THE THEORY AND ANALYSIS OF CENTRAL PLACE SYSTEMS IN GEOGRAPHIC EDUCATION

by

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A B S T R A C T

The relationship between the various philosophies of geography and their relation to the school curriculum is traced, particularly with reference to the recent nomothetic approach. In this regard, the pre-eminent position of Central Place Theory is examined as an example of the structure of the discipline.

The contributions of Galpin, Christaller and Lösch to the classic development of Central Place Theory are examined. The variations and interpretations resulting from the work of Ullman, Brush, Berry, Hodge, Stine, Burton, Friedman and Miller, and Huff are reviewed. The critiques of Guelke, Relph and Harris are also considered.

Central Place Theory is applied to education on two levels. Simple exercises involving the concepts of hierarchy, threshold and range are suggested for lower secondary students. The more involved concepts of spatial pattern analysis are presented at a level suitable for senior high school or post-secondary students.

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A C K N O W L E D G E M E N T

This paper has resulted from the inspiration of a variety of great geography teachers whose skills have inculcated in me an interest in the study and teaching of this subject which has not waned in the past decade and a half.

I would particularly like to acknowledge the help provided by my principal research director, Eric Winter, in the preparation of this paper. Through discussion, debate and reflection, he has introduced me to a new conception of the role of geography in education; and for this I am deeply indebted to him. While many of his ideas have become my own, and are implicit in this paper, I alone accept responsibility for its shortcomings.

Chapter One

MODELS, GEOGRAPHY AND EDUCATION

1.1 Introduction

"By our theories you shall know us."

With this rallying cry to "the current generation of geographers" David Harvey (1968, p. 486) concludes his *magnum opus* on geographical methodology. A new breed of geographer professing a new geographical credo has all but taken over the profession. The language of analysis -- quantitative, spatial, network, locational, systems -- has become the *lingua franca* of this new doctrine. Almost left behind in the shuffle have been the standard definitions of the subject -- Pattison's "four traditions", for instance. (Pattison, 1964)

Faced with this situation, educators have felt increasing pressure to redefine the educational role of geography and to develop curricula which reflect this role. In an address before the Annual Convention of the Provincial Association of Protestant Teachers in 1968, Professor G. S. Tompkins considered this problem. Speaking of the philosophical basis of Quebec school geography in the mid-fifties, he stated: (1968a, p. 5)

> We were quite certain of its place as a pure discipline, grounded on a strong physical base, uncontaminated by such outlandish American ideas as social studies, relatively untouched by the academic social sciences, uncluttered by concerns about quantitative methods or model building, all soundly taught we believed via a straightforward regional approach.

At the research level, especially, the situation has changed. Simple man-land relationships are not providing satisfactory explanations of the complex world of today. Increasingly there is agreement with Tompkins' observation "... that some knowledge of economics is more important for the typical geographer of today than a knowledge of geology or climatology." (Ibid., p. 5)

This paper is a study of Central Place Theory as an educational concept. The relationship of this theme to the more general aims of geographic education is examined in the present chapter. Section 1.2 examines the emergence of the "new" geography from the classical origins of the discipline and the position of Central Place Theory within the "new geography". The educational implications of the "new geography" with its emphasis on model building is examined in Section 1.3. Section 1.4 considers the slow but perceptible diffusion of the resultant educational innovations into the teaching of school geography.

1.2 The Emergence of the New Geography

Academic geography has gone through several distinct phases in its development. The first, the "classical school", had its origins in the works of Humbolt and Ritter and reached its apex -- or perhaps its nadir -- in the environmental determinism of Huntingdon and Taylor during the 1930's. While other social scientists dismissed determinism as "... simply a misunderstanding of history" (Bronowski, 1960, p. 93 as reported by Haggett, 1965, p. 101) the legacy of determinism lingered on in school geography. Scarfe (1964, p. 299) writes: "Those who claim that a good solid course in physical geography is necessary _before_ real geography can be tackled are still fostering ... (environmental determinism) ... albeit unwittingly."

The work of Paul Vidal de la Blache represented one academic reaction to the classical school. His concept of the _pays_ or local area as the proper unit for the study of geography provided impetus to the regional school. Thus a unique area which would be an intimate connection between the physical and human aspects of the environment would, over centuries, evolve a characteristic landscape, such that "what was significant in one area might prove irrelevant in another." (Wrigley, 1965, p. 8)

Vidal de la Blache was aware that changing social conditions were breaking down his system even as he was proposing it. Nevertheless, regional geography became and remains the established form of school geography. Long and Roberson (1966, p. 16) quote Mackinder's view of regional geography -- "the key to the right method in school and in the University" -- and continue: "In schools we hold it still to be valid." Scarfe (1965, p. 158) concurs, writing, "There is no doubt, that for school purposes, geography should be primarily regional rather than systematic ..."

At the academic level, the paramount place of the region in geographical studies is no longer tenable. (Wrigley, 1965, p. 13) This is not to say that the concept of the region has been entirely abandoned. Rather it remains as a "means" rather than the "end" of geographical research.

The decline of the regional school produced a vacuum in the early 1950's into which the "new geography" moved. Anxious not to repeat the errors of the determinists and conscious of the disrepute their unsubstantiated assertions had earned for the discipline, the "new geographers" were not content to devote their energies to producing more polished regional descriptions. Proceeding slowly at first, the "new geographers" sought relationships which could be tested statistically. Their early results often lacked sophistication and occasionally demonstrated a complete ignorance of the nature of mathematical analysis. Nevertheless, in spite of the criticisms and resistance of the geographical establishment, the "new geographers" gained both confidence and expertise. By 1963, Burton was able to report that the quantitative revolution was over -- that quantitative techniques had been accepted as part of the conventional wisdom of the discipline. (Burton, 1963a, p. 153)

The new rigour which the quantifiers brought to geography had as its aim the development of theories, paradigms and models to explain spatial relationships. While not rejecting the role of the natural environment entirely, it was increasingly evident that the explanation of man's activities on the earth had their basis in the social environment. Thus it has been in human geography that the "new geography" has emerged so strongly.

The place of models and quantitative techniques has been particularly recognized in economic geography. Haggett (1965, p. 102) recognizes three distinctive developments in economic geography: convergence with other branches of human geography, the extension of models in teaching and research and the growing interest in chance processes. Brown and Elliot Hurst (1969) go even further. The five areas of development in economic geography which they recognize include as the first four: quantitative methods, systems analysis, probability and chance process, and the use of models.

Of the various models which have been proposed to explain spatial phenomena, Christaller's Central Place Theory has enjoyed a pre-eminent position. Gould, (1969, p. 91) while admitting that "tried and true" bodies of theory are rare in geography, goes on to observe that

"... there is one quite major exception -- central place theory." Garner (1967, p. 307) states that "there is no doubt that the model has had a profound impact on geographical research." Burton (1963a, p. 159) has called Central Place Theory the "one relatively well-developed branch of theoretical economic geography" while Berry (1967, p. 3) sees it as "the theoretical base of much of urban geography and of the geography of retail and service business." Bunge (1966, p. vii) who recognizes Christaller as "the father of theoretical geography" is particularly effusive in his recognition of the role of Central Place Theory. He writes (_Ibid_., p. 133)

> If it were not for the existence of central place theory, it would not be possible to be so emphatic about the existence of a theoretical geography independent of any set of mother sciences. Geography is a basic science since it produces new theory and the proof of that assertion lies most clearly in the existence of central place theory. With the possible exception of cartography, this author is of the opinion that the initial and growing beauty of central place theory is geography's finest intellectual product and puts Christaller in a place of great honor.

The place of Central Place Theory in modern geography is undisputed. Besides being the basis of a great deal of significant research in geography over the past two decades, it effectively ties together urban and economic geography. Hence, in this day and age when "the great bulk of employment in modern industrial countries is to be found in secondary and tertiary occupations, and ... when in almost all industries the most important locating factor is accessibility to the major markets" (Wrigley, 1965, p. 15) an appreciation of the economic-urban milieu becomes mandatory for a proper understanding of the modern world.

1.3 Educational Implications

There is little doubt that Central Place Theory has its role to play at the research frontiers of the discipline and is good geography -- but is it good pedagogy? It is not the purpose of this paper to examine the contributions that geography makes to education; suffice it to say that geography has equally important roles to play in both the affective and psychomotor development of the child as well as in the traditional cognitive domain. It is in the development of the latter attribute that this paper directs its attention and that Central Place Theory is judged to have the greatest contributions to make.

Confronted with a growth of geographical information, teachers as well as researchers are faced with various alternatives. The least satisfactory is an intensification of capes-and-bays data accumulation. Somewhat superior would be the adoption of bigger and better pigeonholes to classify the data -- Berry's geographical data matrix, for instance. (Berry, 1964) The best method of all would seem to be the development of a conceptual framework so that new data can not only be assimilated, but also understood and explained. Haggett and Chorley (1967, pp. 19-20) make this point by observing that "factual information only has relevance within some more general frame of reference, and such a basic operation as the definition of a relevant fact can only be made on the basis of some theoretical framework." Increasingly then, the emergence of models and theories is providing the conceptual framework which heretofore was lacking in geography.

In recent years a recurrent theme that has emerged in education has been the call for teachers to teach (or lead students to learn) the basic structure of the discipline, rather than a collection of unsorted data. Jerome Bruner has been most closely associated with this view.

How can students with a limited exposure to a subject be given a lasting educational experience? Bruner (1960, p. 11) claims "the answer ... lies in giving students an understanding of the fundamental structure of whatever subjects we choose to teach." Bruner advocates the use of such structures to actual problem solving.

Fenton (1967, p. 7), while supporting Bruner's views, stresses the need for students to learn a method of inquiry rather than "the mass of facts and generalizations which burden so many social studies courses." Winter provides an indication of how this is to be accomplished. Expressing concern with existing textbooks in geography which "rarely reveal" that "geography is what geographers do", he sees one aspect of syllabus reform as providing "a structure for intuitive as well as analytical thinking in such a way that 'what the child does for the first time is what the scholar does at the forefront of his discipline.'" (Winter, 1967, p. 76)

The need to bring to school geography the techniques of the academic discipline receives further support from educational taxonomies. Bloom's study of educational objectives in the cognitive domain (Bloom, et al., 1956) has been applied to geography by Tompkins (1968b) and others. A cursory examination can not help but lead to the conclusion that traditional school geography largely involves the recall of specific facts which ranks at the lowest level of intellectual significance. Only by engaging in those activities which involve the application and testing of hypothesis and from it to the more rigorous analysis of geographical relationships can the subject be imbued with adequate intellectual content and stimulating inquiry to attract and hold the interests of the better student, while at the same time providing worthwhile educational experiences for students of general ability.

1.4 Educational Applications

The time-lag between the postulation of a concept at the research level of the discipline and its filtration down to a level where it can become innovative teaching is an unduly long one. The educational establishment and bureaucracy is by nature, and perhaps by necessity, a conservative if not cumbersome one. Thus Molly Long's review of research in educational geography in Britain contains not one reference to innovations in quantitative or theoretical geography. (Long, 1965) Scarfe and Tompkins make only passing reference to the "new geography" by suggesting Alexander's text in Economic Geography as "the latest and best single source of materials and ideas for what is coming to be called the 'new' geography." (Scarfe and Tompkins, 1969, p. 135, footnote 6) Similarly, from the United States, needs for research in the application of the "new geography" to education receives scant mention. (Bacon and Kennamer, 1967)

Thus Chorley and Haggett (1965, pp. 366-7) make the observation

> We cannot but recognize the importance of the construction of theoretical models, wherein aspects of "geographical reality" are presented together in some organic structural relationship, the juxtaposition of which leads one to comprehend, at least, more than might appear from the information presented piecemeal and, at most, to apprehend general principles which may have much wider application than merely to the information from which they were derived. Geographical teaching has been markedly barren of such models, partly as a result of the interest which has centered largely on the unique and special qualities of geographical phenomena, and geographers have been loath to use these powerful frameworks, despite the teaching successes of, for example, the Davisian cyclical model. This reticence stems

> largely, one suspects, from a misconception of the nature of model thinking, wherein such frameworks are expected to be "true", or "real", or to possess other equally equivocal qualities.

The type of thinking Haggett and Chorley were referring to is reflected in a recent paper by Scarfe, presented before the Annual Meeting of the Geographical Association. He observes that "a very important aspect of modern geography is central place theory which seems to have inherited much of the esteem given to the Davisian cycle of erosion." (Scarfe, 1971, p. 198) "Let us, therefore, beware of excessive emphasis on models," he warns. "We can be taken in by them. They are useful technology only." (Ibid., p. 199)

In spite of Scarfe's fears, models in general and Central Place Theory in particular are slowly finding their way into school geography. Although it has its share of critics, the High School Geography Project of the Association of American Geographers was one of the first examples of a curriculum designed to introduce school children to the frontiers of research geography. Designed originally to fill the glaring gap in geographic education at the grades 9 and 10 level in American high schools, its success lies not in its geographical content as much as in its methodological innovations. Bryan (1965) even goes as far as to give it partial credit for recent rethinking in geography teaching presently underway in England. While admitting that it contains many elements unsuited to the British situation, he observes that "the method is exciting, and it has stimulated many teachers in this country to strive for a similar project based on our own resources." (Ibid., p. 331)

The various units in the High School Geography Project use modern geographical techniques extensively. In the urban unit, for instance, students perform "nearest neighbour analysis" of settlements in the American Middle West. (Fitzgerald, 1969, p. 59)

In Great Britain, where geography for several decades has enjoyed an esteemed position in the school curriculum, teachers have refused to remain complacent in the light of recent developments in the discipline. Led by younger teachers who are increasingly unwilling -- and as a result of new university curricula, untrained -- to teach the traditional regional syllabus, a new movement is underway. "To them," Bryan writes, "such matters as urban hierarchies, rank size correlations and central place theory seem more vital to a child's understanding of his environment than the customary lists of facts about the site, position and functions of individual towns the world over." (Bryan, 1965, p. 326)

The establishment of a Standing Committee on the Role of Models and Quantitative Techniques in Geographical Teaching by the Geographical Association in 1967 was one response to the winds of change which had begun to blow. The dedication of the January 1969 issue of the Association's journal, Geography, to this theme is certain evidence of the increased importance that British teachers give to the role of the "new geography". The revision of A-level syllabi to include topics in such aspects of geography will continue to give impetus to these changes.

Similarly there have been recent changes evident in Canada. Textbooks are beginning to reflect more modern concepts. Thus the latest edition of one of the standard school textbooks in North American regional geography makes two references to the central place hierarchy (Tompkins, Hills and Weir, 1970, pp. 278 & 470-1) whereas earlier editions contained none. Eric Winter's recent text on urban geography includes a concise explanation of Central Place Theory (Winter, 1971, pp. 134-5), making it one of the first to appear at the pre-university level. Winter's book is certainly within the spirit of both the "new" geography and the "new" education. In the Preface he writes: "In teaching geography there are broadly speaking two sets of operations: one is knowing what geographers have done; the other is doing what geographers do." (*Ibid*., p. viii)

1.5 Conclusions

This chapter has attempted to briefly trace the development of geography, and show its continuing relationship to the teaching of geography at the school level. It proposes the thesis that the "new geography" with its emphasis on quantification and model building is firmly established at the core of the discipline and not merely "useful technology". It further maintains that within the "new geography" Central Place Theory has a pre-eminent position. The view is maintained that the integration of models into the subject represents the structure of the discipline, and consequently provides a worthwhile basis for syllabus construction aimed at cognitive development. While recognizing the slowness and obstacles involved in integrating such concepts into existing courses of study, evidence of some changes is indicated.

The balance of this paper conforms closely to the two operations which Winter sees in teaching geography. Chapters Two and Three involve "knowing what geographers have done". Chapter Two traces the development of the classic concepts of Central Place Theory from early workers in America through Christaller and Lösch. Chapter Three reviews some of the empirical research that geographers have applied to studies of the Central Place hierarchy, and goes on to examine the modifications and limitations that such studies have imposed.

Chapters Four and Five provide some suggestions for "doing what geographers do". In Chapter Four, the concepts of hierarchy, threshold and range are examined and appropriate teaching exercises are suggested. Chapter Five considers the teaching of the more sophisticated concept of pattern analysis and provides examples of exercises suitable for the classroom. Finally Chapter Six provides the concluding statement on the use of Central Place Theory in geographic education.

Chapter Two

THE DEVELOPMENT OF CLASSIC CENTRAL PLACE THEORY

2.1 Introduction

The British were prepared for the Boer War by 1914 and for trench warfare by 1939. How often, as Haggett (1965, p. 101) reminds us, has this appeared to be true of geography teaching! Thus, while Burton (1963a, p. 151) was able to claim a decade ago that geography had completed a quantitative revolution, school geography continues to neglect one of the fundamental concepts of the discipline.

Studies of the relationship between towns and their hinterlands have been known in Europe for over a century. The work of rural sociologists in America blazed a similar trail over a half century ago -- a trail that has remained largely unknown. Christaller's theory, first published forty years ago, is even today largely found only in the realm of academic geography.

