mountains for the first settlements is explained by the motives that guided the Spanish colonization, that is, the mineral exploitations, as well as because of the climatic conditions of the lowlands. During the 16th century a number of mining centers were founded in the western part of the country while the ports along the coast were the complementary centers of these extractive functions.<sup>34</sup>

In the 17th century, when the mining exploitations were proven not to be what the first expeditions had thought to have found, the settlers turned to agriculture; their settlements took now the form of permanent homesteads. Up to 1925 the country's area was sparsely populated; the small towns and villages served their corresponding rural population and cities existed to perform administrative and commercial functions for their regions. The structural element in the linear pattern is the mountain range that runs first along the northern coast and then inland to the southwest. Prior to 1925 the linear pattern was not yet an interdependent system of cities but rather a line of separate units depending on the ports along the coast for exterior communications. Caracas, the largest city, had 168,000 inhabitants in 1926 while Maracaibo, a port city serving the mountainous areas of the west, was the second with 75,000 -- the rest of the 10 largest cities ranged from 10,000 to 30,000 inhabitants.<sup>35</sup>

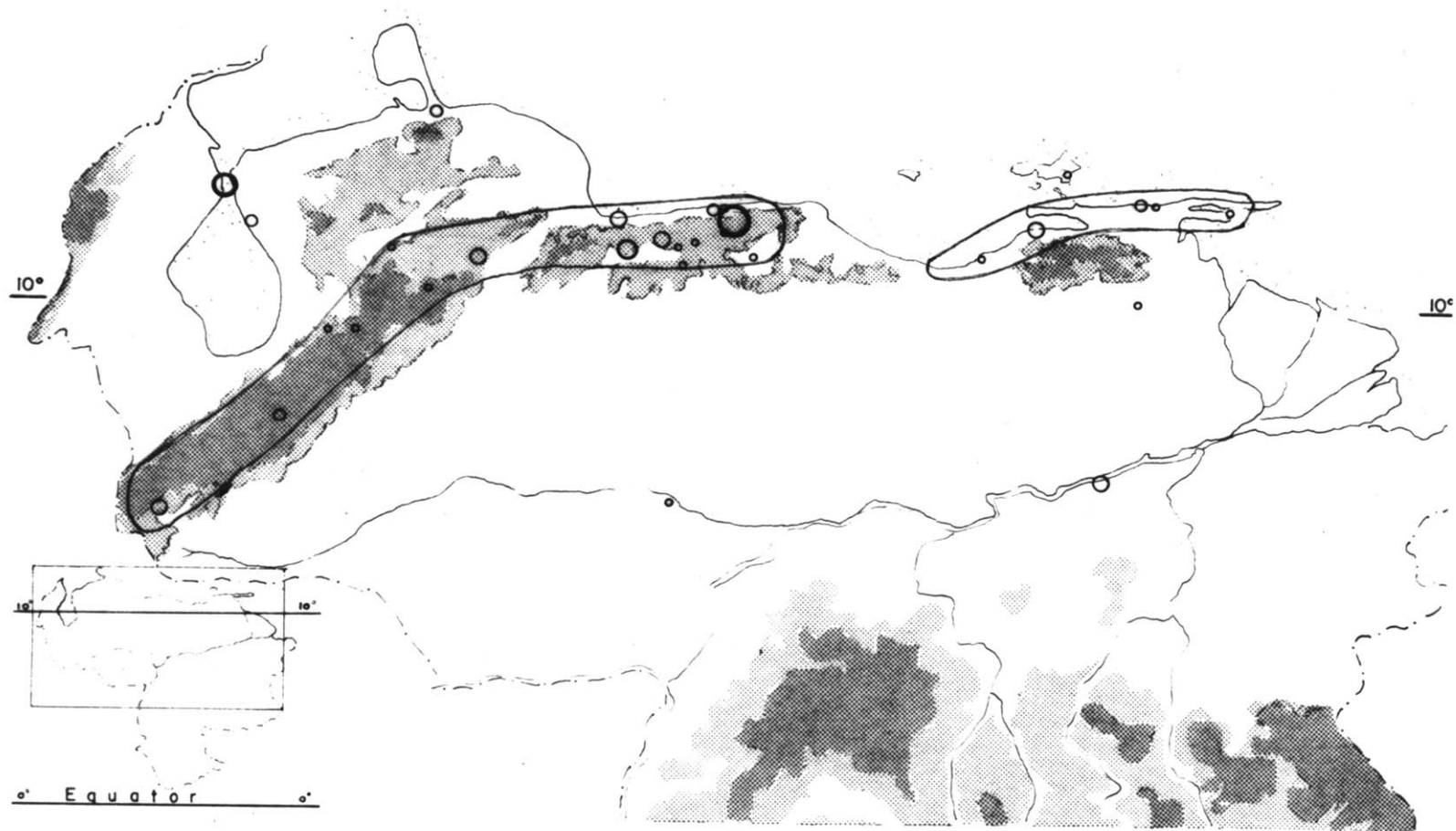
With the oil exploitations, started in 1925, an increase in urban population was observed, particularly in the central coastal states. The centers along the Andean range grew and maintained themselves as local trading centers; only two, San Cristobal at the Colombian border and Barquisemento on the line between Maracaibo and Caracas, grew to be distinguishable from the rest by their sizes. Figure 17 shows the arrangement of cities as it existed in 1936, resembling the pre-existing patterns.

During the period from 1936 to 1950 changes in the country's economy and an increase of the urban population introduced modifications on the first observed linearity (Figure 18). A further centralization occurred in the area of the central coastal states around Caracas; new lines of cities appeared at the foot of the mountains, another line was formed along the lake shore in the vicinity of Maracaibo, and in the eastern region new cities appeared near the oil fields and along the route that joins this area with the federal capital.

The transition from the first linear pattern to one that approximates a band with ramifications is due to the development of new resources in oil and demands for cultivable land that forced the population to move to the lower inland areas. The original conditions that restricted the settlement to the upper lands were now overcome by new techniques, the most important in tropical health.

A look at the network of roads shown in Figure 19 shows the linkages among the centers and the position of Caracas at the geographical center of the system. Although the road system has accentuated the linear system, it also has contributed to reinforce the preeminent position of the center; movements from east to west and vice versa have always to






