AGRICULTURAL SETTLEMENT PATTERNS IN UPPER CANADA

AGRICULTURAL SETTLEMENT PATTERNS IN UPPER CANADA, 1782-1851: A SIMULATION ANALYSIS

By

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ABSTRACT

This study of agricultural settlement patterns in Upper Canada, 1782-1851, has two principal aims. They are the isolation of variables relevant to a settler's decision to locate and the production of patterns for years between 1782 and 1851. Data are available for 1782 and 1851 so that these patterns are known; data for years between 1782 and 1851 are limited. Considerations of available pertinent literature and of the settlement history of Upper Canada suggest several principal variables; namely, availability of agricultural lots, distance from entry point, land quality for agriculture and potential in relation to market centres. These four variables are incorporated into a model of the settlement process which is probabilistic and is operationalised by means of simulation. The township is the scale of analysis. On the basis of the variables, attractiveness values are calculated for each township and interpreted as the probability of receiving a settler.

Patterns are produced for 1851 and for years between 1782 and 1851. These model outputs are compared to the available real world data. The two principal means of comparison are visual analysis of settlement maps and correlation analysis.

The four variables are shown to be relevant and exponent values for each variable are estimated. The

following ranking is suggested:

1. Entry points
2. Land quality
3. Lot availability
4. Potential

It is also demonstrated that, for patterns before 1851, the surveying of townships is important, although the effects of this factor are not evident in 1851.

This research, then, is an excursion into a relatively new field of historical geography - the creation of theoretical worlds of the past. Comparison of theoretical and real worlds indicates that the model formulated is appropriate. Further, because the model is quite general it is thought that it might be relevant for other areas and other times.

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CHAPTER 1

INTRODUCTION

This study seeks to reconstruct the early patterns of agricultural settlement, in terms of township population density, in Upper Canada, or what is now southern Ontario.[1] The period of study ranges from the initial migrations into this area during the 1780's and through the subsequent large scale movements prior to the mid-nineteenth century to 1851, the date of the first complete census of Upper Canada (Canada, 1853-55). By 1851 the volume of migration had declined and the frontier had moved north of the original settled areas resulting in the settlement of a large part of Upper Canada (Fig. 1).

A. Aims of the Research

The aims of the research are to isolate the principal variables involved in the process of settlement, to construct settlement patterns for periods for which data are limited and to produce patterns which might have developed given particular processes. If the known pattern of 1782 is used

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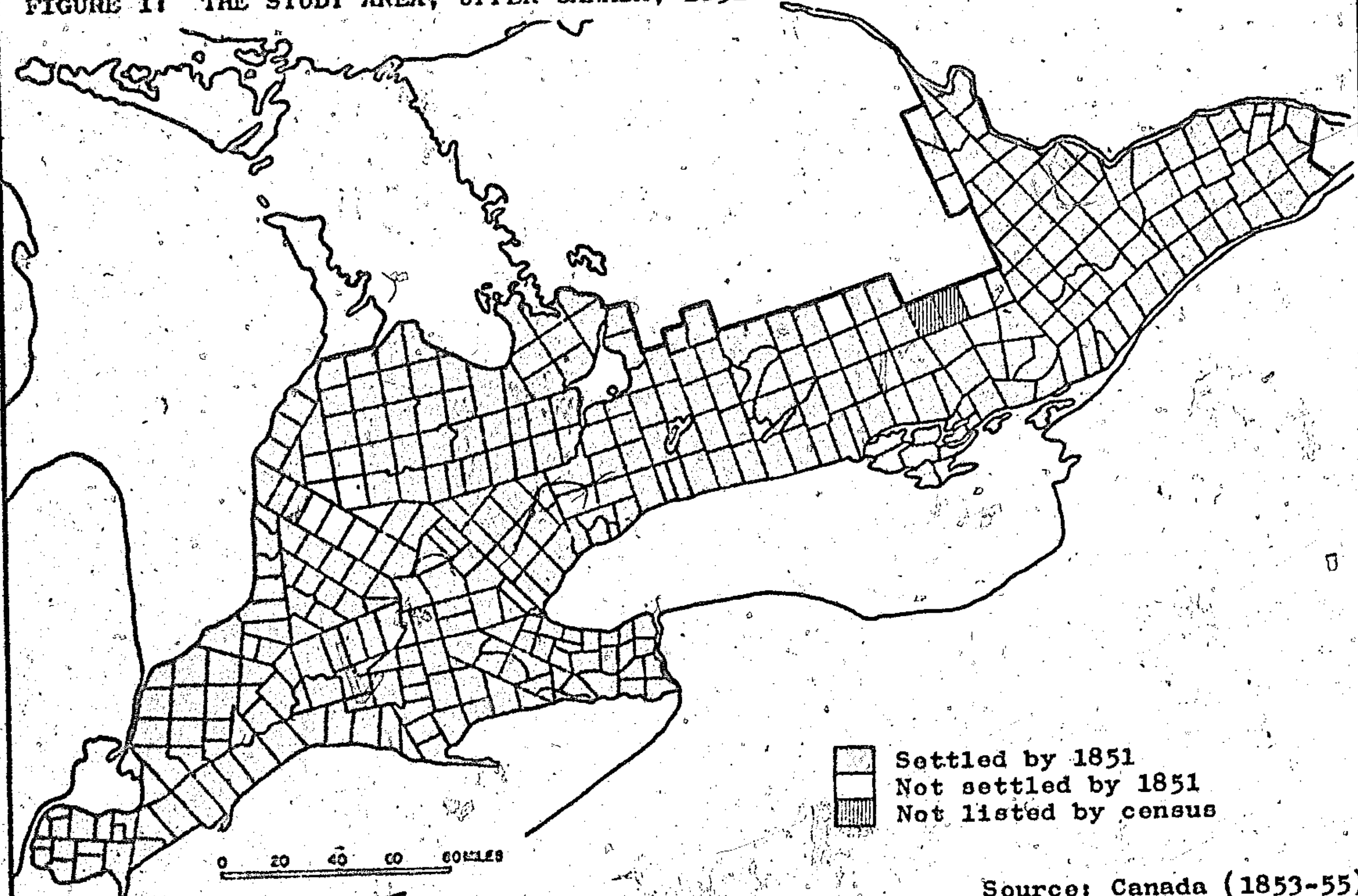
[1]The place names used throughout this study are those which were prevalent during the period, 1782-1851.

FIGURE 1: THE STUDY AREA, UPPER CANADA, 1851



Source: Canada (1853-55)

as a base from which an approximation of the known pattern of 1851 is simulated, the three aims may be achieved. First, the rules of the simulation model and the input data may represent the real world variables responsible for the actual 1851 pattern. Second, intermediate stages of the output may correspond to the actual patterns between 1782 and 1851. Third, changes in the input to the simulation model will produce patterns which may have resulted from alternative conditions.

Whatever the spatial characteristics of a pattern, comprehension is facilitated by the introduction of the concept of process. Because patterns are the product of some process, the two are related. This relationship, however, is not simple: similar patterns may result from different processes, a possibility that is investigated in this research.

It is the purpose of analysis to test the validity of the following hypotheses.

(a) The spatial expansion of agricultural settlement patterns through time is related to distance from immigrant entry points or zones. There are entry points along the Detroit River, at Niagara, at York (Toronto), at Kingston, along the St. Lawrence and, during the latter part of the study period, at several additional locations on the St. Lawrence and on the north shore of Lake Ontario. The importance of these entry points changes through time

(Landon, 1967).

(b) The pattern is related to the spatial distribution of nucleated settlements. Once established, these serve as market centres for the rural population (Kirk, 1949, p.133).

(c) The varying characteristics of the physical environment are reflected in the location of rural settlement (Kirk, 1949, pp.10-39).

B. The Means of Analysis

The problem defined is historical and might be approached by means of an analysis of primary and secondary data and literature. However, the extent of such an investigation would be limited as adequate data are not available for the reconstruction of agricultural settlement patterns for years between 1782 and 1851, particularly for the province as a whole. For studies of specific counties or townships, however, adequate data may be available.

Current trends in historical geography emphasise a variety of new approaches, particularly in the application of statistical procedures for data analysis (Baker, Hamshere and Langton, 1970). Some historians are advocating the study of "hypothetical history". J.D. Gould (1969) suggests that, "it is sometimes possible and convenient, or even necessary, to make counterfactual assumptions as a starting point for argument designed to assess the effect of historical events or processes". Similarly, Prince (1971) develops a threefold classification for historical geographic enquiries, the third of which is the construction of theoretical worlds of the past. The present research is an excursion into this realm of enquiry.. The feasibility of this approach is recognised by P. Gould (1964) who advocates the use of Monte Carlo simulation models to answer questions which appear intractable and to indicate "what might have happened if .....", and by Pred (Hagerstrand, 1967, pp.322-323), who similarly proposes Monte Carlo formulations for the purpose of practising "would have been" historical geography. Thus, historical geographers face a new challenge, that of creating theoretical worlds to assist in the study of both past landscapes and geographical change through time. It is to create such theoretical worlds, and to test the hypotheses listed, that this research develops a model of the settlement process and operationalises the model using Monte Carlo simulation. This procedure of Monte Carlo simulation was initially introduced into geography by Hagerstrand (1967), and has since been used in a wide variety of applications, particularly by Morrill (1965a, 1965b and 1965c).

For this research, the township is the unit of analysis and, since it is a study of agricultural settlement, settlers are defined as occupiers of land greater than ten acres. Non-farming settlements, including smallholdings in the vicinity of urban centres, are not considered. The model employed is probabilistic and is operated by means of simulation. A probabilistic formulation is used because there is an element of chance in each location and hence in the resulting patterns. The actual pattern of 1851 is only one of a variety of possible "realities", given identical environmental conditions. The model is thus formulated so that it can produce a variety of patterns which reflect the role of the chance factor. Simulation, when applied to a probabilistic model, allows the experimenter to study processes in ways nature prohibits. The model may be run several times under differing conditions and thus a variety of alternatives examined. The procedure is suited to the incorporation of the time dimension.

C. Application of the Model

The following analysis is accomplished by means of varying the input to the model.

(a) A number of settlement patterns are produced for 1851 representing the possible consequences of alternative processes.

(b) Using model structures which produce 1851 outputs similar to the actual 1851 pattern, intermediate outputs are produced for years between 1782 and 1851.

(c) Finally, as an example of the counterfactual argument, intermediate and 1851 patterns are produced for models known to be unrealistic in one important respect:

all townships are made available at all times rather than limiting the number which may be settled to those known to be surveyed.

D. The Study Area

The study area is made up of 347 townships of Upper Canada.[1] The period of study is selected to coincide with the era of colonisation and with the availability of data. White settlement is minimal prior to 1782, and 1851 is the first date for which an accurate map of agricultural settlement may be compiled.

The principal numerical data are the aggregate census returns for 1851 (Canada, 1853-55). Data are available for the total population by townships, the number of land occupiers and the number of occupiers by classes of farm size. Data regarding the size of townships are available, as are data regarding the township population totals for the years from 1824 to 1841 and for 1848 (Upper Canada, 1825-40 and Province of Canada, 1841-51). More general historical data are taken from a variety of sources, especially the group of contemporary eighteenth and nineteenth century documents known as the Crown Land Papers

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[1]The 1851 Census of Canada (Canada, 1853-55) is the basis used for delimiting the area, with all of the townships listed being included and only two additional townships introduced. Those two - Kaladar and Kennebec - are surveyed prior to 1851 and are located on Fig. 2, as are several other townships which the census notes as "uninhabited".

(1793-1872). Data are collected for the date of survey of each township from a variety of sources (see Fig. 5).

E. Content of the Thesis

The first two chapters following this introduction discuss the factors influencing the decision to locate. Chapter 2 reviews a variety of migration and settlement studies which propose factors liable to influence the decision to locate. These are not adequate to develop a settlement model and Chapter 3 discusses a second set of factors, the particular institutional controls for Upper Canada. The structure of the model developed on the basis of the findings in Chapters 2 and 3 is presented in Chapter 4. Details of the analysis and results are presented in Chapter 5. In Chapter 6 the simulated settlement patterns for years between 1782 and 1851 are presented and compared to available data and theoretical notions, and instances of feasible alternatives to the actual 1851 pattern are introduced. The principal findings of the research are stated in Chapter 7.

CHAPTER 2

FACTORS INFLUENCING THE SETTLEMENT DECISION

I. A REVIEW OF PERTINENT LITERATURE

This discussion, and that in Chapter 3 relating to regional historical factors, assume that the decision to locate in Upper Canada is already made and the question remains as to where to settle within Upper Canada. The decision to locate is related to a variety of factors suggested by (a) literature relating to settlement, migration and distance and (b) the historical evidence. In this chapter little reference is made to Upper Canada and the factors discussed are those derived from a review of relevant literature. Because individuals and groups may perceive identical stimuli differently and because the pertinent variables are continually changing, any two decisions are unlikely to be based upon precisely the same information. Further, decisions based upon identical information are liable to vary. However, at any point in time, decision making reflects the existence of particular factors which are of overall importance. An awareness of these factors facilitates the development of an appropriate model.

A. Rural Settlement

I. Empirical Considerations

There are available many descriptions of farming landscapes in the geographic literature. Early descriptive studies are provided by nineteenth century French and German geographers (see Stone, 1965) and the emphasis continues to be on landscape features, including house types, rather than on problems of locational choice (Dickinson, 1956). In such studies, when location is considered it is frequently related to the physical environment, particularly to land quality, relief, vegetation and the availability of water. Hence, these works suggest several physical variables which might contribute to constructing a model of the process of settlement.

II. Theoretical Considerations

Theoretical works in rural settlement are limited and the theory is not well advanced. Olsson (1968, p.116) notes that, "the theory of colonisation and spread of rural settlement has not yet been developed to the extent that a set of axioms and theorems can be derived from it".

Bylund (1960) develops deterministic theoretical formulations for rural settlement advance into hitherto unsettled territory. His suggested models are based upon three principal factors; (a) distance from the parent settlement, (b) relative land attractiveness on the basis of soil, climate and minerals, and (c) the out movement of offspring, which he considers least important. Attraction values are assigned on the basis of actual research of the Pite Lappmark area of northern Sweden. Six models are constructed, two of these representing wave settlement and the others more gradual and complex settlement by offspring. The models are simplified descriptions of settlement expansion in the Pite Lappmark area. Visual comparison with maps of actual settlement indicates that the model outputs replicate the essential features of real world settlement. Two variables, then, are suggested; various physical factors and distance from point of origin. In addition, distance from line of communication and the location of church or market are recognised as important. Although emphasis is placed on colonisation by offspring rather than by immigration, these formulations are of value to the present study which is concerned with the effects of mass migrations into an area during a relatively short span of time. The basic variables recognised by Bylund (1960) are similar to those posited for this research. Wood (1966) employs these concepts in a study of the Long Point region of Upper Canada and develops a probabilistic model. Settlement patterns are simulated and three variables shown to be of importance for the location decision; distance from entry point, distance from lines of access - in this instance the access lines are existing Indian trails - and relative ease and cost of land clearing.

An alternative approach to rural settlement theory is presented by Hudson (1969) whose work is deductive and is based upon central place studies in geography and ecological distribution theory. Three stages for the rural settlement of an area are proposed; colonisation, spread and competition. Colonisation is the stage during which settlement enters into a hitherto unoccupied area; spread is the subsequent filling up of the habitat by the offspring of colonisers and their offspring (this is the stage considered in the models developed by Bylund); competition is the final stage when nucleated settlements compete for hinterlands and a central place network results. For each stage there is a corresponding characteristic spatial pattern. For colonisation, the pattern is one of concentric rings; for spread, nebula like with several distinct clusters; and for competition, a regular lattice, as in central place theory. From ecological distribution theory comes the basic concept of a biotop space, the physical space within which settlement is feasible at a given point in time.

A principal determinant of increasing density in many frontier areas is not spread but rather continuing colonisation, or continuing movement to the frontier from outside the area. Thus, colonisation and spread may occur together as they did in Upper Canada during the years, 1782-1851. Hudson furnishes little evidence as to the validity of the ideas regarding colonisation, although some of the ideas regarding competition are tested.

The theoretical discussions of Hudson do not consider particular variables influencing the settlement decision. It is evident that the wave motion proposed for the colonisation stage is related to distance from origin points. Grossman (1971) argues that Hudson has failed to provide any general laws and that the biologically derived principles may not be applicable to patterns of human mobility because of the interference of central planning. He suggests that the process of settlement is largely dependent on cultural factors which vary from place to place, and not on some constant human behaviour. These criticisms are based upon investigations of an African society of Iboland, Nigeria, whose settlement pattern is conditioned by centralised control. With regard to Upper Canada similar controls are, indeed, evident during the phase of colonisation.

Hudson's theory focuses upon the spatial patterns resulting from particular hypothesised processes, rather than upon the underlying variables influencing movement and decision making. Curry (1964) emphasises the need to consider individual behaviour in any study of settlement evolution, but there are no models of rural settlement choice available. Olsson (1968, p.117) concludes that, "the existing theory of settlement diffusion is inconclusive and the specific models which can be derived from it are essentially descriptive".

B. Migration and Distance

Since the decision to settle is linked to the reasons for the original movement the causal factors in settlement overlap those in migration. A variety of theoretical and empirical migration studies are available and propose factors liable to influence the decision to locate. Two are dominant: the economic motive and the role of distance. In the context of the research problem the latter is more important.

I. Laws of Migration

Ravenstein (1885 and 1889) suggests a number of laws, three of which are relevant to this discussion. First, the volume of migration is associated with the distance between the source and the receiving points; the tendency is to migrate as short a distance as possible. Second, the original decision to migrate is influenced by the anticipated economic gain. Third, the volume of migration increases with increasing levels of technology which facilitate the moving process.

Lee (1966) proposes four sets of factors thought to influence migration, including factors associated with the area of origin, largely negative and encouraging out movement, and positive factors associated with the receiving country, basically economic gain; in a nineteenth century rural context a principal attraction is the availability of land. These two sets of factors represent the "push-pull" concept. Third, the volume of migration is decreased where intervening obstacles are most numerous and intense; the most significant intervening obstacle is distance. Finally, personal factors, unique to each individual, influence decision making. Lee suggests that most migrations are begun with only limited knowledge of the destination; the push factors are clear, the pull factors a little more uncertain.

The role of the economic motive is emphasised by Isaac (1947) and both this and the role of distance are noted in several regional examples of migration which isolate specific factors at work for the areas in question. The importance of the antecedent location of relatives and friends is noted by Nelson (1959). Wolpert (1965) discusses the role of behavioural factors, recognising that the decision to migrate is primarily a response to stress in the home environment and emphasising the need to appreciate the significance of subjective environments. In the case of Upper Canada, it is acknowledged that the decision to locate is partly a response to the migrants' perception of the new land.

II. The Economic Motive

As Isaac (1947) notes, most long distance migrations are economically oriented, locating a migrant in a county, state or province; other factors are at work regarding location within the larger area. This point is also noted by Porter (1956). For the purpose of this research the decision to enter Upper Canada is accepted at the outset and it is the location within Upper Canada which is pertinent. It is therefore not critical to analyse either the push or pull factors of the source areas and Upper Canada. On this basis the relevance of the economic motive declines.

Many of the migrations to Upper Canada prior to 1851 are movements of people with little to lose. Descriptions of the conditions of Irish and Scottish peasants illustrate the suffering experienced by many (Woodham-Smith, 1963). Given sufficiently poor home conditions, migration anywhere appears desirable and hence the pull exerted by Upper Canada need only be its availability. Such conditions render the decision to migrate virtually inevitable if the opportunity arises.

III. The Distance Factor

The basic premise that the factor of distance is one of the principal determinants of spatial patterns is widely accepted (Watson, 1955), but merely to recognise that distance is an important factor in the location decision is not adequate. It is necessary, first, to ascertain what form of distance is appropriate and, second, to examine the nature of the relationship between distance and the volume of movement.

1. The several roles of the distance factor. The impact of distance may be in terms of the physical distance, the perceived distance, the cost of travel or the time involved in travel. The several roles of the distance factor are relevant to this study when distance is a basis for some of the hypotheses. Physical distance may not be critical; distance expressed in some other manner may be the operating factor.

Distance in early Upper Canada reflects at least three elements; transport costs, time of travel and effort expended. It is assumed that settlers desire to minimise the all three, each of which may increase with distance. The problem is further complicated because in making a location decision an individual may not actually be moving. The decision may be made in, say, York prior to any move. Further, an individual may be only slightly concerned about the cost, time or effort of the original move; the principal concern may be the distance between the location selected and a market and distributing centre, for the prospective farmer will anticipate frequent trips for the purpose of buying and selling.

Prior to the advent of modern transport facilities it is likely that the cost of travel increases only slightly with increasing distance. The time taken in moving to a new home in Upper Canada is probably directly related to the distance moved. Given the above two assumptions it follows that a critical relationship is that between the effort of the initial movement and distance. It is assumed that the difference between one and two units of effort is greater than that between, say, ten and eleven units. The assumption that the attractiveness of each location is directly related to the effort expended in reaching that location means that the friction of distance increases with increasing distance. With these considerations in mind the relationship between distance from a centre or zone of attraction and the volume of movement is now discussed.

2. The friction of distance. It is assumed that the volume of migration decreases with increasing distance between source and destination. The problem is to specify a relationship between migration and distance which indicates the friction of distance. Empirically derived distance decay functions are not acceptable in this context for they reflect the operation not only of distance, but a multitude of variables; they describe the decrease of movement with increasing distance but do not indicate how much of this decline is due to distance. What is required is a distance decay function for an isotropic surface so that the effects of all other variables are eliminated.

Most empirical functions are of essentially the same form, negative exponential, and one, the pareto formulation, has been given a wide variety of applications (Zipf, 1949).

3. Distance decay functions. "Mathematical distance decay functions are convenient formalisations to reflect real behaviour of perception and response to distance" (Morrill and Kelley, 1970, p.297). A variety of functions are available in the literature and this section reviews the most important of these. A major difficulty arises from the fact that these functions are descriptive and not explanatory; they are able to describe a relationship but not to isolate cause and effect. Essentially this results from the fact that they reflect the effects of a variety of factors, all of which are associated with distance. An empirically derived function can be attained by either an analysis of, say, migration statistics to determine the best fit or use of surrogate data where the necessary information is lacking (Hagerstrand, 1967, p.187). When a simulation model is to be used neither of these procedures are really satisfactory, and ideally, a function ought to be theoretically derived. When a function is empirically derived it is difficult to ascribe any behavioural interpretation (Morrill and Kelley, 1970, p.297).

Morrill (1963 and 1965a) discusses a variety of functions with the intention of fitting these to observed data such that the most appropriate are discovered. It is emphasised that, "it is futile to seek one simple function that will always relate distance to migration since the underlying logical conditions or circumstances of nature constantly vary for different kinds of movement" (Morrill, 1963, p.76). A function and specific parameters which might successfully indicate the friction of distance on migration in the Upper Canada of 1790 might be a poor indicator of movements in the 1840's. With increasing technology, distance friction tends to decrease.