The purpose of this chapter is to investigate three major contributions to the study of the relationship between a city and its region. The pioneering work of C.

J. Galpin is first examined in Section 2.2. In Section 2.3 the major contributions of Walter Christaller are reviewed. Section 2.4 considers the further refinements introduced by August Lösch, particularly as they apply to the geography of Central Places. Section 2.5 concludes the chapter with a comparison between Christaller and Lösch.

2.2 The Pioneering Work of Galpin

The relationship between villages and the surrounding rural population was first investigated in North America by C. J. Galpin, a rural sociologist. Galpin's empirical study of Wolworth County, Wisconsin, is significant in two ways: his field techniques provide a useful model for school use; his conclusions about the shape of the trading area predated the similar conclusions of Christaller by almost two decades.

Galpin's survey was a modest one. It sought "to find out how the village or small city plays its part in the life of the farmer and his family". (Galpin, 1915, p. 1) Galpin was intrigued by the distribution of towns and villages across the landscape. "Is it possible," he asks, "that the farms are related to the village clusters in such an intimate way that in any serious treatment of the one the other must be taken into account?" (Ibid., p. 2)

To find the answer Galpin surveyed each of the twelve villages and cities in the county. From local merchants and bankers he first determined the furthest farmers who used their various services in order to establish a tentative trade area. Then, expanding this approximation by a mile on all sides, a working zone was created. Survey takers -- teachers, high school principals, clergymen, bankers and librarians -- then completed a questionnaire for each farmer (a total of 600 were involved in the survey) by visiting specific merchants and services (banking, dry goods, groceries, milk factory, village high school, village church, village paper and village library). Each was asked a direct question: "Does John Doe buy dry goods in this village?"; or "... take your paper?"; or "... have his children attended the high school in the last three years?"; or "... is any of his family connected with your church?" (Ibid., p. 5) Once all villages had been surveyed in this way pins were stuck in a map of farm locations and surrounded by a thread to define the boundaries of each trade area.

Once mapped, it was seen that the trade areas had a tendency to overlap, producing a neutral or common zone a mile or two wide. In this zone farmers did not obtain particular goods or services from a single village, but rather from two or even three alternate centers. Moreover a larger trading center had a tendency to include virtually all the area from smaller incomplete centers.

Galpin noted that the trade zones were irregular in shape, a reflection of irregular transportation links and topographic features. In what is the most striking aspect of the study, Galpin theorizes on the shape of the trade area and the ideal location of the trade centers on an isotropic plane -- i.e. equal-sized and equidistant trade centers connected to farms by equal access in all directions. He concludes (<u>Ibid</u>., p. 19):

> Then apparently each community would be a circle (see Figure 1) with the agricultural city as its center, having a radius somewhat longer than half the distance between any two centers. In order to include all the farm territory within some circle and to have the least possible common area we must impose the further condition that the centers be arranged so that only six centers are equally distant from any one center ...

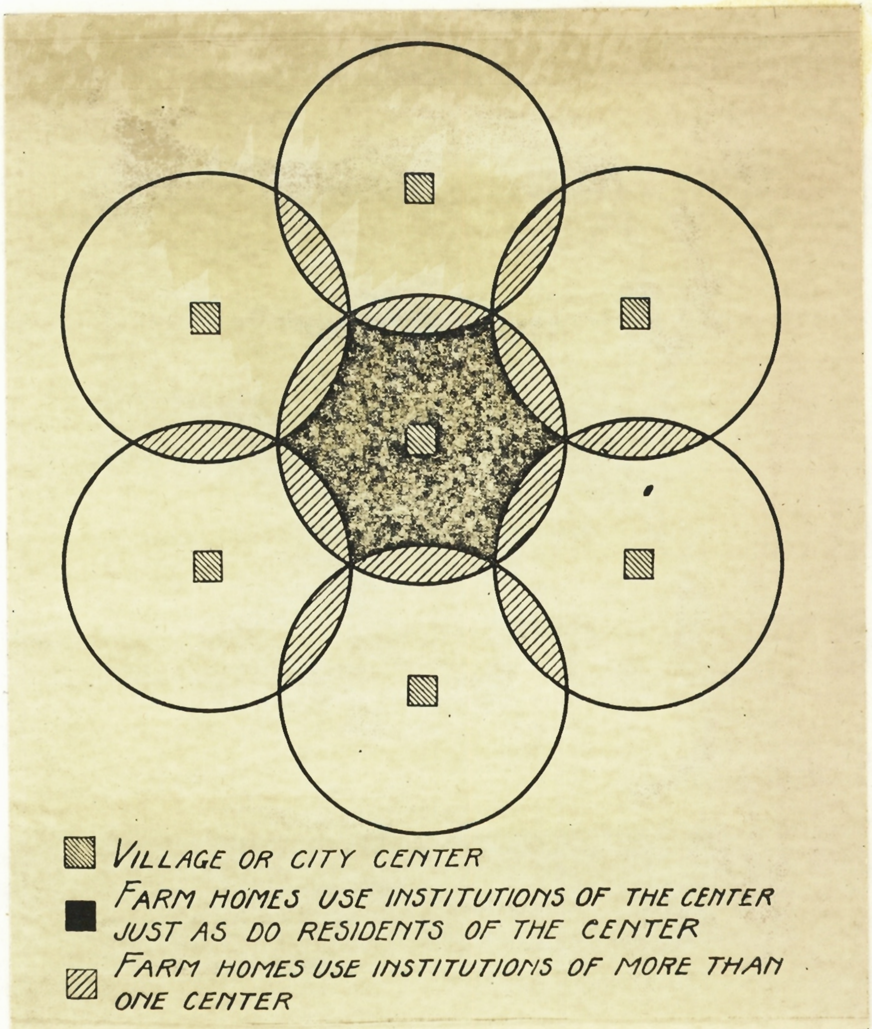

FIGURE 1: The Theoretical Form of an Agricultural Community According to Galpin. (Source: Galpin, 1915, p. 17)

Galpin did not go further than this in his theoretic treatment, being more concerned with practical solutions than hypothetical discussions. Nevertheless, if we carry his considerations a step further -- that is with equal access in all directions and with equivalent goods available at all centers, then it follows that farmers in the neutral zone will not be influenced by "a particularly aggressive business spirit in any (one) center" (Ibid., p. 8), but will use the center closest to them. The actual shape of the trade center becomes a hexagon, and Galpin's study must receive a full measure of credit for its discovery.

2.3 The Contributions of Christaller

Are there laws which determine the number, sizes and distribution of towns? This is the provocative question that Walter Christaller set about to determine in his classic treatise Die Zentralen Orte in Suddeutschland, first published in 1933.

Proceeding differently from Galpin, Christaller's approach was deductive. He began with certain assumptions which appeared reasonable. From these he evolved a general theory which allowed him to hypothesize certain relationships.

Christaller's underlying premise is that of centrality. There can be little doubt that he was influenced by von Thunen and Weber, both of whose theories embody the concept of centralization. Indeed, Christaller (1956, p. 7) sees his theory as the urban locational counterpart of von Thunen's theory of the location of agricultural production and Weber's theory of location of industries.

Centralization was seen by Christaller as a principle of order. Thus, he saw the chief characteristic of a town as the center of a region. (_Ibid_., p. 16) Yet he recognized that not all towns or settlements had this central function. Agricultural settlements on the one hand, or resource-based towns on the other, were examples of non-central settlements, whose location was determined by the nature of the area, or the specific location of the resource.

Christaller takes great care in defining his terms. He avoids the use of _town_ or _settlement_, for each have non-central implications. Rather, he coins the term _central place_, and proceeds to differentiate between _central places of higher order_ (whose functions extend over a wider region) and _central places of lower order_ (which serve a smaller region and provide fewer goods and services).

He demonstrates the validity of viewing a town as a central place of a region by showing how a town gains importance from the region as a result of centrality. It is possible to measure the importance of a town on the basis of its combined economic activities. Some of these activities -- that is, some degree of the town's importance -- are the direct result of the town's own size, and the functions it performs for its citizens. Where it is found that a town has a surplus of importance -- that is, performs more functions than can be used by its own citizens -- it must be concluded that this surplus comes about as the result of functions it performs for inhabitants outside the city's limits. Christaller refers to this surplus of importance as _centrality_ (_Ibid_., pp. 17-8).

The centrality of a place comes about because it provides _central goods and services_. The region which obtains central goods and services from a central place is the _complementary region_. The theory which Christaller develops is based on the integral nature of the city and its complementary region. He writes (_Ibid_., p. 22):

Remembering the meaning of _centrality_, we find

> that the complementary region is that region in which an importance-deficit exists. This importance-deficit is counter-balanced by the importance-surplus of the central place. Thus the region and the central place together make an entity.

It follows that an equally important consideration is the size of the complementary region, for this determines the importance of the central place. The complementary region is determined by the range of a good -- "the farthest distance the dispersed population is willing to go in order to buy a good offered at a place". (*Ibid*., p. 22) By distance, Christaller does not simply mean linear distance, but rather economic distance, which takes into consideration costs of travel in terms of mileage, storage, lost wages, and discomfort. (*Ibid*., p. 22, footnote 23)

The range of a good is determined in several ways. In order for a good to be made available in any central place, a certain threshold consumption must be assured. This defines the inner limit of the good and contains "the minimum amount of consumption of this central good needed to pay for the production or offering of the central good." (*Ibid*., p. 54) Within this ring is the area containing the fewest number of people willing to consume this good at a given price. Beyond this distance is the profit zone, where additional sales exceed the marginal production costs. The profit zone extends to an outer limit which defines the furthest distance people are willing to come in order to obtain this good. Here we must distinguish between the "real" range and the "ideal" range of the good. The former defines the actual limit and extends "to where the central good can be obtained with greater advantage from neighbouring central places" (see Figure 2), whereas the latter "reaches to the full limit of the range of the central goods from an isolated central place." (*Ibid*., p. 57)

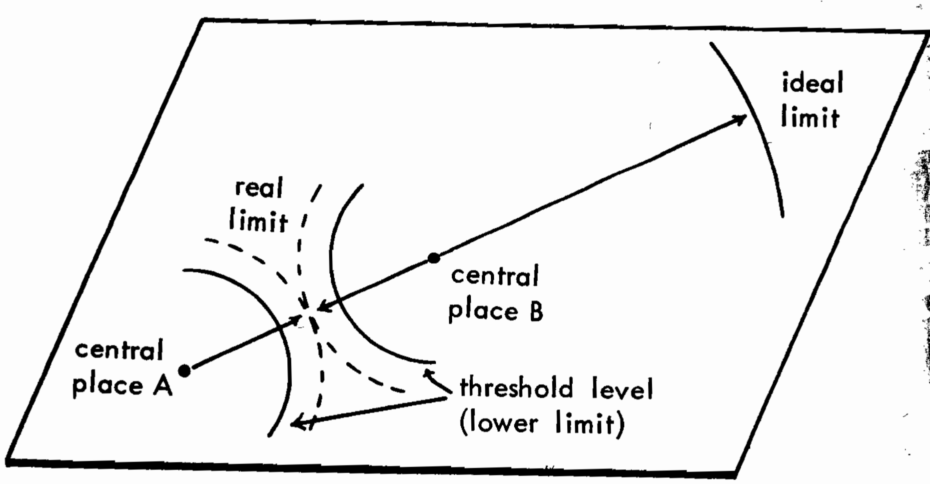

FIGURE 2: The "Ideal" and "Real" Range of a Central Good. (Source: Getis and Getis, 1966)

Each good therefore has a special characteristic range, which varies not only from good to good, but from place to place and from time to time for a given good offered at a certain central place. Moreover, the range of a central good is affected by a number of other factors, including the price at the central place, the distribution and structure of the population, the income levels of the inhabitants and the competition from other central places. Christaller provides a number of examples showing how these factors affect the range of a good.

Because of variations in the range of central goods and services, not all complementary regions contain the threshold population required to provide a given good or service. This is what is implied in Christaller's designation of central places _of lower order_, _of higher order_ and _of highest order_. There exists a hierarchy of central places with larger centers offering central goods of higher order. This is the crux of Christaller's Central Place Theory!

Christaller (_Ibid_., pp. 66-8) sums up these observations as follows:

1. central places are distributed over the region according to certain laws;
2. there are different size-types of central places as well as complementary regions;
3. the number of central places and their complementary regions which are to be counted form a geometric progression.

The hierarchy of central places (see Table 1) ranges from hamlets (H-centers) to world cities (R-centers).

TABLE 1: Christaller's Central Place Hierarchy

SYMBOL	GERMAN	ENGLISH	POPULATION	RANGE (Km)
H	Hilfszentrale Orte	hamlet	800	4
M	Marktflecken	market center	1,200	4- 7
A	Amtsstadtchen	office town	2,000	7- 12
K	Kreisstadtchen	county town	4,000	12- 21
B	Bezirkhauptorte	main district places	10,000	21- 36
G	Gaubezirk	middle administrative center	30,000	36- 62
P	Provinzialhauporte	provincial capital	100,000	62- 108
L	Landeszentrale	regional capital	500,000	108- 186
RT	Reichsteilstadte	national metropolis	1,000,000	186- 323
R	Reichhauptstadte	world city	4,000,000	323- 560

Hamlets do not really qualify as central places for they offer only the most ubiquitous goods and services. The hierarchy of central places really begins with the M-centers or market centers.

In applying his theory to southern Germany, Christaller starts with Munich, an L-center. He shows that surrounding each L-center are six P-centers; around each P-center are six G-centers; and so on. But each of the P-centers in turn surrounds three L-centers; and each G-center surrounds three P-centers. Christaller thus calculated that for every L-center there would be two P-centers; each of these would in turn have two G-centers -- a total of four G-centers would therefore be associated with each L-center. Each center of higher order is also a center of the next lower order as well. Thus the L-center performs P-center functions, and must be considered a P-center in its own right. It too, would have two G-centers surrounding it, making a total of six G-centers associated with the L-center. There emerges a geometric progression of central places: 1 L, 2 P, 6 G, 18 B, 54 K, 162 A and 486 M for a total of 729 places in an L-system. (Ibid., p. 65)

The hierarchy of central places implies a hierarchy of complementary regions. How, then, do these regions share the available space? Christaller concluded, as did Galpin, that the regions served by the central place will be hexagonal (see Figure 3). Central places of the next lower order occupy the vertices of these regions. (Ibid., pp. 63-4) Consequently, an L-region will include three P-regions -- all of its own P-region plus one-third of each of the six P-regions surrounding it. There follows a geometric progression of market areas based on three: 1, 3, 9, 27, 81, . . . (Berry, 1967, p. 65)

The principle behind this arrangement of central places was referred to by Christaller as the "Marketing Principle". Christaller recognized two other principles, one economic and one socio-political, which could also influence the location and number of settlements.

The first arises from the observation that while the Marketing Principle economizes on the number of settlements, traffic routes between central places of higher order are circuitous at best. Thus a route from one G-center to another G-center passes through only one K-center and three M-centers. From a B-center to a G-center, the most

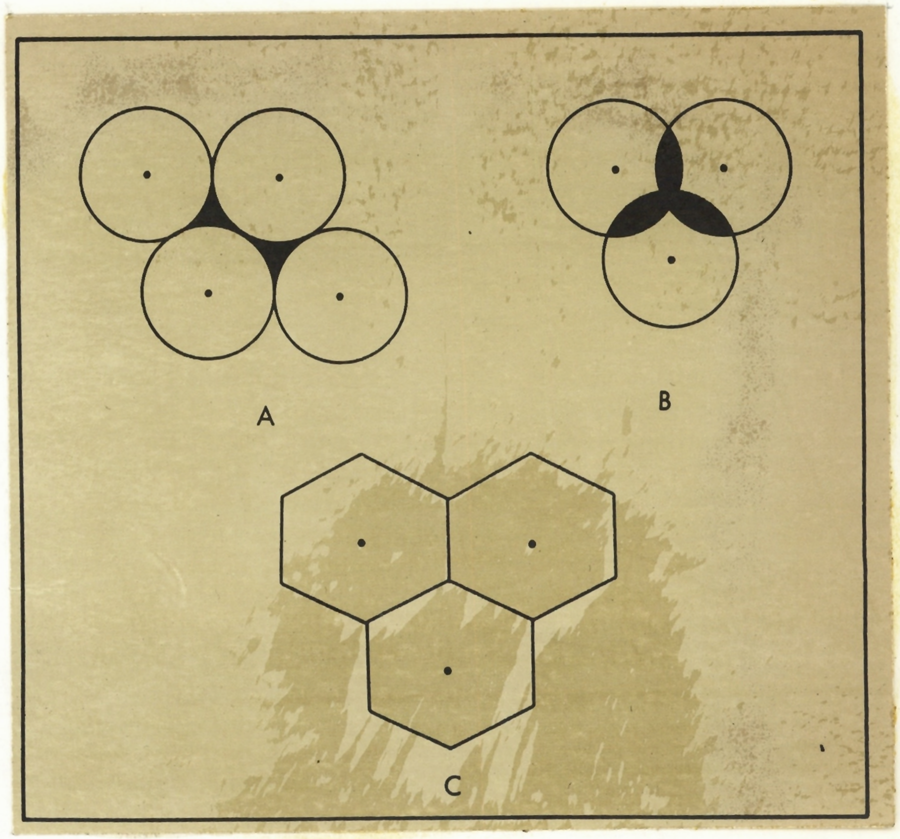

FIGURE 3: The Shape of Complementary Regions.