CITY-SIZE DISTRIBUTION - 1936

 The basic linear pattern

 Over 1000 mts

 Between 500 and 1000 mts


 200,000-500,000

 100,000-200,000

 50,000-100,000

 20,000-50,000

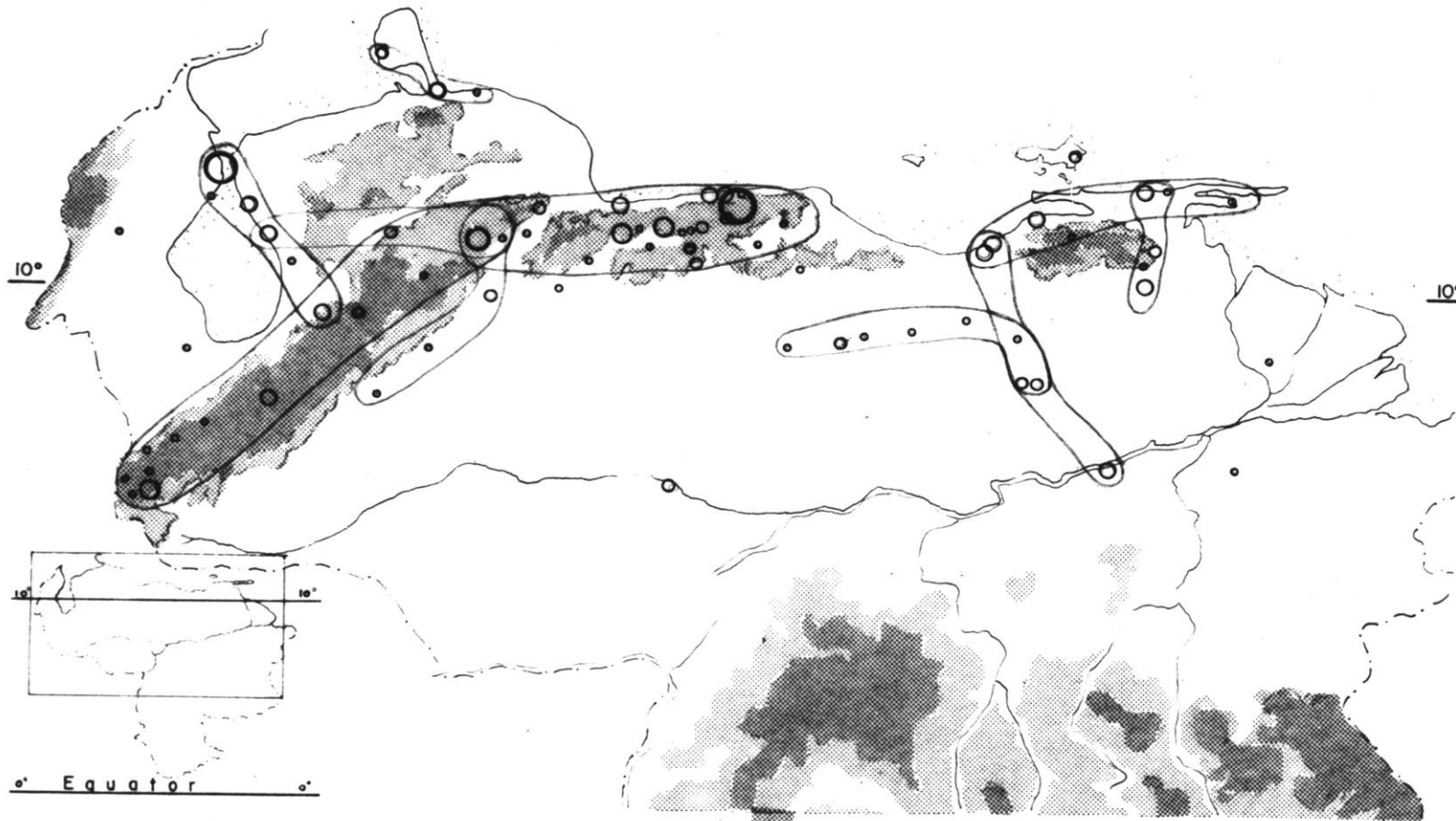
 10,000-20,000

 5,000-10,000

VENEZUELA

miles 0 50 100 200

FIGURE 17



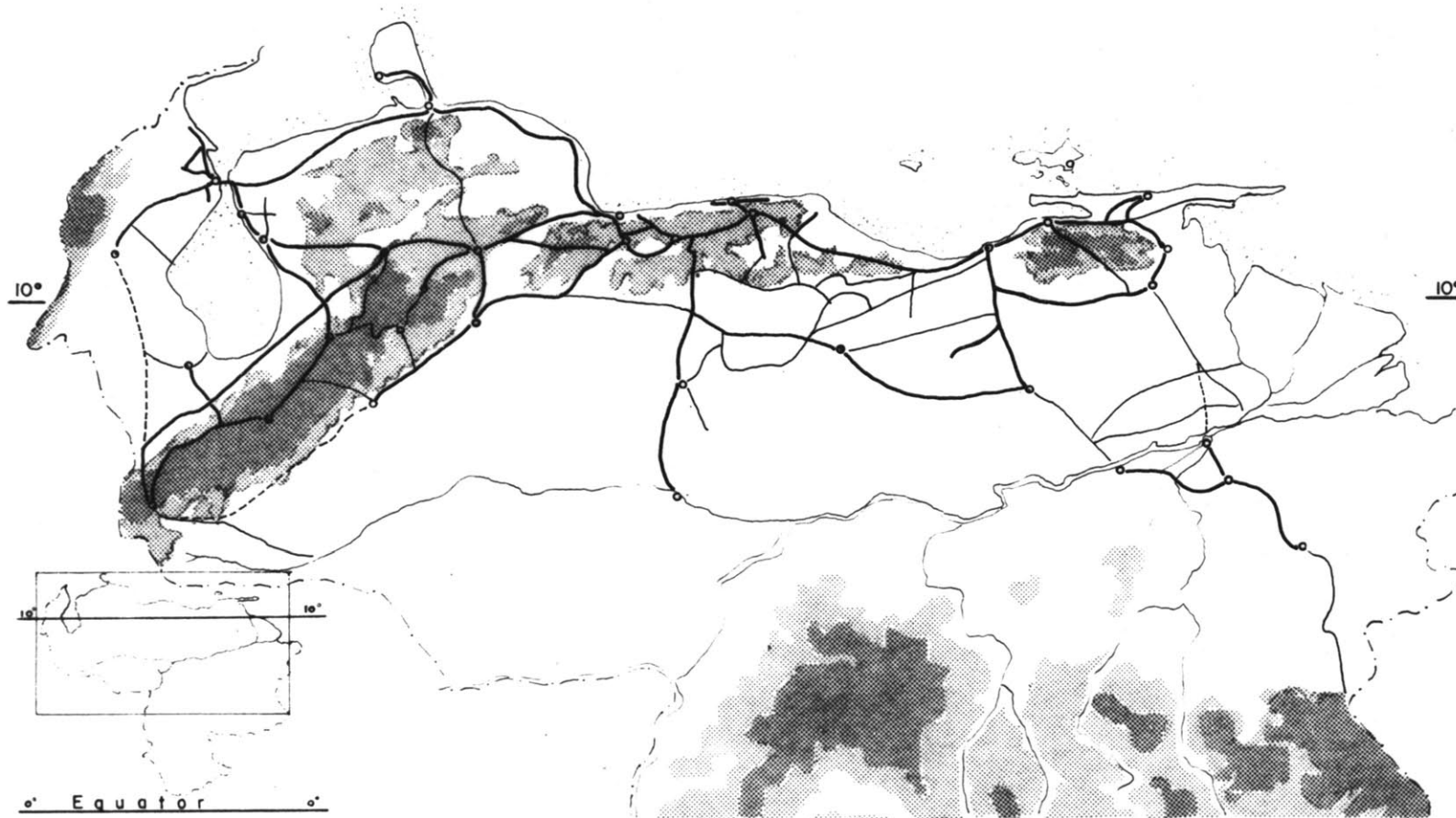
CITY-SIZE DISTRIBUTION - 1950

- |                            |                     |                   |
|----------------------------|---------------------|-------------------|
| ○ Over 500,000             | ○ 100,000 - 200,000 | ○ 20,000 - 50,000 |
| ○ 200,000 - 500,000        | ○ 50,000 - 100,000  | ○ 10,000 - 20,000 |
| ■ Over 1000 mts            |                     | ○ 5,000 - 10,000  |
| ▨ Between 500 and 1000 mts | — Linear patterns   |                   |

VENEZUELA



miles 0 50 100 200




FIGURE 18



ROAD NETWORK (1962)