The following discussion of distance decay functions is largely taken from the work of Morrill (1963).

A simple inverse linear relationship of the form,

$m = c - bD$ where, m is volume of migration
c and b are constants
D is distance

is considered to be quite unrealistic. All available studies show that the friction of distance is greater than that accounted for by this relationship.

The following negative exponential relationships are discussed by Morrill (1963) and his terminology is used.

(a) $m = cD^{-b}$ Simple logarithmic, pareto, gravity

(b) $m = ce\text{-}D^2$ or $m = ce^{-\log D^2}$ Gaussian normal or log normal.

(c) $m = ce\text{-}D$ or $m = ce^{-D}$ Exponential function

(d) Various gamma functions

(e) A combined pareto-exponential function (absorption)

Brownlee (1911) criticises the normal function and proposes the exponential form, a distribution which shows extreme kurtosis. Morrill (1963, p.79) notes that there are at least three functions which are leptokurtic as noted by Brownlee; the exponential, the log normal and the pareto. These three are now considered, the pareto being emphasised as it is the most popular.

Morrill (1965a, p.114) uses the pareto form with b values ranging from 2.0 to 0.5; the highest b value representing the greatest friction of distance resulting from a relatively low level of technology. A value of 1.5 is proposed for representation of a pre-railway technology, 1.0 for a railway technology and 0.5 for an automobile technology. The second constant, c, relates numbers to real conditions. All areas less than six kilometres distant are taken as equal to six kilometres because of the tendency of the pareto to over-estimate short distance migrations.

In the Taaffe, Garner and Yeates (1963) model of commuter movement, probability calculation is also based upon a pareto formulation. The exponent, b, is derived from regression analysis and is 1.0. Hagerstrand (1967, p.187) suggests that migration data can be most simply expressed by a pareto equation; b values of between 1.6 and 2.2 are derived using least squares. Hagerstrand emphasises that the equation is purely descriptive and notes the tendency to exaggerate short distance movements.

Brown and Moore (1963) observe that the pareto curve provides the best fit for contacts not involving permanent or costly moves; an exponential is suggested for marriage and migration distances.

Kulldorf (1955) discusses the log normal function in some detail and Morrill (1963, p.81) notes that, "much migration behaviour seems closer to these conditions than those required for normality". The absorption formula suggested by Johnston (Morrill, 1963, p.83) is a combination of exponential and pareto functions. It is able to reduce the values of short distance movements and thus remove a prime obstacle to the adoption of the pareto formulation. The migration of people is seen as a flow emanating from a centre and being gradually absorbed by a medium, the residual population. Like the absorption of a ray of light, it is presumed to be proportional to the flow per unit of length - that is, always of the same percentage.

Cavalli-Sforza (1962, pp.132-158), Stewart (1947) and Zipf (1949) relate movement to distance and the populations of the origin and receiving points. These particular formulations are inappropriate as they relate attractiveness to population and distance, not simply to distance.

4. Summary. The need for a clear appreciation of the distance factor is evident. Unfortunately, results are contradictory. A consideration of the particular frontier situation at hand suggests that distance in terms of cost,

time and effort is related to the attractiveness of townships. Effort, the most relevant aspect of distance, may display a simple curvilinear relationship, and thus a pareto formulation may be appropriate. Such a relationship cannot produce an attractiveness value of zero and there is no limit to the distance which may be travelled. Very large indices of attractiveness may arise for the shortest distance and if there are distances of zero then the problem of division by zero arises.

Use of this simple formula does not conform to the observed evidence which advocates a form of negative exponential with a steeper slope for the shortest distances; that is, with higher attractiveness values for the shortest distances. However, it is not difficult to reconcile the two. The additional attractiveness afforded to the nearer townships by several other functions is a result of the operation of factors other than distance; in other words, to the existence of a non isotropic surface; hence, the comments in the literature to the effect that such relationships are descriptive rather than explanatory. A majority of settlers are attracted to those townships which are best served by roads and are generally most developed, namely the earliest settled locations. The suggestion here is that these are factors other than distance.

C. Conclusions

The available literature suggests and verifies the importance of a number of variables including the distance from a point of origin, accessibility, attractiveness of land for agriculture, personal factors and the role played by a central authority. Chapter 3 examines these variables in the context of Upper Canada, 1782-1851, and, especially, considers the critical role which particular land policies and other institutional controls may have in the decision to locate.

CHAPTER 3

FACTORS INFLUENCING THE SETTLEMENT DECISION

2. HISTORICAL CONSIDERATIONS

The purpose of this chapter is to recognise major factors in the settlement process and to describe known patterns for Upper Canada. In addition, information is provided which may facilitate the explanation of differences between simulated and actual patterns of settlement. Several of the factors proposed as being relevant to the decision to locate are confirmed and a number of other factors, peculiar to Upper Canada, suggested. The chapter is in five sections: a brief narrative of settlement and land policy, a note on the variety of factors which operated to influence location choice, a discussion of the process of obtaining a land grant in Upper Canada, a consideration of the attractiveness of townships in Upper Canada in terms of the likelihood of new arrivals being aware of some townships or areas and not others and, finally, a concluding statement. The intimate association of the settlement process with the land policies of the government is emphasised. The historical data sources consulted are presented in Appendix 1.

A. Land Policy and Settlement

I. Pre-1791

Prior to 1763, Upper Canada was a part of the French colonial empire which reached from Quebec, along the Great Lakes, to the mouth of the Mississippi. Initial penetration into Upper Canada was accomplished by French explorers, missionaries and fur traders. Military posts were established at strategic positions along trade routes; at Kingston[1] in 1673, Niagara in 1678, along the Detroit River in 1701 and at York in 1748. Agricultural settlers located close to the fort on the right bank of the Detroit River; the first permanent settlement in Upper Canada began during the 1740's when settlers located on the left bank in the vicinity of a Jesuit mission. Only limited and ephemeral agricultural occupation was associated with the remaining forts.

The early French penetration was significant to the subsequent settlement of Upper Canada as three of the four fort locations became foci for the first settlers under British rule. The territory later known as Upper Canada was transferred to British rule in 1763 and the first settlers arrived as a result of the 1776 Declaration of Independence by the United States, the subsequent war and the British recognition of independence in 1783.

Migration of United Empire Loyalists began in 1776

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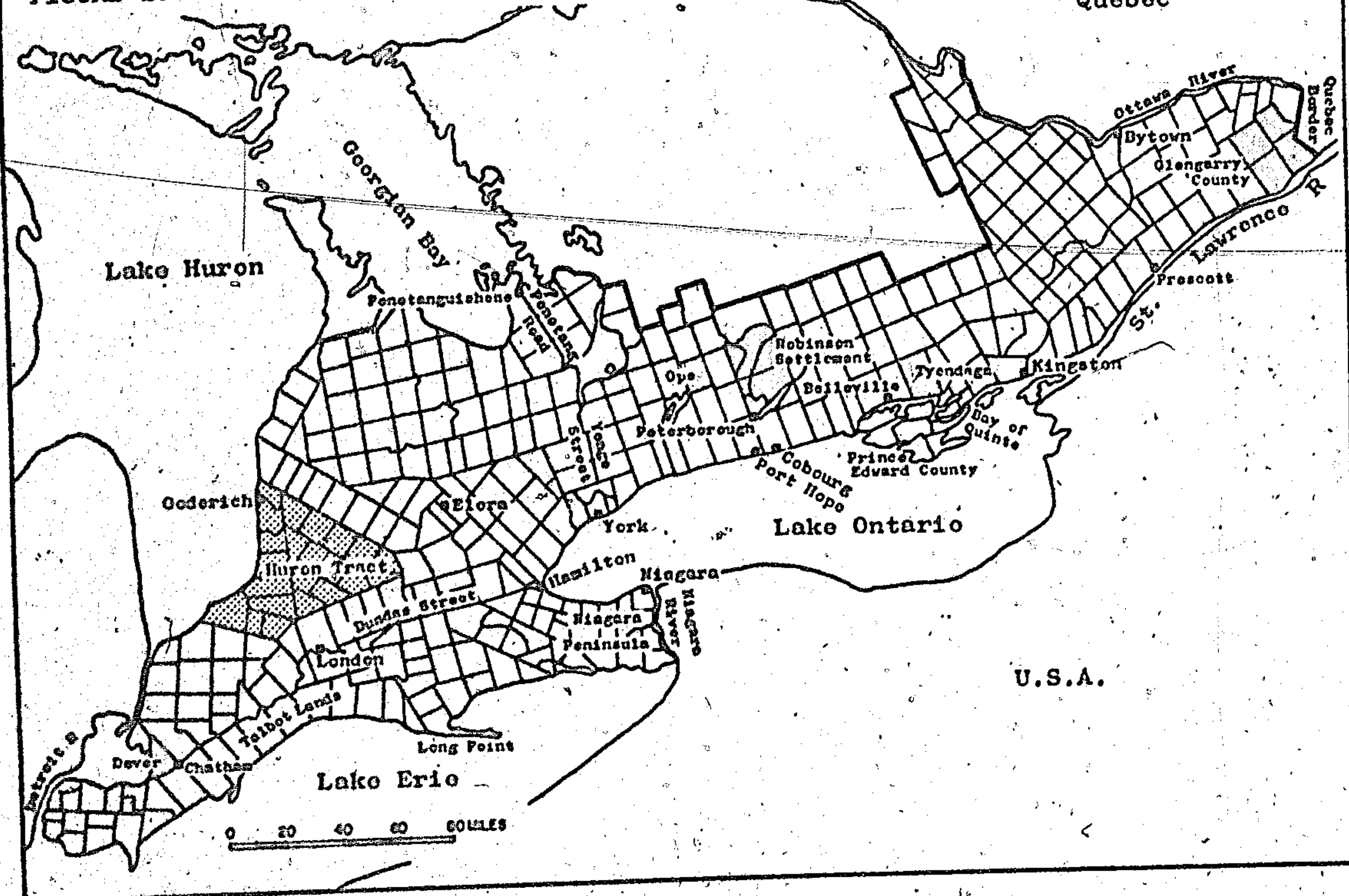
[1]For place names referred to, see Fig.2.

FIGURE 2: UPPER CANADA, PLACE NAMES



and was a small and steady movement until 1783 (Patterson, 1921, p.1). Land was authorised for the earliest Loyalists in Upper Canada at both the Niagara and Detroit River areas in 1780 (Gates, 1968, p.11). The selection of these two areas was related to the presence of Loyalists in their vicinity and to the fact that both had been the location of previous French settlements.

Land surveying to accommodate the settlers began in 1780 with Kingston, where many Loyalists had gathered, as the centre of operations and, in three years, townships and lots were laid out along the St. Lawrence west of Montreal and along the Bay of Quinte (Patterson, 1921, p.21). Settlement of the surveyed townships began in 1783 (Patterson, 1921, p.22). By 1785 there were 1800 families in the Kingston area, 300 families at Niagara and a small group on the Detroit River (Cowan, 1961, p.10). The first known group migration into the study area from Britain was in 1785 when a number of Scottish settlers arrived to join clansmen in Glengarry County; a second migration of this type occurred in 1803-04 (Cowan, 1961, p.11).

The pre-1791 immigrants consisted predominantly of Loyalists. Their migration was part of a move to British soil in common with Loyalist movements to the Maritimes, Britain and the West Indies (Cruikshank, 1900). Some Loyalists were based in Upper Canada during the Revolutionary War as members of Loyalist regiments and tended to remain after 1783; others moved from New York, Pennsylvania and other states while still more came by sea to the St. Lawrence. Non-Loyalists were attracted by the availability of free land and supplies and posed as Loyalists to obtain these aids to settlement. Upper Canada was at this time north and west of the American settlement frontier so that most of these migrations were aimed specifically at Upper Canada.

Two hundred acres was established as the most common grant size, although instructions in 1783 provided for grants of up to 1000 acres according to military rank (Patterson, 1921, p.22). Heads of families who settled and improved their original allotments were entitled to an extra two hundred acres. Provisions were also made for grants to Loyalist children and a register of Loyalists begun.

By 1791 the settlement pattern had cores at Kingston, Niagara and Detroit, with the majority of settlers east and west of Kingston along the St. Lawrence and the Bay of Quinte. Each of the three centres had previously been a military and trading post, all were on navigable water, close to the United States border and served as convenient entry points.

II. 1791-1815

In 1791 Upper and Lower Canada, the future provinces of Ontario and Quebec, were established with separate administrations, an action that acknowledged the Loyalist and English-speaking character of Upper Canada. Hitherto Loyalist lands had been granted in fief and siegneury but after the organisation of Upper Canada in 1792, land was granted in free and common socage, as petitioned for on several occasions by dissatisfied Loyalists. Land granted prior to 1792 could be transferred by request. The new basis of Upper Canada land policy was established in 1792 by the first Lieutenant-Governor, John Graves Simcoe.

Surveyors were to delimit townships ten miles square inland and nine by twelve miles along navigable water. The size of individual lots was set at two hundred acres, although provisions were made for the granting of much larger areas. Petitioners were expected to settle and begin cultivation, conditions difficult to enforce in a pioneer society. Land was granted ~~free except for a fee payment~~ and even this was waived for military personnel and Loyalists.

Provisions were made for the establishment of reserve lands for the support of the Crown and Protestant clergy. One seventh of each township was set aside for the Crown and one seventh for the clergy. These lands were selected according to the "chequered plan" which attempted a regular distribution of reserved lots within each township.

Simcoe was enthusiastic at the prospect of increasing settlement and evolved a plan for urban centres and routes which achieved some success, notably in the establishment of York and the building of Yonge Street, (Gentilcore, 1972a, p. 24). Immigration of suitable settlers from the United States was encouraged as there was little prospect of any substantial movement from Britain because of wars in Europe.

Few changes in the prevailing trends of immigration and settlement were evident before 1812 when the outbreak of war curtailed American immigration. Settlement proceeded steadily in the interval, with continuing American immigration and most of the townships west of the Bay of Quinte along Lake Ontario receiving settlers. Available lots along the two principal roads, Yonge and Dundas Streets, both constructed during the 1790's, were also settled (Craig, 1966, p.43-47). By 1812 it is estimated that non-Loyalists outnumbered Loyalists by four to one (Craig, 1966, p.47). The 1812 population is estimated at 75,000, with the largest centres at York and Kingston (Craig, 1966, p.51).

III. 1815-1827

Following the cessation of hostilities in 1814, the entire character of immigration into Upper Canada changed. A strong current of anti-American opinion brought on laws, at first to stop the American immigration, but later only to make it more difficult. This decrease in American immigration coincided with the beginnings of significant migration from Britain. Many of these settlers from Britain were associated with organised attempts at settlement, some government-assisted and others private (Gentilcore, 1972a, p.30). Free passage was offered by the British Government and a number of companies were initiated in Britain to assist emigration. During the ten years, 1815-24, some 7000 settlers, out of an approximate total of 65,000, were settled with government help (Schott, 1936, pp.142-143.)

A report of the granted and ungranted lands is available for Upper Canada in 1824 (C.O., 42, Vol. 377, pp. 218-220). The total quantity of surveyed land, excluding reserves, totalled 9,319,569 acres and it was noted that, overall, the quality of the land was good. The ungranted but surveyed land comprised 1,319,569 acres and was reported as good, although a little further from navigable water and roads.

During the mid 1820's a number of policy changes affected the means by which land was transferred from the Crown to the individual settler. In 1824 the Crown reserves were purchased by the Canada Company which then made these lands available for sale. By 1837, one third of the Crown reserves were sold (Gates, 1968, p.169). In 1826 a system of land sales was introduced for available ungranted land. This change in policy had little effect, however, on the progress of settlement. All vacant lands were evaluated annually and minimum prices established. Auctions were held for the sale of land to the highest bidder, although if the highest bid did not exceed the minimum price stated the land remained vacant. A credit system was the method of payment.

IV. 1827-1851

Table 1 summarises the immigration from Britain to the North American colonies, including Upper Canada, and to the United States. Precise details for the numbers entering Upper Canada are not available. However, it has been

TABLE 1

EMIGRATION FROM THE BRITISH ISLES, 1819-51

Year	To North American colonies	To the U.S.A.
1815	680	1209
1816	3370	9022
1817	9979	10280
1818	15136	12429
1819	23534	10274
1820	17921	6745
1821	12995	4958
1822	16018	4137
1823	11355	5032
1824	8774	5152
1825	8741	5551
1826	12818	7063
1827	12648	14526
1828	12084	12817
1829	13307	15678
1830	30574	24887
1831	58067	23418
1832	66339	32872
1833	28808	29109
1834	40060	33074
1835	15573	26720
1836	34226	37774
1837	29884	36770
1838	4577	14332
1839	12658	33536
1840	32293	40642
1841	38164	45017
1842	54123	63852
1843	23518	28335
1844	22924	43660
1845	31803	58538
1846	43439	82239
1847	109680	142154
1848	31065	188233
1849	41367	219450
1850	32961	223078
1851	42605	267357

Source: (Cowan, 1961, Appendix B, p.288) estimated that 4000 disembarked at Cobourg in 1831 (Patterson, 1921, p.151) and that in 1833, 7000 landed at York, 7000 at the "head of the lake" (mainly Hamilton), 3500 at Cobourg and 3500 at Port Hope (Patterson, 1921, p.165). If a total of 21,000 did arrive in 1833, then this represents 75 per cent of the total arriving in the North American colonies in 1833 (Table 1). Further, this 21,000 is the number arriving at Quebec (Table 2). The vast majority of arrivals are from Britain (Table 2).

Formation of the Canada Company in 1824 followed the example set by the United States of using land companies to open new areas. The company purchased the crown reserves and one million acres called the Huron Tract (see Fig.2) which was unsurveyed and unsettled at the time of purchase. By 1830 the Huron Tract was an attractive area for settlers with a minimum of capital (Johnston, 1962). These townships were the new frontier in Upper Canada; land to the south was being settled, and that to the north not yet opened. Total land sales in this area up to 1839 are shown in Table 3; settlement is oriented towards selected townships rather than being dispersed throughout the tract.

The distribution of townships having ungranted land during the year, 1829-34, is indicated by Fig. 3; the quantity of ungranted land is not specified. The data source used is incomplete but the map does suggest that a significant number of townships had no land available at

TABLE 2

ARRIVALS AT QUEBEC, 1829-51

Year	From England	From Ireland	From Scotland	From Europe	From Maritimes	Total
1829	3565	9614	2643	-	123	15945
1830	6799	18300	2450	-	451	28000
1831	10343	34133	5354	-	424	50254
1832	17481	28204	5500	15	546	51746
1833	5198	12013	4196	-	345	21752
1834	6799	19206	4591	-	339	30935
1835	3067	7108	2177	-	225	12527
1836	12188	12590	2224	485	235	27722
1837	5580	14538	1509	-	274	21901
1838	990	1456	547	-	273	3266
1839	1586	5113	485	-	255	7439
1840	4567	16291	1144	-	232	22234
1841	5970	18317	3559	-	240	28086
1842	12191	25532	6095	-	556	44374
1843	6499	9728	5006	-	494	21727
1844	7698	9993	2234	-	217	20142
1845	8833	14208	2174	-	160	25375
1846	9163	21049	1645	896	-	32753
1847	31505	54310	3747	-	-	89652
1848	6034	16582	3086	1395	842	27939
1849	8980	23126	4984	436	968	38494
1850	9887	17976	2879	849	701	32292
1851	9677	22381	7042	870	1106	41076

Source: (Cowan, 1961, Appendix B, p.289)

TABLE 3

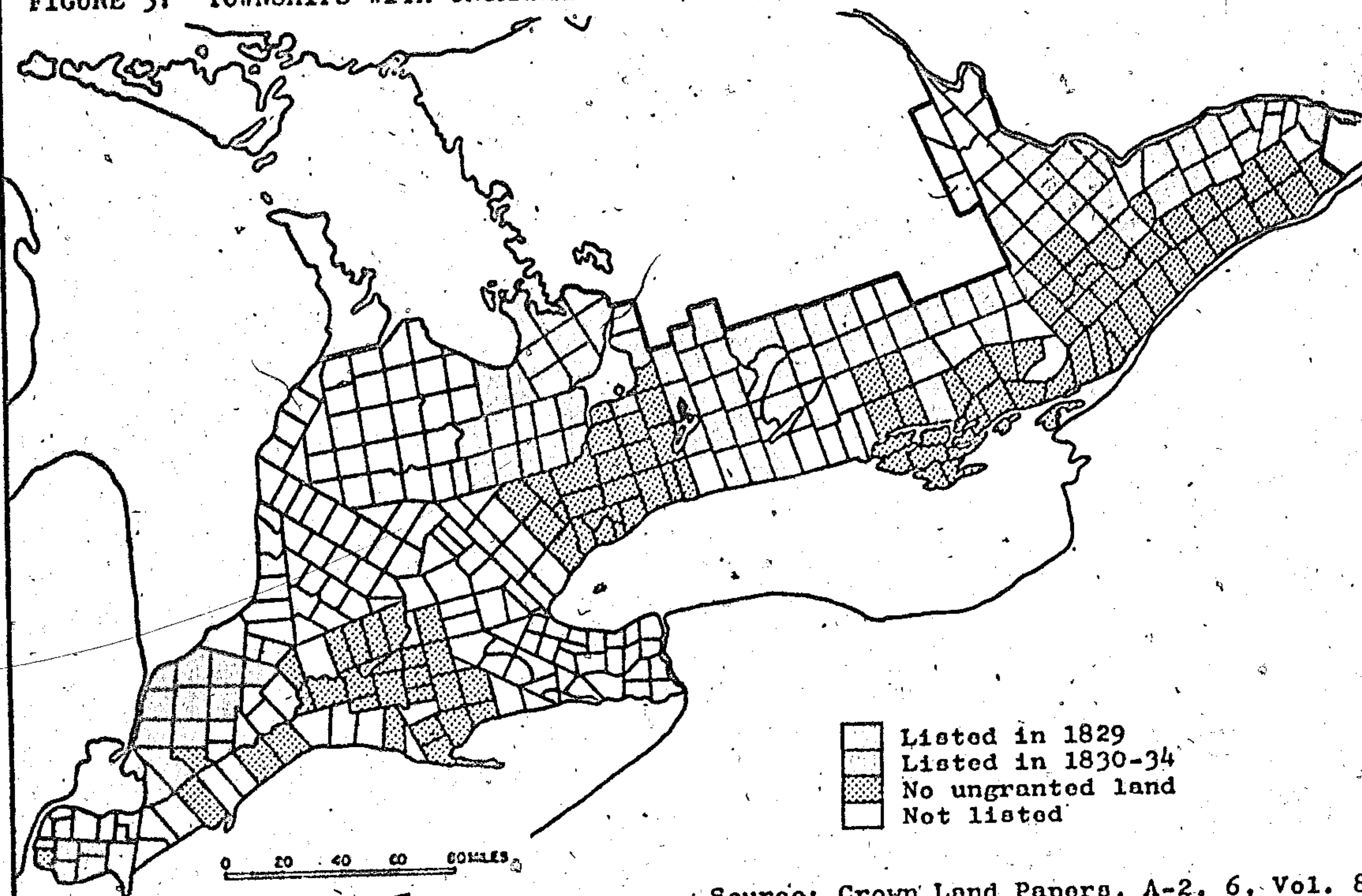
LAND SALES IN THE HURON TRACT UP TO 1839

Townships	Number of lots	Remarks
Williams (E)	171	Mostly 100a lots
Williams (W)	16	"
Goderich	471	Mostly 80a lots
Stanley	70	Mostly 100a lots
McKillop	65	"
Logan	11	"
Ellice	42	"
Easthope, N.	60	"
Easthope, S.	101	"
Downie	70	"
Downie Gore	29	"
Fullarton	23	"
Hibbert	14	"
Tuckersmith (Huron Rd.)	105	"
Tuckersmith (London Rd.)	55	"
Hay	31	"
McGillivray	89	"
Colborne (W)	112	"
Colborne (E)	97	" (33 to 1 person)
Bosanquet	29	" (22 to 1 person)
Biddulph	100	"
Usborne	31	"
Stephen	29	"
Hullett	46	"
Blanshard	88	"

N.B. In Goderich, 48 lots sold of approximately 15a

Source: Canada Company Papers

FIGURE 3: TOWNSHIPS WITH UNGRANTED LAND, 1829-34



Source: Crown Land Papers, A-2, 6, Vol. 8

this time. The majority of northern townships are recorded as having available land. For 1838, Fig. 4 shows the percentage of granted land, rather than occupied land, by township, and the majority of townships have most of their land granted. A comparison with Fig. 5 indicates that the majority of townships surveyed by 1840 are included on Fig. 4; the principal exceptions are in the vicinity of London.