A. The unshaded areas are not served.
B. As proposed by Galpin, the shaded areas indicate neutral zones.
C. Hexagons completely cover the area and eliminate unserved or neutral zones.
(Source: Getis and Getis, 1966).

direct route would connect only two A-centers. Christaller (Ibid., p. 74) writes about this problem:

> In a system of central places developed according to the marketing principle, the great long-distance lines necessarily bypass places of considerable importance, and the secondary lines built for short distance traffic can reach great places of long-distance traffic only in a roundabout way -- often even in remarkably zig-zag routes.

Christaller proposes the "Traffic Principle" as a solution. By locating centers of the next lower order at the mid-point of the side of the hexagon rather than at the vertices, a line connecting two G-centers would pass through one B, one K, two A and four M-centers. The Traffic Principle, or k = 4 system, requires more central places to supply a given region with goods. The number of centers progress in the order of 1, 3, 12, 48, 172, . . ., while market areas increase by a rule of fours: 1, 4, 16, 64, 256, . . . (Berry, 1967, p. 65)

Christaller does not enter into a consideration of which is "more correct". Both are rational, and which prevails depends on concrete circumstances. A densely populated and prosperous area could support many central places and the Traffic Principle might prevail. Moreover, topographic impediments may constrain city locations to valleys, and again the Traffic Principle would operate. A poorer, more rural area, might require an economy of places and would be organized according to the Marketing Principle.

Christaller's third principle, the "Administrative" or "Separation Principle" is an arrangement based not upon economic considerations, but rather upon strategic or political ones. In this system, a central place of higher order would administer an entire region. Certain more local functions would be administered by smaller centers, which would report directly to the larger center. Thus the entire complementary region of lower order would be contained within the region of higher order. Each G-center would contain a total of seven B-areas -- its own, plus six others surrounding it.

2.4 The Refinements of Lösch

The concept of centrality and its affect on the geography of settlements was further advanced by the work of August Lösch. Before death claimed him in 1945 at the premature age of 39, Lösch was on the way to developing a general locational theory that would tie together agricultural and manufacturing location as well as the location of settlements.

Lösch's approach differs from that of Christaller in several significant respects. Whereas Christaller works down from his largest place (e.g. the L-system of Munich), Lösch begins with the smallest settlements - villages, hamlets, even individual farms. He hypothesizes an isotropic plane in which self-sufficient settlements are evenly distributed. Suppose on one farm, the farmer decided to manufacture beer for surrounding farms. By concentrating production at one location, the economies of scale would produce savings. It would become advantageous for surrounding farmers to buy their beer from the first farmer in order to share in the savings. Part of the potential savings, of course, would be counteracted to a certain extent by increased transportation costs that the potential customers would have to pay. This is represented by a Cost Curve, as shown in Figure 4. At the production site, the price of beer is P and the quantity sold is Q. As transport costs are added to P, the demand decreases. Thus at price R, the quantity sold is S. At a certain price, F, the economies of scale are completely lost due to the extra transportation costs, and no beer is sold.

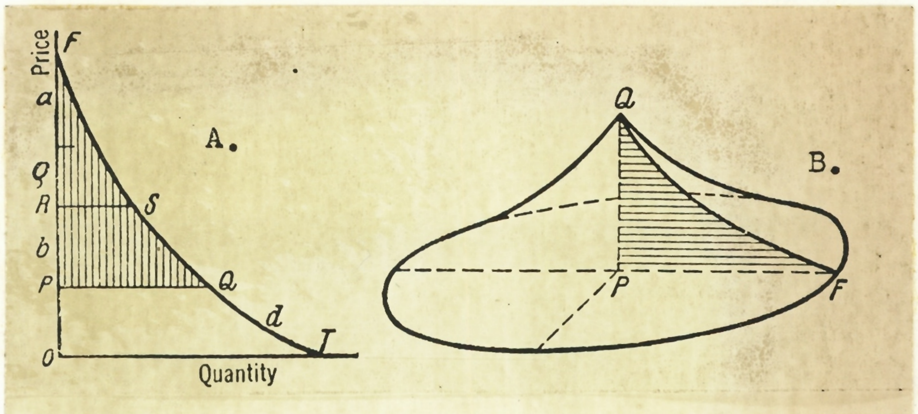

FIGURE 4: A. Cost curve for beer sold at a single farm.
B. The demand cone for beer, which defines the market area of beer sales. (Source: Lösch, 1954)

PF therefore represents the "economic distance" of beer sales. This can be converted to miles by dividing the price difference by the freight costs per mile. This economic distance extends in all directions around the brewery. By rotating PF about Q, we trace a demand cone for the beer, which defines the theoretical market area for this good. (Lösch, 1954, pp. 105-6).

Economic regions, however, are not circular in forms. Rather, Lösch discovered, as did Galpin and Christaller before him, that the hexagonal shape enclosed the greatest demand per unit area. Lösch goes beyond Christaller to show mathematically that the "regular hexagon becomes more favourable as a regional shape the larger and more rounded-off the whole area, the more elastic the demand at the boundaries, and the more closely the necessary shipping distance approaches the possible one". (*Ibid*., p. 114)

In the Löschian landscape the population is not continuously scattered over the economic region. Settlements are separated from one another by definite distances. Moreover, the size of the original settlements exerts a considerable influence.

Lösch shows that the smallest market area must contain three settlements. The pattern which emerges is identical to Christaller's Marketing Principle, with the centers being supplied by the main center located at the vertices of the hexagon surrounding the main center. Again, the larger center supplies itself plus one-third of each of the six surrounding towns. It controls, in other words, the equivalent of three fully supplied settlements (i.e. $k = 3$).

Lösch shows that the next two market areas control four and seven settlements respectively, corresponding to Christaller's Traffic Principle and Administrative Principle. But whereas Christaller's theory does not go beyond this point, Lösch shows that these are only the three smallest complementary regions. By using mathematical formulae, Lösch in fact produces a complete series of complementary regions, representing various k-values. Several are illustrated in Figure 5.

By centering a number of market areas upon a single center, one can evolve a hierarchy. The larger the central place, the more market areas (or nets) it would control. Thus the metropolis or highest ranking central place acts as the center not only for the greatest number of nets, but also those of highest rank (i.e. having the largest k-value).

Lösch goes beyond Christaller in the importance he assigns to the role of transportation. By rotating his nets around the central point in the system (i.e. the metropolis) twelve sectors are produced -- six with many centers, and six with few. From the center a total of twelve communication lines radiate, but in areas with few towns

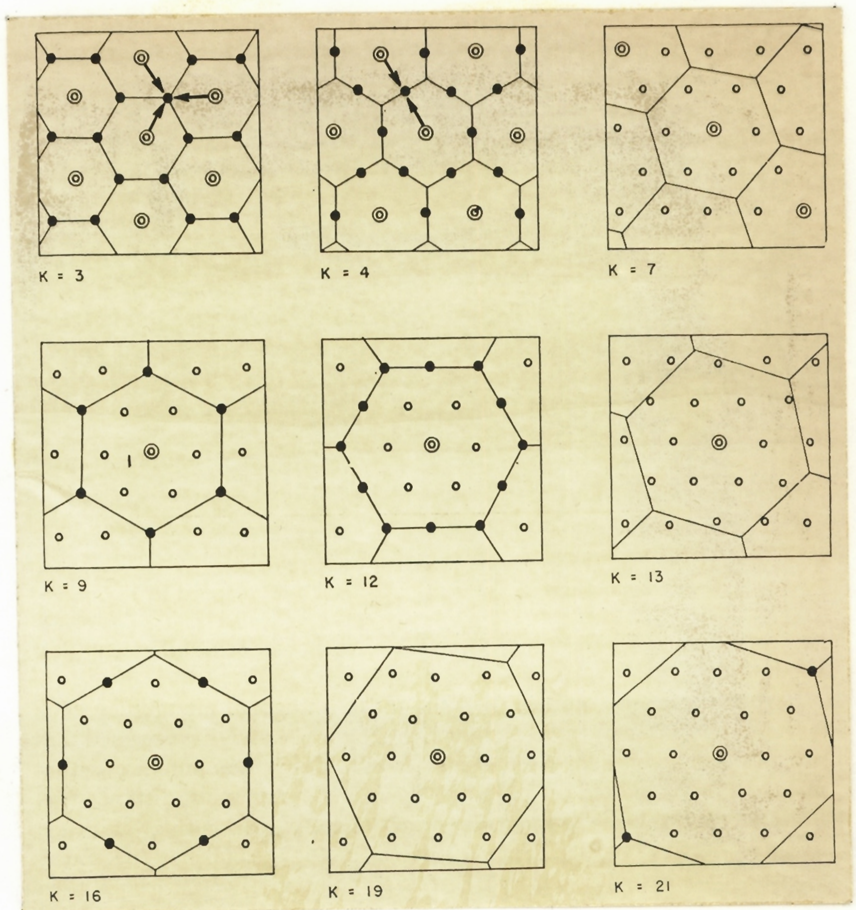

FIGURE 5: The nine smallest hexagonal regions according to Lösch. (Source: Haggett, 1965b, p. 119).

these communications are fewer and not as well developed.

The result is a cogwheel or web-like urban landscape. Valvanis (1965, pp. 62-3) ascribes three advantages to this arrangement:

1. the greatest number of locations coincide,

and a maximum number of purchases can be made locally,

2. sums of minimum distances between industrial locations are least, and consequently shipments, transport costs and highways are minimized,

3. a very deep price funnel around the metropolis is surrounded by a ring of quite deep funnels around regional centers, and in between are rings . . . of less deep funnels.

2.5 Conclusion

The study of Christaller, the man, is almost as interesting as the theory for which he is famous. The original treatise was prepared over a period of nine months in 1932, but gained slow acceptance. Not until the 1950's and '60's when the "Quantitative Revolution" in geography made theoretical models part of the discipline did Central Place Theory blossom. Christaller played little part in these later developments and applications of his work. Ironically, geography's pioneering and best known theoretician never held an academic position in a major university. Much of his life's work was in the field of planning -- in the hopes of conforming actual settlement patterns to his theoretical model. Recognizing that this could only be accomplished under a strongly centralized and authoritarian government, he lent his services to the Nazis prior to the War, and flirted with Communism after it. This latter association prevented him from visiting the U.S.A., even to receive the highest award of the Association of American Geographers. He died in 1969 at the age of 74, following a lengthy illness which left him penniless. (Carol, 1969).

A comparison between Christaller and Lösch is inevitable. Both were essentially investigating the same phenomenon -- the spatial distribution of settlements -- albeit from different directions. Both ultimately evolved a basically triangular lattice as the optimum pattern of settlement locations.

An important difference is the type of hierarchy each conceived. In the Christallerian system, the hierarchy is rigid. In it centers of a particular level all provide the same types of goods and services. The Löschian hierarchy is more flexible. Not every center provides the same types of functions. Moreover, larger centers may not provide all lower order goods and services, while some smaller centers may provide goods and services of higher order.

Christaller's central place hierarchies, according to Berry (1967, pp. 72-3) seem more relevant to an understanding of retail and service centers, while Lösch's more complex "economic landscape" deals with specialized centers and appears more relevant to an analysis of market-oriented manufacturing.

To the traditional geographer, the highly theoretical framework in which Lösch works is an anathema. "The real duty of the economist," he writes, "is not to explain our sorry reality, but to improve it. The question of the best location is far more dignified that the actual one." (Lösch, 1959, p. 4) He had no intention of testing his theory against reality, but rather to "determine whether reality is rational" by testing it against his theory. (*Ibid*., p. 363). Nevertheless, the rigorous analysis of spatial patterns of economic phenomena which Lösch brought to the subject has been widely acclaimed and its results may yet prove to be more wide-ranging than the conceptually neater framework of Christaller. Yeates and Garner (1971, p. 210) note that the Löschian system "does correspond more to the real world structure of service centers, particularly to the hierarchy of shopping centers found within urban areas..." Valvanis (1965, p. 74) concludes "That familiar concepts should generate startling results more than any other thing attests to the genius of August Lösch."

Chapter Three

APPLICATIONS, MODIFICATIONS AND LIMITATIONS

3.1 Introduction

The leap from the theoretical models of Christaller and Lösch to the real world is a precipitous one, yet one which must be made. Tests of Christaller's hierarchy were slow to follow his original publication, but in recent years there has been a flood of studies which have opened entirely new avenues not conceived in the original treatise.

This chapter reviews several papers which have contributed to the development of central place studies. Section 3.2 begins with a review of Ullman's paper which first appeared in 1941. Brush's paper on the central place hierarchy of southwestern Wisconsin, Berry's study of Iowa and Hodge's survey of trade centers in Saskatchewan provide three empirical examples.

Section 3.3 considers variations of classic Central Place Theory. The Section opens with a consideration of periodic markets. The hierarchy of shopping districts within a metropolitan region is then considered as an application of Christaller beyond the original context of his theory. The possibility that a central place hierarchy may fail to develop under certain conditions is examined by reference to Burton's "Displaced City hypothesis" and the concept of the "urban field". Finally Huff's paper considers a perceptual framework for analyzing the problem of consumer behaviour.

The final section of the chapter, Section 3.4, investigates some recent critiques of Central Place Theory, particularly in the light of recent reaction to quantification and the resulting attempts to obtain a new perspective on the nature of geography. The chapter concludes with a consideration of the implications of Central Place Theory within the context of this paper.

3.2 Applications and Empirical Studies

The credit for introducing Central Place Theory to English language readers is usually given to Edward L. Ullman. His study (Ullman, 1941) not only provides a resume of the main points of Christaller's theory, but also presents some relevant criticisms. Ullman recognized that

Christaller's criterion for centrality, the number of telephones, was inappropriate in the United States of 1941. He observes, however, that other measures of centrality, perhaps using the number of out-of-town calls, might be used. He suggests that "Christaller may be guilty of claiming too great an application of his scheme." (Ibid., p. 65) He mentions Bobeck's earlier (1938) reservations of Christaller's theory on the grounds that although two-thirds of England's and Germany's population live in cities, only one-third of these cities are, in reality, central places. Although Ullman recognizes that Christaller has his early critics, he does not reject Central Place Theory out-of-hand. Rather, he suggests that the theory, like Burgess' concentric zone theory, has its uses as a tool for further investigation.

Empirical testing of Christaller's theory was to await another dozen years before Brush's seminal work in Wisconsin. Brush (1953) centered his attention on 234 settlements in the Driftless Area of Wisconsin, the unglaciated region between the Mississippi River and Madison, and south of LaCrosse. The area he studied was a region in which mining, although of historical significance, was at the time minimal, and manufacturing was also of very minor importance. Consequently the main sources of employment were agriculture on the one hand, and services and trades supporting the agricultural community on the other. The ratio of employment was approximately two farm workers for every service worker.

Brush delimited the settlements in his study into three types: hamlets, with an average population of 65 (range, 20 to 300); villages, with an average population of 481 (range, 115 to 1415); towns, with an average population of 3324 (range, 1329 to 7217). Although the spacing of settlements approaches the distances suggested by Christaller's theory, the spatial pattern shows a strong tendency to clustering or allignment in rows, rather than an even distribution. This pattern Brush attributes to the location of the railway which was an important force in the settlement of the area. Once the site of community was fixed on the basis of the nineteenth century rail network, a settlement inertia fixes the locational pattern even though the original _raison-d'être_ -- the railway -- has declined as a factor. The railways in turn, were restricted in their location by the nature of the topography. "The incised terrain of ridges and valleys contributed to the development of rows where these terrain features were followed by rail lines." (Ibid., p. 209)

As a result of changing patterns of transportation, the area has been characterized by the decline of hamlets as trade centers, the stagnation of villages and the growth of towns. Brush did not observe Christaller's theoretical road network -- i.e. six routes converging on a town. Nor were trade areas easily demarcated. Moreover, the trade areas of towns usually overwhelmed those of the villages, making the latter areas indistinct. Thus Brush was unable to find a positive confirmation of Christaller's pattern. Rather than reject the central place concept entirely, however, he concludes by stressing the need for additional studies of central places.

Brush's choice of southwestern Wisconsin may not have been the most appropriate to test Christaller's principles, which presuppose a uniform surface. Berry (1967, p. 4) points out that "Iowa has been the traditional, classic area for study of central places in the United States, because scholars thought that it satisfied the assumptions of central place theory more nearly than any other region in North America."