VENEZUELA

 Over 1000 mts  
 Between 500 and 1000 mts

 MAIN ROADS (paved)  
 Roads (gravel)  
 Projected roads

miles 0 50 100 200

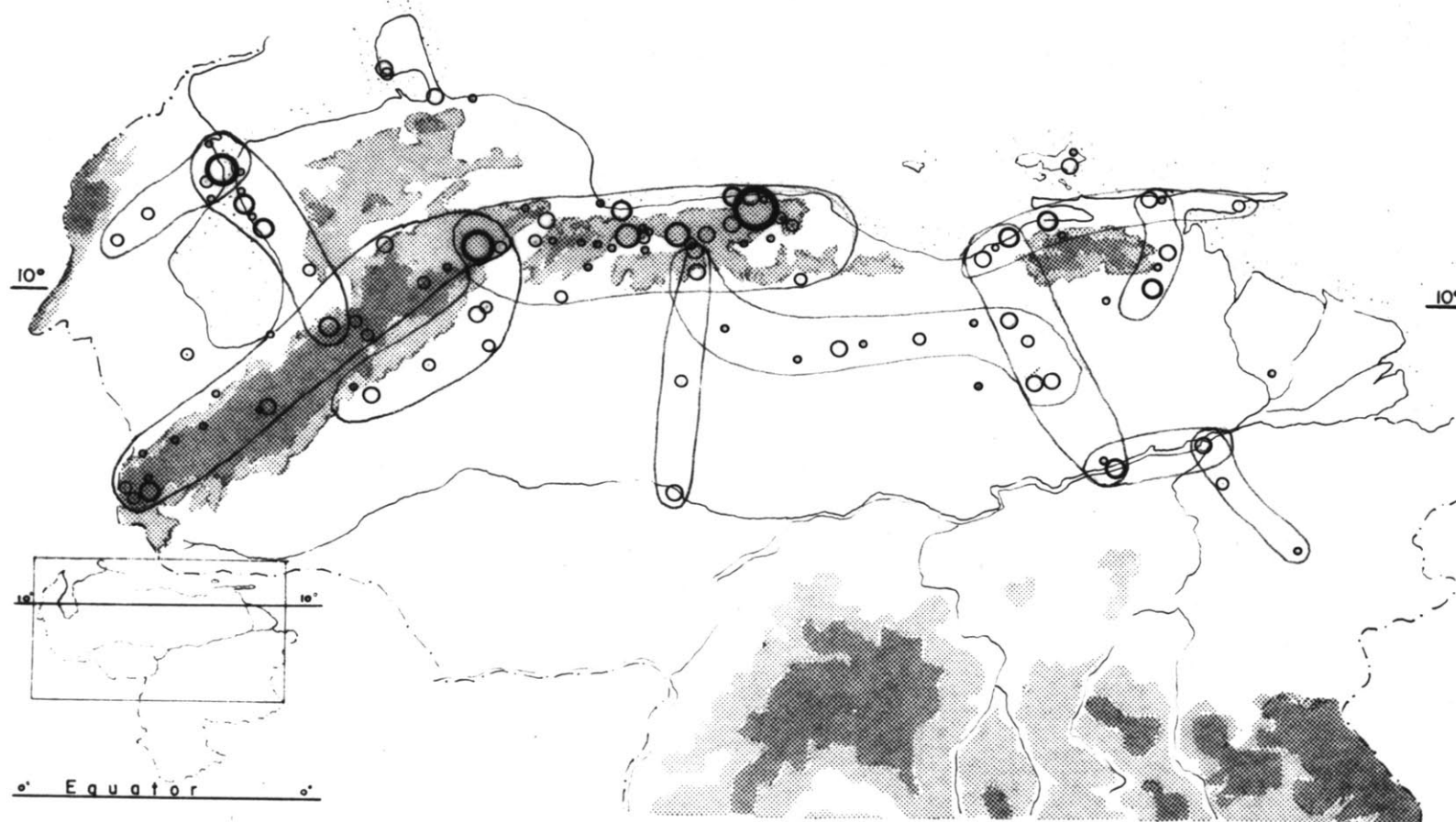
FIGURE 19

go through the capital. The map also shows the orientation, north-south, of the inland centers towards the coastal cities. Figure 20 shows Venezuela in 1961. The heavy concentration of cities in the core area demonstrates the strength of the mid-position, while the old settled areas in the mountains in contrast have not experienced a similar growth. The eastern inland region is now being developed south of the Orinoco River and it appears as the further appendix of the linear system.











During the 50's we observed the rapid growth of the metropolitan core, the movements to the new oil regions of Maracaibo and El Tigre as well as the movements into the plains that formed new lines of cities to serve the surrounding farming populations. An interdependent system of cities started to emerge and several regions of the country were beginning to be linked among themselves and with the capital.<sup>36</sup> During the 60's this process continues and emphasizes the position of the core area by the concentration of industrial activities in the Caracas - Valencia basin. The following step, the development of the eastern region, seems to be directed to a further transition of the pattern by the deliberate development of a growth pole outside the core area as well as the reinforcement of the position of secondary growth poles.

In the case of Venezuela, linearity affects a flexible pattern; the reasons are:

- a) Because of the characteristics of the terrain, the location of cities responds to particular aspects of the mountains and valleys rather than to a single linear element such as a river.
- b) Roads in the mountains have had to follow the contour lines; a natural communication route did not exist.



CITY-SIZE DISTRIBUTION 1961

- |  |   |   |
|--|---|---|
|  Over 1,000,000           |  100,000 - 200,000 |  20,000 - 50,000 |
|  200,000 - 500,000        |  50,000 - 100,000  |  10,000 - 20,000 |
|  Over 1000 mts            |   |  5,000 - 10,000  |
|  Between 500 and 1000 mts |  Linear patterns   |   |

VENEZUELA

miles 0 50 100 200

FIGURE 20

- c) A line of railroads connecting the cities did not develop to reinforce the position of the centers along the line.
- d) Agricultural land still exists within areas now to be developed and areas exist where resources are not yet well known. Thus the potentiality for further development still exists -- that is, the pattern is not yet restricted.

Thus, although the pattern has maintained its basic linear structure through the strength acquired by the old centers, it seems now in a stage of transition towards a more complicated system. The pattern now developing seems to be one of a number of interlocking linear patterns (Figures 19 and 20).

#### THE MISSISSIPPI RIVER BASIN

The Mississippi basin was settled by two different streams of colonization. The first, the French colonization, moved north along the Mississippi and founded New Orleans and Natchez. In addition, French forts were located on the Upper Mississippi on the shores of Lake Michigan. By the mid-seventeen hundreds the settlements on the American coast from Maine to South Carolina were in continuous expansion and already occupied to a considerable depth the coastal area, almost to the Appalachian Mountains, a width of 100 miles.<sup>37</sup>

Around 1780 the first advance of settlers started from the British colonies to the West; it was this flow of migrants that was to prepare the future growth of the urban south and middle west. This second stream of colonization, with east to west direction, had the Ohio River to serve as the main route into new territory. Both banks of the river were settled very soon and Pittsburgh, Lexington, Cincinnati, Louisville, Marietta and Wheeling grew from these foundations.<sup>38</sup>

Once the first obstacles of settlement were overcome the growth of this area depended on the development of an adequate transportation route. The waterways were the natural means of transport and very soon an active trade was established down the Mississippi.<sup>39</sup> The pattern of settlement in 1830 (Figure 21) had its main center at the mouth of the Mississippi River; thus New Orleans was the concentration point for the system.