Hansen (1940) notes that the popularity of Upper Canada in North America was waning by 1835, that the frontier had passed and left the area essentially unsettled, and it had little prospect of receiving numbers compared to those moving to the American West. However, Upper Canada continued to receive many settlers and the period through until 1851 is one of sustained immigration and settlement (Tables 2 and 4). Richards (1958) notes that by the 1840's most of the desirable land in southern Ontario was alienated from the Crown; Fig. 4 confirms this observation.

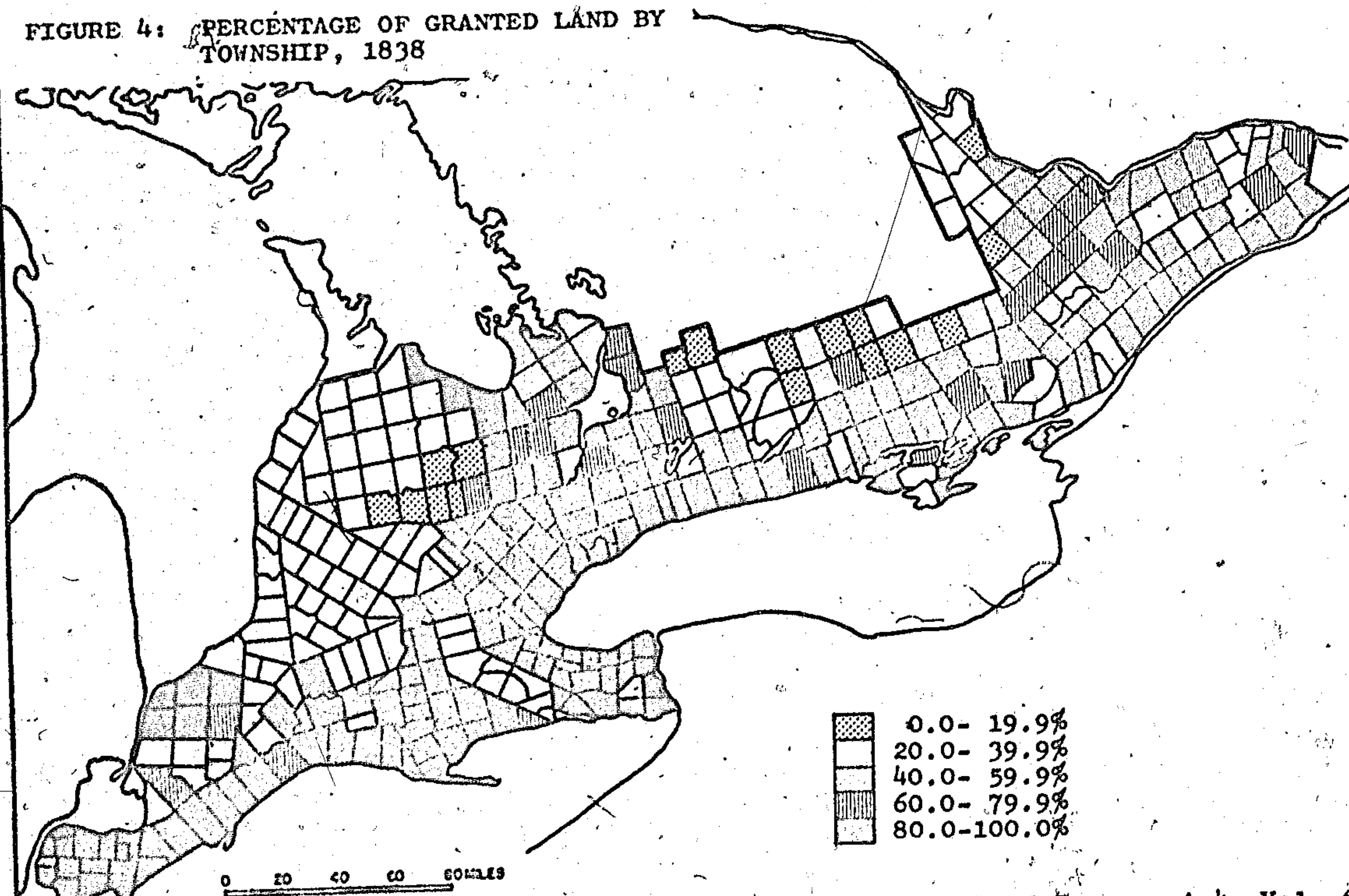
B. Restrictions on Location

During the years 1782 to 1851 the 347 townships of the study area were not all available for legal settlement at any one time. Once in Upper Canada, settlers were restricted in their choice of location, as a result of several factors; namely, township survey, speculating, and the policy of reserving lands.

I. Township Surveys

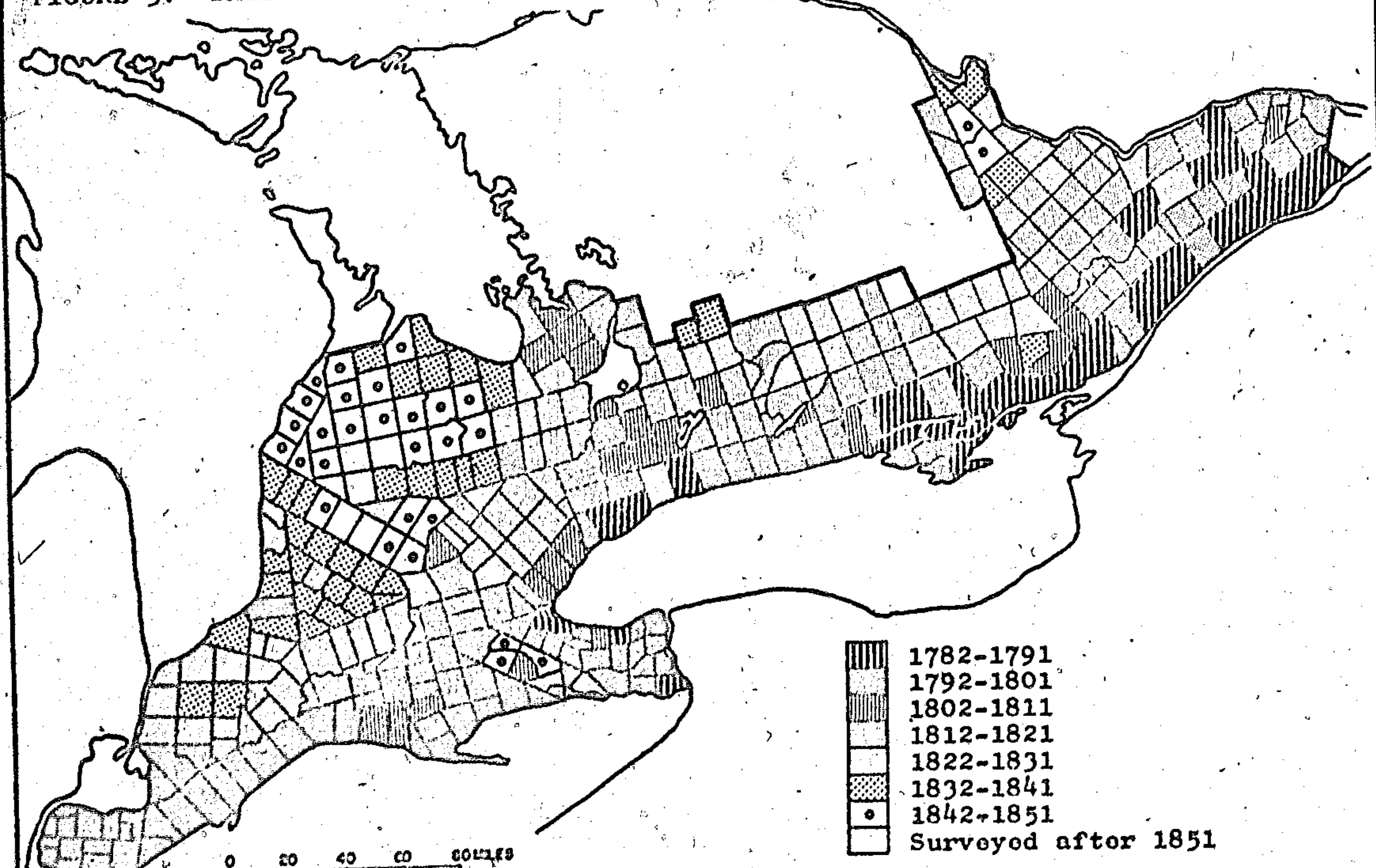
Fig. 5 indicates the earliest known date of survey for each township. The date is for the beginning of survey,

FIGURE 4: PERCENTAGE OF GRANTED LAND BY TOWNSHIP, 1838



Source: Crown Land Papers, A-4, Vol. 6

FIGURE 5: DATES OF TOWNSHIP SURVEY



Sources: Dean (1969) and Original Survey Notes

TABLE 4

DISTRIBUTION OF EMIGRANTS IN UPPER CANADA, 1833-44

Area	1833	1834	1835	1842	1843	1844
Ottawa, Bathurst, and Eastern District to Kingston.	1200	1000	2000	4250	4075	2238
Newcastle District and Bay of Quinte.	2750	2650	900	-	1539	4181
Toronto and Home District.	4600	8000	2500	-	7500	8009
Hamilton, Guelph, and Western Districts and Huron Tract.	2900	2660	1300	-	-	1829
Niagara frontier, Welland Canal, etc.	1500	3300	1300	-	2000	520
London District, north side of Lakes Erie and St. Clair	3000	4600	1800	-	1800	1289

Source: (Cowan, 1961, Appendix B, p.294; C.O., 42, Vol. 258).

not the subdivision of the entire township into concessions and lots[1]. However, the map does serve to indicate the progress of surveying and the relative dates of survey.

The townships first surveyed for the Loyalists were concentrated along the St. Lawrence - Kingston - Bay of Quinte axis. The rate of surveying increased substantially during the 1790's; townships were opened in the east between the St. Lawrence and Ottawa Rivers, along Lake Ontario towards York and on the Niagara-Detroit axis, including many townships away from the lakeshore (Fig. 5). Relatively few townships were surveyed during the first decade of the nineteenth century, possibly reflecting the restrictions imposed on surveying by Lieutenant Governor Peter Hunter during the 1799-1805 period (Gates, 1968, pp.67-68). These restrictions were an attempt to strengthen the province by increasing settlement density. The few townships surveyed were generally adjacent to already surveyed areas. By 1820 a steady development was taking place between York and Penetanguishene, along Yonge Street and Penetanguishene Road, and to the north east of Kingston (Fig.5). Surveying continued in the eastern and central areas during the 1820's but there was only scattered surveying in the relatively isolated western area. Substantial progress is evident in the west during the 1830's with the opening of the Huron Tract townships and the

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[1]Usually the front concessions were the first surveyed.

surveying of several townships on the Georgian Bay shore. Finally, the pattern of mid-century includes the late opening of a block of townships in the north west, including the Queen's Bush townships.

Initially, only a few townships, or parts of townships, were available for settlement. During the period of early Loyalist settlement the areas to be settled were predetermined by British authorities. Both the Niagara and Detroit River surveys were a response to the fact that settlers were already located at these sites, both being fort locations and both serving as entry points from the United States. Kingston was the centre of the first surveys and was also a fort location and an entry point. Because most of the Loyalists desired the free land and free supplies offered by Britain in Upper Canada it is logical that they should respond to the surveys and settle accordingly (Bradley, 1932). Location outside the surveyed areas might be both illogical and illegal. In 1784 it is estimated that over 90 percent of the settlers were drawing free rations (Craig, 1966, p.8). The settlement pattern of 1791 is largely explained by the availability of surveyed land.

Once the promise of free land and free supplies ceased to apply - free supplies before 1792 and free land in that year - it becomes difficult to determine whether the availability of surveyed land was a major factor in the location decision. An alternative to settling on surveyed land was squatting which we know occurred as early as 1794 and remained an issue throughout the first half of the nineteenth century (Patterson, 1921, p.50). It is difficult to estimate the numbers of squatters; in 1830 the problem is referred to in Dover, Tyendaga and Elora townships, the number of squatters noted and recommendations made that squatters be allowed to purchase land (Crown Lands Papers, A-1,7, Box 19). Usually squatters were given the option of purchase.

II. Speculation

A second policy which served to limit the available locations was that of bestowing large grants to middlemen and to favoured individuals, resulting in the problem of land alienation without concomitant settlement. By 1806, 4,500,000 acres in Upper Canada had been alienated, an average of 7,100 acres per individual (Macdonald, 1939).

Hopes of settling parts of Upper Canada with the aid of companies and settlement leaders were expressed by Simcoe and, in 1792-93, 32 townships were granted to settlement leaders (Gates, 1968, p.30); the "Home Government seems to have assumed that it was chiefly by associated companies that crown lands would be settled" (Patterson, 1921, p.42). Unfortunately most of the grantees were speculators with no intention, it appears, of settling either themselves or others. These monopolies did not last long for most of the grants had been rescinded by 1797. It is likely, therefore, that these grants did not restrict settlement to any great extent.

The bestowing of rewards, in the form of land, to military and civil officials was a policy pursued by successive Lieutenant Governors. Particularly prevalent in the vicinity of York, many of these lands were held for years before being made available for genuine settlement. This point is well presented by Johnson (1971) in a study of the Home District, which centred on York. Between 1795 and 1799, 55 per cent of the patented land was obtained by individuals receiving in excess of 5000 acres (Johnson, 1971, p.45). The early granting of large areas favoured speculation.

The imposition of settlement duties in 1788 was a largely unsuccessful attempt to reduce speculation (Schott, 1936, p.104). These duties were reformulated in 1818 and for the first time their enforcement taken seriously (Gates, 1968, p.128). Each settler was to erect a dwelling and clear each year five of every 100 acres occupied; Loyalists, military and officials were included.

The paucity of data relating to speculation precludes definite conclusions. Certainly, speculation appeared to be widespread, particularly in the vicinity of larger urban centres. However, it is probable that the effects of speculation on settlement were minimal since such land was in fact often occupied by squatters (Gates, 1968, p.288).

III. <u>Reserve Lands</u>

Reserve lands provide another instance of tracts of land within the surveyed area possibly withheld from settlement. In 1792 provisions were made for the establishment of reserve land to be held by the Crown and the Protestant clergy. Both the crown and clergy received one seventh of each township, to be distributed within the township according to the chequered plan of 1793 (Craig, 1966, p.32). Leasing of these reserves was introduced in 1803, with little success at first; by 1811, only 359 crown and 421 clergy reserve lots had been leased (Crown Land Papers, A-2,6, Vol.1). Few settlers desired to become lessees, apparently, when there was an opportunity to become an outright landowner. In 1819 the clergy reserves were placed under the supervision of a clergy reserve corporation and, in 1824, the unsettled crown reserves were purchased by the Canada Company. The sale of the crown reserves removed these lands from public criticism. Between 1811 and 1818, only 158 clergy reserves were leased, and many of these were never occupied after the timber was removed (Wilson, 1969, p.9). Under the clergy reserves corporation, the lands were no better handled than they had been by the Executive Council. By 1825 it had been decided that the clergy reserves should be sold, and a limited sales policy was introduced in 1827.

Sales of reserve lands for the period 1829-51 are listed in Table 5. Sales increased notably from 1839 onwards although clergy reserve sales were temporarily reduced during the years 1842-44. Fig. 6 shows the

TABLE 5

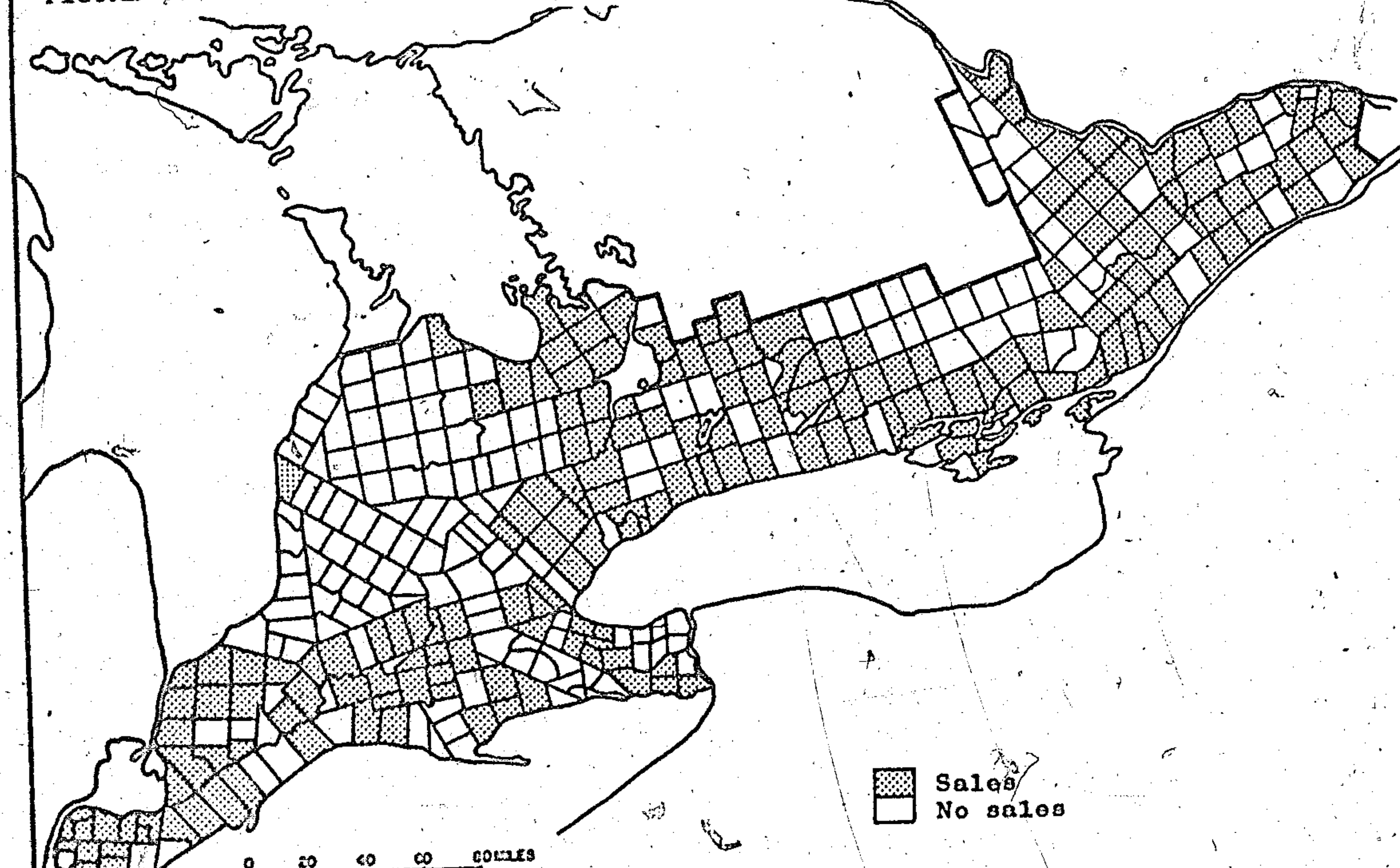
SALES OF RESERVES, UPPER CANADA, 1829-51, ACRES

Year	Crown	Clergy
1829	3883	18014
1830	6135	24705
1831	4365	28563
1832	10352	48484
1833	26417	62282
1834	8891	59326
1835	22707	59003
1836	7923	63440
1837	7003	81549
1838	3556	21475
1839	12110	24949
1840	26342	23586
1841	14701	2665
1842*	19780	1486
1843*	42501	613
1844*	40510	569
1845	32256	40602
1846	67879	179271
1847	25933	196568
1848	6583	81373
1849	14265	70726
1850	36636	93245
1851	81949	91706

*Includes sales in Lower Canada

Source: (Gates, 1968, Appendix, p.309)

FIGURE 6: CROWN RESERVE SALES, 1830-41



Source: Crown Land Papers, A-2, 6, Vol. 17

distribution by townships of crown reserve sales for the years 1830-41; the pattern is a scattered one.

During the first half of the nineteenth century the policy of reserving lands for both crown and clergy was subject to appreciable criticism (see, Wilson, 1968, pp.59-61), on both political and economic grounds. An intensive study of the clergy reserves by Wilson (1968) has, however, indicated that their effect on settlement was slight. Reserved lots were frequently settled by squatters (Gates, 1968, p.288).

Because the regulations of 1792 resulted in all new townships having two sevenths of their acreage reserved, the overall spatial consequences for settlement were limited. These lands were available for leasing, were squatted upon, and later offered for sale and were, therefore, not a major obstacle to settlement.

A third type of reserve land was introduced in 1798 with ten townships and parts of two others being held to provide financial support for schools; Table 6 details the townships concerned and the acres reserved. In several of these townships all or part of the land was granted and not actually reserved, and seven additional townships were substituted. Sales of these reserves did not begin until the 1820's, so that they were withheld from settlement for twenty years; Table 7 indicates dates of sales for some of the townships.