Berry is able to trace the historical development of a central place hierarchy in southwest Iowa from the first white settlements in 1846 (Ibid., p. 5-9). By 1868 a rudimentary set of central places had emerged which were centrally located with respect to the consumers. In these early years several stores would often be established within a mile of each other. Competition would usually result in only one survivor -- that store which had the fortuity to be located near other central services, such as a grist mill for instance. Over the subsequent century of settlement, the dynamic aspects of Christaller's theory apply. Thus the pattern of market centers which emerges in 1961 is one which reflects "...the successive (and for the major centers cumulative) definitions of points of access to the population: grist mills, post offices, county seats, railroad stations and paved highway intersections." (Ibid., p. 9)

Hodge's study (1965) in Saskatchewan provides an example which is significant in two respects: it furnishes a Canadian frame of reference and more importantly it treats the dynamic aspects of the spatial pattern of market centers. Hodge begins with the central place hierarchy of 1941, a time when the 909 centers represented the greatest number in Saskatchewan's history. In the two decades which followed significant changes occurred in the nature of Saskatchewan's economic base. Fewer farmers remained to run the smaller number of farms which earned correspondingly increased incomes. It was also a period which saw greater personal mobility as automobiles allowed farmers to travel greater distances to obtain central goods. The results on the various centers in the hierarchy are illustrated in Table 2.

Effectively, what had happened between 1941 and 1961 was that larger centers grew at the expense of smaller ones, especially in the lower middle section of the hierarchy. Thus the hamlet, not really part of the hierarchy (cf. Chapter 2) provides ubiquitous goods -- a gas station, bread, etc. -- and continues to grow in numbers (from 358 to 404

TABLE 2: Trade Center Viability in Saskatchewan.

Type of Center	Median Pop.	Average No. Stores	% Change 1941-61
Primary wholesale retail*	103,800	1414	0
Secondary wholesale retail	10,000	232	+80.0
Complete shopping	1,800	58.5	+11.6
Partial shopping	610	26.1	+49.2
Full convenience	360	16.5	-41.2
Minimum convenience	210	9.9	-47.8
Hamlet	50	3.3	+12.8

*Regina and Saskatoon

between 1941 and 1961). But for more diversified shopping, the increasingly mobile farmer can now bypass the next levels in order to enjoy the greater variety of goods and services in the larger partial and complete shopping centers. Hodge's paper concluded with "some implications such a study has for central place theory". He rejects Christaller as providing only a model for static equilibrium. "Thus, there is a challenge for more dynamic models of trade center systems and of trade center change." (*Ibid*., p. 195)

3.3 Variations and Modifications

Classic Central Place Theory supposes a market situation in which the range of the good exceeds the threshold, thereby assuring excess profits and continuing business for the entrepreneur. What happens if the maximum range of the good is less than the threshold? Stine (1962) in an early study in Korea suggests that an alternative to going out of business is available to the merchant: he may become itinerant. By travelling over a wide area and offering his goods at various markets rather than from a single one, the merchant effectively extends his range. This system of "periodic markets" is a fundamental part of the tertiary economic activity throughout much of the underdeveloped world. By concentrating marketing activities on one or two days during a week or ten-day cycle, a wider range of goods are available than the level of the economy would allow in a fixed market situation.

Periodic markets contain qualities of more familiar central place systems. Bromley (1971, p. 126) classifies markets on the basis of their periodicity as daily, periodic or special. The daily market can only be supported by larger settlements and therefore corresponds to higher order centers. Periodic markets can be located at smaller settlements which they visit only once or twice over the market cycle. They represent lower order centers. In order to serve the society as efficiently as possible, basic economic considerations such as the "friction of distance" will operate, often causing the markets to avoid existing settlements and locate at an equilibrium location. This equilibrium "between the desire for a large thriving market and the desires of the local inhabitants to minimize effort expended in journeys to the market" (Ibid., p. 127) is responsive to changes in productivity or consumption in ways similar to a traditional central place system.

Periodic markets are commonly associated with developing economies. As communications improve there is a general tendency for the periodic markets to give way to daily markets and for the latter to become permanent shops. Nevertheless, even within as advanced and complex an economy as that of the United States, elements of the periodic market system can be found. Abler, Adams and Gould (1971, p. 367) provide several examples including circuit courts, professional sports and circuses.

Perhaps the closest approximation of the theoretical isotropic plane postulated by Christaller is a modern metropolis. A dense street network, often supported by a rapid transit system and other forms of mass public transportation, allows virtually unlimited access in all directions. Thus Berry observes "that the hierarchy of business centers within cities is consistently related to the hierarchy of market centers in rural areas." (Berry, 1967, p. 42) The hierarchy can be seen in two ways. First, the larger the city or town, the greater the number of business districts within it. Secondly, a hierarchy of business districts can be established within a given city.

At the apex of the hierarchy within the metropolitan area is the Metropolitan Central Business District. This is the "heart" of the city particularly well described in the literature by urban geographers. (see, for example, Harris and Ullman, 1945) On the smallest scale, the general stores, service stations and public services clustered along the main street of a village could be recognized as the CBD of that settlement. Usually it would be located at the focus of transportation -- near the railroad station -- and thus reflects the most important factor in its emergence; the best access to intraurban and interurban transportation and maximum exposure to consumers. In the case of Chicago's CBD -- the "Loop" -- Berry advises that in 1948 there were 2000 retail outlets employing in excess of 46,000 persons. (Berry, 1967, p. 47)

In descending order in the hierarchy is the regional shopping center. (see Figure 6) This may or may

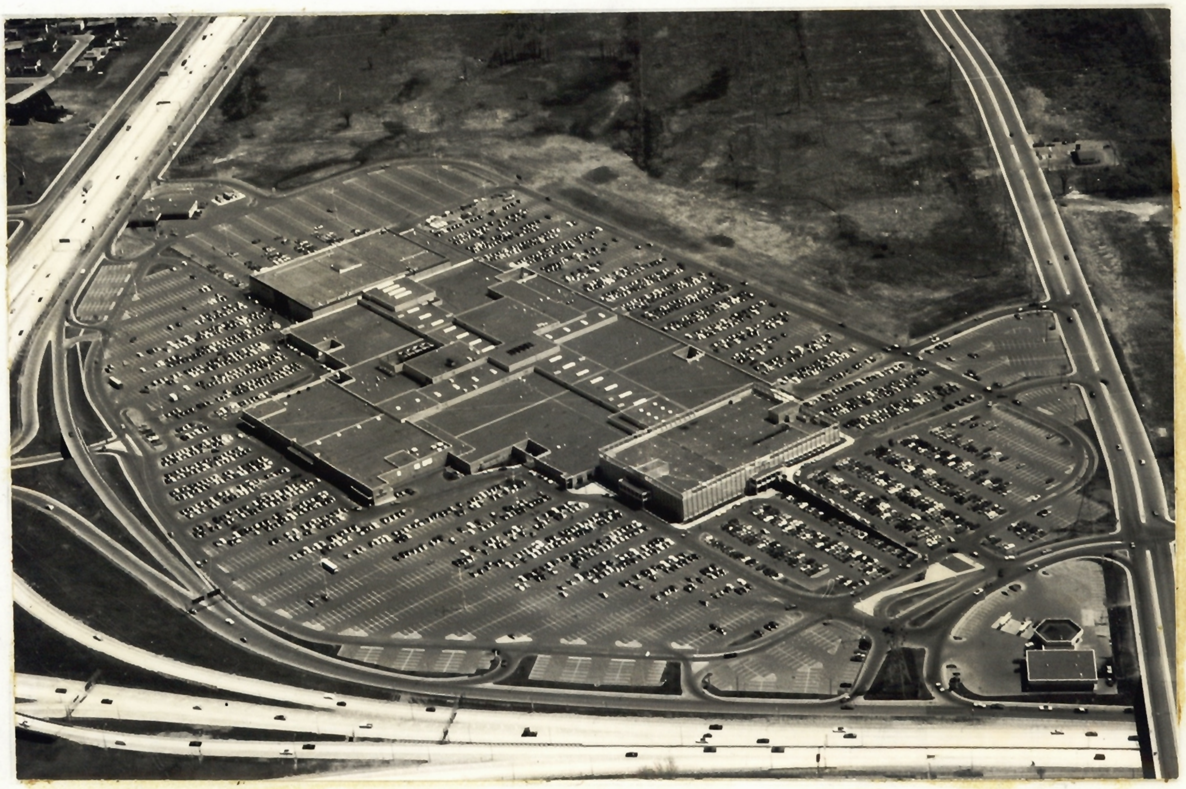

FIGURE 6: A Regional Shopping Center
(Galeries d'Anjou, Ville d'Anjou, Qué.)

not be a planned shopping mall. It may take the form of an outlying business district or as an arterial development. We should expect to find several regional shopping centers in most major cities. In the Chicago examples, Berry quotes figures of 70 different kinds of stores employing over 4,000 people as typical of regional shopping centers in that city. (Ibid., p. 49)

FIGURE 7: Two concepts of the lowest order shopping center. On the left is a traditional "corner store"; on the right is a chain store providing essentially the same range of goods.

FIGURE 8: A poorly located shopping center: Laurier Shopping Center, St. Lambert. Difficult access, competition from newer centers and a shrinking trade area have lead to the abandonment of this center by normal retail functions and their replacement by a variety of non-central wholesale activities.

The community shopping center is at the next level in the intra-city hierarchy. Such centers have fewer stores (an average of 70) and functions (36) and employ fewer people (500). Finally, two other types of centers complete the hierarchy: neighbourhood centers and convenience centers -- the latter often being little more than street corner clusters of convenience shops.

Few of these points are lost to those who earn their livelihood by planning the location of shopping centers. The size of the trade area served by the center is critical. Bursa (1969) suggests that a large regional shopping center must provide goods to attract consumers from as far as twenty miles. This requirement effectively delimits the trade area of such a center and dictates the spatial pattern which will emerge.

Central Place Theory thus appears to have some application in low density rural areas when applied to the hierarchy of market towns and to high density metropolitan areas when applied to shopping districts. Between these two extremes, it appears to have less application. Berry refers to this breakdown as a "Phase Shift". (Berry, 1967, pp. 57-8). Figure 9 illustrates this concept.

In the middle of this shift, a phenomenon first identified by Beimfohr (1953) in Southern Illinois and developed further by Burton, (1959 and 1963b) appears to exist. Referred to, perhaps confusingly, as the "Dispersed

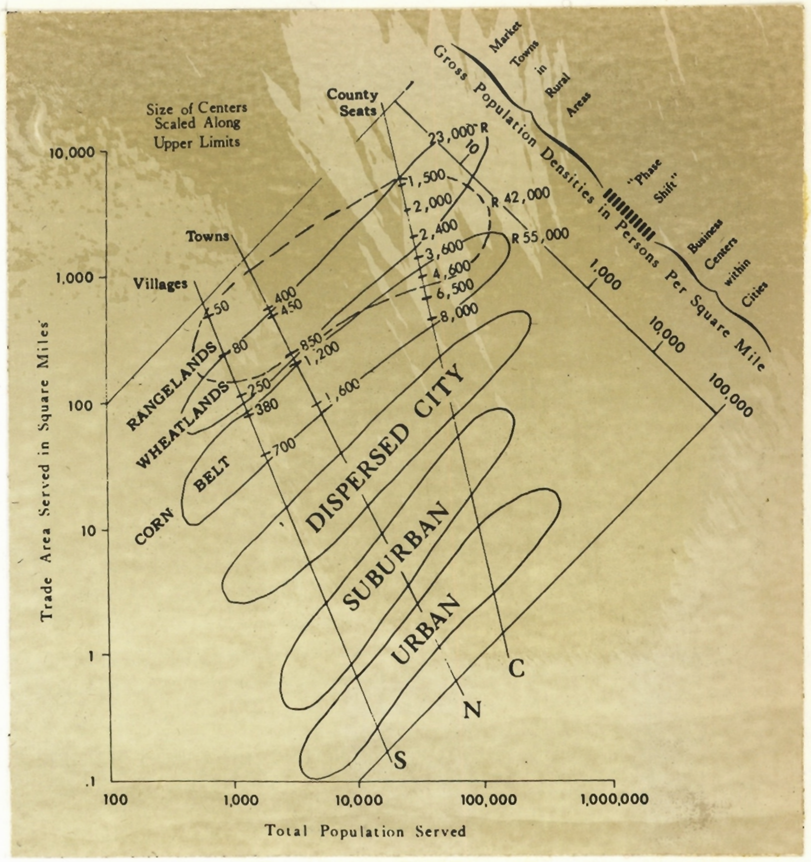

FIGURE 9: The Region of "Phase Shift" occurs between the areas of sparsest and densest population. (Source: Berry, 1967, p. 34)

City", (see for instance Stafford, 1962) "it refers to a group of politically discrete cities, which although separated by tracts of agricultural land, function together as a single urban unit." (Burton, 1963b, p. 285) In certain areas, or under special conditions -- Burton suggests mining areas or areas of intensive agricultural production (Ibid., p. 286) -- the functions normally concentrated in a single regional center are distributed amongst several. Thus a number of cities -- none dominating -- develop a retail or service complexity with each contributing a part. One city might provide the best clothes shopping, another furniture sales, a third medical or university facilities. Burton suggests that "a dispersed city resembles a truncated hierarchy in which the functions of the missing regional center have in part been taken over by the next lower group of centers in the hierarchy ..." (Ibid., p. 287) Several examples of "Dispersed Cities" have been suggested, including the Upper Grand River valley in Ontario. Although complicated by the existence of a large Mennonite community, the closely spaced cities of Waterloo, Kitchener, Guelph, Preston, Galt and several smaller centers may be developing local specializations.

The growth of large metropolitan areas with strong centrifugal forces has further undermined the growth of central place hierarchies in many parts of the world. A new concept, first proposed by Friedman and Miller (1965) has emerged to accomodate this feature: the _urban field_. They view the United States as composed of two parts: the metropolitan areas and the inter-metropolitan periphery which have suffered losses in population and are often regions of economic depression. The urban field, as defined by Friedman and Miller, would have a core area population of at least 300,000 and would extend up to two hours driving time beyond the center (a distance of 100 to 120 miles). In the United States in 1960, it can be shown that 85% of the population and 35% of the area are included within the urban fields of metropolitan areas.

Greer-Wootten (1968, pp. 112-134) has examined the urban field of Montreal, which effectively stretches from the Ontario border on the west to Scottstown in the Eastern Townships in the east. Sherbrooke lies 93 miles from Montreal, and represents 99 minutes driving time over the Eastern Townships Autoroute; Scottstown lies 134 miles and 143 minutes from Montreal. (_Ibid_., p. 132) Within this area an interesting pattern emerges, which again differs from the theoretical patterns of Christaller. Surrounding

Montreal are the suburban communities, often with large populations but functionally incomplete -- their tertiary sector being captured by Montreal.

FIGURE 10: Market place in St. Hyacinthe, Qué. At a distance which removes it from the direct influence of Montreal, this facility combines aspects of a periodic market with traditional central place functions.

Further out, at a distance of 25 to 40 miles from the city center, are a series of <u>ring cities</u> -- Valleyfield, St. Jean, Granby, St. Hyacinthe, Sorel. These cities developed as retail and wholesale trade centers, as well as industrial centers served by the early railway network. Sherbrooke, itself, represents a regional capital, the economic center of the Eastern Townships.

There is an additional dimension to the spatial distribution of towns which may prove to be one of the most significant. The range of a good on the operational level ultimately becomes the range of the consumer. The basic premise of Christaller that the consumer invariably travels to the closest center offering the good which he desires may not be entirely valid. One early analysis of the problem was provided by Reilly (1931) who proposed a gravitational-type model to predict consumer movement. Thus the attraction of a center becomes a function not only of its distance, but also of its "mass" in the sense of its population, number of stores and variety of functions. "Two centers attract trade from intermediate places approximately in direct proportion to the sizes of the centers and in inverse proportion to the square of the distance from the two centers to the intermediate place." (Berry, 1967, p. 41) This may be expressed as follows:

$$\frac{T_A}{T_B} = \frac{P_A}{P_B}\left(\frac{D_B}{D_A}\right)^2$$

where T_A, T_B, = proportions of trade from the intermediate place attracted by centers A and B;

P_A, P_B, = the sizes of A and B;

D_A, D_B, = distances from A and B to the intermediate place.