The ports of the lower Mississippi were founded between 1800 and 1820; Vicksburg, Memphis and Baton Rouge came to join Natchez and New Orleans on the east bank of the river. They became concentrating points for the exports of cotton from the areas to the east and distributing points for imports carried upstream from New Orleans. These cities began to grow when the Mississippi was not only the great trade artery but also the frontier of settlement and commercial development. Their location depended on topographic factors: all were located at points where meanders of the river created natural ports.<sup>40</sup>

The upper Mississippi was settled by the east-west movements of migrants coming from the East Coast across the mountains to Pittsburgh. This center then became the focus of the routes of migration. From there the settlers continued down the Ohio River to Cincinnati; the migrants could then settle in its fertile surroundings or continue to the west. This westward movement reached the upper Mississippi around 1820; the census of 1840 recorded the cities of Alton, Quincy and Galena on the east bank of the river. The movement of settlers continued and as the areas of the West were settled, the new towns on the west bank outgrew those on the east bank. Here the river was in the way of movement of people instead of serving the traffic. The upper Mississippi towns developed more rapidly on the west bank due to the fact that their





hinterlands lay also to the west. The east bank by then had already its own links to Chicago on the Great Lakes.<sup>41</sup>

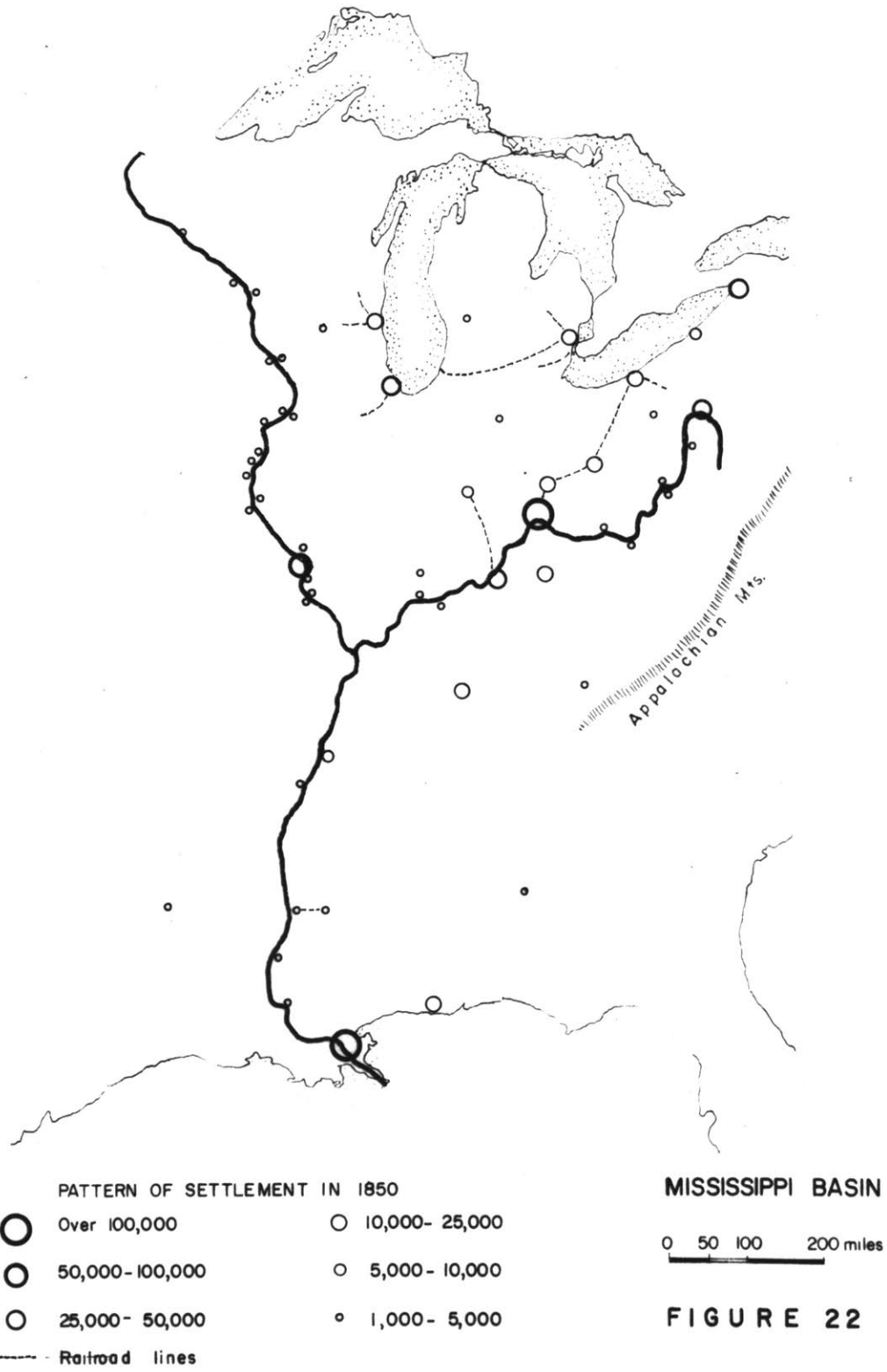
Wade, in referring to the settlement of the middle west, says that: "The key to this economic growth was transportation. It determined the pattern of settlement, the direction and volume of commerce, and the ease and speed of the occupation of the West."<sup>42</sup> This transportation route was almost exclusively the system of rivers which allowed the movement of migrants and goods into the west. The trade of the region formed a triangular shape. Eastern goods were carried across the mountains on credit extended by Philadelphia, Baltimore and New York firms. Western merchants found a market for their produce in New Orleans, from where it would be sent to the East Coast. This exchange was not highly satisfactory to the Westerners; the cost of transportation created an imbalance adverse for the region, and it was this imbalance that induced the growth of manufacturing in the western cities.<sup>43</sup> Pittsburgh and Lexington turned to industry, while St. Louis maintained a reliance on commerce; Cincinnati and Louisville experimented with both.