TABLE 6

SCHOOL LANDS, UPPER CANADA

Township	Acres originally reserved	Acres alienated	Acres disposable	Alienated lands disposed of
Alfred	25140	25140	-	Granted to individuals
Plantagenet	40000	40000	-	Granted to individuals
Bedford	61220	5388	53684	2681a to individuals
Hinchinbrooke	51100	51100	-	48663a to Crown
Sheffield	56688	3158	53350	-
Seymour	47484	47484	-	25000a to U.C.C. 18969a to Crown
Blandford	20400	6179	14221	5000a to U.C.C.
Houghton	19000	3192	15893	1597a to individuals
Middleton	3500	24267	10733	22600a to individuals
Southwold	40500	31619	8881	30900a to individuals
Westminster	51143	41943	9200	40723a to individuals
Yarmouth	20000	8110	11900	7084a to individuals
Java*	12000	12000	-	12000a to U.C.C.
Luther*	66000	66000	-	Reinvested in Crown
Sunnidale*	38000	38000	-	Reinvested in Crown
Osprey*	50000	50000	-	Reinvested in Crown
Merlin*	40000	28312	11688	28312a to Crown
Proton*	66000	-	66000	-
Warwick*	600	-	600	Reserved

*indicates townships substituted in lieu of lands granted to individuals in Alfred, Plantagenet, Bedford, Houghton, Middleton, Southwold, Westminster, Yarmouth.
U.C.C. is Upper Canada College.

Source: C.O., 42, Vol. 460

TABLE 7

SCHOOL LAND SALES, UPPER CANADA

Township	Date
Bedford	1828-37
Sheffield	1825-39
Blandford	1830-40
Houghton	1819-37
Middleton	1828-40
Southwold	1819-38
Yarmouth	1819-40
Westminster	1824-40
Seymour	1824-30

Source: (Crown Lands Papers, B-3, Vol. 25)

In summary, a number of circumstances have been noted, all of which limited locational choice to some extent. Basically, all of these contributed to the existence of areas of empty land. Within the surveyed area, empty lands resulted from the policy of bestowing large grants to Loyalists, military and officials and the policy of reserving lands. For the purpose of this research the progress of surveying is the most important factor with the remaining practices merely serving to decrease township population densities, rather than restricting settlement altogether. It is possible that parts of Upper Canada were settled by squatters, individuals who ignored all regulations and perhaps countered many of the worst features of the land policies.

C. <u>Obtaining a Land Grant</u>

Throughout the period prior to the introduction of land sales in 1826, the actual process of obtaining a grant appears not to have influenced the location choice.

Upper Canada was divided into four districts in 1788, each with a land board appointed to receive and report upon applications for land; previously all land was allotted by the Surveyor General. The following procedure was to be adopted by the applicant (Patterson, 1921, pp. 24-25).

(a) The applicant sent a petition to the land board, addressed to the Governor in Council, asking for a grant of land in a specific township.

(b) The board examined the petition and gave the settler the required oath of allegiance.

(c) The board sent a certificate to the deputy surveyor stating the facts of application.

(d) The deputy surveyor assigned a specific lot and made available a location ticket or certificate. This ticket was invalid if the petitioner did not occupy the land within one year.

(c) Title deeds were not to be handed over until after settlement duties were completed.

In 1792 seven land boards were set up as part of the re-organisation of Upper Canada to supercede the old district boards with the Lieutenant Governor in Council receiving petitions for certain townships on Lakes Ontario and Erie. As previously, all petitions for land were to be for specific lots. In 1794 it was decided that prospective settlers should deal directly with permanent government officials and the land boards of 1792 were abolished (Patterson, 1921, p.51). Magistrates received petitions and made recommendations to the deputy surveyors. This land granting power of the magistrates was suspended in 1796, all granting becoming the responsibility of the Lieutenant Governor in Council (Patterson, 1921, p.58).

Procedures for land granting stabilised somewhat by 1797. Each petition for land was referred to a Committee of the Executive Council who made a recommendation to the Lieutenant Governor. A warrant of survey was made out by the Clerk of Council and presented to the Surveyor General who then assigned a specific lot, from among those available, to conform as best as possible with the wishes of the applicant. A patent was prepared and sent to the applicant.

A requirement was introduced in 1804 that all future applicants for land should present themselves in person at York (Schott, 1936, pp.142-143). This could have been a critical factor in the development of Upper Canada. If, indeed, all settlers were required to go to York then this centre would have assumed paramount importance as an entry point; in fact, it could have been the sole entry point for settlers dealing with government land authorities. There is, however, no indication that this requirement was enforced.

There are at least two factors which served to hinder settlement. First, the free land grants in Upper Canada were subject to payment of fees which were at times sufficiently high to discourage settlement.[1] Fee payments contradicted the principle of free land grants and proved a source of difficulty to many immigrants. Second, many settlers had to wait so long for title to land that they either squatted or departed for the United States (Bradley, 1908, p.245).

Introduction of a system of land sales in 1826 changed the procedure by which immigrants obtained lands. Each year the Commissioner of Crown Lands submitted a report to the Executive Council detailing the lands to be offered for sale the following year and the minimum or upset price for these (Crown Lands Papers, A-1,7, Box 11; and, C-1,2, Vol. 8). These reports, however, are not available. It is not known whether factors other than surveying influenced the reports of the Commissioner. All land so offered was to be made available for public inspection before the auction. Land was auctioned in a number of centres; in 1833 they were Bytown, Belleville, Peterborough, York, Hamilton, London and Chatham (Crown Lands Papers, C-3,1, Vol. 5). Sales were held on the first and third Tuesday of

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[1] In 1819, fees were £8 for 200 acres; 1820, £16; 1823, £30 (Cowan, 1961, p.58).

each month. This system of sales possibly penalised the poor who were obliged to delay settlement while waiting for an auction.

Within Upper Canada there were several areas which experienced rather different conditions with respect to the mechanics of obtaining land; these included the Talbot lands, the Huron Tract and the Robinson settlement. Colonel Thomas Talbot controlled a large area in the south west after originally receiving a military grant of 5000 acres in 1803 and these lands were immune from the majority of government regulations. The opening in 1829 of the Huron Tract represented another area not controlled by the government.

In summary, the procedure of obtaining a land grant in Upper Canada varied according to the time of application and the particular area requested. Although certainly a complex procedure before 1826, there is no indication that the selection of land was influenced by authorities. After 1826 the only crown lands offered for sale were those detailed by the Commissioner of Crown Lands. Generally, throughout the period, 1782-1851, it was possible for prospective settlers to negotiate for land at a number of centres throughout the province.

D. Awareness of Townships

It is recognised that any one immigrant might not have been equally aware of all the available townships; further, that different immigrants might not have evaluated any one township similarly. Although it is not feasible to reconstruct the perceived environment of each individual it should be noted that all townships were not similarly perceived. A principal factor operating to encourage awareness of particular townships was the availability of letters and accounts in the home country, and of land advertisements in Upper Canada.

On the basis of a study concerning Scottish migration to Upper Canada during the first half of the nineteenth century, Cameron (1971) suggests that a principal link between settlers in Upper Canada and prospective settlers in the originating country was the emigration letter. Such letters prompted migration and, furthermore, suggested specific parts of Upper Canada as suitable areas, understandably the area from which the letter was despatched. Many letters were published in newspapers and the majority of these presented a favourable opinion of Upper Canada. Financial assistance might have been forthcoming and this also prompted migration to the area from which the money was received. With reference to Wellington County, Cameron (1971, p.178) shows that there was a general tendency for Scottish settlers to group together. It appears that the overall effect of emigration letters was to encourage further settlement in already settled areas and to produce a degree of ethnic grouping. This is an important conclusion.

Emigration letters were essentially a personal affair with any one letter influencing very few people, but emigration guide books represented a second source of information for the prospective settler that was more widely available. One example of such a work is that by Catermole (1831) initially delivered as lectures in England to prospective settlers. The chief aim of this work, according to the author, was to correct the wrong impressions that the British people had of Upper Canada (Catermole, 1831, p. iii). The advantages of Canada above other alternative areas for immigration are emphasised; advantages of climate, soil and agriculture are noted. Within Upper Canada the area west of York is suggested as the most suitable area for settlement. Descriptions of all the major nucleated settlements are given and the Huron Tract was especially favoured for advantages of location and purchase. A list of the Canada Company agents in Britain is given - two in England, four in Scotland and four in Ireland. A comparison of New York State and Upper Canada is made and Upper Canada judged better in all respects; in prices received for agricultural produce, health factors, land prices, and increasing value of land. Two routes to Upper Canada are noted; the St. Lawrence and the New York route. Regardless of the route taken, York is suggested as the port of arrival in the province.

The effect of emigration letters and guide books was apparently to encourage continued settlement in already established areas. Similarly, works such as that by Howison (1821) recommend already settled areas. Howison complains that immigrants to Upper Canada have no real means of obtaining information regarding places to settle and opportunities to work and he attempts to rectify this situation. Howison is strongly in favour of settlement in the south west and claims that the Niagara - Detroit axis was the most valuable part of Upper Canada. The Talbot settlement is reported as being especially well suited to poor people and to be attracting many Britons.

The lands of the Canada Company in the Huron Tract were especially well advertised. Johnston (1962) records that, after 1829, the Company distributed pamphlets throughout Britain in addition to having agents in towns. The Company was also prepared to give free transportation to the Tract from Quebec City if the settler made a down payment on land; this was largely intended to limit movement to the United States.

In addition to the above, two other factors operated to increase some immigrants' awareness of particular townships. First, a number of group settlement schemes were attempted between 1815 and 1825. For most of the members of such schemes settlement in the chosen area was the most logical course. Second, from the 1820's onwards, immigration agents were set up in several towns, including Quebec City, Montreal and receiving towns along the St. Lawrence and Lake Ontario.

These agents were to advise settlers as to employment and land holding opportunities (Crown Lands Papers, A-1,4, Vol. 2). Such agents were involved in the deliberate settlement of Ops Township during the administration of Lieutenant Governor John Colborne (1828-36).

In summary, those areas within Upper Canada which were most clearly seen as possible settlement sites by incoming migrants were those adjacent to entry points (already established by the Crown), those where friends or relatives were located and those especially well advertised.

E. <u>Conclusions</u>

The material presented in this chapter indicates that the making of a settlement decision in Upper Canada was a response not only to some variables which were of universal importance but to a variety of conditions peculiar to the local environment. Of particular importance for this research is the recognition that the first settled areas after 1782 were those already established during the French penetration. It is also shown that not all townships were available at all times as a result primarily of the rate or lack of surveying. Other factors, namely, speculation and the chequered plan, appear to have been relatively unimportant as regards influencing location decisions. The settlement model which is formulated includes variables based upon the discussion in Chapter 2 and is also framed with reference to the particular characteristics of Upper Canada.

CHAPTER 4

THE SIMULATION MODEL: LOGIC, FUNCTIONS AND STRUCTURE

The process of settlement involves a large number of individual events, each involving the making of a decision. Since it is not feasible to study every event, a model is used which attempts to incorporate the most important factors influencing the making of decisions. The anticipated result is a settlement pattern which approximates the actual but which is incapable of allowing for variations attributable to particular local conditions. Thus the best output anticipated from the simulation is itself a generalisation. It is not possible or desirable to exactly replicate a real world pattern. To do so would require either a most unlikely chance occurence or inclusion of all the variables in the correct fashion. The reason for model building is the desire to learn more about the variables via testing of the model; it is the initial ignorance of the settlement process that renders model building of value. The simulation model employed considers only the most important variables. Hagerstrand (1967, pp.132-133) notes: "The digging up of as many causal factors as possible is not an economic allocation of research resources. On the contrary it is desirable to isolate a few crucial factors which go a long way towards substantially explaining the phenomenon in question". The multitude of local and minor variables help to explain discrepancies between simulated and real patterns.

A. The Purpose and Means of Enquiry

The concern is with the genesis and development of a spatial distribution. Because the distribution reflects human decisions, behavioural factors are considered. Olsson (1969) emphasises the need to establish links between individual behaviour and spatial patterns and, further, to distinguish between the spatial and behavioural approaches to location theory. The two approaches are, (a) making inferences about human behaviour on the basis of known spatial patterns, (b) deriving spatial patterns on the basis of assumptions regarding behaviour. Olsson (1969, p.22) emphasises that the fundamental process and pattern problem can be approached from either a spatial or behavioural viewpoint. Traditionally, the former viewpoint is taken, as by Hudson (1969) and by Bylund (1960). In this study the latter course is followed.

The evolving 1851 pattern of rural settlement in Upper Canada is assumed to be a consequence of a probabilistic process. Real world development does not follow deterministic lines because of the inevitable effects of a variety of chance factors. A chance element is introduced into the model by means of a Monte Carlo procedure which uses random numbers in the selection of a settlement location. The simulation procedure may be regarded as a "regulated accident" (Olsson, 1969, p.24). Use of aggregate data in this simulation analysis is necessary because it is difficult to discuss individual behaviour. Justification for the use of aggregate data is not difficult. The magnitude of the problem precludes consideration of each individual decision. Harvey (1969) notes that, "when we are concerned with the aggregate effects of countless individual decisions it would be senseless to attempt a behavioural analysis of each individual decision and then aggregate these into a model that copes with the total process".

The building of a simulation model requires a series of rules. Where do these rules come from? Because of a lack of appropriate laws and theories recourse may be made to hypothesis testing by means of a probabilistic simulation model. Without pertinent laws or theories these hypotheses are derived from material presented in the two previous chapters, that is, deductively, from available similar studies and previous knowledge of the problem. If found to be acceptable these hypotheses may form the basis for inductive theory development.

B. Functions of Simulation Models

Models make use of an alternative system and have the great virtue of simplicity. Analysis of this relatively simple system provides insight into the operation of the more complex. Simulation bypasses complexities and is a legitimate approach to the modelling of dynamic spatial systems. Marble (1969) regards such a model as, "an explanatory model of the time path development of a series of spatial distributions".

"One of the most significant advantages of simulation is that it permits the experimenter to study processes in ways nature prohibits" (Guetzkow, 1962). A simulation model can be run many times with many different values. Conway, Johnson and Maxwell (1959) note that simulation is used for the comparison of alternatives. A further advantage is the ease with which the time dimension is incorporated. Also the method is appropriate for sensitivity analysis. The procedure may be as follows; "By varying the value of a parameter or input variable in successive runs one can measure the difference in outcome associated with a given change. If the response is weak this may indicate that the parameter is superfluous. Extreme sensitivity indicates a need for great care" (Lowry, 1965, p.24). Olsson (1969, p.24) notes the importance of such analysis rather than emphasising the more obvious spatial patterns and relations to the known pattern.

Malm, Olsson and Wärneryd (1966) consider that the derivation of a correct distance function is the most important step in the formation of a spatial simulation model; this problem is discussed in Chapter 2. If the parameters are calculated best fit values then the model is econometric. If, however, the parameters are fitted independently then heuristic methods, rules of thumb, are used. Lowry (1965, p.18) regards the latter as the typical method and suggests four approaches; trial and error, use of empirical analogues, assigning a plausible value and altering the output as desired.

C. The Location Process

All individuals who chose a location in Upper Canada had to decide on one location from a choice of many. At the township scale there was, ideally, a choice of 347 locations. Assumptions regarding the manner in which the decision was made are critical to the operation of the model.

It is assumed that the attractiveness of townships for settlement is a function of several variables and of the available lots in the townships, and that individuals are most likely to locate in the most attractive townships. Specifically, it is assumed that the decision making process of each individual settler is such that there is a direct relationship between the attractiveness value of the township and the probability that a settler chooses a location in that township. Further, the location process is stochastic. "Many ingredients of individual human behaviour are causally so complex that their aggregate spatial expression is usually randomly determined within certain constraints (stochastically determined), even though the reasons behind the behaviour are not randomly motivated" (Hagerstrand, 1967, p.307). It is necessary, then, to propose variables and to formulate a model of the location process such that township attractiveness and, thus, the probability of each township receiving a settler may be calculated. Because the analysis is at the township scale, all locations within a township are treated as identical.

It is assumed that township attractiveness is a function of four variables as follows:

$A_i = A_i(I_i, S_i, Q_i, V_i)$ where, A_i is the attractiveness of the i^{th} township

I_i is the index of availability for the i^{th} township

S_i is the distance between the i^{th} township and the nearest entry point

Q_i is a measure of the land quality of the i^{th} township

V_i is a measure of the potential of the i^{th} township

I. The Index of Availability

The number of available locations varies according to the size of the township and the number of settlers in the township. It is assumed that each township has a maximum density of one settler per 100 acres. Empirical justification for such a capacity is obtained from the 1851 census (Canada, 1853-55) which indicates very few townships in Upper Canada with more than one settler per 100 acres. In the operation of the model the number of available 100 acre locations is calculated at the beginning of each time period:

$I_i = T_i - O_i$ where, T_i is the number of 100 acre locations in the i^{th} township

O_i is the number of occupied 100 acre locations in the i^{th} township

Initially, in 1782, the value of O_i is zero for all townships. When a township attains the maximum density of one settler per 100 acres, the value of O_i is equal to that of T_i and the index of availability equals zero.

II. Entry Points

The quantity of movement to townships is assumed to be related to distance from the nearest entry point. The nearer a township is to an entry point, the greater is the quantity of movement. The following are proposed as entry points to be incorporated in the model structure; the Detroit River, Niagara, York, Kingston and the Quebec border.

After approximately 1821 other entry points were important, including all of the ports along the Saint Lawrence and Lake Ontario shore, such as Prescott, Port Hope, Cobourg and Hamilton. The precise nature of the relationship between quantity of movement and distance is not known but is assumed to correspond to a pareto function (see pp.22-23).

III. Land Quality

The suitability of land for agriculture varies throughout Upper Canada and it is assumed that the townships with the highest land quality are the first settled. Within townships the land is regarded as being of uniform quality. Contemporary data relating to nineteenth century land quality are not available. The records of surveyors are of limited value for this purpose as they are not systematic, largely qualitative and are influenced by the particular surveyor. A present day source (Canada Land Inventory, 1970), which recognises eight classes of land suitable for agriculture, is used as a convenient and necessary surrogate to calculate a land quality value for each township.

The eight classes are assigned values ranging from eight for the best land to one for the poorest land. For each township the percentage in each class is multiplied by the corresponding values and the eight products are summed. The highest value possible is 800 with all high quality land, the lowest value possible is 100 with all low quality land, and the mean value is 450 with equal shares of the eight classes. Thus:

$$?_i = \sum_{j=1}^{8} (C_{ij} . D_j)$$

where, j refers to class

C_{ij} is the percentage of land in the i^{th} township and in the j^{th} class

D_j is the value of the j^{th} class

IV. Township Potential

Township potential is related to the availability of market centres in terms of the distances between townships and centres and the size of centres. Potential is a concept which indicates the likelihood of interaction (Carrothers, 1956). For the i^{th} township the potential influence, or possiblity of interaction, generated by the k^{th} centre is greater as k is larger and is less as the distance between i and k increases. Rather than relate potential to the nearest centre, which can be misleading if several centres are at similar distances, a potential value is calculated for each township on the basis of the three nearest centres. The relationship is as follows:

$$= \sum_{k=1}^{3} (S_{ik}^{-w} . P_k)$$

where, V_i is the potential of the i^{th} township on the basis of the three nearest centres

k refers to centres

S_{ik} is the distance between the i^{th} township and k^{th} centre

P_k is the population of the k^{th} centre

w is a constant

There are three measures of this variable, for the years 1821, 1831 and 1841. Prior to 1821 the few market centres which did exist were also entry points. Table 8 lists the urban centres and their populations for these three dates and indicates the several sources of this information. No attempt is made to measure distance along roads as information relating to the availability of roads is limited.

V. Township Attractiveness and Probability Calculation

Given one variable, it is assumed that the most attractive townships according to the one variable are the most likely to receive settlers. Given more than one variable, it is necessary to calculate an attractiveness value corresponding to all of the variables. The

TABLE 8

URBAN CENTRES IN UPPER CANADA, 1821, 1831 AND 1841

Centre	Population 1821	Population 1831	Population 1841
St. Thomas		600	800
Woodstock			1085
Simcoe			1400
Thorold			1000
Chippewa		400	1000
Paris			1000
Newmarket		200	600
Preston		700	600
Goderich		400[1]	387[4]
Amherstburg	400	800[1]	985
Chatham			1500
St. Catherines		700	3500
Guelph		800[3]	1240
Dundas			1700
York	1685[4]	3969[4]	14249[4]
Hamilton		1400	3413[4]
Bytown		200	7000
London			2078[4]
Brantford		200	2000
Galt		200	1000
Kingston	2849[4]	3820[4]	6292[4]
Port Hope		1000	1200
Prescott	150[2]	1600	2000
Belleville	150[1]	1800	2040
Brockville	450[2]	1200	2111
Cobourg		1300	3347
Peterborough		1000	2006
Napanee			500
Perth		800+	1800
Oshawa			1000
Picton			1079[4]
Cornwall	200[2]	1000	1407[4]
Bowmanville			500
Smiths Falls			700
Fitzroy			500
Niagara-on-the Lake	1140[4]	1230[4]	2291[4]
Trenton		600	800
Dunnville		400	600
Oakville		300	500
Sandwich		500	700

TABLE 8 (cont.)

Centre	Population 1821	Population 1831	Population 1841
Queenston	300[2]	500	700

There are 9 centres in 1821, 28 in 1831 and 41 in 1841.

Sources:

Unless otherwise noted, all statistics for 1831 are from Rolfe (1836); 1841 statistics from Smith (1851).

1. Fowler (1832).
2. Talbot (1824).
3. Emigrants letters (1833).
4. Upper Canada (1828-40) and Province of Canada (1841-51).

following assumptions are made.

(a) As the number of available lots in a township declines the attractiveness declines, so that with no lots remaining the attractiveness is zero.

(b) As the distance to the nearest entry point increases the attractiveness decreases, so that with infinite distance the attractiveness is zero.

(c) As the value of the land quality approaches zero, the attractiveness approaches zero.

(d) As the potential approaches zero, the attractiveness approaches zero.

Thus, a general form for the calculation of attractiveness values is as follows:

$A_i = h.I_i^{\,a}.S_i^{\,b}.Q_i^{\,c}.V_i^{\,d}$ where, h,a,b,c and d are constants

The constant, h, is assumed to be equal to one as the attraction is scaled in the same manner for all townships regardless of the value of h. A second simplification involves assigning a value to the constant, w, which is contained in the expression for V_i. On the basis of existing potential formulae (Carrothers, 1956) the value of w is taken as equal to two.

Because it is necessary to express the final attractiveness as a probability, the value of A_i is divided by the sum of all values:

$$P_i = A_i / \sum_{i=1}^{m} A_i$$

where, P_i is the probability of the i^{th} township receiving a settler
m is the number of townships available for settlement

The purpose of the analysis, then, is to test the model formulated and to estimate values of the four parameters, a,b,c and d.