Huff (1960) has considered the problem of consumer preferences in a behavioural context. Christaller, like most economists in the classic tradition, assumes a rational man acting on the basis of perfect knowledge. Real man may not act rationally and his "perfect" knowledge can only represent his perception of reality. Figure 11 provides a simplified version of the model which Huff used to explain consumer behaviour. The Stimulus Situation (the physical, social and cultural objects and processes affecting his consumption) and the Physiological Drive provide the conditioning which results in the "Desideratum" -- "the readiness on the part of the consumer to secure some object of desire which will satisfy a particular need state that has been aroused by the initiating stimulus situation and/or

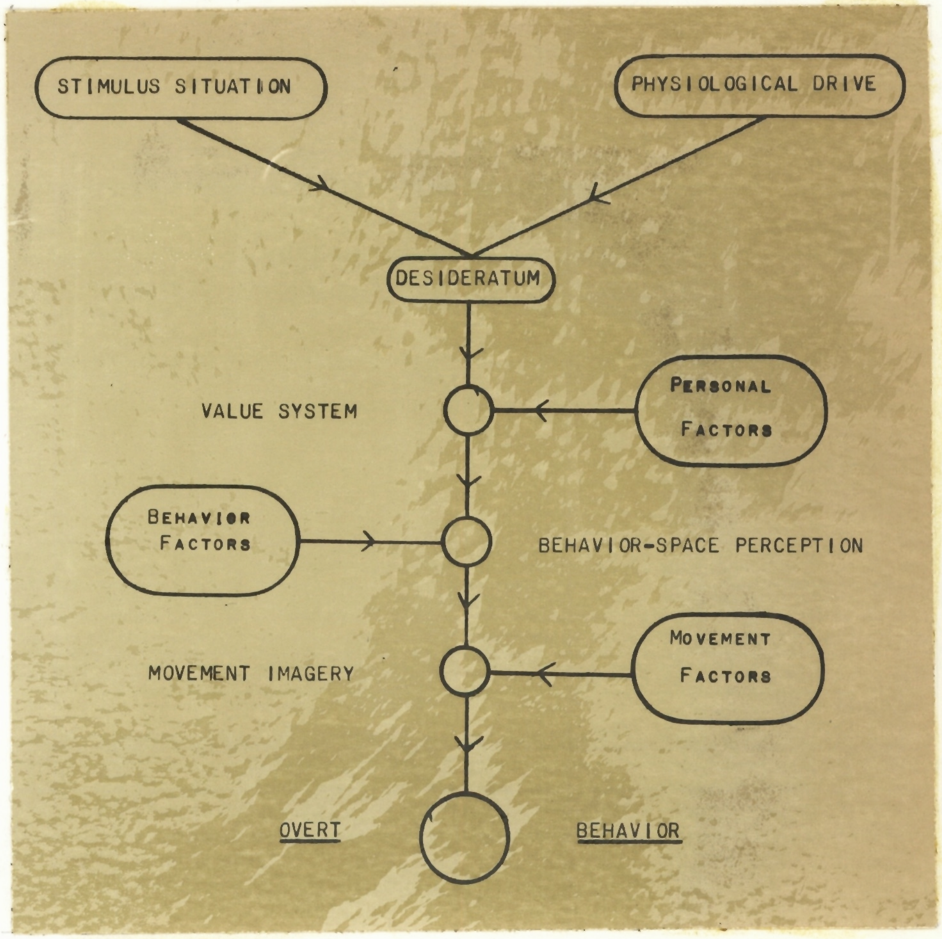

FIGURE 11: Huff's Model for Analyzing Consumer Space Preferences.

the physiological drive determiner." (Ibid., p. 161)

Between this stage and the final one of purchasing the desired item, various factors influence his behaviour. His behaviour is first shaped by his personality and character as molded by the various components of what Huff calls his Value System. This is "a composite of elements all of which condition perception and resultant actions of the consumer ..." (*Ibid*., p. 162) and comprise those personal attributes of the consumer including his geographical location, ethical and moral code, ethnic affiliation, income, personality, sex, occupation, age, education and "mental synthesizing ability".

The consumer must next consider where he can go to shop. His "Behaviour-Space Perception" is "an array of location sources of varying distances and directions ... which are perceived by the consumer at a given moment ..." (*Ibid*., p. 163) These include the reputation of the source, the personal amenities involved, the breadth of merchandise, the services rendered and the price of the product.

Finally he considers what is involved in getting to the shop. Thus his Movement Imagery is "the perceived movement of the consumer from one region to another in his quest for a desired goal object." (*Ibid*., p. 163) and includes modes of travel, travel costs, travel times and finally parking costs.

Huff tabulated twenty-five factors in a 25 X 25 interaction matrix. He first identified those factor which affected each other. By successively multiplying the matrix by itself, Huff then identified higher-order linkages between elements. This was done seven times, and the totals of all seven matrices were summed to show the most important elements. The most dominant elements were those from the Value System: Age (accounting for 26% of linkages), Personality (14%), Sex (13%) and Education (10%). Elements more in line with those anticipated from the theoretical models ranked well down on the list: geographical location (1.21%) was eleventh, travel time (.52%) was eighteenth while travel cost and parking cost ranked at the bottom.

Huff does not suggest that his model is a predictive tool. Rather, it seeks to explain already observed behaviour, and to suggest <u>why</u> we should expect variations between the actual behaviour of "real" man and the ideal behaviour of "economic" man predicted by the theoreticians.

3.4 Limitations and Critiques

The foregoing review of empirical studies confirms that "actual patterns do not conform with theoretical expectations." (Harvey, 1969, p. 138) A number of geographers have therefore suggested that the theory must be rejected or at least substantially revised. Guelke (1971, p. 48) is particularly critical. He questions the entire attempt by geographers to formulate a nomothetic methodology. About Central Place Theory he writes

> Today central place theory has acquired much of the esteem once given to the Davisian model. Central place theory comprises in fact a series of models, which have been constructed on various assumptions about human behaviour. These assumptions, it is pointed out, are simplifications of reality; the models therefore show what would happen under ideal but not necessarily actual conditions. However, even when appropriate situations are found to test a given central place model its poor performance in these tests does not necessarily lead to its abandonment. An ad hoc hypothesis can easily be introduced to protect it from refutation. This procedure has even been followed in cases where the empirical results contradict certain basic features of the model. Thus Ian Burton explains the failure of a city to develop as expected (on theoretical grounds) in a central place system by showing that the towns in the system had each "captured" one set of functions which according to the model, have been found in the city that had not materialized.

A further assault on the movement towards geographical quantification and model building comes from the phenomenological school. It stands as an antithesis to what has become known as the "new geography" on two grounds --

its opposition to the dictatorship of scientific thought over other forms of thinking, and its attempt to formulate some alternative method of investigation to that of hypothesis testing and the development of theory. (Relph, 1970, p. 193) It effectively replaces the "objective" world of quantification with the perceived experiences of the observer. Accordingly "there is no single, objective world; rather there is a plurality of worlds -- as many as there are attitudes and intentions of man." (Ibid., p. 194) Regarding nomothetism, Relph observes

> From the basis of these phenomenological assumptions attempts to develop mathematical models and theories of man's behaviour in space are seen not as a contribution to an understanding of some "real" geography of man's activities, but as the reflection of the limited intentions of those geographers presenting the explanations. If geography is to be considered solely as a nomothetic discipline, then it must be recognized that geographers have to operate within this narrow range and that any resulting law will be of little significance for the worlds of man's experience. (Ibid., p. 198)

A resurgence of interest in historical geography casts a further shadow over the "new geography". Cole Harris, who fears that geography's attempt to establish itself as a deductive science has lead geographers away from some of their best research, has argued "that spatial considerations are not particularly geographical, and that geography cannot be defined as the study of spatial relations". (Harris, 1971, p. 161) Harris sees the role of geography as that of synthesis rather than explanation through model building.

> To substitute laws for synthesis in history or geography is to lead to all embracing schemata such as those of Spengler or Toynbee in history, or those of Huntington or some spatial theoreticians in geography, that are too vague, or tautological to cast new light on anything in particular; or to the breakdown of geography and history into more specialized social science. (Ibid., p. 164)

The problem facing the educator seems to be of two orders. First, are the quantitative and model building aspirations of geography legitimate? Guelke, Relph and Cole would appear to suggest that they are not. Whether or not the "new geography" has run full cycle, and we are about to embark on a <u>new</u> "new geography" is an intriguing prospect. Nevertheless, even though the recent developments in educational geography reviewed in Chapter 1 might encourage the cynical view that change must be imminent again at the research levels of the discipline, the bulk of the geographical establishment still seems firmly committed to nomothetic pursuits. At the moment, at least, arguments opposing this position are at the philosophical rather than the operational level. The arguments opposing quantification and model building have reached the stage that the "new geographers" were at twenty years ago. Such arguments must be acknowledged, but curriculum designers must be wary of attempting to accomodate every will of the methodological wisp.

At another level, the question which must be considered is this: Even if model-building is a valid pursuit, is Central Place Theory a valid model which has an educational role? Harvey (1969, p. 138) recognizes the problem when he writes

> The difficulty of finding empirical evidence for central-place theory has proved a major dilemma in human geography, given the generally acknowledged importance of the theory in geographic thinking. Yet it is surely evident that central-place theory will not and cannot yield empirically testable hypotheses since it is founded on a theory of demand which is itself inherently untestable except by introspection.

Central Place Theory must be viewed in the same light as other theoretical attempts to account for human behaviour in psychology, economics or any of the social sciences. Central Place Theory has had a fundamental impact on the historical development of geography. It may yet, through the miriad studies it has generated, pave the way to a unified field theory which will ultimately provide the explanations Central Place Theory alone was unable to. Until that time, as geographers we must recognize its limitations, but as educators we can still appreciate its significance in the historical development of the discipline.

Chapter Four

TEACHING THE CONCEPTS OF HIERARCHY, THRESHOLD AND RANGE

4.1 Initial Considerations

The decision to include central place studies in any pre-university geography curriculum involves a number of considerations on the part of the teacher. At the outset, after having decided that Central Place Theory has both educational and geographical merit, he must identify those concepts in the theory that are teachable. He must then decide at which level and in what context these concepts will be taught. Finally he must devise suitable activities which will make these concepts relevant and meaningful to the student.

The present chapter, and the one which follows, represent but one such decision, and are not a definitive statement of what should be taught, or how it is to be taught. In this chapter the more fundamental ideas relating to the size and spacing of elements within a central place system are considered. These are defined as hierarchy, threshold and sphere of influence. In most cases, these are concepts with which the student is inherently familiar. Consequently, it is felt that they could be introduced as early as the initial high school geography course, and certainly by the middle years of high school with fourteen or fifteen year olds.

Chapter Five considers the more sophisticated concepts of spatial pattern analysis. While some simple mathematical calculation is required, this is a facility not known to exist universally amongst high school geography students. Consequently, it is felt that the activities suggested in this chapter might be more suitable at senior high school or even junior college level.

At any level at which Central Place Theory is introduced, however, several points must be made quite clear to students. First Christaller's original concepts applied to a predominantly rural agricultural economy and, as Berry (1967, p. 118) notes, the increasing concentration of North American population in metropolitan regions "may be eliminating central-place hierarchies as we know them from the continent." Consequently the teacher, as well as the student, may be hard-pressed to find a central place system operating around or within many major cities in Canada.

Secondly, we must never lose sight of the fact that central place is, in fact, a theory -- an idealization of the real world. At best we should only ever expect to find tendencies towards the pattern, rather than a perfectly formed system.

4.2 The Hierarchy

With the foregoing reservations firmly in mind, the teacher should now be prepared to identify and test certain of Christaller's assumptions in the classroom. A basic premise of his theory is the concept of a hierarchy. This makes a good beginning point for a consideration of central place for several reasons. It is a concept with which the students are inherently familiar, and is moreover, one which suggests several activities.

Students who are sports fans will realize that major league baseball, football and hockey teams are found in the largest cities only. The minor professional leagues operate out of smaller towns with non-professional and junior teams being located in even smaller centers.

The educational system itself forms a complete hierarchy. Elementary schools serving local neighbourhoods supply a single larger high school. Several high schools provide the students for a community or regional college. The various colleges send most of their graduates to a single university. At each successive level, the facilities are more specialized and serve a greater population over a wider area.

An initial activity, therefore, would be to test the Christallerian hierarchical assumption in several areas. Table 3 provides 1961 census data of population and number of stores for 24 centers in Saskatchewan. Figure 12 shows a graph plotted on a logarithmic scale from this data. Appendix 1 provides similar data for Montreal, which might provide a basis for comparison. The question under investigation is this: Does there appear to be a hierarchy of urban centers in the region under consideration? Which region appears to show the greatest and least tendencies towards the theoretical pattern?

Within towns, as has been suggested in Chapter Three, the system of shopping centers appears to form a

TABLE 3: 1961 Census Data for Saskatchewan

Municipality	Population	No. of Stores
Estevan	7,728	81
Weyburn	9,101	75
Assiniboia	2,491	37
Maple Creek	2,291	31
Shornehaven	2,154	36
Melville	5,191	70
Regina	112,141	656
Moose Jaw	33,206	272
Swift Current	12,186	120
Kenora	2,117	41
Kamsack	2,968	42
Yorkton	9,995	90
Saskatoon	95,526	628
Biggar	2,707	38
Rose Town	2,450	44
Kindersley	2,990	42
Meffort	4,039	53
Nippawin	3,836	55
Tisdale	2,402	40
Humbolt	3,245	45
Prince Albert	24,168	181
North Battleford	11,230	123
Lloydminster	5,667	72
Meadow Lake	2,803	49

hierarchy. An exercise involving field work could have the students examine this system. Small groups of students can be assigned a shopping center in a selected area to investigate. They should report back on the total number of stores in the centers, the number of functions, the number of establishments of each function and, if possible, such

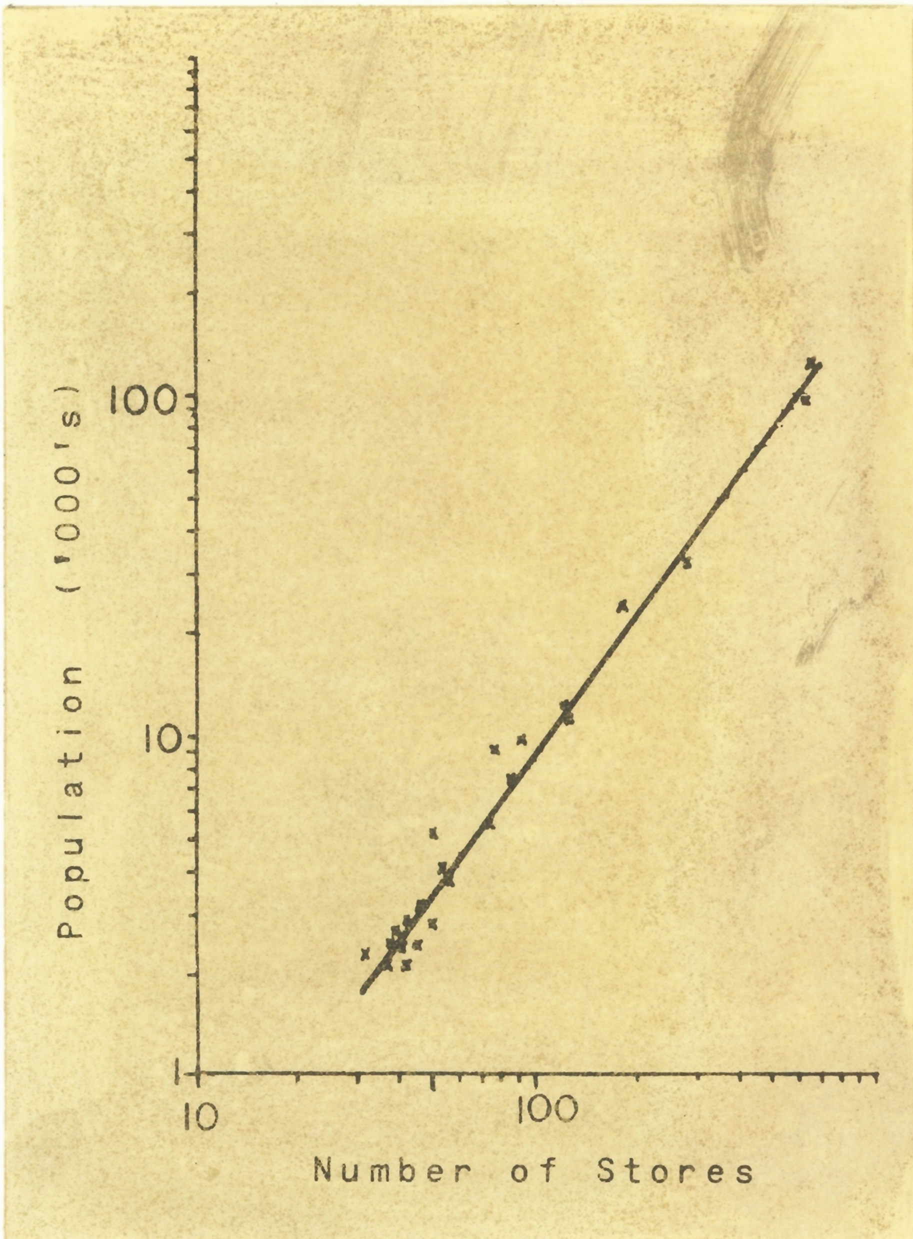

FIGURE 12: Relationship between Population and Number of Stores. (Source: 1961 Census Data for Saskatchewan)

other measures of size as retail floor space, parking spaces and total area of the complex. The latter three pieces of data, of course, would require the co-operation of a sympathetic shopping center manager. A prior letter from the teacher might pave the route for the students. Back in class, the data can be tabulated and graphs drawn. Can a hierarchy of regional, community and neighbourhood centers be identified?