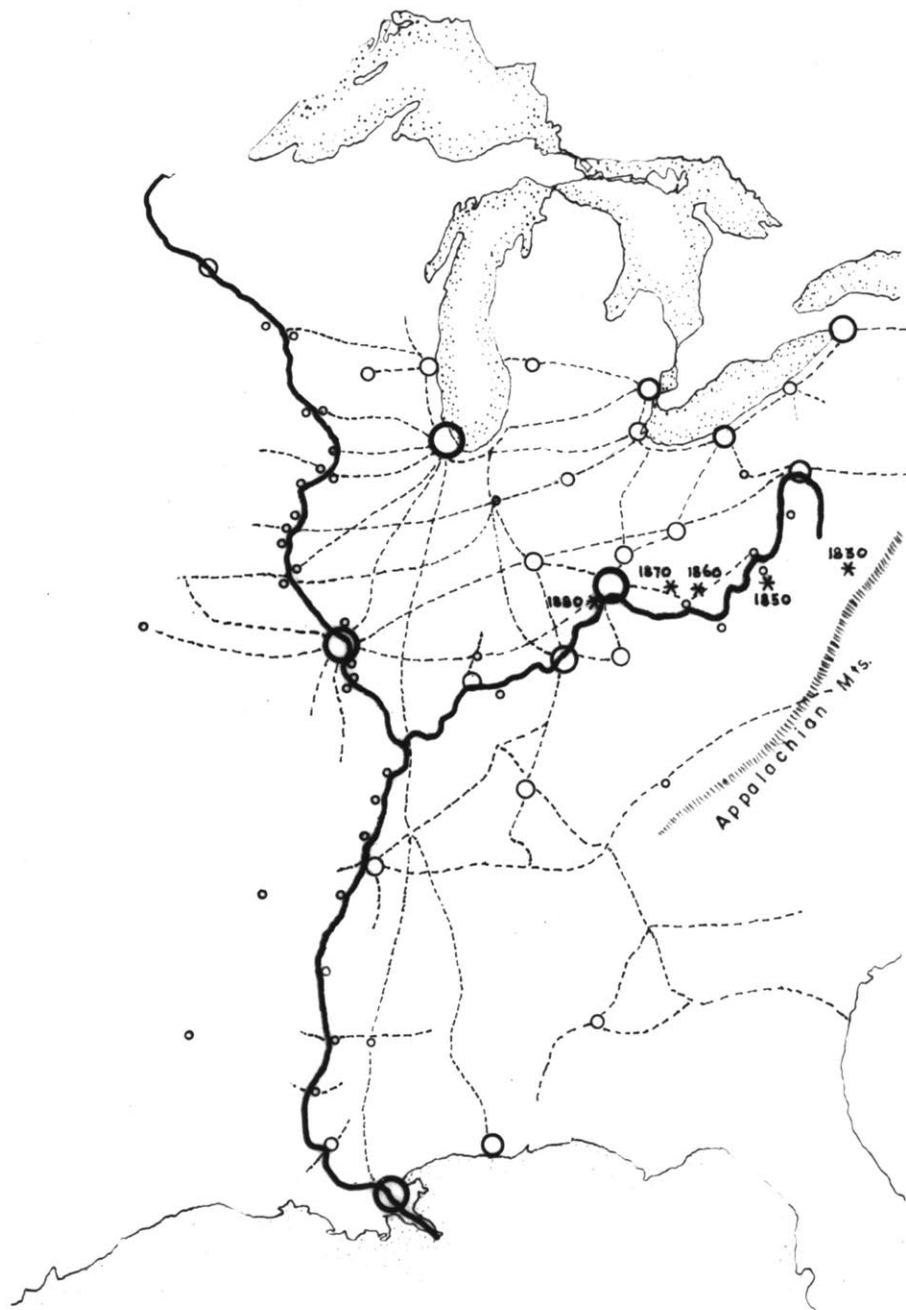
During this period of great immigration (1820-1850) the occupation of vast territories was accomplished and large areas were now developed by the newcomers. The first cities had been founded along the rivers but now the population spread out over the whole frontier region. The most densely populated areas were between the Great Lakes and the Ohio River and along the Tennessee River.<sup>44</sup> A new route opened along the Great Lakes to New York and bypassed the first lines of trade, taking away from New Orleans its supremacy. At this time, about 1850, the railroads made their appearance and their development further favored

east-west trade along a northern route. Figure 22 shows the existing centers in 1850; Cincinnati and New Orleans are of equal size and a large number of centers had grown around the Great Lakes. By 1860 (Figure 23) further transformations had occurred, Chicago and St. Louis had come to join the already existing larger centers and the railroads had crossed the plains in many directions, giving life to the inland centers. The growth of these centers was affected by their relative position in respect to the main lines and opportunities to enlarge their hinterlands to the west or south.<sup>45</sup> Thus St. Louis and Chicago were the great beneficiaries by their positions at the gateway to the west.

Through the development of the railroads there was a shift in the line of east-west movement from the Ohio River to the railroads further north and to the Great Lakes; this meant the loss of the privileged position held by the Ohio cities. In this way they became now only crossing points for north-south flow of goods, and local manufacturing centers. Louisville and Cincinnati, for example, have thus changed their role. Although they have continued importance, it is due primarily to their size and their long established commercial functions; however, their rates of growth have diminished considerably.

In the lower Mississippi area the situation did not change substantially in the following years since the first railroads ran parallel to the bank (although farther inland on the eastern side). The centers, Vicksburg, Natchez, Greenville and Memphis, established their hinterlands to the west of the Mississippi and now performed the function of crossing points (Figure 23). New centers did not appear on the west side because of the dominance of the already existing centers across the river. The





- PATTERN OF SETTLEMENT IN 1860**
- Over 100,000
  - 50,000 - 100,000
  - 25,000 - 50,000
  - 10,000 - 25,000
  - 5,000 - 10,000
  - 1,000 - 5,000
  - Railroad lines
  - \* Center of population

**MISSISSIPPI BASIN**

0 50 100 200 miles

**FIGURE 23**

cities of the upper Mississippi on the west bank had the same function of crossing points but they reinforced their position of domination over the cities of the east side.

Chicago was the great center that grew from this play of development of hinterland and attraction of products to a concentration point. In 1840 it had only 4500 inhabitants; during the next 10 years it grew to 30,000, and by 1860 to 112,300. During 1850-60 six lines of railroads crossed Illinois to link 6 points along the Mississippi to Chicago. Chicago was thus extending its hinterland and at the same time becoming the largest center of the eastern region. By 1870 it was linked to San Francisco and its position had been firmly established; it was now the core of the east-west route. The dominance of the east-west movements can be observed in the shifts of the center of population of the United States (Figure 23). During 1850 to 1860 it experienced a great western movement, and again a similar one in 1870 to 1880.

It is interesting to compare the pattern of cities in 1860 with that of a hundred years later (Figures 23 and 24). Clearly there have been major changes in the distribution of centers and a growth in their sizes. The first linear patterns formed when the rivers were the main arteries of movements have been lost in the present pattern.

The area most densely populated lies north of the Ohio River, where resources are abundant; this is also the area more highly urbanized and industrialized. Transport routes form a dense network corresponding to the large number of cities performing diversified activities.<sup>46</sup> These observations reflect the favorable position of the area in respect to the eastern markets and the richness in resources of the region.