D. The Operation of the Model

I. Division into Generations

The need to subdivide the time period, 1782-1851, is apparent. Since conditions in Upper Canada changed over time, the variables in the model require modification while settlers are being located. Further, one of the aims of the study is to produce intermediate outputs representing possible settlement patterns for years between 1782 and 1851. Subdivision may be achieved by at least two means: by having periods in which equal numbers of settlers are located, or by specifying fixed time periods. Both pose essentially the same difficulty: migration or settlement data are not available to permit exact divisions. However, sufficient information is available to permit useful approximations of settler numbers (Table 9). In

TABLE 9

SETTLERS TO BE LOCATED

Generation	Number of Ten Acre Occupiers at End of Generation	To be Located		Total Population (End of Generation)	Urban Population (End of Generation)	Rural Population (End of Generation)
1782-91	2625	2625		25000[1]	1000[2]	24000
1792-1801	5250	2625		50000[2]	2000[2]	48000
1802-11	8695	3445		82500[3]	3000[3]	79500
1812-21	13234	4539		126000[4]	5000[4]	121000
1822-31	21321	8087		203962[4]	9019[4]	194193[4]
1832-41	44754	23433	11716 11717	440395[4]	31198[4]	409197[4]
1842-51	90160[5]	45406	9081 9081 9081 9081 9082	952004[5]	127651[5]	824353[5]

Sources:

1. Patterson (1921, p.32)
2. Estimates
3. Craig (1966, p.51)
4. Upper Canada (1828-40) and Province of Canada (1841-51)
5. Canada (1853-55)

order to obtain the required outputs it is decided to subdivide into seven periods of ten years each. Thus, outputs are obtained from the model for the years 1791, 1801, 1811, 1821, 1831, 1841 and 1851. Because this involves the location of approximately one quarter of the total settlers during the period, 1832-1841, and approximately one half of the total during the period, 1842-1851, these final two generations are further subdivided. The period, 1832-1841, is divided into two periods each of five years duration, and the period, 1842-1851, is divided into five periods each of two years duration. This means that the variable input to the model may be changed at ten year intervals until 1831, and then at five year intervals until 1841 and then at two year intervals until 1851. This additional subdivision of the period 1832-51, when the majority of settlers are located, is necessary because the calculation of values of the lot availability variable is related to the members already located in each township.

In order to accomplish the desired subdivision into generations, it is necessary to establish the number of settlers for each of the seven ten year periods so that the total is equal to the known total of 90,160 for 1851 (Canada, 1853-55). The two periods between 1832 and 1841 are assumed to have equal numbers of settlers as are the five periods between 1842 and 1851. Estimations for the seven ten year periods are made as follows. For each of the years, 1791, 1801, 1811, 1821, 1831, 1841 and 1851, three sets of data are obtained, total, urban and rural population.[1] Total population poses no problem after 1824; various non systematic sources are used prior to this. Urban population is relatively easy to obtain after 1824, with little information before this date; urban estimates are not as reliable as estimates of the total population since many centres were not recorded until becoming incorporated places. Rural population is estimated by means of subtracting the urban from the total population (Table 9).

The number of land occupiers is some percentage of the total rural population. Assuming little change in average family size this percentage will not change appreciably, although it might tend to be higher in the early years of settlement prior to the establishment of many rural services. Again, it is assumed that the number of occupiers with greater than ten acres does not change sugnificantly relative to the total occupiers. In 1851 the 90,160 occupiers with greater than ten acres of land represented 9.14 per cent of the rural population. Thus, to calculate the number to be located in each generation this same percentage of the rural population is calculated. The results of such calculations are included in Table 9.

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[1]See Table 9 for data and sources.

II. The Assignment of Settlers

The destination of each settler is determined by means of Monte Carlo simulation. Settlement probabilities for each township are calculated on the basis of the specified variables, so that each township is ascribed a single probability which reflects the variables employed. The probabilities for each township are cumulated and corresponding numbers assigned. As many random numbers as there are settlers are called and location in the appropriate township occurs.

III. Details and Operating Rules

1. The model operates through the time period, 1782-1851, and locates 90,160 settlers in 347 townships of Upper Canada.

2. The area is subdivided into townships. All analysis is conducted at this township scale and, in principle, each settler has a choice of 347 locations.

3. The 90,160 settlers are the number recorded in the 1851 census as being occupiers of land greater than ten acres. Settlers recorded as landowners with less than ten acres are not included because such plots are regarded as smallholdings, not necesarily indicating agricultural settlement. This contention is supported by an appraisal of the census data which indicate that such plots are especially prevalent in the vicinity of large urban centres.

4. Whether a settler originates from within or

without Upper Canada is not critical to the operation of the model, although it is evident that individuals with local experience are better equipped to make a decision.

5. Once located a settler cannot move; this is a logical simplification. It is true that many of the early settlers in particular may have moved quite often, but marked township depopulation did not occur before 1851.

6. During each generation the variables do not change.

7. After each generation the variables are changed according to predetermined decisions; new variables may be introduced and existing variables changed or removed.

E. Testing the Outcomes of the Model

The basic comparison required is that between each simulated pattern for 1851 and the real pattern for that date. When a simulated pattern resembles the real one, the stage outputs may be examined. The simplest means of comparison available is visual appraisal of the patterns; however, such comparisons are quite subjective and alternative methods are preferable. There are considerable references to this problem in the literature and these comments are reviewed prior to stating the tests to be used in this study.

The testing of spatial simulation models represents a problem well recognised by several authors (Colenutt, 1969, p.110; Gould, 1969; Morrill, 1965a, pp.171-174; Pitts, 1963, p.117). The majority of these authors discuss the relative merits of goodness of fit tests such as the chi square and Kolmogorov-Smirnov tests, quadrat analysis in general, measures of nearest neighbour, the contiguity ratio and visual analysis. Colenutt (1971) also discusses the use of spectral analysis and spatial autocorrelation functions. Cliff (1966) provides an example of the use of the contiguity test and Harvey (1966) reports the use of quadrat analysis. Morrill (1965c) concludes in favour of visual analysis when evaluating his ghetto model.

The choice of an appropriate statistical test clearly depends upon the purposes of evaluation. In this instance the aim is to compare patterns with one another. Such a comparison assumes determing the degree of correspondence between two surfaces and discovering those areas where discrepancies are particularly high. Given this object, some form of correlation analysis appears appropriate. Pitts (1963, p.117) quotes Cohen as suggesting the use of regression analysis, with the simulated pattern as a function of the real one and then observing the a and b values. In this analysis there seems to be no justification for regressing one surface against another as a cause and effect relationship is not postulated. Available non parametric tests of covariation, discussed by Siegel (1956), are the Spearman rank r and the Kendall rank r. The corresponding parametric test is the Pearson product moment coefficient

(King, 1969). It is decided to estimate the covariation between the data sets by calculating a correlation coefficient, r. The r value may reach 1.0, indicating a perfect relationship, with lower values of r showing that there are areas of discrepancy. The use of r is discussed in Chapter 5.

F. The Computer Program

A single program is utilised for the purpose of township selection, probability calculation, settlement simulation and statistical testing. Use of such a program facilitates experimentation with the model. Input consists of data for date of survey, which are used for determining the availability of townships. Data on township size are used to calculate maximum numbers for each township and the remaining input consists of data used for probability calculation.

The procedure of probability calculation and settlement simulation is accomplished for each generation. Output may be obtained at the end of each generation. Finally, the program provides the results of statistical comparison between the 1851 simulated and actual patterns. Appendix 2 lists the stages necessary to operate the model.

CHAPTER 5

THE ANALYSIS

A. Introduction

A settlement model is formulated and used to calculate attractiveness values for each township on the basis of four variables; the availability of lots, land quality, township potential and distance to entry points. These values are transformed and interpreted as probabilities of each township receiving a settler. Given four variables, various exponent values, twelve generations and various alternatives for township selection, it is possible to produce many simulated patterns. To limit the number of feasible runs, several simplifying assumptions are made.

I. Assumptions

(a) It is assumed that the data for township survey reflect the availability of townships such that, for example, townships not available until 1818 are not available for settlement until the fourth generation, 1812-1821.

(b) It is assumed that the variables are appropriate the following time periods:

Variable	Time Period
lot availability	1782-1851
entry points	1782-1821
land quality	1782-1851
potential	1822-1851

Entry points are not incorporated into the model after 1821. Their number increases appreciably so that, by 1821, there is, effectively, one entry zone along the Lake Ontario and Saint Lawrence shores. Further, much of the initial advantage afforded by land adjacent to entry points is nullified by the expansion of surveyed land and the high settlement densities in their vicinity. Township potential, which is dependent upon the number and location of urban centres, is not incorporated into the model structure until 1822. The majority of pre-1822 urban centres are the entry points and these are considered in that variable.

(c) The model locates one tenth of the total number of settlers, 9,016 rather than 90,160, and the number in each township is multiplied by ten at the end of each generation. This procedure serves to reduce the necessary computing time and does not radically alter the final pattern.

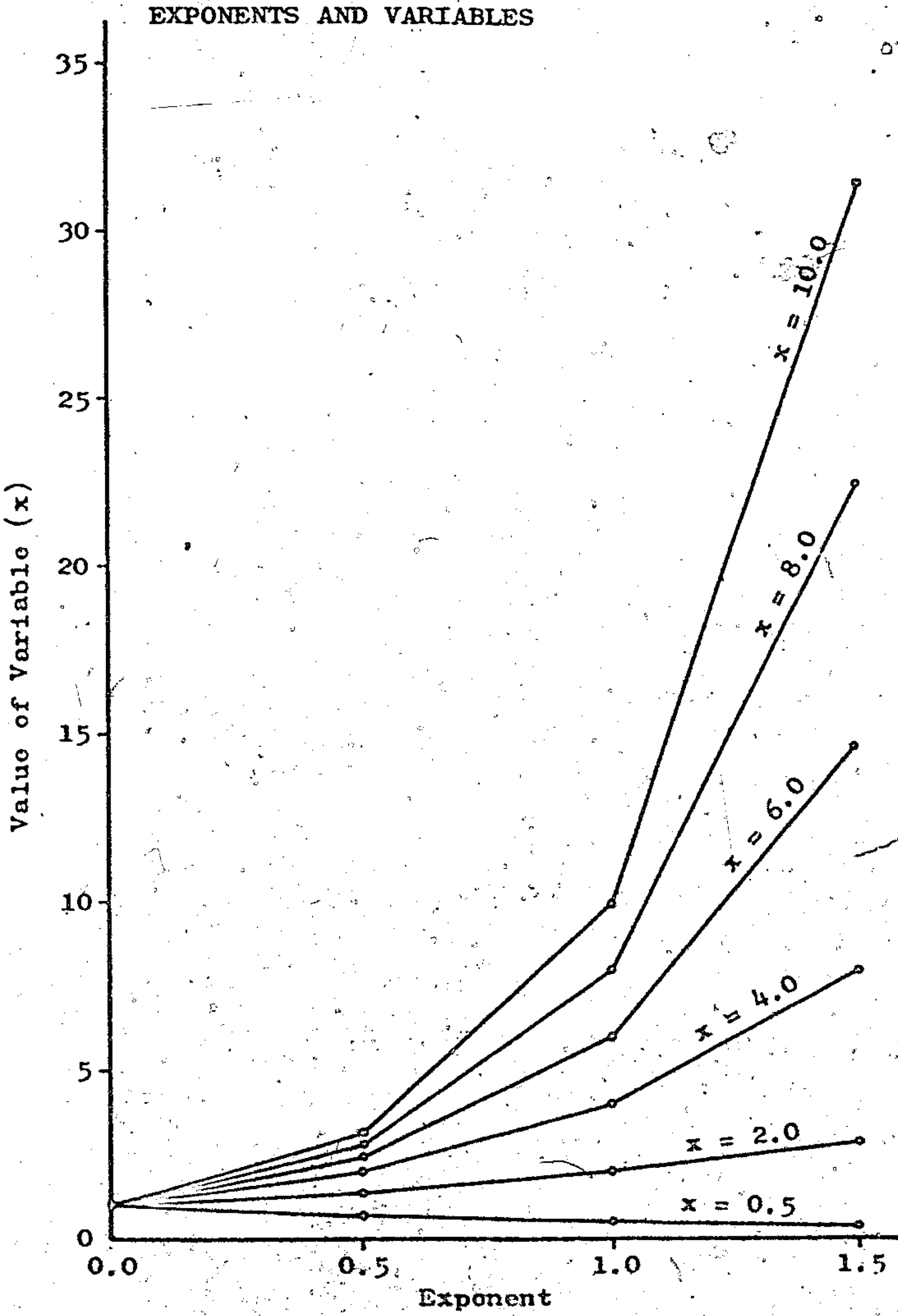
(d) In each township a maximum density of one settler per 100 acres is imposed. Such a limit is implicit in the formulation of the lot availability variable, but this additional constraint ensures that once the limit is reached in a township no more settlers are located in that township. The lot availability variable can assign a zero probability only at the commencement of the next generation.

(e) It is assumed that the exponent for each variable may have values of 0.0, 0.5, 1.0 or 1.5. No other value is permitted. An exponent of 0.0 implies that the variable is omitted; $x^{0.0} = 1$, and in the calculation of probabilities multiplication by 1 has no effect. An exponent of 0.5 decreases the range of values assumed by the variable, thus lessening the impact of the variable for probability calculation; $x^{0.5} = \sqrt{x}$. An exponent of 1.0 serves to retain the original values of x; $x^{1.0} = x$. Finally, an exponent of 1.5 increases the range of values, thus emphasising the variable in probability calculation; $x^{1.5} = \sqrt{x^3}$. Fig. 7 illustrates the effect of exponent changes for variable values ranging from 0.5 to 10.0.

II. Aims

There are two principal aims of this anlysis. First, to test the model formulated and to estimate values of the exponents. This facilitates conclusions regarding the ranking of variables. Second, once spatial patterns corresponding to those of reality are produced, the intermediate outputs at ten year intervals are mapped and compared to available data. This chapter reports the results of the first analysis and Chapter 6 outlines the

FIGURE 7: THE RELATIONSHIP BETWEEN VALUES OF EXPONENTS AND VARIABLES



second.

III. Pattern Comparison

For each 1851 output, two statistics are presented. First, the standard deviation (s.d.) of the number of settlers in each township is calculated. The lower the s.d., the smoother the pattern with few very high or very low densities; the s.d. of the actual 1851 pattern is 170. Second, a correlation coefficient, r, is calculated. This indicates the strength of the relationship between the actual and simulated numbers of settlers by townships for 1851. The r value may vary between -1.0 and +1.0; the closer r is to +1.0 the better is the relationship. Both the s.d. and r are used to measure the degree of correspondence between actual and simulated patterns of settlement and to indicate which of the simulated patterns represent the best approximations to the actual. For several of the 1851 simulated outputs, a histogram of the number of townships in each of five density classes and a map of the township densities are presented. The histograms of simulated patterns and actual settlement are compared as are the maps of simulated patterns and actual settlement. The means of comparison do have limitations as the histogram and the s.d. are nonspatial (Dacey, 1966). However, the use of the several procedures together provides a suitable basis for pattern comparison.

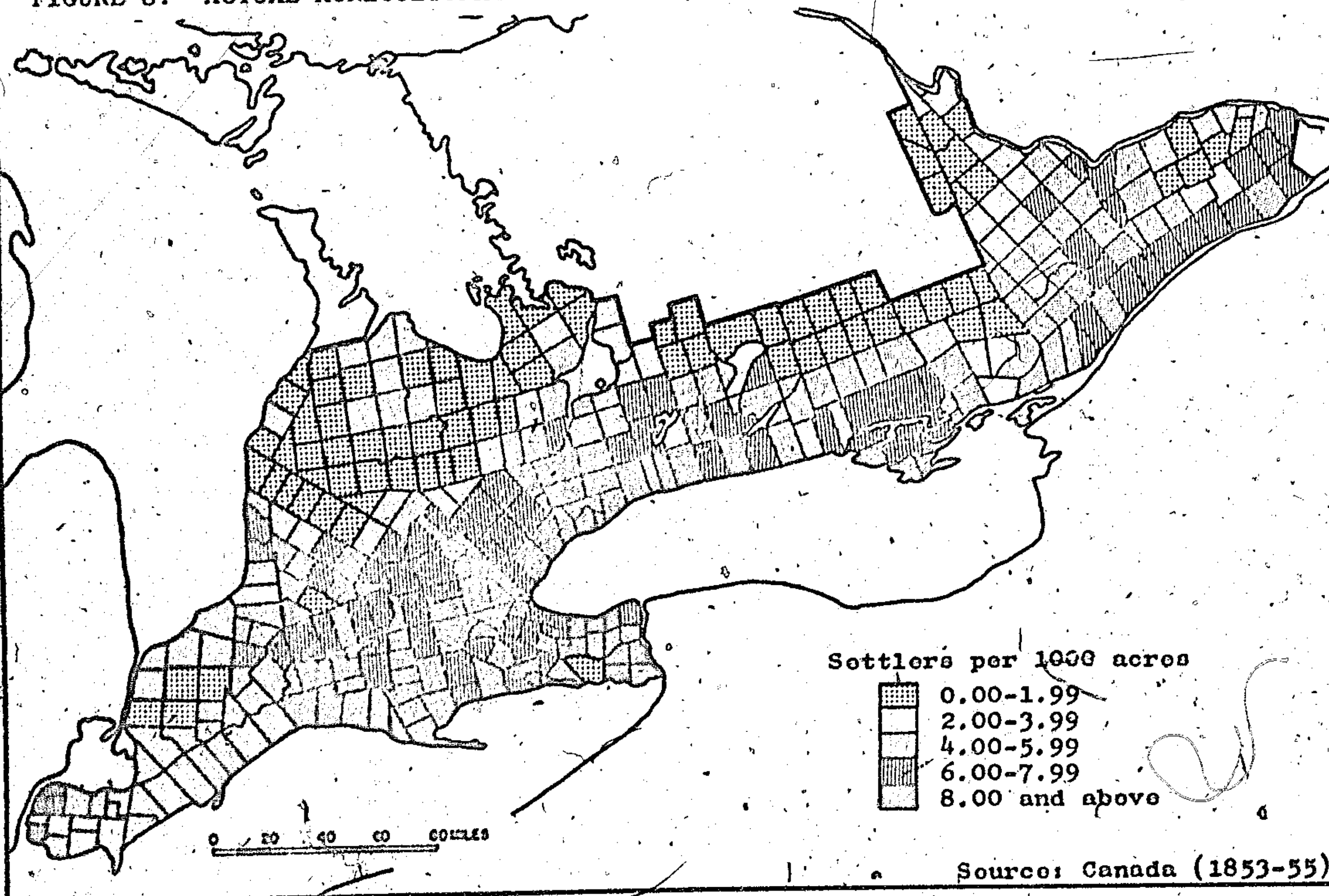
IV. The 1851 Pattern

The township densities for 1851 are indicated on Fig. 8. The majority of townships have 0.00-9.99 settlers per 1000 acres; only ten of the 347 townships have more than 9.99, and only seventeen have 0.00 density. High densities prevail in the vicinity of York, Hamilton, London, Prince Edward County, Kingston, the shores of the Saint Lawrence and Lake Ontario and in parts of the Niagara Peninsula. Northwards, the transition to lower densities is quite sharp. Fig. 9 shows the number of townships in each of five categories of density; the distribution has 60-80 in each class and approximates a uniform distribution.

B. The Basic Analysis

Given four variables and four values of each exponent there are $4^4 = 256$ possible runs. These 256 runs represent the initial analysis performed and detailed statistical results are presented in Appendix 3. This appendix indicates the exponent values, the number of townships in each of five density classes, the r value between the simulated 1851 numbers and the actual 1851 numbers and the s.d. of the number of settlers in each township. Fig. 10 shows the distribution of r values and emphasises the large number (106 of 256) included in the highest class (greater than 0.6500). This is a principal

FIGURE 8: ACTUAL AGRICULTURAL SETTLEMENT, 1851



Source: Canada (1853-55)