The regularity of Christaller's urban hierarchy is one side of the coin; the other side of the coin is the Rank-Size Rule proposed by Zipf (1949), which states "if all cities are ranked in descending order of population size, the population of the r^{th} ranked city will be $1/r^{th}$ the size of the largest city". (Yeates and Garner, 1971, pp. 53-4) The exact significance of this relationship is not entirely clear, but the most plausible explanation is that it represents a stochastic process -- i.e. one generated by random forces. Evidence suggests that the rule applies best to self-contained areas, especially industrialized countries. While a number of simple, repetitive calculations are required to apply this rule, it does provide an activity for students. A number of countries representing different stages of industrial development might be tested and the results compared. In addition, as suggested by Everson and Fitzgerald (1969, pp. 67-8) tests should be made using the urbanized area, the central city and the metropolitan area population data. The same concept could, of course, be tested for shopping centers, using such size data as number of establishments, number of functions, floor space or parking spaces.

4.3 Spheres of Influence

Another fundamental concept of Central Place Theory is that of threshold -- "the minimum amount of sales needed per time period to bring a firm into existence and keep it in business" (Abler, Adams and Gould, 1971, p. 364) and range -- "the average maximum distance people will go to purchase it" (*Ibid.*, p. 365). In reality, such information is extremely difficult to obtain for individual goods or firms. Instead, it has been common to conduct field studies to determine the spheres of influence of individual towns and thence to draw maps to illustrate these areas.

The technique that is most widely used to do this is the interview-questionnaire method. A number of books have appeared illustrating typical questionnaires and data processing techniques. The book by Briggs (1970) is typical. The suggested activities, aimed at the geography teacher in the United Kingdom, are perhaps less appropriate in the North American setting, where the shorter history and more mobile population tend to blur the distinctiveness of urban shopping zones. Even within the U.K., cautionary notes have been sounded on the overuse of such techniques; and the dubious value of the results which they generate. (Mottershead and Owen, 1972)

There is another approach to this problem, based on the use of the Gravity Model. Drawing an anology between social interaction and Newton's law of Gravitation, the gravity model states that "two places interact with each other in proportion to the product of their masses and inversely according to some function of the distance between them". (Abler, Adams and Gould, 1971, p. 22)

The masses of a place may be any parameter, although populations are commonly used. The distance function most frequently used is the square of the distance.

One of the earliest people to use this concept to define sphere's of influence around towns was Reilly (1931). Consider two towns, I and J, between which we wish to determine the boundary line of interaction. The basic formula for this interaction is

$$I_{ij} = \frac{P_i P_j}{(d_{ij})^2}$$

where I_{ij} is the interaction between towns I and J,

P_i is the population of town I,

P_j is the population of town J,

and d_{ij} is the distance between I and J.

By manipulation of this formula, (see Everson and Fitzgerald, 1969, p. 98) we can find the location of point K between I and J, by the formula

$$d_{jk} = \frac{d_{ij}}{1 + \sqrt{\frac{P_i}{P_j}}}$$

where d_{jk} is the distance from city J to interaction point k.

An exercise appropriate to Canadian geography is suggested. The Quebec section of the St. Lawrence Lowlands is commonly divided into three parts: the Quebec Plain, the Three Rivers Plain and the Montreal Plain. Exactly how the boundaries between these sub-regions are determined is never made entirely clear; although it is presumed that physical criteria were used.

Students should become acquainted with the fact that regions may be defined on other bases. Thus a class discussion might elicit such suggestions as the range of radio advertisements, the circulation of newspapers, milk-sheds and others as types of regions. The boundaries determined this way might make an interesting comparison with those given in the textbook diagrams.

On the intraurban level, an exercise in field work, map reading and the gravity model can be used to determine the zones of influence of shopping centers. Using a large scale (1:25,000) topographic map, the various shopping centers in selected regions can be located. The distances between them may be measured from the map. It might be of interest to use both the direct "as the crow flies" distance and the "Manhattan" distance by using routes along streets. If data has been collected for the hierarchy exercise, this may be used. It is necessary that the hierarchy exercise be done before or in conjunction with this exercise. The break-even point between each shopping center and surrounding ones of the same higher order can be calculated using the above formula. The boundaries can be drawn on the map (preferably over tracing paper, on which the location of each shopping center has been marked -- each order in the hierarchy shown by a different colour). The boundaries of the zone of influence would be shown by the same colour as the shopping center colour.

4.4 Conclusion

The exercises which have been discussed in this chapter are ones which may be introduced at early levels to illustrate some of the basic central place concepts. Mathematical calculations in most instances are minimal. At early years of high school, these exercises might be sufficient in themselves. With more advanced students they should be considered as preparatory to the more advanced concepts in the next chapter.

Chapter Five

TEACHING SPATIAL PATTERN ANALYSIS

5.1 Illustrations of Spatial Patterns

It is significant that both Christaller and Galpin arrived independently at the hexagonal shape as the most efficient placement of settlements over a surface, a shape confirmed mathematically by Lösch. The hexagonal pattern which develops as each town effectively tries to maximize its distance between all others (and thereby maximize its trade area) is perhaps the most sophisticated concept in Central Place Theory, yet it can be made intelligible to students with several simple demonstrations.

Gould (1969, p. 93) suggests one such activity. "If you were locked in a large room with others, and were told that one unknown person had bubonic plague, you too would try to maximize your distance from the rest." With the desks pushed to the side of the classroom students will participate in such an operation enthusiastically. Experience suggests, however, that the teacher will have to do a bit of traffic directing to make sure that students do

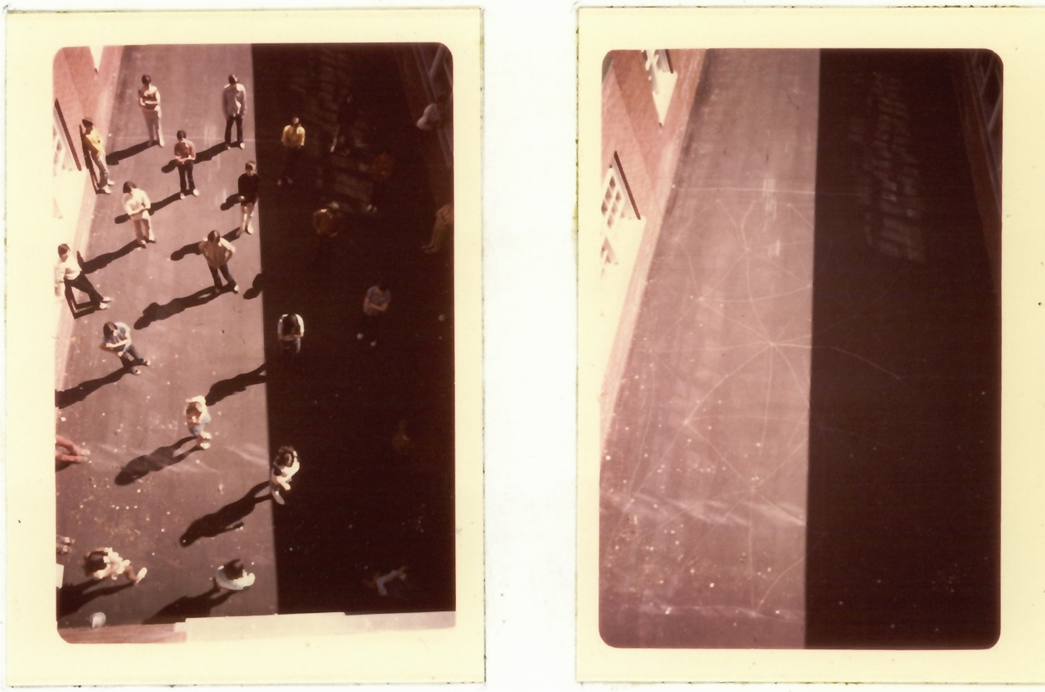

FIGURE 13: "Avoid the Plague". On the left students have maximized distances between each other; On the right the resulting lattice is shown.

indeed attempt to maximize the distance between themselves and every other student, and not presume that they know who is "it". Once the students have maximized their distances, their locations can be marked. These marks should form a triangular lattice.

A problem approach to the same situation could be the following: how should desks be set up in a classroom assuming that it is desirable to minimize student contact. Once again, distances must be maximized, and a pattern of hexagons will emerge.

Bunge (1966, p. 153) proposes a variation on this theme. Faced with the problem of raking leaves, where should one place the compost pile or bonfire and where should the smaller collector piles be located. When the job is over, the largest compost pile will be located in the middle of the lawn, while the collector piles will each be located at the vertices of a hexagon surrounding the compost heap. It takes little imagination to visualize the compost heap as the central place of higher order surrounded by six lower order centers. The areas from which the leaves were raked therefore correspond to the "complementary regions" of the lower order centers, and the number of leaves to their populations.

In most neighbourhoods having mail delivery, the post office delivers the mail to collector boxes from which the mailman picks it up for home delivery. Starting with a neighbourhood street, students might be asked to test the "spatial efficiency" of the collector boxes. Such an exercise could begin around the school area -- perhaps during the regular geography period. As a follow-up, students could conduct similar surveys in their home neighbourhoods, with the view to testing these locations by the methods described later in this chapter.

Analogue models can also provide effective classroom demonstrations of central place systems. Bunge (1964) describes a method for simulating the central place pattern using magnets in corks. Twenty one-inch diameter corks, with bar magnets pushed through their centers, were dumped into an 18-inch diameter plastic bowl. With like poles protruding from the corks, repulsion of the magnets made the corks achieve an equilibrium position. Out of one hundred random tosses, a hexagonal pattern was established on 68 percent of the throws.

Morgan (1967, pp. 757-9) describes a more sophisticated analogue using electromagnets in place of simple bar magnets. With such a system it is possible to vary the degree of repulsion by varying the number of turns of the magnetic winding in direct proportion to some particular property of the central place, such as population, number

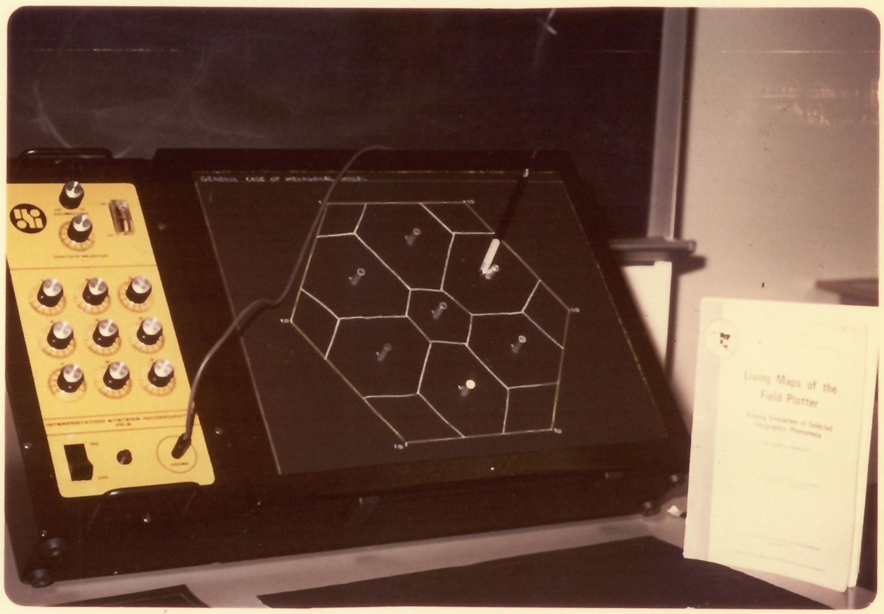

FIGURE 14: Analogue Simulator.

of retail outlets, service trades employment, etc. The electromagnets can be placed under a sheet of glass in appropriate positions to represent town locations. Then small plotting compasses can be used to show spheres of influence of the "towns", for the needle changes direction abruptly at the point of balance between magnetic fields.

A more elaborate model consists of a series of electromagnets each attached to a rheostat. While Morgan suggests that such an apparatus has a number of applications, he advises "that it is best to confine first experiments to real situations where a degree of uniformity is present." (Ibid., p. 759).

Another analogue suitable for classroom demonstration is based on the diffusion of a liquid over a piece of blotting paper. (Ibid., pp. 759-62) A solvent composed of 45 parts N-butanol, 25 parts pyridine and 40 parts of distilled water, will, as it diffuses across pink blotting paper, carry some of the red pigment of the paper with it. As the paper dries, the limits of the solvent diffusion is marked by a thin red line.

This system can be used to simulate a central place system. Small wicks are made of tightly rolled blotting paper. The wicks, all of the same length, and each containing the same amount of paper rolled with equal tightness, can then be inserted into holes in a sheet of blotting paper. If the wicks are located at the vertices of equilateral triangles a perfect hexagonal pattern will be produced.

More sophistication can be attached to this model by introducing coloured dyes to the solvent and by cutting out negative areas -- i.e. areas which impede diffusion, such as rivers. Parker (1971) produced a central place analogue of the Cambridge - Ely - Newmarket area of England using the 1:63,360 Ordance Survey sheet as a base map. Parker ran his analogue for a period of 100 minutes at room temperature. He concludes that analogues are not ends in themselves, but rather provide a simple yet valuable visual impression of a much more involved concept.

5.2 The Measurement of Spatial Patterns

The attempt to simulate a central place system with various analogue models represents one approach to the problem; the testing of existing patterns to see to what extent they conform to an expected pattern is another. Spatial statistics, the techniques which allow us to do this, were developed by plant ecologists. The traditional approach to this problem was the use of "quadrat sampling". Quadrat sampling is a method to determine the randomness of a distribution of points (plants or cities, as the case may be) over an area. If the area is sub-divided into equally sized sub-areas, a random distribution of points will be distributed in such a way that every sub-area will have as much chance of receiving a point as every other sub-area. A Poisson distribution provided a measure of the randomness of the distribution. Quadrat sampling provides an initial technique to test for random distributions or non-random distributions, but it has certain inherent limitations. Not the least of these is the fact that it can be influenced by the size and number of quadrats. Moreover, the quadrat method provides no absolute measure of the pattern, but must ultimately be subjected to additional statistical tests, such as the Chi-square statistic, to determine its significance.

The work of Clark and Evans (1954) has applied a more accurate quantitative measure to the quadrat sampling technique. Essentially this technique compares the average of actual distances between nearest neighbours ($\bar{r}_A$) to that of a randomly distributed pattern ($\bar{r}_E$). Thus, in an area, A, with N points, the average distance between nearest neighbours would be calculated as follows

$$\bar{r}_A = \sum_{i=1}^{N} r_{i1} / N$$

where $\overline{r}_A$ = observed mean distance

r_{i1} = distance of any point to its nearest neighbour

N = the number of points

For a random distribution of points, the expected mean distance, $\overline{r}_E$, is given by the formula

$$\overline{r}_E = \frac{1}{2\sqrt{p}}$$

where p = density of points per unit area, i.e. N/A

The Nearest-Neighbour Statistic, R, represents a comparison of the observed mean distances ($\overline{r}_A$) and the expected mean distances ($\overline{r}_E$), i.e.

$$R = \frac{\overline{r}_A}{\overline{r}_E}$$

Clark and Evans (1954, p. 447) have shown that the value for R can range from 0 to 2.1491. A value of zero represents a completely clustered distribution, that is all points superimposed so that the average distance is nil and the quotient is 0. The value of 2.1491 represents conditions of maximum spacing in which "individuals will be distributed in an even, hexagonal pattern, and every individual (except those at the periphery of the population) will be equidistant from six other individuals". (*Ibid.*, p. 447) If, in fact, the distribution is random, the observed distances will equal the expected distances, and the resulting quotient will be one.

King (1962) has applied this technique to settlement patterns in several areas of the United States. He has shown that the tendency towards uniform spacing "appears to be more pronounced in those areas in which the amount of cropland is high, or the percentage of total area in farms is high, or finally, the percentage of total population classed as rural farm population is high." (*Ibid.*, p. 167)

Keeble (1969, p. 22) suggests a method which might also be appropriate for school use. To test the distribution of towns on a map, a grid consisting of fifty squares is superimposed over the map. The number of towns in each square is counted, and the average value for each square is calculated. Next, the variance is calculated, and the mean value is divided by the variance. Since, by definition, in a Poisson distribution the variance is equal to the mean, this division should produce a value of 1 for a random distribution. "Index values much below 1.0 indicate settlements which cluster together; those around 1.0 indicate a strong tendency towards a random, chance arrangement; and those above 1.0 suggest a regular, equally spaced layout of settlements." (*Ibid*., p. 22) Greater statistical sophistication could be applied to this index by applying tests of significance between the computed index and the theoretical random value of 1.0, although Keeble suggests that this operation could be omitted at the school level. (*Ibid*., p. 22, footnote 10).

5.3 Classroom Demonstrations of Pattern Analysis

The school provides a number of opportunities to illustrate the technique of quadrat sampling. Consider, for instance, a typical distribution of students within a classroom. Suppose a class of thirty students is made up of twenty boys and ten girls. An interesting problem is to analyze the seating arrangement. For convenience, let us assume the classroom has five rows of desks, with each row having six desks.