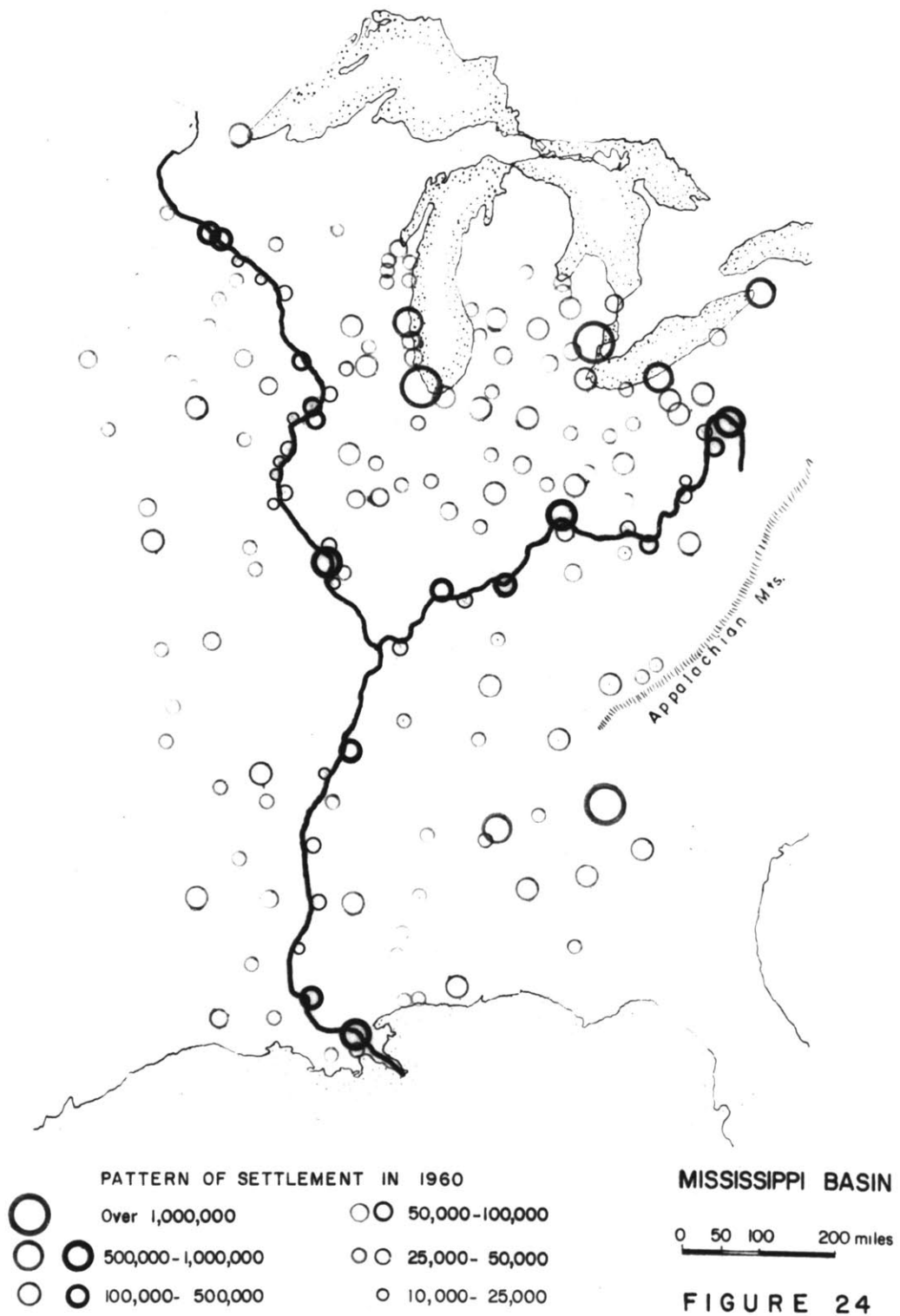


FIGURE 24

The southern part of the Mississippi Basin has undergone a great transformation; the population is more uniformly distributed and second and third order centers are located throughout the region. The original centers along the river still are important and continue to dominate their immediate hinterlands but many other centers of equal or greater importance have developed. The traffic density on the Mississippi is still high but the further development of the railroads throughout the south and the development of roads has removed the restrictions that previously concentrated the transportation activities along the river.<sup>47</sup> In this way the southern Mississippi Basin, which is otherwise a relatively uniform area, developed a free distribution of centers.

Thus, throughout the Mississippi Basin region a transformation has occurred over the last hundred years. The original linear pattern, established along a route of exploration and maintained by its advantages to transportation, has given way to a 'field' distribution of centers. This has been brought about by the development of new means of transportation, opening new resources, establishment of new centers of trade and industry, a shift in the trade routes from north-south to east-west and finally the lack of natural constraints that might otherwise have strengthened the original linear pattern.

## DISCUSSION

Linear patterns of settlement are originated by structural elements of obvious linear character. These elements may be natural features, political boundaries, or man-made transportation lines. In this study natural features have been represented by rivers which provide transportation and fertile land; mountain chains, which offer a variety of resources and good climatic conditions; but it is clear that other features not represented, such as coasts, may play a similar role. In a like manner a number of man-made structures may provide the linear element; examples would be roads and railroads, only the last of which has been examined here.

Although the initial founding of a linear settlement may revolve about a single linear element, the existence of more than one linear structural element seems to be needed to maintain the original pattern. These linear forces are called constraints and secondary linear forces and seem as important for the development of a linear pattern as the original element.

These remarks have been restated as three hypotheses, which can now be treated in detail with examples taken from the cases to substantiate them.

- I. Systems of settlements assume linear form in response to a strong element of linearity in the environment which favors accessibility and/or permanent occupance.

All five cases considered originated as linear patterns by the presence of a distinctive structural element. In Egypt, eastern Canada



and the Mississippi Basin, rivers were the original structural element. In Siberia, early linear forces were represented by boundary lines and climatic conditions favoring the southern band of this vast area. The structural element appeared in the form of a man-made route when the Trans-Siberian Railroad was built. The mountain band in Venezuela served as the linear force there, giving rise to the pattern of settlement in this tropical region.

In the origin of the linear pattern of settlement two developmental characteristics can be pointed out. First, the settlements that took place along the structural element had primary activities, such as agriculture or mining, as their economic base. The productivity of the hinterland was thus the determinant of the growth of the established centers. It is in this way that environmental conditions, favorable to the activities in which the population engages, give rise to the first pattern of settlement.

In the cases of Canada and the Mississippi Basin this phenomenon is seen in the early growth of Toronto, Kingston, and Montreal, and the Ohio River cities, Cincinnati, Louisville, and Pittsburgh. Each of these cities had rich areas lying behind it and served as a concentration point for the agricultural surplus. In Siberia the areas lying to the west were the richest agricultural land and it is there that the first waves of settlers located, giving rise to Omsk and Novosibirsk along the railroad line.

A similar development can be seen in Venezuela, where after the short period of mineral exploitation the population engaged in farming and the towns that flourished were located in fertile valleys; the surrounding areas of Caracas still are distinguishable today as the

most fertile in the country. Needless to say this proposition holds also for Egypt; as has been pointed out before, this system was born by the special characteristics of fertility of the valley and delta.

The second developmental stage of a linear settlement is marked by the extension of population over a larger area. From this extension of population, centers now grow favored by their geographical location and transportation facilities. These centers serve as central places for their hinterlands and they establish the contacts with the outside world. Trade is the important function through which the system grows.

It is possible to say that this is a selective stage in which centers begin to differentiate among themselves and market forces operate to create new centers where needed and enhance the position of existing ones. This point can best be illustrated in the cases of Canada and the Mississippi. In both cases shortly after the first settlements were established greater numbers of immigrants arrived and moved into new areas. The farming land was occupied to larger extent and in the St. Lawrence system new port cities developed along the banks of the river. Moreover, Toronto and Montreal expanded their tributary areas and engaged in exterior trade. When the new settlers arrived in the Mississippi Basin they occupied the vast area lying between the Mississippi River and the Appalachian Mountains. Thus the south was rapidly settled and centers were created on the Lower Mississippi (Baton Rouge, Vicksburg, Memphis) as trading centers along the main artery of commerce. The same occurred in the Upper Mississippi when the east and west were occupied: centers strung along the banks of the river. On the Ohio the old centers continued to grow, performing the trade functions for their enlarging hinterlands.