FIGURE 9: HISTOGRAM OF ACTUAL AGRICULTURAL SETTLEMENT, 1851

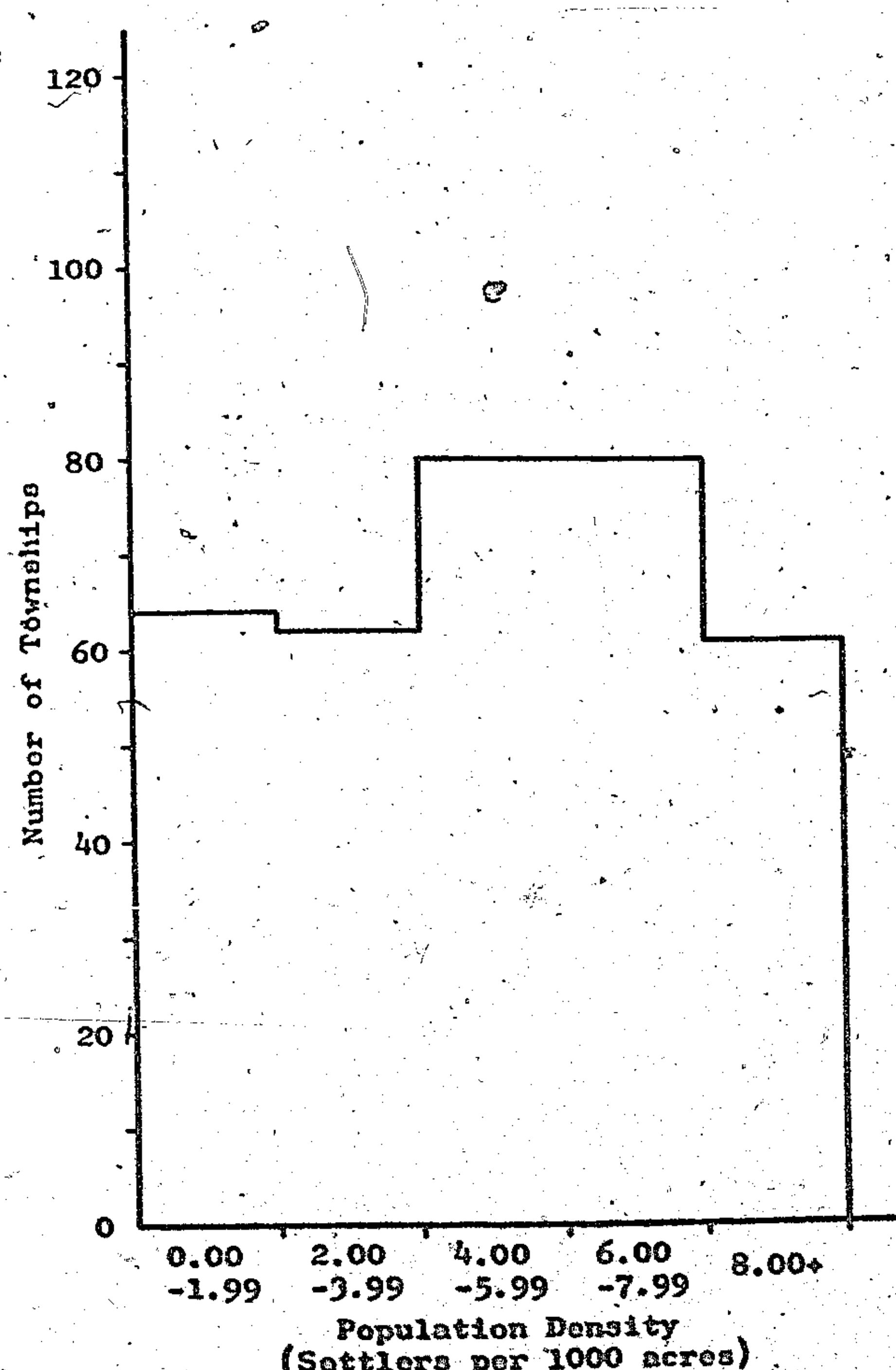
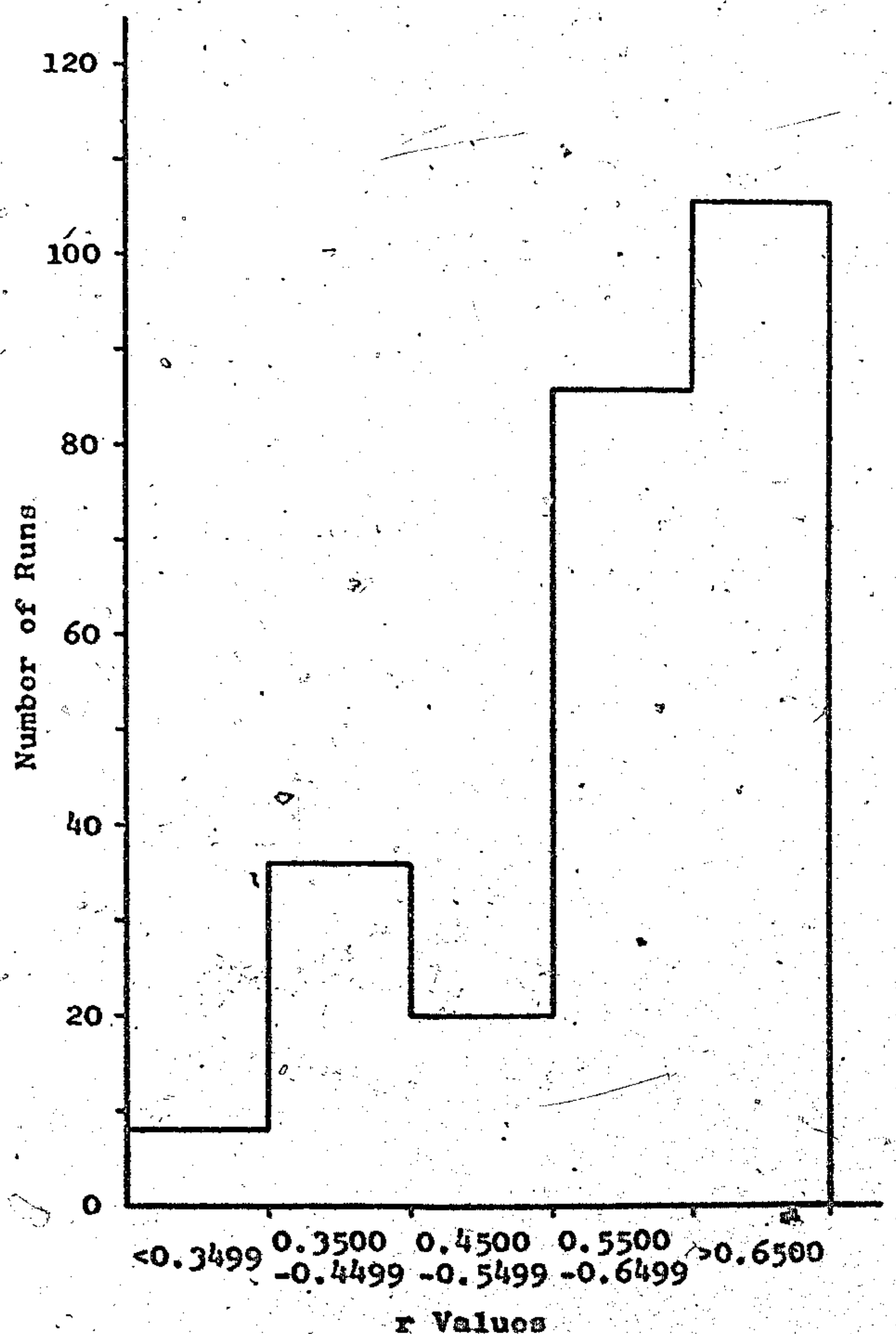


FIGURE 10: HISTOGRAM OF THE 256 r VALUES



feature of the results. Frequently, changes in the exponents results in only a nominal change in the r value and, consequently, there is no one r value which is clearly the highest.

I. Outputs With Low r Values

The runs which result in the lowest r values are as follows:

Number of Run	a	b	c	d	r Value
193	1.5	0.0	0.0	0.0	0.2884
197	1.5	0.0	0.5	0.0	0.3156
209	1.5	0.5	0.0	0.0	0.3045
213	1.5	0.5	0.5	0.0	0.3304
225	1.5	1.0	0.0	0.0	0.2992
229	1.5	1.0	0.5	0.0	0.3479
241	1.5	1.5	0.0	0.0	0.3150
245	1.5	1.5	0.5	0.0	0.3456

where, a is the exponent for the lot availability variable
b is the exponent for the entry point variable
c is the exponent for the land quality variable
d is the exponent for the potential variable

Several points emerge from these results. First, the exponent a is equal to the maximum value of 1.5 in all cases. This suggests that the lot availability variable is ascribed an exaggerated influence with an exponent of 1.5. Second, c, the exponent for the land quality variable, assumes the two values 0.0 and 0.5, indicating that the omission of this variable or the use of a low exponent hinders the development of patterns similar to the actual. Finally, d, the exponent for the potential variable is 0.0 in all cases, demonstrating that any formulation which excludes a consideration of this variable is likely to achieve a poor result.

Further, each of these eight results shows a similar distribution of densities and Fig. 11 is a histogram of run 193 (the lowest r value). In each case the s.d. is a close approximation to the actual, the lowest being 166 and the highest being 179. The tendency in all of these runs is towards the production of a regular pattern with the vast majority of townships having densities between 2.00 and 5.99.

II. Changing Individual Exponents

Four sets of results are now presented which indicate the effect of one variable operating in isolation; the remaining three variables being excluded by means of ascribing zero exponents.

Fig. 12 shows the resulting r values when the exponents b,c and d are held constant at 0.0 and a varies between 0.0 and 1.5. All of the r values are low; the highest resulting from a equal to 0.5. Similar analysis on the exponent, b, produces analogous results with low r values resulting from employment of the entry point variable only (Fig. 13). Fig. 14 again indicates that use of one variable only, in this case land quality, results in low r values. The results of analysis allowing d to operate in isolation are rather different. The potential variable produces r values as high as 0.6570 suggesting that this variable is of appreciable significance (Fig. 15).

FIGURE 11: HISTOGRAM OF SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 193

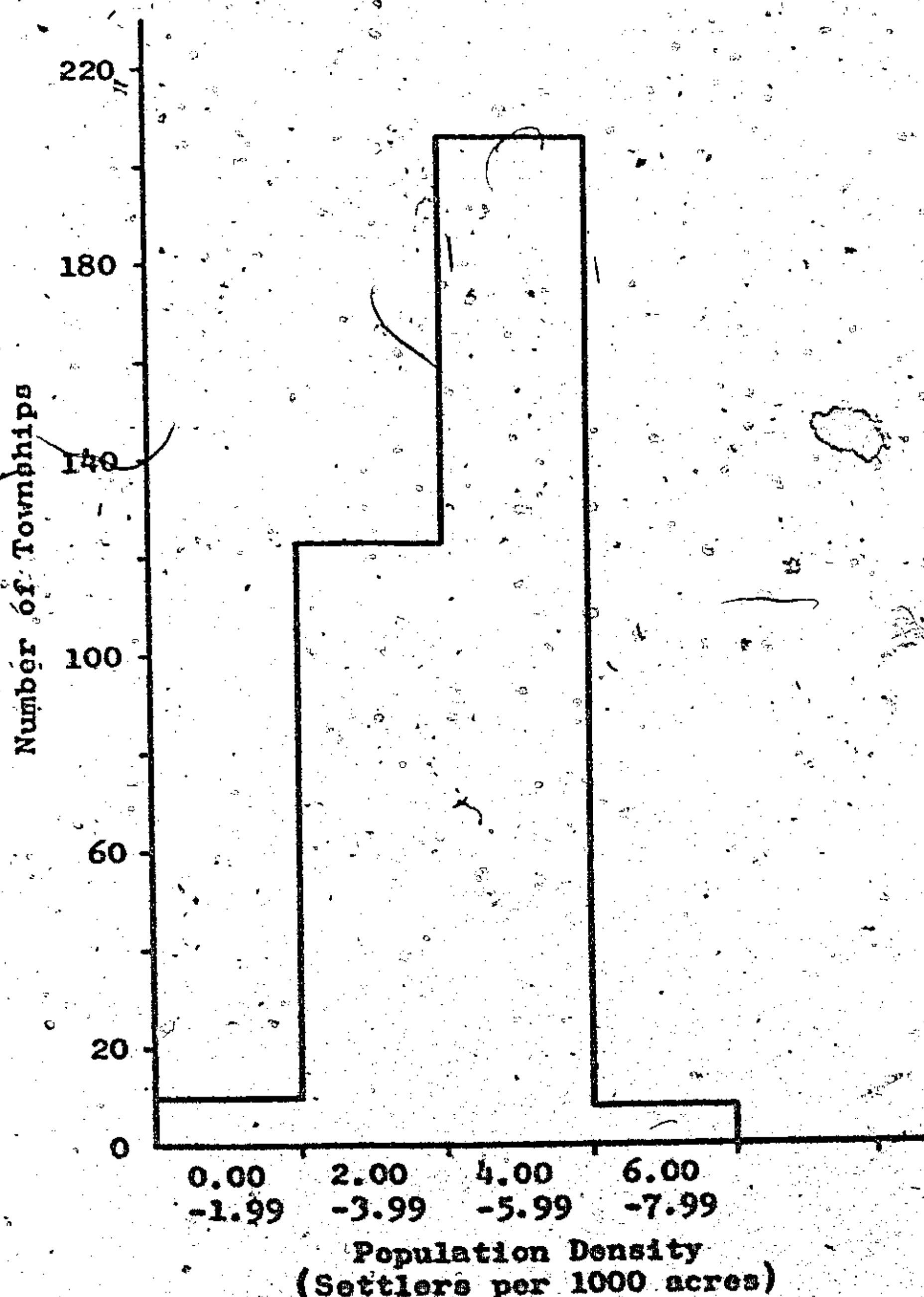


FIGURE 12:
VARYING THE VALUE OF a

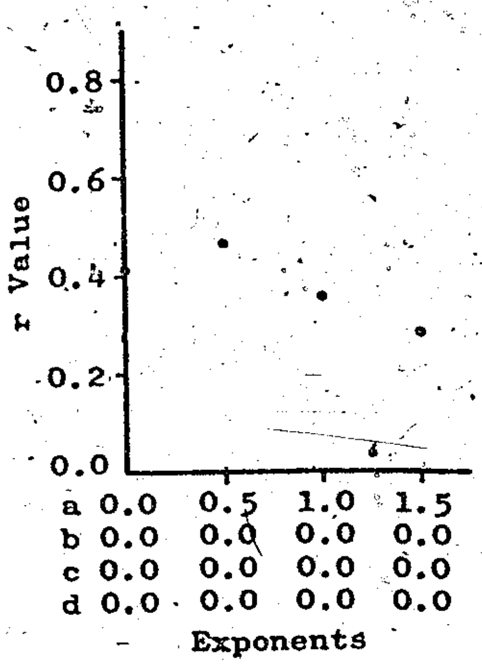


FIGURE 13:
VARYING THE VALUE OF b

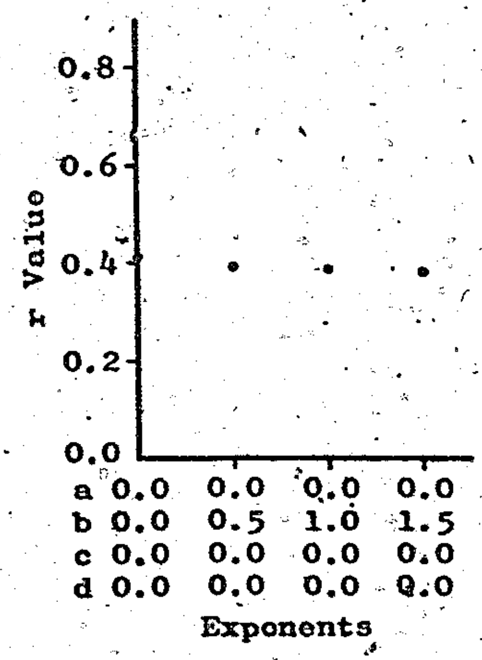


FIGURE 14:
VARYING THE VALUE OF c

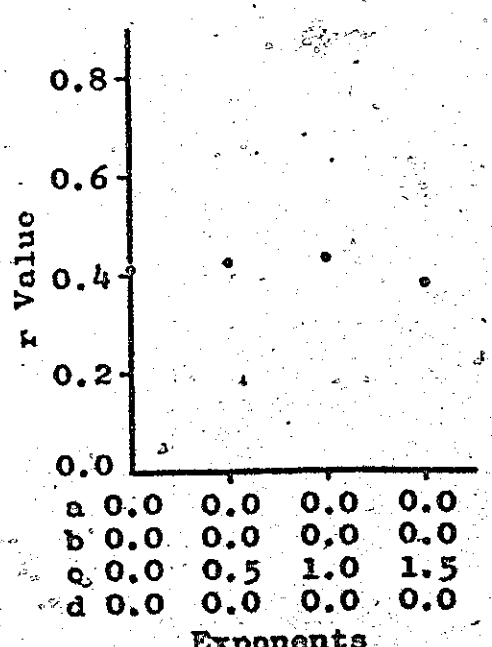
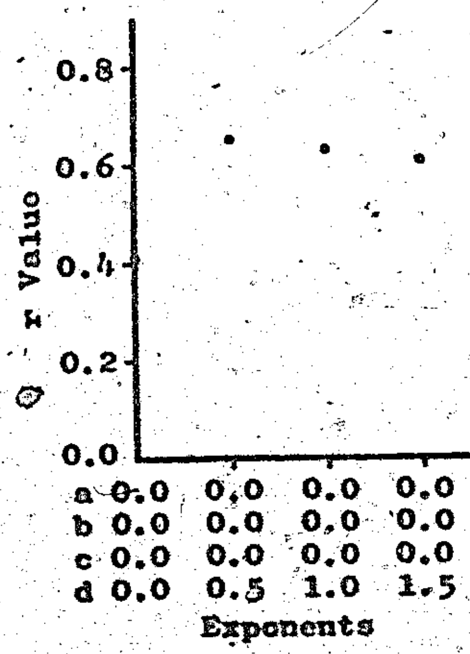


FIGURE 15:
VARYING THE VALUE OF d



In summary, these four sets of results suggest potential as a critical variable and indicate that the three remaining variables are not capable of producing high r values when applied in isolation.

III. Variations in the Simulated Standard Deviation

The actual 1851 pattern of settlement has an s.d. of 170, but the tendency in the simulation runs is to produce higher values. Of the 256 runs, the s.d. is 170 or less on only 59 occasions. Appraisal of the exponent values and the resulting s.d. shows a close relationship between the value of d and the s.d. On all 59 occasions the value of d is 0.0. On the additional five occasions when d is 0.0 the s.d. is 171, 174, 175, 177 and 179. Similarly, the highest values of the s.d. result when d equals 1.5, producing values of approximately 265. The s.d. reflects the distribution of townships in density classes. With a low s.d. most of the townships are in the middle classes and, with a high s.d. the majority of townships are in the lowest and highest classes. The general tendency of the 256 runs is to produce an s.d. that is too high.

C. An Analysis of Outputs With High r Values

The most important runs to analyse are those which most nearly replicate the actual 1851 pattern. The ten runs which produce r values in excess of 0.6900 are selected for further investigation. The ten are each run an additional eight separate occasions, each run employing a different sequence of random numbers; a mean r is calculated for each of the ten. This procedure is appropriate as there are only slight differences between the ten initial r values which are possibly related to random factors. The following are the ten runs investigated:

Number of Run	a	b	c	d	r Value
78	0.5	0.0	1.5	0.5	0.6916
86	0.5	0.5	0.5	0.5	0.6998
90	0.5	0.5	1.0	0.5	0.6935
94	0.5	0.5	1.5	0.5	0.7000
110	0.5	1.0	1.5	0.5	0.6982
122	0.5	1.5	1.0	0.5	0.7002
158	1.0	0.5	1.5	0.5	0.7057
174	1.0	1.0	1.5	0.5	0.7026
186	1.0	1.5	1.0	0.5	0.6938
190	1.0	1.5	1.5	0.5	0.7097

Appendix 4 lists the eight additional results produced for each of the ten runs. It is on the basis of the additional runs that mean r values are calculated, thus facilitating a definite ranking.

Below are listed the rank, the number of the run, the mean r value and the exponents:

Rank	Number of Run	Mean r Value	a	b	c	d
1	190	0.7012	1.0	1.5	1.5	0.5
2	110	0.6974	0.5	1.0	1.5	0.5
3	186	0.6973	1.0	1.5	1.0	0.5
4	158	0.6952	1.0	0.5	1.5	0.5
5	122	0.6939	0.5	1.5	1.0	0.5
6	174	0.6927	1.0	1.0	1.5	0.5
7	94	0.6923	0.5	0.5	1.5	0.5
8	90	0.6895	0.5	0.5	1.0	0.5
9	78	0.6894	0.5	0.0	1.5	0.5
10	86	0.6886	0.5	0.5	0.5	0.5

I. Characteristic Features

Each of the ten runs has the exponent for the potential variable, d, equal to 0.5, and any change in this value causes a decline in the r statistic. The exponent for the lot availability variable, a, assumes two values, 0.5 and 1.0; c, the exponent for the land quality variable assumes three values, 0.5, 1.0 and 1.5, while b, the exponent for the entry point variable, assumes all four possible values.

II. The Estimation of Exponents and the Sensitivity of Variables

The four variables may be assessed by two criteria. First, appropriate exponents are indicated, and, second, variable sensitivity to exponent change is discussed. The ten results outlined above are used to assess variables. It is emphasised that all conclusions are related to the manner in which the variable is formulated. The exponents of the ten runs are, with one exception, non zero, and this confirms the relevance of the four variables.

Using the highest mean r (Run 190) the following ranking of exponents is possible:

Variable	Exponent Value
Entry points	b = 1.5
Land quality	c = 1.5
Availability	a = 1.0
Potential	d = 0.5

These four values represent the most satisfactory combination of exponents. Given that it was desired to apply the model elsewhere, research might commence by testing this specific model formulation. Rather than simply accepting these values, however, it is advisable to analyse the sensitivity of variables.

On the basis of the range of values which each exponent exhibits, the four variables may be ranked as follows for sensitivity:

1. Potential (always 0.5)
2. Availability (0.5-1.0)
3. Land quality (0.5-1.5)
4. Entry points (0.0-1.5)

The distinction between 2 and 3 is slight as c = 0.5 on only one occasion (Run 86 ranked tenth). This ranking for sensitivity represents a fundamental result. The potential variable is most sensitive to exponent change and the entry point is least sensitive.

Looking for similarities in the values of the exponents, three groups are distinguished. In these groupings it is decided to ignore b, as it is such an inconsistent exponent. The first group consists of ranks 1, 4 and 6 and is of the form:

$$a = 1.0, \quad c = 1.5, \quad d = 0.5$$

The second group consists of ranks 2, 7 and 9 and is of the form:

$$a = 0.5, \quad c = 1.5, \quad d = 0.5$$

The third group consists of ranks 5 and 8 and is of the form:

$$a = 0.5, \quad c = 1.0, \quad d = 0.5$$

These three groupings illustrate that c is consistently the exponent with the highest value, a ranks second and d third; b being too unreliable to merit consideration. The variable with the highest exponent is, therefore, land quality, followed by lot availability and potential. These results, then, confirm the ranking of exponent values suggested by the consideration of Run 190.

It is now possible to further demonstrate the relative sensitivity of variables. Run 190, having the highest mean r value, is further investigated by means of experimenting with the exponent values and ascertaining the effect upon the simulated pattern as assessed by the r values. Each of the four exponents is adjusted to one value lower and to one value higher. The results are as follows:

With a = 0.5	r = 0.6859
" a = 1.0	r = 0.6766
" b = 1.0	r = 0.6927
" b > 1.5	not possible
" c = 1.0	r = 0.6973
" c > 1.5	not possible
" d = 0.0	r = 0.4488
" d = 1.0	r = 0.6753

Again, these results indicate that only when the exponent for the potential variable, d, is changed is there any significant change in the r value. This serves to confirm that, of the four variables, only potential is sensitive to change.

This lack of sensitivity exhibited by three of the four variables indicates that the variables are intercorrelated. Of the four, only potential appears unaffected, for this is the only variable whose value is crucial to the high correlation. As indicated, the effects of the other variables are interchangeable; that is, they are "explaining" essentially the same variation in the settlement pattern and it is difficult, therefore, to assess their relative importance in generating patterns. The fundamental conclusions are that the potential variable is critical and that the effects of the other three variables are unclear. Historically, these are important conclusions. The technical issues involved in multicollinearity, are detailed by Wonnacott and Wonnacott (1970).

In summary, this analysis of the outputs resulting in the highest r values produces an important conclusion. It is shown that the exponent with the highest value is that for the land quality variable. This exponent, c, has a value of 1.5. The exponent, a, for the lot availability variable is second with a value of 1.0, and the exponent d, for the potential variable is third with a value of 0.5. These values of the exponents are those from Run 190, the run with the highest mean r, and they are also confirmed by the grouping of exponents on p. 98.

III. The Mapped Patterns

The r values are useful to establish the most satisfactory results but a comparison of maps facilitates discussion of the spatial patterns. Maps of Runs 190 and 110 (ranked first and second respectively) are produced (Figs. 16 and 17) and compared to each other and to the map of actual 1851 settlement (Fig. 8). Histograms showing the distribution of townships in each of five density classes are also produced (Fig. 18 for Run 190 and Fig. 19 for Run 110) and compared to the histogram of the actual data (Fig. 9).