Initially we might propose several hypotheses about the seating arrangement which will evolve, assuming each girl has a free choice of seats and a stable equilibrium pattern is established in which each girl is sitting where she wishes. One hypothesis might be that the girls, timid things that they are, will seek the security which comes from sitting as close to one another as is physically possible. Consequently, when the first girl selects a seat, the next will occupy a seat adjacent to her. This will lead to a clustering of the girls. While the ultimate in clustering, i.e. all ten girls in one seat is impossible, we could perhaps find them in ten adjoining seats in one section of the classroom.

A second hypothesis is that the girls are really in the class to meet the boys. In this situation, each girl would attempt to seat herself in the midst of as many boys as possible and would see other members of her own sex as competition. Consequently each girl will try to sit as far away from each other as possible. This will produce the maximum dispersal of the girls throughout the classroom and a regular pattern will emerge.

Finally we might hypothesize that in this age of "woman's lib" the girls view the boys neither as threats nor as attractions, but simply as other students. They are likely to sit anywhere in the classroom without considering next to whom they are sitting. The result will be a random distribution of the girls throughout the classroom.

6	7	18	19	30 GIRL
5	8	17	20	29 GIRL
4	9	16	21 GIRL	28 GIRL
3	10	15	22	27
2 GIRL	11 GIRL	14 GIRL	23	26
1 GIRL	12 GIRL	13 GIRL	24	25

FIGURE 15: Hypothetical Classroom Seating Plan

Having decided on our hypothesis, we test the actual seating plan against theoretical clustered, regular and random patterns which we have generated. The test is performed by means of quadrat sampling. For mathematical ease, let us divide the class into ten quadrats, of three seats each, as shown in Figure 15. The seats have been numbered from 1 to 30, with the girls sitting as shown in seats 1, 2, 11, 12, 13, 14, 21, 28, 29 and 30. We can first test this arrangement against a perfectly clustered pattern. If the pattern is perfectly clustered, nine of the ten girls will be sitting in three adjoining quadrats and the tenth girl will be nearby. The other quadrats will have no girls. We can set up a table in order to compare the actual pattern with a theoretical one (see Table 4).

TABLE 4: Quadrat Test Against a Clustered Pattern

Quadrat	Seats	Actual	Theoretical	Difference
A	1-3	2	3	1
B	4-6	0	0	0
C	7-9	2	3	1
D	10-12	0	0	0
E	13-15	2	3	1
F	16-18	0	0	0
G	19-21	2	1	1
H	22-24	1	0	1
I	25-27	0	0	0
J	28-30	3	0	3
	TOTALS	10	10	$\sum = 8$

By summing the differences between the actual and theoretical values we arrive at a value of 8. This we can look upon as an "index of Agreement". If we have perfect agreement between the actual and theoretical patterns, the sum of the differences will be zero. Any other value, including the one produced above, suggests that we do not have perfect agreement, but it can tell us little more unless we have another figure with which to compare it.

The next step is to see whether we get greater or lesser agreement when we compare our actual pattern against another theoretical pattern. A regular pattern will emerge if the girls are distributed throughout the classroom with complete evenness. In this case each quadrat would have one girl. The results are shown in Table 5.

TABLE 5: Quadrat Test Against a Regular Pattern

Quadrat	Seats	Actual	Theoretical	Difference
A	1-3	2	1	1
B	4-6	0	1	1
C	7-9	2	1	1
D	10-12	0	1	1
E	13-15	2	1	1
F	16-18	0	1	1
G	19-21	0	1	1
H	22-24	1	1	0
I	25-27	0	1	1
J	28-30	3	1	2
				$\sum = 10$

The value obtained in this case is slightly larger than that obtained in the comparison with a clustered pattern. We might conclude that our pattern is more clustered than regular. This appears to be born out inherently by simply observing Figure 15.

To compare our pattern to a random pattern, it is necessary to generate such a pattern using a random number table. (See Appendix 2) This can be done using the first two figures from a column of random numbers. Every time a number between 01 and 30 appears, we theoretically assign a girl to that seat, until all ten girls have been assigned. A comparison between a randomly generated pattern and our actual pattern is shown below, in Table 6.

TABLE 6: Quadrat Test Against a Random Pattern

Quadrat	Seats	Actual	Generated	Difference
A	1-3	2	0	2
B	4-6	0	2	2
C	7-9	2	1	1
D	10-12	0	0	0
E	13-15	2	0	2
F	16-18	0	1	1
G	19-21	0	1	1
H	22-24	1	1	0
I	25-27	0	2	2
J	28-30	3	2	1
				$\sum = 12$

In this example, testing against a random pattern, the value obtained for the index of Agreement has an even greater value. At this point it is necessary to go back to our original hypotheses. The first would be the most acceptable in this case -- that confronted by twenty males in the classroom half that number of girls will tend to seat themselves in groups.

An exercise of this sort has several advantages. At the middle high-school age, students usually need little encouragement to enter into the feminist - male chauvinist debate; an exercise based on this idea should generate a good deal of interest. Moreover, one's colleagues may provide a source of exercise material by turning over their seating plans for analysis.

The concept of randomness will likely be a difficult one to explain. Humans tend to apply regularity to the patterns they perceive, and purely chance distributions are seldom recognized as such. There is a device which may make this concept more understandable. Have the students attempt to arrange themselves into a completely random arrangement of boys and girls. Once the pattern has stabilized, plot the distribution not of boys or girls, but rather of blue-eyed students. It is important that this criterion not be mentioned until after all students are seated. The occurrence of blue eyes should have absolutely no effect on the seating pattern adopted and the resultant distribution should approximate a random pattern.

Several limitations of quadrat sampling should be drawn to the attention of students if it does not come up in class discussions. The more mathematically inclined may question the validity of the index of Agreement which is based on absolute values of the differences rather than the real differences. By using actual differences, some positive and others negative, the signs will always cancel out leaving a sum that is invariably zero, which we have suggested indicates perfect agreement. More advanced classes can be introduced to the statistical device for handling this problem, that is, squaring the differences. While this operation, of course, increases the magnitude of the differences, it may be explained that this value can be reduced to more manageable size either by dividing it by another number or by taking its square root. In this case, the square of the difference between the actual and the expected (or theoretical) value is divided by the expected value. We may then add up these quotients to arrive at a different type of index. From here it is a short step to the Chi-square statistic which tests the significance of such a relationship. It is beyond the scope of this paper to discuss the use of this statistic, but interested readers are referred to texts in nonparametric statistics (for example, Siegel, 1956) or quantitative techniques in geography.

A second concern must be to avoid letting the results of spatial analysis replace actual observation of the map. Frequently one's inherent conclusions will be almost as valid as those calculated using sophisticated statistical techniques.

The technique of nearest neighbour analysis can be introduced using the classroom exercise described above. This can be done using ordinary graph paper, on which the positions of the ten girls are plotted as points. Ideally, this should be drawn to scale, but approximations to the nearest neighbour statistic may be obtained even when perfect scale is not maintained. Once the points are located, the distance between them can be measured with dividers and the distances expressed as inches or centimeters.

5.4 Analysis of Actual Geographic Patterns

The exercises which follow provide examples of the sort of material that can be subjected to spatial analysis. Map 1 (Appendix 3) provides a map of the Commercial Structure of Montreal which lends itself to quadrat sampling. It will be noted that a hierarchy of shopping districts has been delimited. Seven regional shopping centers are indicated by the largest circles, and have been identified by name. Five of these are located on the Island of Montreal, one on Ile Jésus and one on the South Shore. A total of sixty-two shopping centers of the next lower order are located on the Island of Montreal alone.

To simplify the analysis, the Island has arbitrarily been divided into three sections. The western section contains nineteen shopping centers of the second order and one regional shopping center. This area could conveniently be overlain by a grid of ten equal quadrats. The design of the quadrat grid will provide certain problems which are inherent in this type of analysis. Nevertheless, the mathematics is simplified, for a regular pattern would yield a two shopping centers per quadrat relationship. The central area contains twenty second order centers and two regional centers. Using the same approach, a sample of eleven quadrats would seem suitable. Finally the eastern-most area contains twenty-four second order centers and two regional centers for a total of twenty-six. Thirteen quadrats would be appropriate.

The next step in the analysis is the formulation of a suitable hypothesis. On the basis of previous discussions, we might expect the principles of a central place system to be operative in the spacing of shopping centers and that a regular pattern would emerge.

It will soon become apparent to students that various problems are encountered when using the quadrat sampling technique, particularly on this scale. Larger maps, for instance the Emergency Measures Organization series covering Toronto and Vancouver, could be analyzed and might provide more satisfying results. Nevertheless, the choice of the correct number, size and shape of quadrats presents a problem which is difficult to resolve.

Nearest-neighbour analysis therefore provides a superior analytical tool. Map 1 could be analyzed using this method. The area of Montreal Island is 122,166 acres or 198.88 square miles. Ile Jésus comprises 60,601 acres or 94.69 square miles. Distances measured in inches or centimeters can be converted to miles in order to complete the analysis.

There is another aspect of Montreal's geographical pattern which lends itself to this type of analysis. In 1967 the City Planning Department unveiled a master plan entitled "Montreal: Horizon 2000". Essentially the plan attempted to present a scheme to guide urbanization in the Montreal region during the last three decades of the Twentieth Century. One particularly significant aspect of the plan involved the directed growth of satellite cities in the Montreal area. Six cities -- St. Jean, St. Hyacinthe, Sorel, Valleyfield, St. Jerome and Joliette -- which today have average populations between twenty and thirty thousand, were envisioned as growth poles which would ultimately reach populations of 100,000 to 200,000. In addition, smaller towns such as Beloeil, St. Therese, Repentigny and others were anticipated as secondary growth centers which would grow to populations approximating 30,000 by the year 2000.

The 1:500,000 Map Sheet provides a convenient scale on which to conduct a nearest-neighbour analysis of the locations of these towns. It is first necessary to join the Ottawa-Montreal N.W. 44/76 sheet to the Parent-Trois Rivières N.W. 46/76 sheet. A section (see Map 2, Appendix 3) can then be cut from the combined sheets. An advantage of this scale is that major urban areas appear distinctly. Smaller centers are located with small yellow squares. Moreover, a sufficiently large area can be covered on a map which is neither inordinately large so as to be cumbersome, while showing the major settlements.

A nearest-neighbour analysis requires that the distance between every point and its nearest neighbour of the same or higher order be measured. Therefore an initial series of calculations would be completed for the six satellite towns (remembering to include Montreal in the calculations). This would then be followed by including all other towns identified by yellow squares in a subsequent calculation.

5.5 Conclusion

The exact data to be subjected to analysis is in many ways incidental to the method itself. Regardless, then, of what geographical pattern or system is to be studied, the teacher must never lose sight of the fact that this operation is meant to be a learning experience. Consequently the proper application of the technique within the context of a formal method of scientific enquiry is of greater value than the results obtained. Students must be encouraged to follow a systematic approach to the problem. This involves the following steps:

1. The identification of a problem to be analyzed;
2. The formulation of a hypothesis to explain the resulting geographical pattern;
3. The selection of an appropriate analytical tool (e.g. quadrat sampling or nearest-neighbour analysis, or perhaps both);
4. The accurate application of the method of analysis;
5. The acceptance, rejection or modification of the original hypothesis on the basis of the results of the analysis.

The purpose of these exercises is to teach students the methods of geographical analysis in order that they may ultimately make their own judgments on the validity of Central Place Theory. In this way they are given the opportunity, not only of learning what geographers have done, but actually doing what geographers do.

Chapter Six

A CONCLUDING STATEMENT

This paper assumes no pretence of being anything other than what its title suggests: an introduction to the theory and analysis of central place systems within the context of geographic education. The exercises which are suggested are not meant to be comprehensive, but merely to provide the seed which the creative teacher will germinate into a variety of educational activities. The possible avenues of school investigation into central place analysis are manifold, of which only a partial listing might include the following:

1. The investigation of the range of a corner store or movie theatre through a student survey.
2. Do chain store outlets require a shopping center of a particular hierarchical level, or do principles of the Löschian economic landscape apply?
3. Do shopping locations, thresholds and ranges

vary according to the socio-economic level of the community?

4. The investigation of consumer shopping behaviour, using a simplified version of the Huff investigation.

It is recognized that many teachers will be hesitant to depart from the traditional regional curriculum. Many arguments against the use of modern analytical techniques support their hesitance.

One such argument is the following: The introduction of Central Place Theory into the school system is an usurpation of the university's curriculum. Surely the work of Bruner, and the success of new curriculum projects in various disciplines refutes such a view. Everson and Fitzgerald (1969, p. ix) comment on this view.

> That is to imply that a concept can only be taught at one level and only once. In the past Central Place Theory has been one of the ideas generally taught in the university and thought to be too complex for school study. However, this and other basic concepts can be introduced early in the school geography syllabus and then developed further as the student progresses through school.

The modern view holds that any concept can be introduced if suitable techniques are developed. The problem facing the teacher is to develop the proper technique, not to eliminate the difficult concept.

A second argument against central place studies is the following: Central place patterns seldom, if ever, exist in reality, whereas the purpose of geography is to teach about the "real" world, not a theoretical or ideal one. An argument against such a statement becomes an exercise in educational philosophy. If we accept that geography is concerned with the real world either exclusively or predominantly, it must be an understanding of the real world with which we are concerned. Central Place Theory provides an instrument against which we can measure reality. It therefore helps us understand reality by providing an ideal situation with which to make a comparison.

There are other valid reasons for teaching geography besides providing an acquaintance with the "real" world. One of these is to familiarize students with the techniques used to gain the conventional wisdom which characterizes the discipline. Students of chemistry continue to study the behaviour of ideal gases in order to understand the behaviour of real gases. Kinetic molecular theory is a fundamental concept in any introductory science course even though it represents an ideal situation. Moreover, the indisputable fact that Central Place Theory has contributed so overwhelmingly to the development of the science of geography makes it an important concept for historical, if for no other reason.

Finally it will be argued that the results students arrive at will be unpredictable. Certainly this is an argument in favour of central place studies, rather than a refutation of that role. Beyond the most mundane locational information, geography is a discipline without absolutes. There are no perfectly correct nor positively wrong answers in geography. It is a discipline which seeks explanation, and exercises conducted by students which are directed to this end are among the most valuable in which they can engage.

"By our theories you shall know us."

Harvey (1969, p. 486) suggests that the current generation of geographers pin this slogan to their study walls. The time has come for the current generation of geography teachers to do the same on the walls of their classrooms!

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Appendix 1

1961 MONTREAL REGION CENSUS DATA

Municipality	Population	No. of Stores
Charlemagne	3,069	28
L'Assomption	4,448	62
L'Ephinaie	2,663	44
Beauharnois	8,704	106
Valleyfield	27,297	300
Boucherville	7,403	31
Chambly	3,737	34
Greenfield Park	7,807	35
Jacques Cartier	40,807	286
Lafleche	10,984	72
LeMoyne	8,057	57
Longueuil	24,131	149
St. Lambert	14,531	87
Chateauguay	7,570	38
St. Eustache	5,463	71
St. Eustache-sur-le-lac	7,274	37
Iberville	7,588	77
Laval des Rapides	19,227	62
Laval Ouest	5,440	44
Pont Viau	16,077	141
St. Rose	7,571	53
Laprairie	7,328	86
Bedford	2,855	46
Cowansville	7,050	83
Farnham	6,354	81
St. Remi	2,276	48
St. Joseph de Sorel	3,588	36
Sorel	17,147	271
Granby	31,463	341
Waterloo	4,543	79
Soulanges	10,075	111
St. Jean	26,988	298
La Providence	4,251	33

Municipality	Population	No. of Stores
St. Hyacinthe	22,354	337
St. Joseph	3,799	32
Dorion	4,996	51
Beloeil	6,283	63
Contrecoeur	2,007	29
McMasterville	2,075	17
Varennes	2,240	21

Appendix 2

TABLE OF RANDOM NUMBERS

Thirty-first Thousand

	1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40
1	87 35	67 44	51 49	18 98	97 84	75 22	53 29	10 52	26 87	54 92
2	25 52	29 67	35 99	48 88	40 68	63 68	82 39	38 47	91 39	11 00
3	87 17	83 31	25 59	87 48	25 80	24 08	81 45	21 32	90 08	44 31
4	05 04	40 35	72 95	48 56	77 57	63 19	80 19	48 52	06 47	64 98
5	81 16	09 24	91 71	29 76	54 01	53 47	30 67	62 95	56 58	10 91
6	54 85	79 88	57 91	11 69	10 22	71 87	24 92	52 64	42 82	78 95
7	44 78	19 18	35 40	27 66	89 72	21 17	71 69	95 17	97 17	62 60
8	97 20	98 97	37 33	93 75	18 88	35 85	46 05	07 20	08 17	66 24
9	98 77	57 51	40 41	76 24	18 54	60 61	79 13	94 57	50 73	89 68
10	78 12	77 30	83 30	59 28	73 33	47 07	60 07	45 38	82 10	73 19
11	41 19	70 62	43 46	06 13	22 38	31 18	64 60	07 14	49 16	28 16
12	70 64	30 55	67 46	95 79	63 66	82 56	67 10	76 77	03 22	42 18
13	06 56	09 89	68 87	79 19	35 94	66 18	17 94	72 81	72 77	92 39
14	29 46	18 28	08 88	48 56	49 44	67 82	72 67	28 83	10 26	58 13
15	42 14	55 51	72 95	29 25	15 18	25 68	48 92	87 16	78 43	17 47
16	33 75	87 15	15 23	13 79	62 73	76 69	09 77	82 65	72 47	59 56
17	09 80	99 61	98 08	34 11	88 79	08 32	46 78	33 58	44 16	12 23
18	98 31	57 50	85 80	53 39	05 92	54 42	29 01	35 23	09 84	96 64
19	51 70	52 55	83 12	95 02	79 11	49 79	87 95	98 48	88 68	64 77
20	27 83	61 07	49 05	46 20	35 78	31 34	42 50	68 11	42 14	29 77
21	78 84	69 15	64 42	92 39	36 08	56 39	35 02	92 78	46 63	82 98
22	22 12	89 66	49 09	99 10	62 53	19 31	81 83	50 43	37 42	10 00
23	69 41	59 54	82 72	44 66	64 03	76 59	12 12	41 56	34 90	26 06
24	54 99	46 54	51 38	59 07	64 21	81 17	88 47	23 05	63 43	08 67
25	99 91	82 79	92 62	44 24	01 34	45 16	33 56	17 78	42 86	70 94

Source: J.E. Freund, Modern Elementary Statistics. (Englewood Cliffs, N.J.: Prentice-Hall, 1960) p. 391

Appendix 3

MAPS FOR SPATIAL ANALYSIS

MAP 1: The Commercial Structure of Montreal.