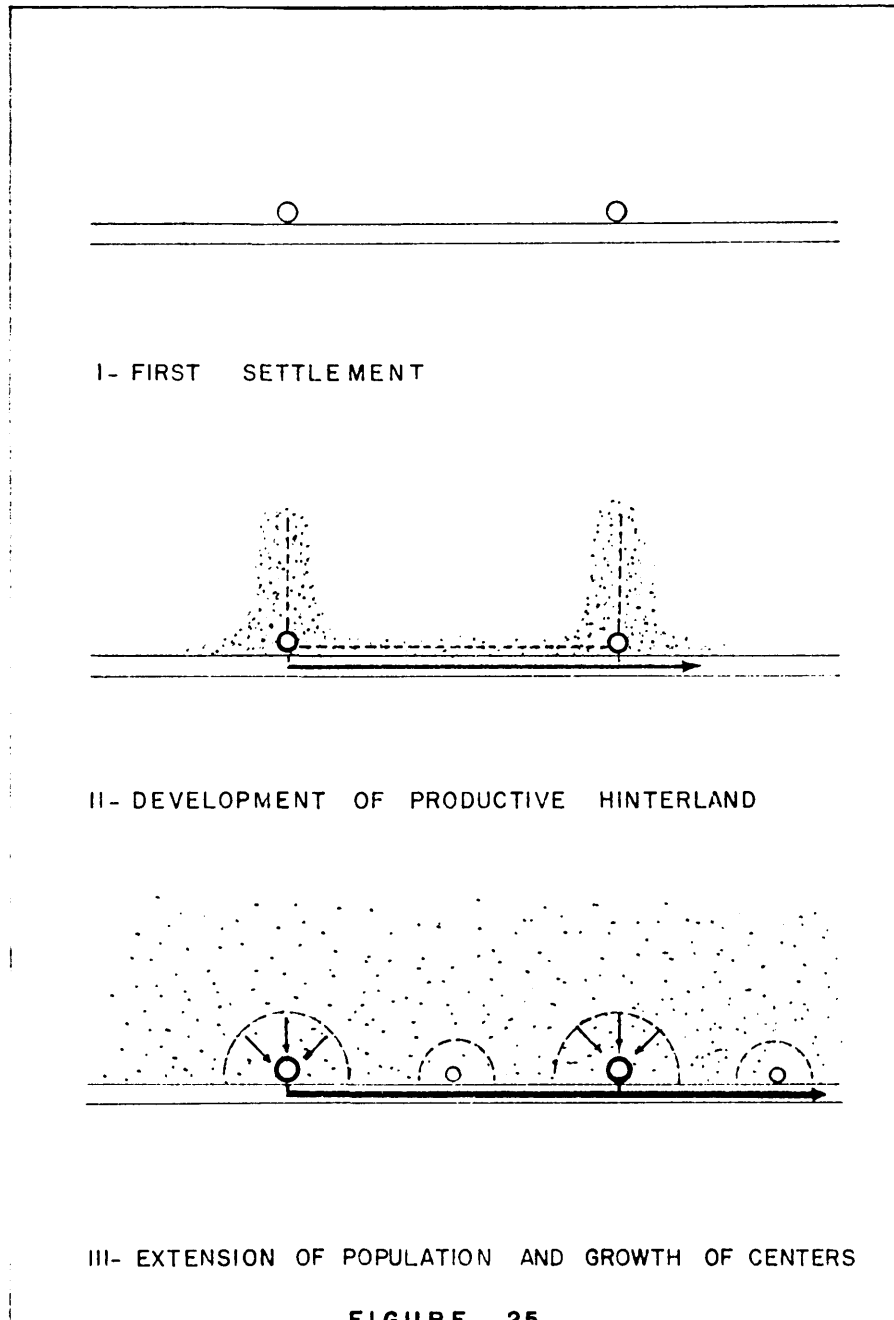
The data presented for Siberia and Egypt do not allow one to detect this situation, although the ancient capitals of Egypt must have performed the exterior trade functions, and in Siberia the trade centers along the line were in fact the fast growing centers.

Venezuela in this respect offers some contrast. The band of settlement in the mountains developed slowly, and originally did not lie along a single route of movement as observed in the cases of river or railroad alignments. It was at the coast that the contacts with the exterior were made; the ports performed the trade functions for areas lying behind them. Later when roads were opened along the mountains and the line of centers was connected, the centers which were favored by their location and transportation features, such as San Cristobal, Barquisemento and Valencia, began to differentiate. Caracas, the original administrative center of the country, by its mid-position along the established lines experienced further growth.

Sketches I, II, and III in Figure 25 summarize this first proposition and the two developmental stages of linear structural patterns.

- II. Linear forms of settlement are maintained through time when there are strong environmental constraints to expansion beyond the original line of settlement and when reinforcing patterns of interaction along this line are built up.

To this point the discussion has centered on the origin of the linear structures by the initial influence of a single element. But as was mentioned before other elements or forces that may or may not appear



initially seem to be required for the development of a linear pattern. These elements I have called constraints. By constraints I mean those linear features which in the course of the evolution of a linear pattern provide stability beyond that introduced by the original linear element. Examples of the constraint are seen in Egypt by the presence of the desert at both sides of the river valley; in Canada in the Canadian Shield bordering the fertile basin along the St. Lawrence on one side and the political boundary line between Canada and the United States on the other; in Siberia in the southern boundary line and the area of permafrost; and in Venezuela in the tropical low lands.

These constraints are not necessarily fixed and rigorous. For example, while the Canadian Shield was uninhabitable for a farming population, it is now settled, although sparsely, for mineral exploitations. As long as the conditions are maintained for which constraints exist these constraints are effective molders of the linear pattern.

Of the cases considered, the Mississippi Basin seems to be the only one without such constraints. On the other hand, in Siberia and Venezuela some of the strength of the constraints has been lost. Then, the cases of the St. Lawrence and Egypt are the ones in which the initial linear pattern had accompanying strong supporting elements.

In this proposition the initial development of a linear settlement has been discussed in terms of the role of the first linear element, the factors that influence the growth of settlements along this element and the importance of constraints that further stabilize the pattern. In addition to the constraints one also sees that other forces develop which help to perpetuate a linear settlement. These, called secondary linear forces, arise from within the settlement. Secondary linear

forces act to reinforce the original pattern and contribute to the persistence of linearity.

In the evolution of the more developed cases of linear patterns studied, there occurred a marked transformation in which a part of the activities of the regions shifted from primary to secondary, from agriculture or mining to manufacturing. These changes have not only involved industrialization and its impact on the pattern of cities but also the introduction of modern means of transportation.

Modern means of transportation have played two major roles in strengthening the linear settlements studied: the strength of the linear structures has been increased by the longitudinal ties formed among the centers and the strength given to the major centers by the radial lines running from them to encompass larger tributary areas.

Figures 5 and 8 of the transportation networks of Egypt and eastern Canada will remind the reader about the linear elements appearing along the Nile and the St. Lawrence rivers. In these cases, all the cities along the railroad lines have become effectively linked, while only certain centers have been able to radiate lines into the hinterlands; in Canada these centers were Toronto and Montreal; in Egypt only Cairo experienced such extension in the Delta area.

The trade routes were reinforced by these means and the relative positions of the centers made clear. Trade was encouraged not only within the system but also with the exterior; the accessibility to the exterior markets was what in turn encouraged the growth of major centers.

It is possible to say that accessibility along the major lines of trade is fundamental for the growth of cities but more important, those centers able to engage in exterior trade will be the ones able to enter

further phases of economic development. Thus Toronto and Montreal by competing for markets across the border were able to substantiate further their positions. The change of economic activities resulting from the interplay of market forces and a communication network can be seen in Canada in the rapid growth of Toronto and Montreal as they engaged in secondary activities.

In the next phase of development the major centers become magnets of population concentration and their functions are diversified. The central place functions performed by these centers at an early stage are now of secondary importance; the new functions mark the transition into the industrial stage in which a large segment of the population will engage in specific urban functions.

This stage has profound consequences for the future development of the systems. The pattern has to adapt to the rapid urbanization and economic development taking place. The organization of the structural pattern reflects the major changes occurring during the technological advances and economic development.

This discussion will not enter into the phenomenon of urbanization and industrialization as a stage of economic development, but rather will attempt to follow the aspects of the structural organization into which these changes operate. Thus, recognizing that the transformation leads to the further ascendancy of some centers over others, by a comparison of the two classical cases of linearity, Egypt and eastern Canada, it is possible to examine the effects of this development on the linear pattern.