Both Runs 190 and 110 result in settlement patterns which correspond in their overall features to the actual pattern. The following features of the actual pattern are produced by both runs: the higher density townships are those along the Saint Lawrence and Lake Ontario shores, particularly at the west end of Lake Ontario and inland towards London; lower densities prevail throughout the north and west; and, local areas of higher density are evident

FIGURE 16: SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 190

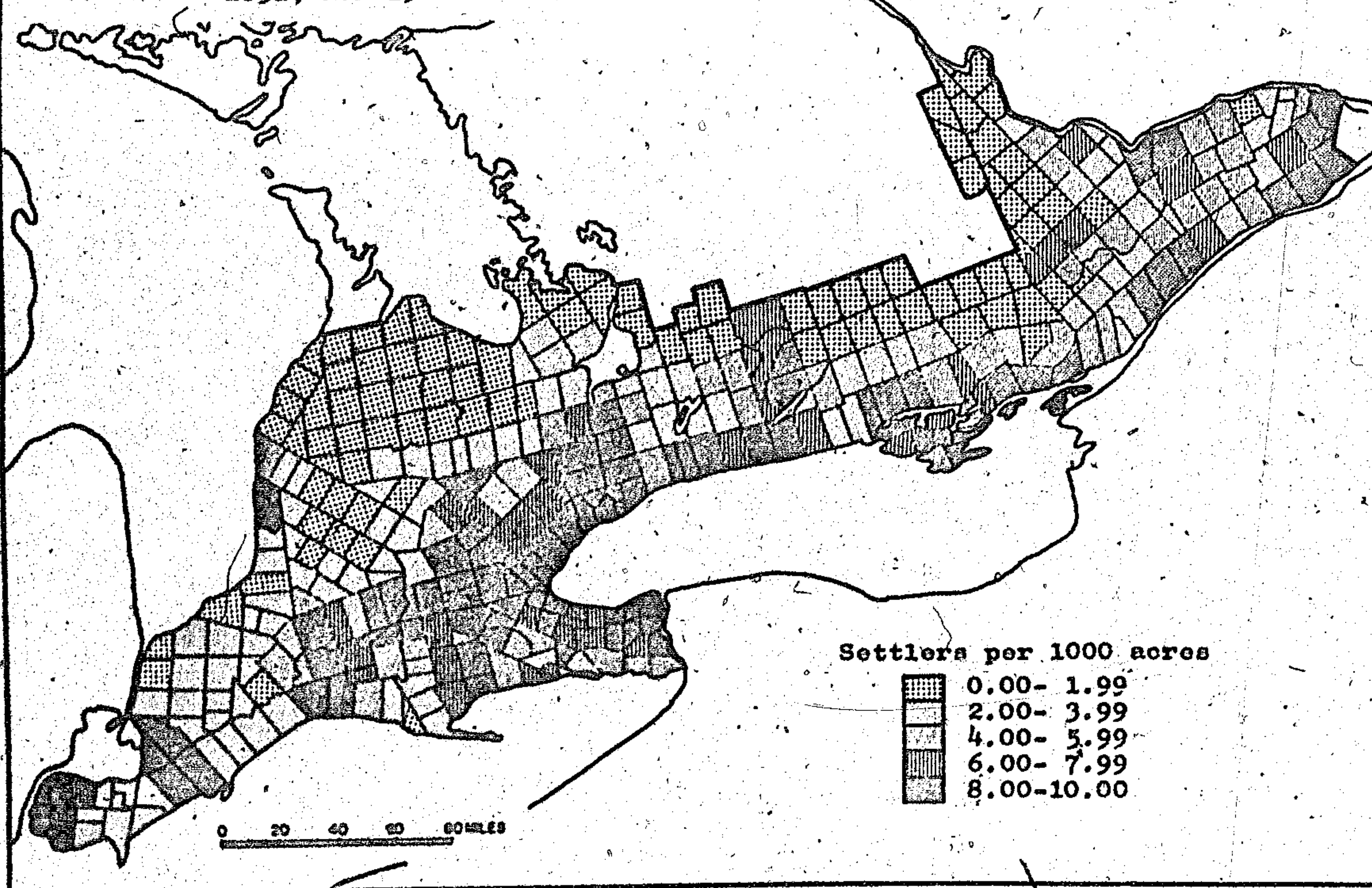


FIGURE 17: SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 110

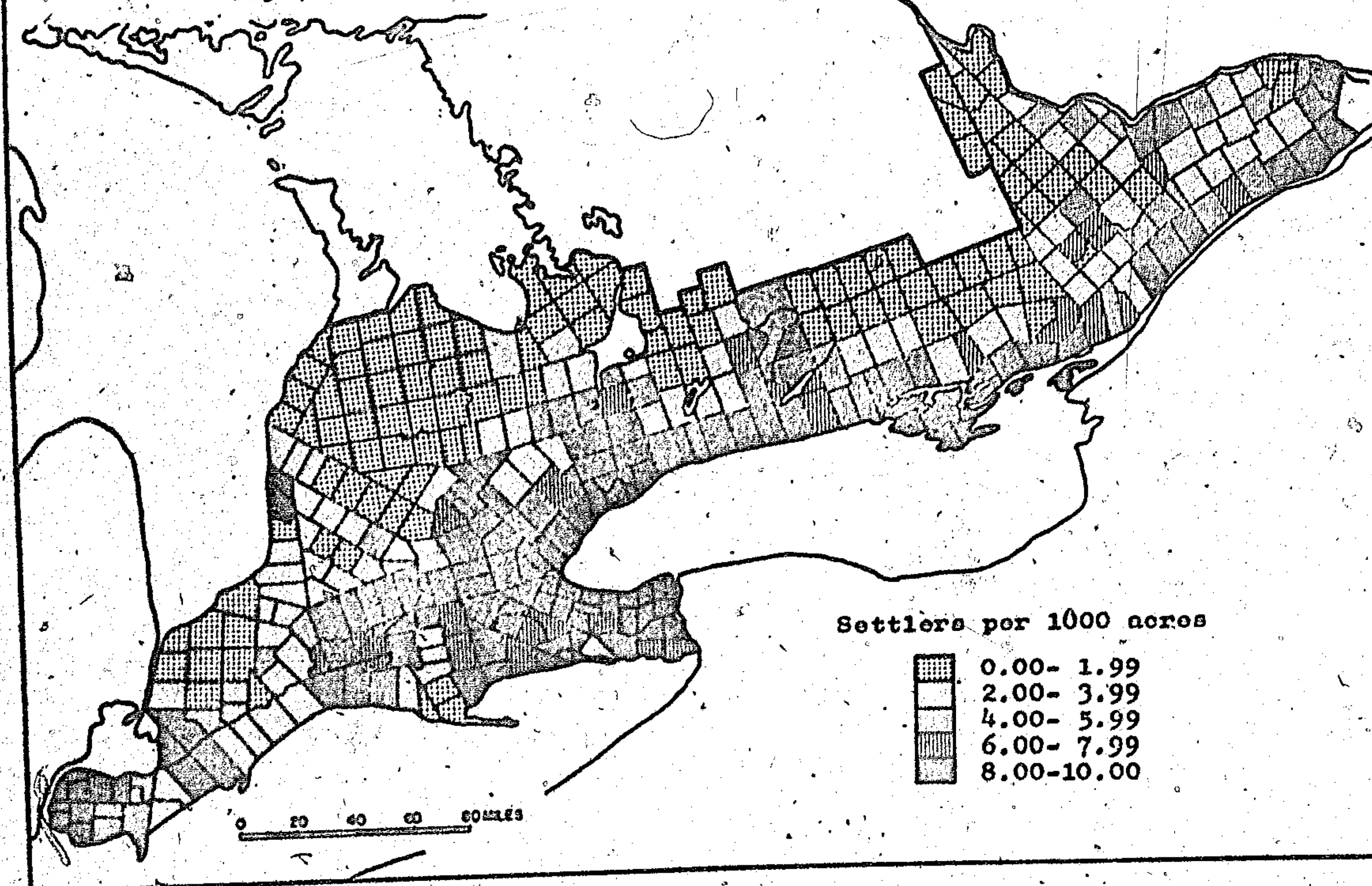


FIGURE 18: HISTOGRAM OF SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 190

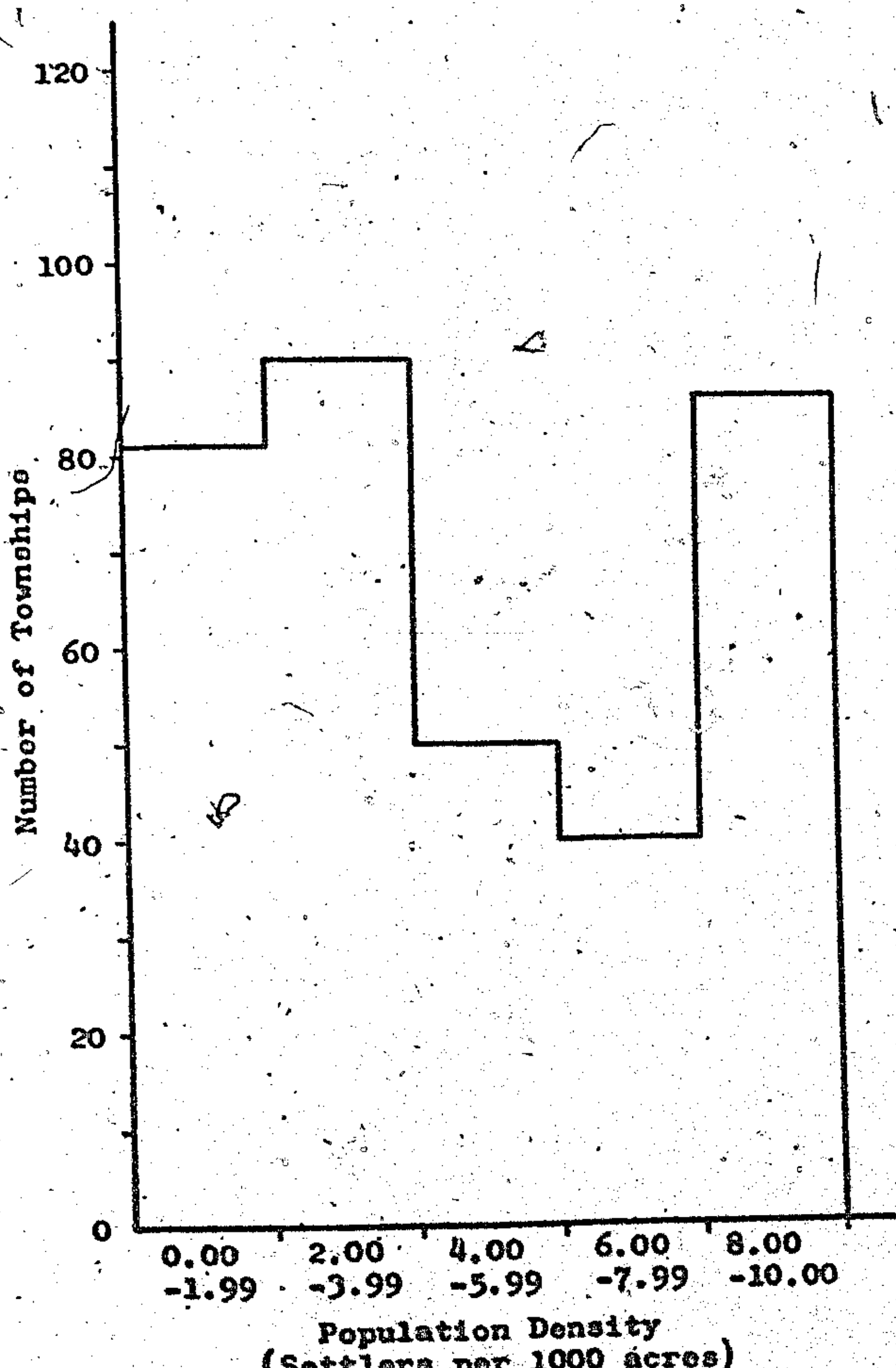
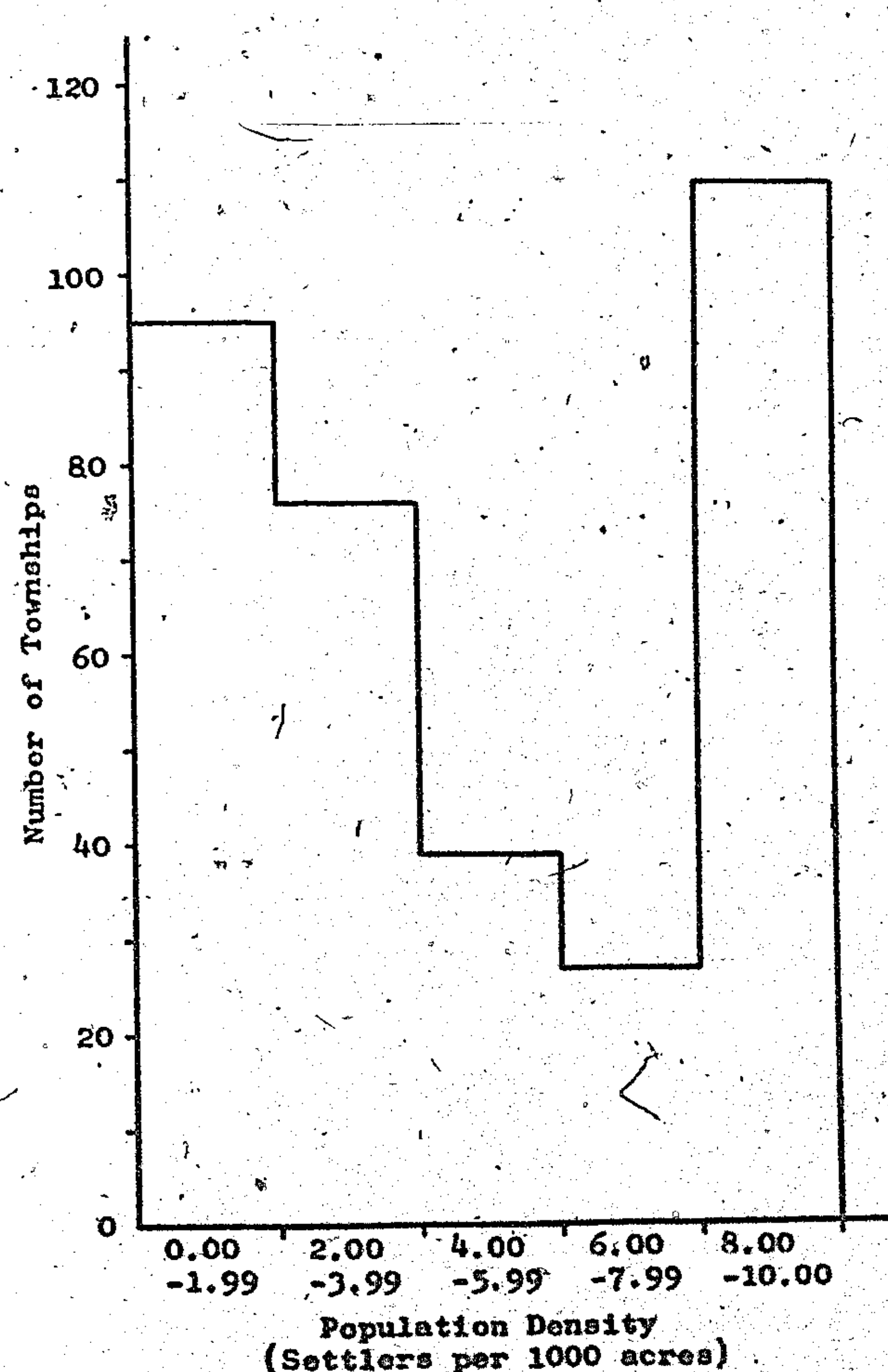


FIGURE 19: HISTOGRAM OF SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 110



near the Detroit River, Goderich, London, Bytown and the Quebec border. Both of the simulated patterns, however, fail to reproduce the high densities north east of Kingston and south east of Goderich. The differences between Figs. 16 (Run 190) and 17 (Run 110) are not appreciable.

Fig. 18 (Run 190) is a better approximation to the histogram of actual densities (Fig. 9) than is Fig. 19 (Run 110). Both of the simulated distributions have too many townships in the lowest two classes and in the highest class and correspondingly too few townships in the two central classes. However, Fig. 18 is the more satisfactory histogram as these characteristics are less developed. Both of the s.d.'s are greater than 170 as suggested by the distributions; Run 190 has an s.d. of 210 and Run 110 has an s.d. of 213.

D. Conclusions

The analysis reported in this chapter includes the running of the model on 256 occasions to assess the four variables. Specifically, the analysis facilitates the estimation of the most suitable exponent values and indicates the effect of sensitivity tests on each of the four variables. Patterns approximating the actual 1851 pattern are simulated and compared to the actual. The following chapter considers the development of the pattern through time and analyses the effect of an alternative means of township selection.

CHAPTER 6

THE SPREAD AND GROWTH OF AGRICULTURAL SETTLEMENT

This chapter attempts a reconstruction of the agricultural settlement history of Upper Canada. First, intermediate outputs of the patterns produced by the model are mapped and assessed with reference to the available data. Second, the intermediate outputs are related to theoretical statements on settlement spread and growth. Third, the several proposed variables are discussed and the structure of the better models analysed. Fourth, the possible effects of permitting widespread squatting during the entire period are introduced and the resulting patterns compared to those which do not permit such freedom of choice in locations. Subsequently (Chapter 7), a number of conclusions are drawn, including a brief methodological statement, a summary of the analysis and results and suggestions for continuing research.

A. The Development of the 1851 Pattern

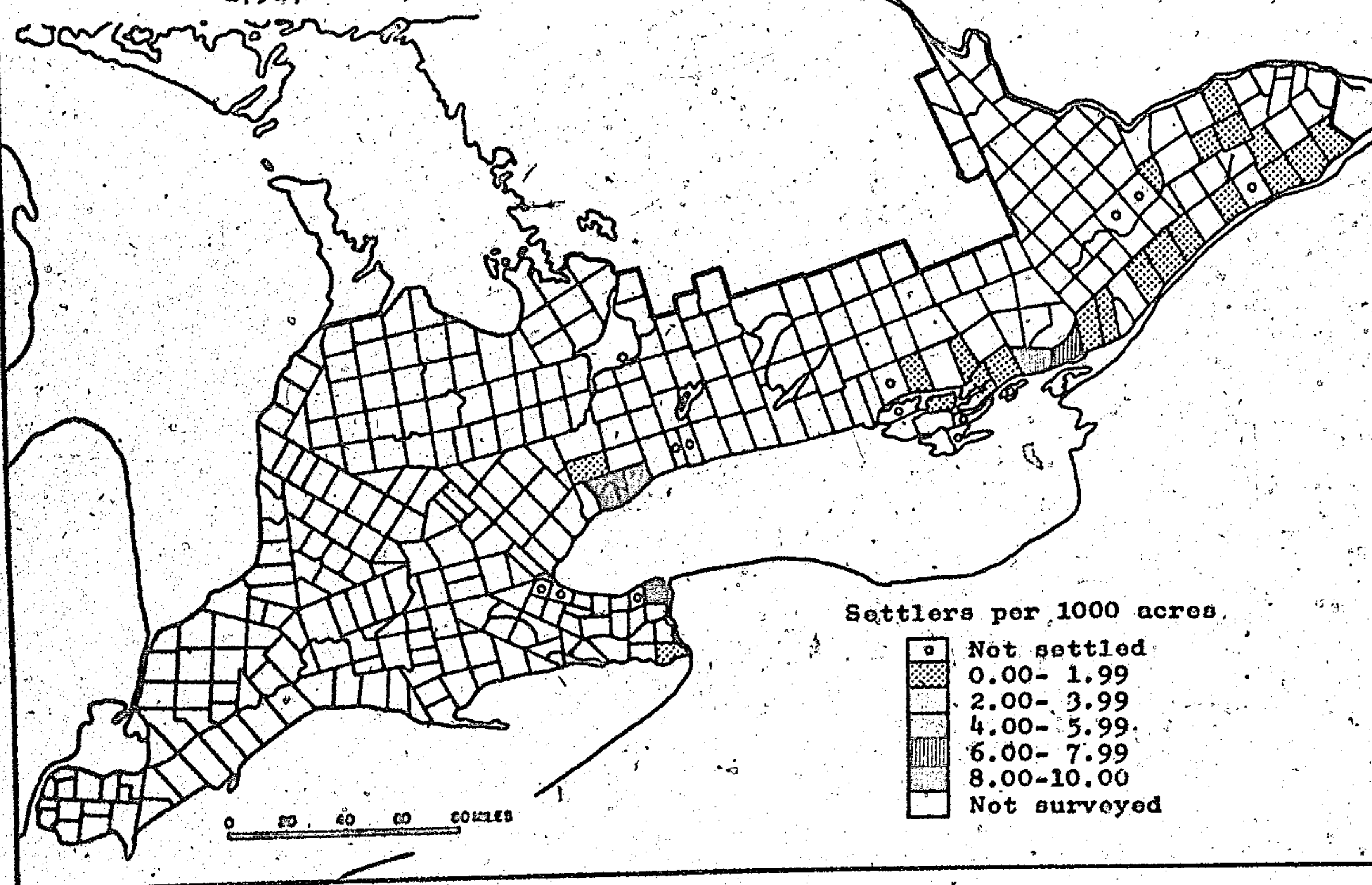
For one of the simulated outputs, Run 190, the intermediate patterns for 1791, 1801, 1811, 1821, 1831 and 1841 are now presented. This run has the highest mean r value and comparisons of the resulting 1851 map (Fig. 16) and histogram (Fig. 18) with the corresponding map (Fig. 8) and histogram (Fig. 9) for the actual pattern indicate that the simulation output approximates the 1851 data.

The run investigated has the following exponent values: a, the exponent for lot availability is equal to 1.0; b, the exponent for entry points is 1.5; c, the exponent for land quality is 1.5; and, d, the exponent for the potential variable is 0.5. The mean r value is 0.7012 and the r for the particular run mapped is 0.7097 and the s.d. is 210. In this discussion comparisons are made between the simulated stage patterns and available real world information.