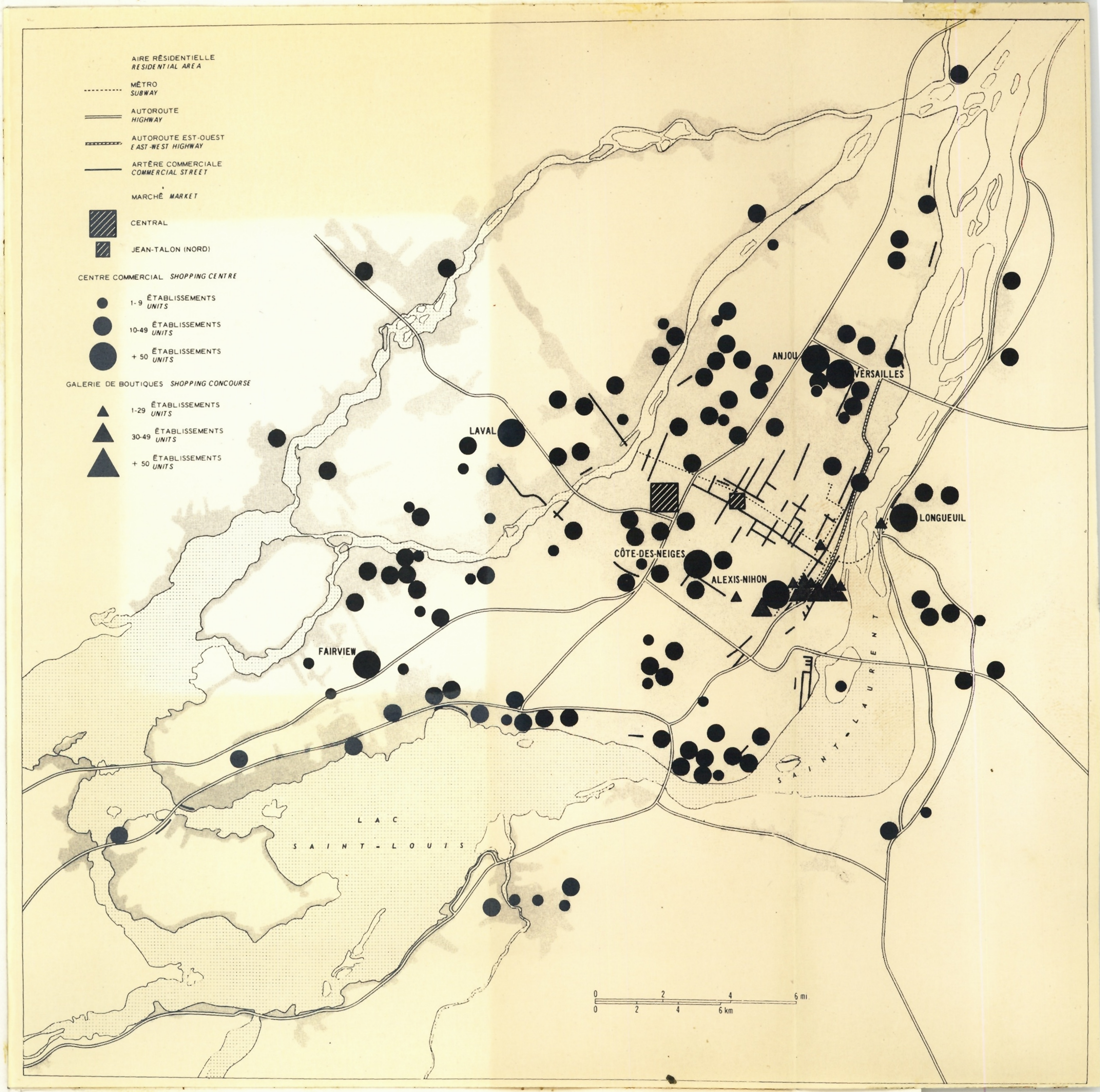
This map was photographically enlarged from: L. Beauregard, 1972, Figure 1, p. 140.

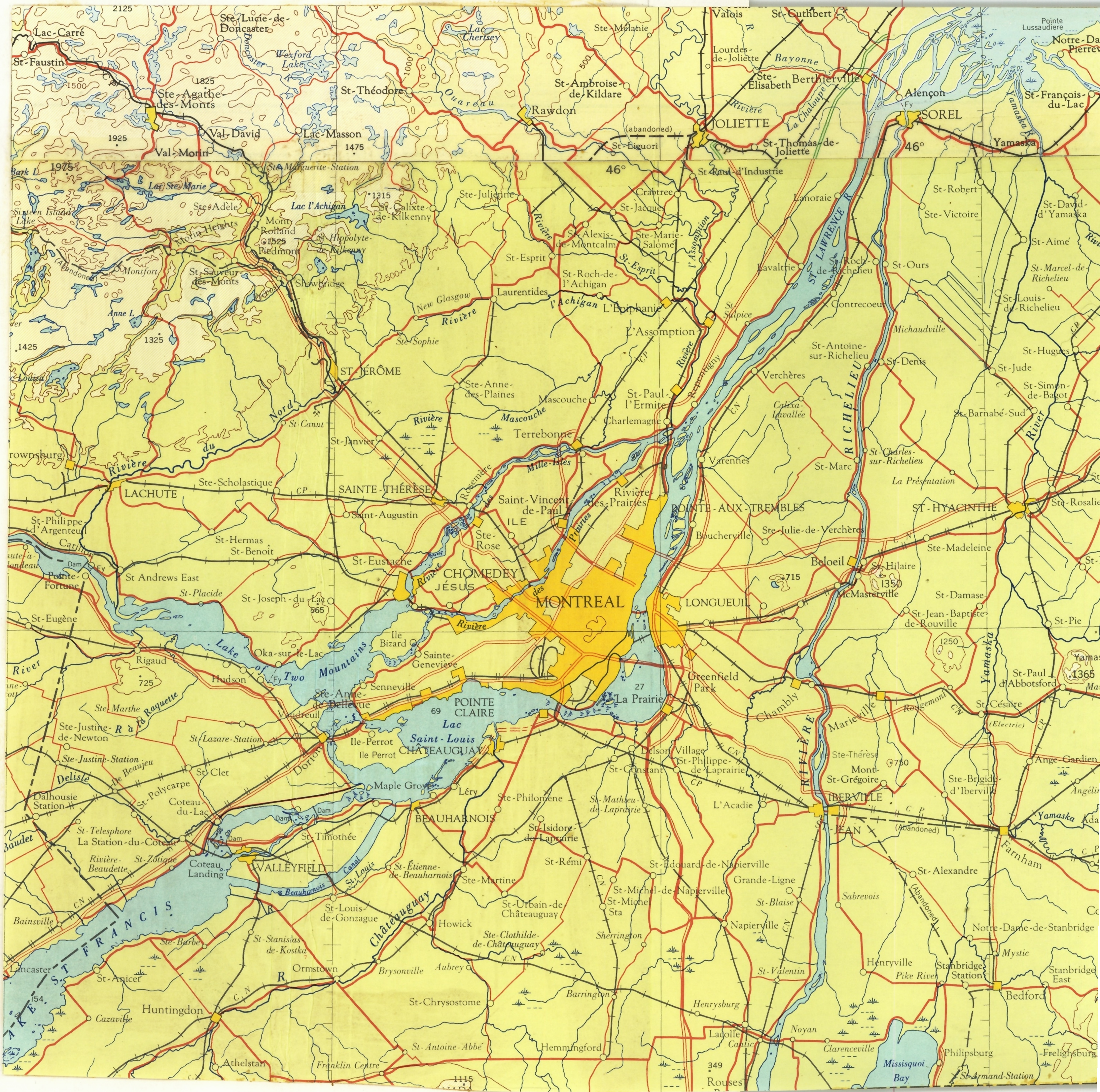
MAP 2: Location of Central Places on Montreal Plain.

This map was constructed from the following 1:500,000 Series maps available from the Map Distribution Office or the local Information Canada outlet:

Lower Section: Ottawa - Montreal
N.W. 44/76
N.T.S. No. 31 S.E.

Upper Section: Parent - Trois Rivières
N.W. 46/76
N.T.S. No. 31 N.E.


AIRE RÉSIDENTIELLE
RESIDENTIAL AREA
MÉTRO
SUBWAY
AUTOROUTE
HIGHWAY
AUTOROUTE EST-OUEST
EAST-WEST HIGHWAY
ARTÈRE COMMERCIALE
COMMERCIAL STREET
MARCHÉ MARKET
CENTRAL
JEAN-TALON (NORD)
CENTRE COMMERCIAL SHOPPING CENTRE
1-9 ÉTABLISSEMENTS UNITS
10-49 ÉTABLISSEMENTS UNITS
+ 50 ÉTABLISSEMENTS UNITS
GALERIE DE BOUTIQUES SHOPPING CONCOURSE
1-29 ÉTABLISSEMENTS UNITS
30-49 ÉTABLISSEMENTS UNITS
+ 50 ÉTABLISSEMENTS UNITS
LAVAL
ANJOU
VERSAILLES
LONGUEUIL
CÔTE-DES-NEIGES
ALEXIS-NIHON
FAIRVIEW
LAC SAINT-LOUIS
SAINT-LAURENT
0 2 4 6 mi
0 2 4 6 km



MONTREAL
Lac-Carré
St-Faustin
Ste-Lucie-de-Doncaster
Ste-Agathe-des-Monts
Val-David
Val-Morin
Lac-Masson
St-Théodore
Rawdon
St-Ambroise-de-Kildare
Ste-Mélanie
JOLIETTE
St-Thomas-de-Joliette
Ste-Elisabeth
Berthierville
Lourdes-de-Joliette
Valois
St-Cuthbert
Alençon
SOREL
St-François-du-Lac
Yamaska
St-Liguori
Crabtree
St-Jacques
St-Alexis-de-Montcalm
Ste-Marie-Salomé
St-Esprit
St-Roch-de-l'Achigan
Ste-Julienne
St-Calixte-de-Kilkenny
Ste-Adèle
Mont Rolland
Piedmont
St-Sauveur-des-Monts
Shawbridge
Laurentides
L'Epiphanie
L'Assomption
Lanoraie
Lavaltrie
St-Roch-de-Richelieu
St-Ours
Contrecoeur
St-Robert
Ste-Victoire
St-David-d'Yamaska
St-Aimé
St-Louis-de-Richelieu
ST-JÉRÔME
Ste-Sophie
Ste-Anne-des-Plaines
Mascouche
Terrebonne
St-Paul-l'Ermite
Charlemagne
Verchères
St-Antoine-sur-Richelieu
St-Denis
St-Hugues
St-Jude
St-Simon-de-Bagot
St-Barnabé-Sud
St-Janvier
Varennes
St-Marc
Brownsburg
LACHUTE
Ste-Scholastique
SAINTE-THÉRÈSE
Saint-Vincent-de-Paul
Rivière-des-Prairies
POINTE-AUX-TREMBLES
ST-HYACINTHE
Ste-Rosalie
St-Philippe-d'Argenteuil
Saint-Augustin
St-Hermas
St-Benoit
Ste-Rose
ILE JÉSUS
CHOMEDEY
Boucherville
Ste-Julie-de-Verchères
Ste-Madeleine
St-Eustache
St Andrews East
Pointe-Fortune
St-Joseph-du-Lac
LONGUEUIL
Beloeil
St-Hilaire
McMasterville
St-Damase
St-Jean-Baptiste-de-Rouville
St-Pie
St-Eugène
Rigaud
Hudson
Oka-sur-le-Lac
Ile Bizard
Sainte-Geneviève
Senneville
Ste-Anne-de-Bellevue
POINTE CLAIRE
Lac Saint-Louis
Lake of Two Mountains
Greenfield Park
La Prairie
St-Paul-d'Abbotsford
St-Césaire
Ste-Marthe
Ste-Justine-de-Newton
Vaudreuil
Ile-Perrot
CHÂTEAUGUAY
Delson Village
St-Philippe-de-Laprairie
St-Constant
Chambly
Marieville
Rougemont
Ange-Gardien
Dalhousie Station
St-Clet
Coteau-du-Lac
St-Polycarpe
Maple Grove
Léry
BEAUHARNOIS
Ste-Philomène
L'Acadie
IBERVILLE
ST-JEAN
Mont-St-Grégoire
Ste-Brigide-d'Iberville
La Station-du-Coteau
St-Timothée
St-Isidore-de-Laprairie
Farnham
Coteau Landing
VALLEYFIELD
Ste-Martine
St-Rémi
St-Édouard-de-Napierville
Grande-Ligne
St-Alexandre
Bainsville
LAKE ST FRANCIS
St-Louis-de-Gonzague
St-Urbain-de-Châteauguay
St-Michel-de-Napierville
Napierville
Howick
Ste-Clothilde-de-Châteauguay
Sherrington
Notre-Dame-de-Stanbridge
Lancaster
St-Anicet
Ormstown
Henryville
Stanbridge Station
Stanbridge East
Huntingdon
St-Chrysostome
Barrington
Bedford
Athelstan
Hemmingford
Lacolle
Noyan
Clarenceville
Missisquoi Bay
Philipsburg
Frelighsburg
Rouses
46°

Appendix 4

A TEACHER'S ANNOTATED BIBLIOGRAPHY

1. B.J.L. Berry, The Geography of Market Centers and Retail Distribution (Englewood Cliffs, N.J.: Prentice-Hall, 1967) x + 146 pp. Price approx. $3.00

If Central Place Theory has reached the level of a geographical dogma, then Brian Berry is the high priest. In this short, soft-covered volume in the "Foundations of Economic Geography" series, the teacher will find more than enough theoretical material to obtain a suitable background.

2. J.A. Everson and B.P. FitzGerald, Settlement Patterns (London: Longman, 1969) xii + 138 pp. Price approx. $4.00

This first book in a British series entitled "Concepts in Geography" essentially provides a series of exercises employing a variety of concepts in urban geography. Various chapters deal with such appropriate topics as "Population and rank", "The spacing of settlements", "The interaction of fields of influence" and "The theoretical basis of central place". The examples are from the U.K., but Canadian teachers should find the ideas stimulating and adaptable to a local setting.

3. M.H. Yeates, <u>An Introduction to Quantitative Analysis in Economic Geography</u> (New York: McGraw-Hill, 1968) vii + 182 pp. Price approx. $5.50

One cannot go very far in modern geography before encountering statistical analysis. This book by Yeates provides reasonably simple explanations of all mathematical concepts discussed in this paper, and moreover, provides a variety of material for analysis. With advanced high school classes, this volume could serve as a useful supplementary text.

4. E. Winter, <u>Urban Areas</u> (Scarborough: Bellhaven House, 1971) xi + 196 pp. Price approx. $5.00

This book represents the second volume in "The Urban Studies Series", which is also edited by Eric Winter. In this volume, Winter concentrates on the internal structure of the city rather than the inter-city relationships. Nevertheless, teachers will find a useful explanation of Central Place Theory (pp. 133-6) as well as a suggestion for applying this to the internal pattern of shopping areas within a city (pp. 175-6).