In the case of the St. Lawrence River settlements, two major metropolitan concentrations have emerged along with a number of cities of

specialized secondary and tertiary activities complementing one another. Thus economic growth has taken place along a line of centers; the tributary area lying in parallel to the main line of growth has benefited by its proximity to the total development.

In contrast to this, the structural pattern of Egypt has organized the area of growth at one extreme of the system with practically only one metropolitan area. The Delta area concentrates the secondary activities as well as the import-export trade with the exterior markets while the Valley area continues to engage in agriculture and lies outside the area of economic growth. This situation of core-periphery imbalance tends to persist by the impulse generated by the large centers. In the particular case of Egypt this type of organization has been perpetuated through many centuries and while politically it helped at early times to unify the system, with time it has contributed to restrict the rate of development.

The location of the growth poles is in essence what determines the efficiency of the structural pattern in spreading the benefits of economic development. And it seems that the location of these centers of high growth is not inherent in the linear structure itself, but the result of the interplay of the original pattern of settlement with internal and external market forces.

To proceed to the third proposition the reader may remember that the two preceding considerations referred to the linear structures in their origin and persistence. This third proposition relates to the alternative pathway of development in which the structure does not maintain its original linearity.



III. In the absence of environmental constraints the linearity of settlements will tend to be modified and may ultimately give way to more complex "field" structures.

Of the five cases studied, Egypt and Canada largely retain today their linear structure. The remaining three examples have undergone varying degrees of change; in the Mississippi Basin, much of the original linear characteristic is gone, while in Venezuela, one can see the transition occurring at present.

All of these cases were initiated by settlement along a linear element. These have had varying degrees of persistency, and different constraints. Different factors have contributed to these transformations; perhaps the simplest example is that of the Mississippi River Basin.

In the case of the Mississippi Basin linearity was promoted by the advantages of the river as a means of transportation. Transition occurred as soon as the population extended itself over the plains and modern transportation made its appearance. Furthermore, a change from north-south to east-west occurred in the direction of movement, as the eastern part of the country grew and the west promised greater opportunity. Population concentration took place in the north where resources were available and spread over the central and southern plains. Figure 24 shows that the centers are at present distributed quite evenly in these areas, resembling to a certain extent the models of Lösch and Isard. Thus, the initial advantages of the river traffic were rapidly dissipated by the absence of constraints and the creation of new, more

evenly distributed routes. Thus market forces undoubtedly have transformed the initial pattern by their action on a nonrestrictive environment.

The transformations taking place in Siberia and Venezuela are more complex. The established centers along the linear patterns are maintained by secondary linear influences and their own momentum, but the strength of the constraints originally maintaining the system are being lost. For instance, in both cases the evolution of these societies from agricultural to industrial makes the development of new and diversified resources an economic necessity. In both cases this has meant the opening of new regions having great potential resources located outside the present pattern. The development of these regions today widely utilizes highway transportation and in Siberia relatively extensive air traffic. These means of transport, as opposed to that of the railroad, make possible the establishment of linkages of a more flexible nature. This factor, and the fact that these systems are undergoing planned changes, may result in a rapid transition to a new pattern.<sup>48</sup>

To elaborate on the preceding discussion and to clarify its observations the following conclusions are presented:

1. In the origin and persistence of linear structural patterns, the forces making for linearity are structural elements and constraints of environmental nature. During these first stages of development, economic mechanisms act constantly upon the system of cities but

they are not more important than the constraints and opportunities provided by environment.

2. Secondary linear forces, that is, the reinforcing elements appearing during technological changes, are influenced by the previous structural elements and constraints, but also market forces, internal and external, start to operate. Economic change and technological advance are both part of a process starting at this point. The structural pattern responds and adapts accordingly.
3. This stage of the evolution, when secondary linear forces make their appearance, clearly defines the future lines of development of the centers as part of a system. The transportation network, the concentration of population, and the specialized functions and diversified activities acquired by the central places enhance the relative position of some centers.
4. Centers created by these means acquire a self-propelling effect that maintains them over the others. These centers, or growth poles, define the location of high development and economic advance.
5. The pattern of organization of the linear system emerges from this interplay of market forces and original pattern of settlement. When the exterior

market forces are stronger than the interior, they may create a highly imbalanced system.

It is interesting to note in closing that in two of the linear cases studied, Egypt and Venezuela, an imbalanced system developed. This situation corresponds to what authors have referred to as the center-periphery imbalance emerging during the first stages of industrialization.<sup>49</sup> This is not a new problem; it is usually found in the "colonial" systems.<sup>50</sup> But in these cases of linearity, as particular instances of core-periphery structure, it poses an acute problem for planning development.

Planning is an instrument by which some aspects of the organization of a society are directed to allow a more complete development of the system. In Venezuela we have a case of a planned transition, and in Siberia a case in which by planned intervention the direction of economic transformation has been guided to allow the incorporation of further productive areas into the structural pattern.

How can planning intervene? What can be concluded on the basis of this study of the evolution of linear patterns is that the first stage of development is the result of forces inherent in particular elements of a region, while the second phase, although reflecting the original shaping forces and constraints, also allows a margin for the action of market forces that can be directed by planning action.

What is implied is the importance of timing in planning intervention. The stage of reinforcement of the linear structure coincides with the reinforcing of growth poles that once established acquire their own forces to perpetuate themselves. Thus, any decisions at this stage may

have profound consequences for the future; a later intervention requires a larger effort to concentrate the strength of already existing growth poles.

Although, from the cases considered, there is no apparent single form of organization of the linear structure, it may be pointed out that when the system had only one outlet, that is, when the line did not communicate to the exterior at both ends, there was the tendency to create a single major center, as in the case of the Mississippi at early times and as is now the case in Egypt. On the other hand, we have seen how in Canada the struggle for the exterior markets allowed the development of two centers although initially Montreal was in a favorable position.

This emphasizes the directional character or focalization of market forces, that only in systems where growth poles are distributed will development take place internally and spread through the pattern.

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7. Ibid., pp. 271-272; figure 52 represents the modified Lösch's scheme.
8. E. Ullman, loc. cit., Reference 1, p. 207.
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23. Ibid. "Isolation was one of the main obstacles to be overcome, both for the settlers and for the government. During this early period it affected deeply the economic, social and cultural development of Upper Canada, and therefore also urban growth. Isolation fashioned, in particular, agriculture, trade and manufacturing. In this connection, however, it was not only internal isolation which played an important part, but also isolation with regard to the world outside Upper Canada, especially Montreal. The rapids of the lower St. Lawrence represented a stout barrier between Lake Ontario and the ocean; the communication system with Montreal remained cumbersome and costly." p. 36.
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31. Population distribution in Soviet Union 1939-56  
For the country and for selected regions (in thousands)

	1939 estimated pop.			1956			% change 39-56		
	total	urban	rural	total	urban	rural	total	urban	rural
Total U.S.S.R.	192,577	60,672	131,905	200,201	86,969	113,232	4.0	43.3	-14.2
%	100	33	67	100	49	51			
Urals	12,474	4,701	7,773	15,661	8,706	6,955	25.5	85.2	-10.2
Western Siberia	9,904	2,629	7,275	11,840	5,216	6,624	19.5	98.4	- 3.9
Eastern Siberia	5,274	1,824	3,450	6,541	3,031	3,510	24.0	66.2	1.7
Far East	2,563	1,212	1,351	4,320	2,903	1,417	68.6	139.0	4.9
Total Siberia	17,741	5,665	12,076	22,701	11,150	11,551	28.0	96.8	- 4.3
%	100	32	68	100	49	51			



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