I. The Pattern for 1791

For the earlier generations the simulated outputs are largely conditioned by the availability of townships, a function of the date of survey. By 1791, eleven of the available townships have not received any settlers. Fig. 20 shows scattered settlement along the Niagara River, Lake Ontario shore and the Saint Lawrence. Settlement is also initiated between the Saint Lawrence and the Ottawa River, representing the sole exception to the initial linear development along the United States border. Three core areas are already evident in response to the entry point variable; at Niagara, York and Kingston. There are no settlers near the Detroit River entry point as the date of

FIGURE 20: SIMULATED AGRICULTURAL SETTLEMENT, 1791, RUN 190



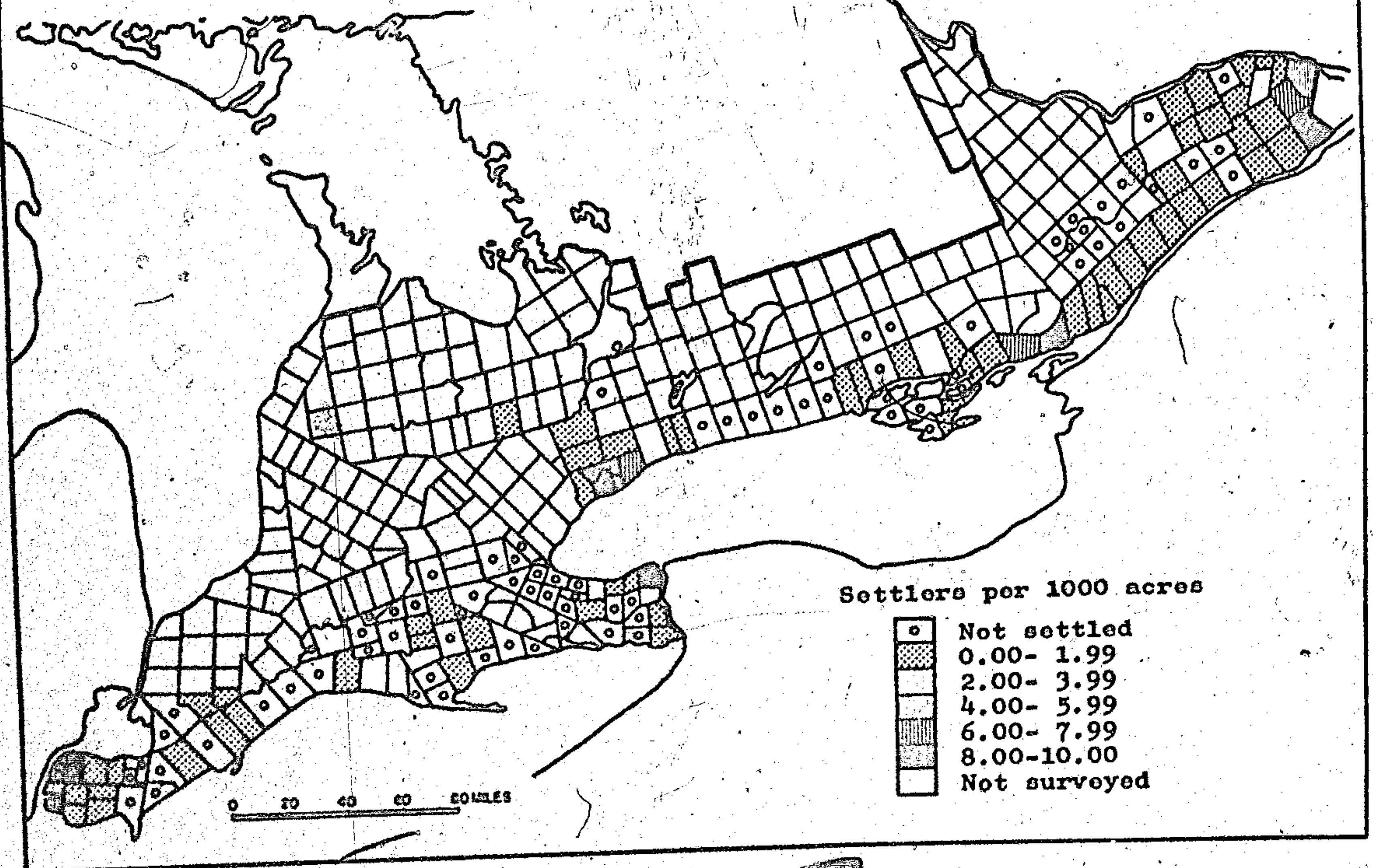
survey data do not indicate any progress in this area.

Because of the limited number of townships available by 1791, (35), the spatial pattern of the simulated output is dictated by the survey data. Thus, it is errors in these data which produce unreal situations as at Detroit and York. Cowan (1961, p.11) suggests cores at Kingston, Niagara and Detroit with the majority of settlers to the west of Kingston. Neither surveying or settlement is begun in the York area at this time (Patterson, 1921, p.32). The simulation, however, does locate settlers in this area as the survey data record townships as being open before 1791.

II. <u>The Pattern for 1801</u>

By 1801 the number of townships available increases appreciably and Fig. 21 shows many townships having low densities and a very few townships with relatively high densities. Further, of the 136 townships available for settlement, 77 do not receive any settlers. There is only limited settlement between Detroit and Niagara and several vacant townships in the east. Instead of dispersing, settlers locate largely in the existing core areas, Niagara, York and Kingston, and two additional core areas develop at the two remaining entry points, the Detroit River and the Quebec border. Under the conditions of Run 190, the area experiencing frontier occupance is substantially less than the total available area and the majority of settled townships have low densities.

FIGURE 21: SIMULATED AGRICULTURAL SETTLEMENT, 1801, RUN 190



III. The Pattern for 1811

During the first decade of the nineteenth century surveying was limited. The tendency, as shown by Fig. 22, is for continued settlement in already settled townships. Particularly, the five core areas receive many settlers and there still remain 53 unsettled townships out of a total available of 163. As for 1801, these townships are mainly located in the south west and in the area east of Kingston. The basic visual impression is of a large and slightly occupied area. This impression is misleading for at least two reasons: information as to the date of survey do not mean that the entire township is surveyed so that the available land is exaggerated, and large areas are known to be alienated by speculators and not open to genuine settlement (Macdonald, 1939). These two factors help to explain the comments by Gates (1968, p.68) concerning the limited choice of location offered to many immigrants. It is important that these early simulated patterns are interpreted with these conditions in mind. The apparently low densities may, in fact, be the maximum possible at this time.

IV. The Pattern for 1821

By 1821 the simulated pattern is more developed with 230 townships available and 63 without settlers (Fig. 23). These townships continue to be in the south west, the area north of York, the area between York and Kingston and north

FIGURE 22: SIMULATED AGRICULTURAL SETTLEMENT, 1811, RUN 190

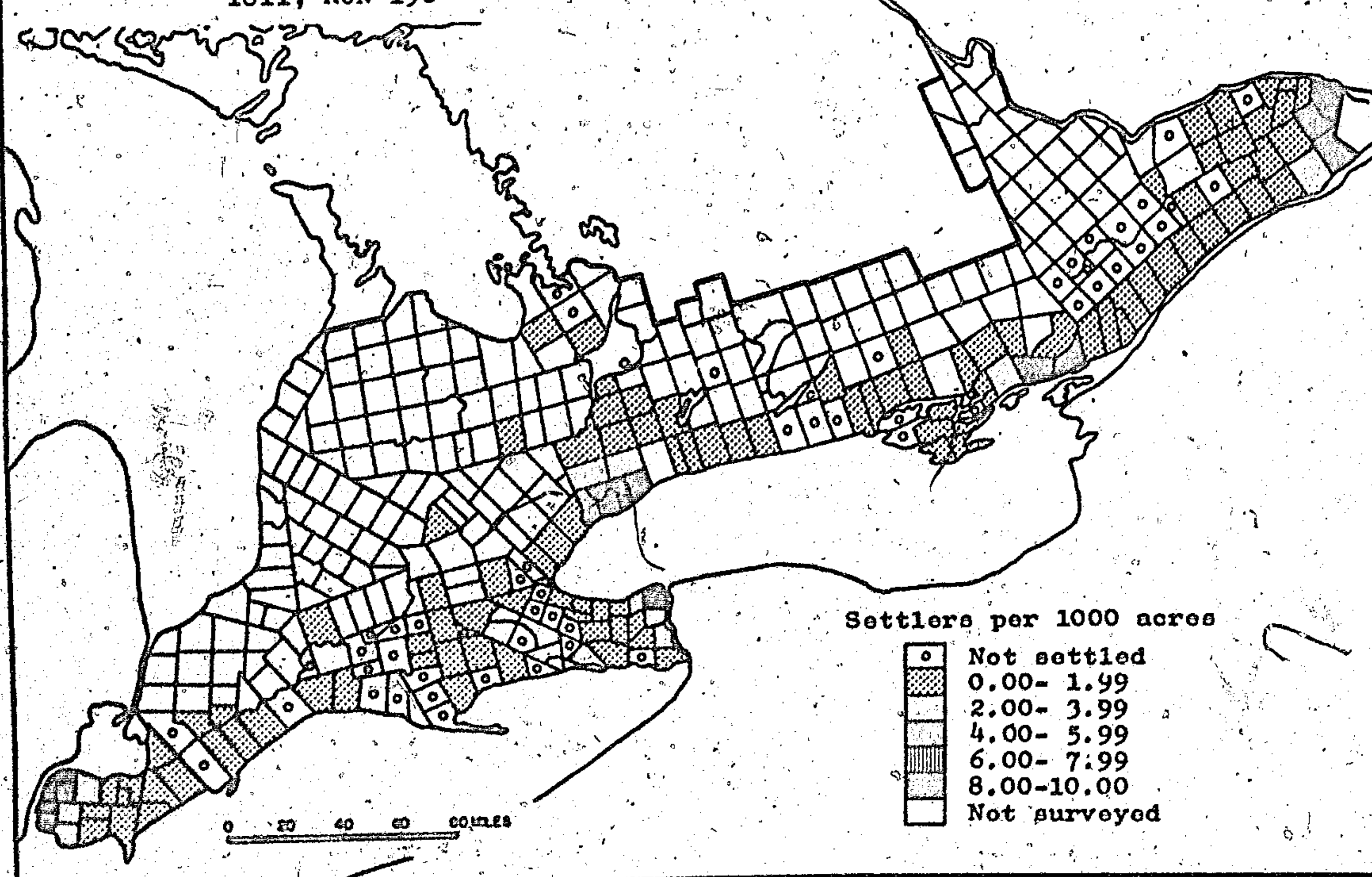
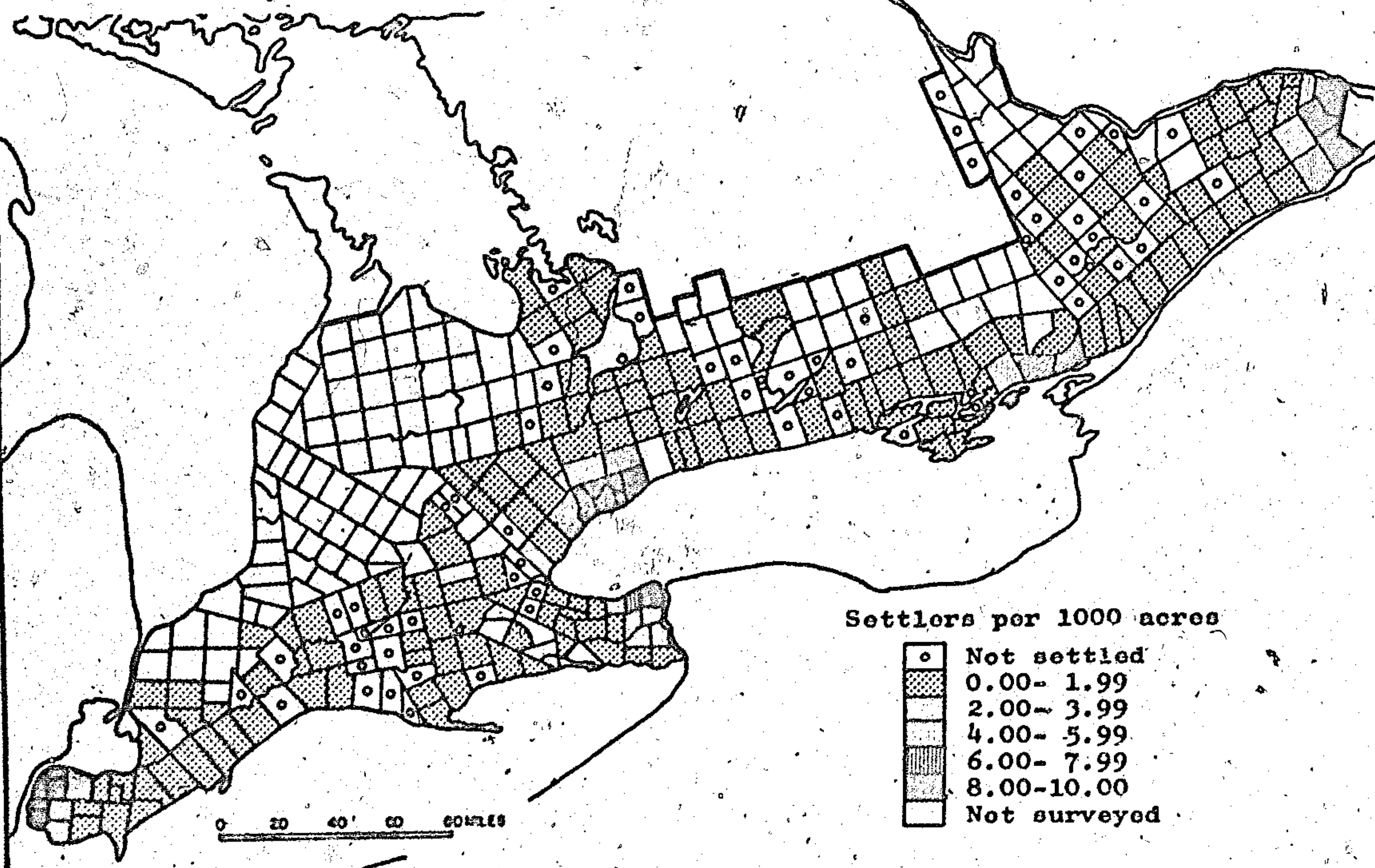


FIGURE 23: SIMULATED AGRICULTURAL SETTLEMENT, 1821, RUN 190



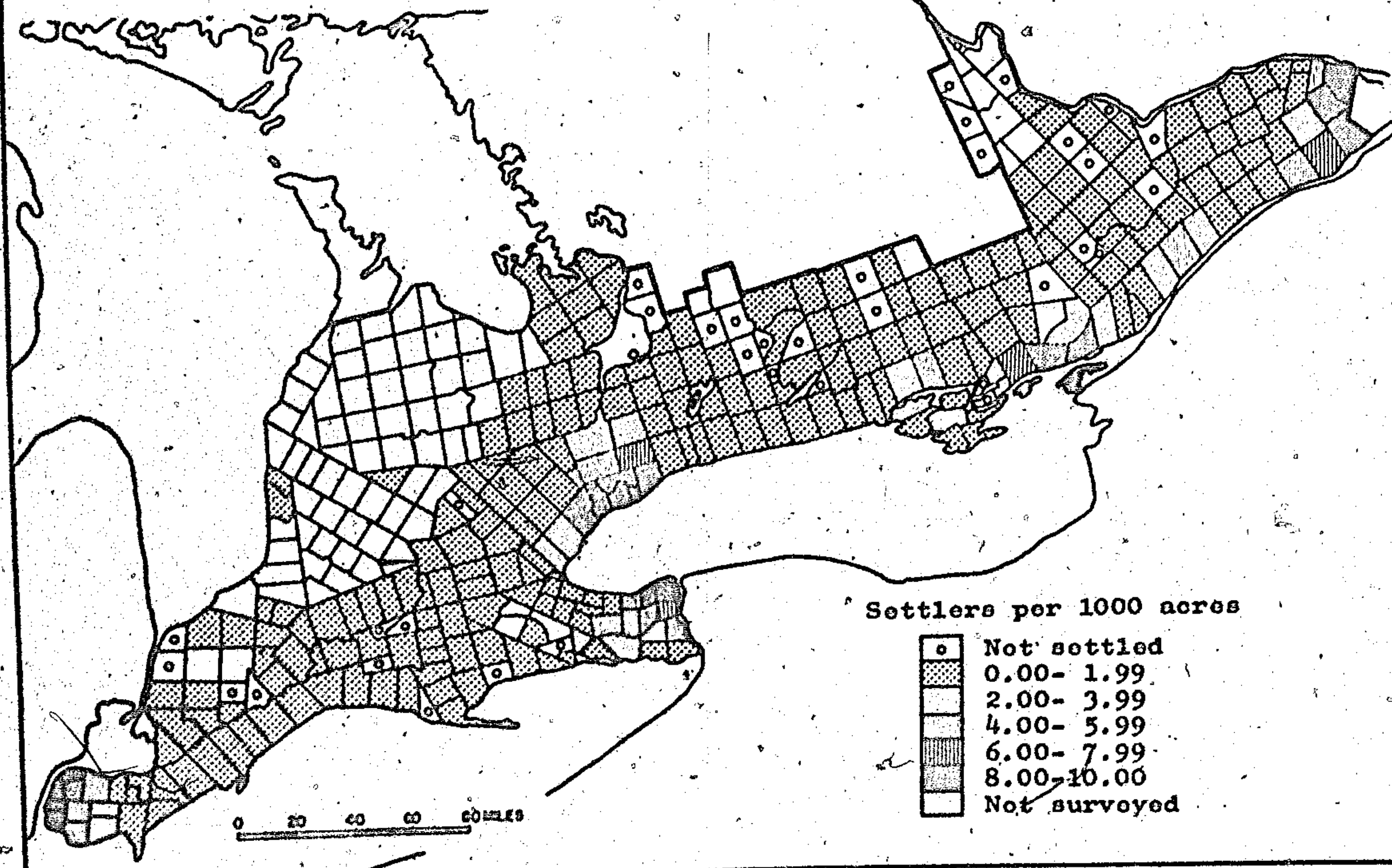
east of Kingston. There are now four major cores and a relatively minor core in the Niagara Peninsula. Townships along the line of Dundas Street from York to London receive no more settlers than their neighbours. Comparisons are possible between the simulated output for 1821 and a map of actual settlement for 1825 (Gentilcore, 1972a, p.25). Based on a variety of sources, this later map shows a close association of settlement with the Saint Lawrence and Lake Ontario shores. In addition, settlers are located along the Quebec border between the Saint Lawrence and Ottawa Rivers, north west of Prescott, along Yonge and Dundas Streets and are scattered throughout the south west. This pattern is similar in terms of the overall pattern to the 1821 simulation. The only basic feature of the actual pattern which is not present on the simulated output is the area north west of Prescott. This area is settled as a result of a number of group settlements, a factor not incorporated in the model structure.

V. <u>The Pattern for 1831</u>

The relatively simple patterns of earlier dates now begin to assume rather more complex forms. This results from the increasing numbers of settlers being located and the introduction, for the first time, of the potential variable.

Of the 276 surveyed townships, only 34 are without any settlers (Fig. 24). The majority of the newly settled

FIGURE 24: SIMULATED AGRICULTURAL SETTLEMENT, 1831, RUN 190



townships are in the previously ignored areas of the south west and the east. Otherwise, the tendency is towards increased core development and the settlement of townships close to urban centres outside of the original core areas.

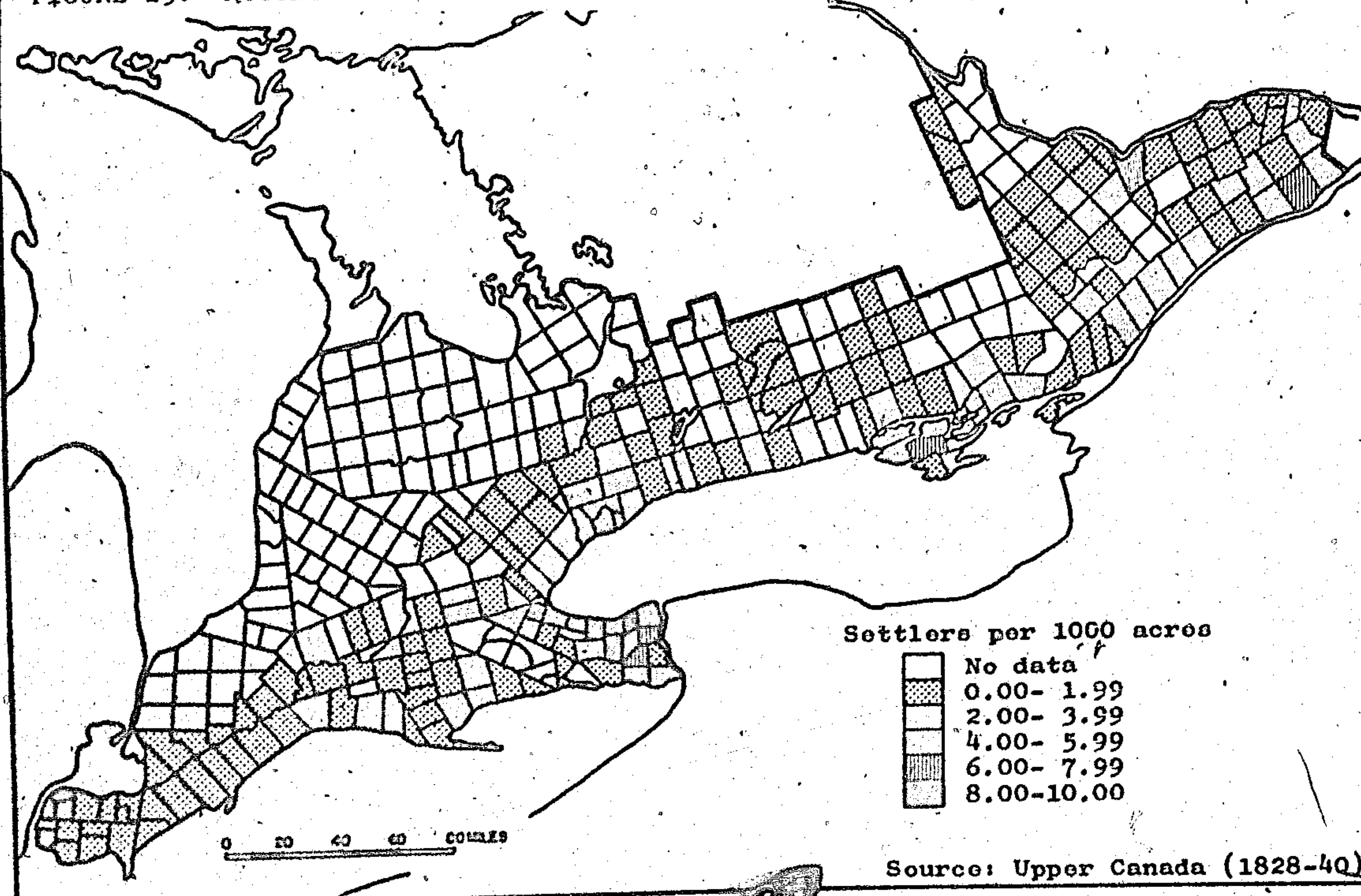
In an attempt to assess the simulated pattern for 1831, a map of the actual settlement pattern for this date is constructed from the limited available data (Fig. 25). The number of greater than ten acre occupiers is estimated for each township in the manner indicated on pp.76-77 of Chapter 4. It is emphasised that this map is based upon a relatively unreliable source, compared to the 1851 census and the data are incomplete.

The actual pattern has cores in the same areas as does the simulated pattern although the numbers in the cores are generally smaller. Also, Fig. 25 shows settlers more widely dispersed than is suggested by the simulation. Precise conclusions are not feasible but there are fundamental similarities between the simulated output and the actual data. This confirms that the developing settlement patterns prior to 1851 are fairly well replicated by the simulation; an important conclusion which further justifies the model structure employed.

VI. <u>The Pattern for 1841</u>

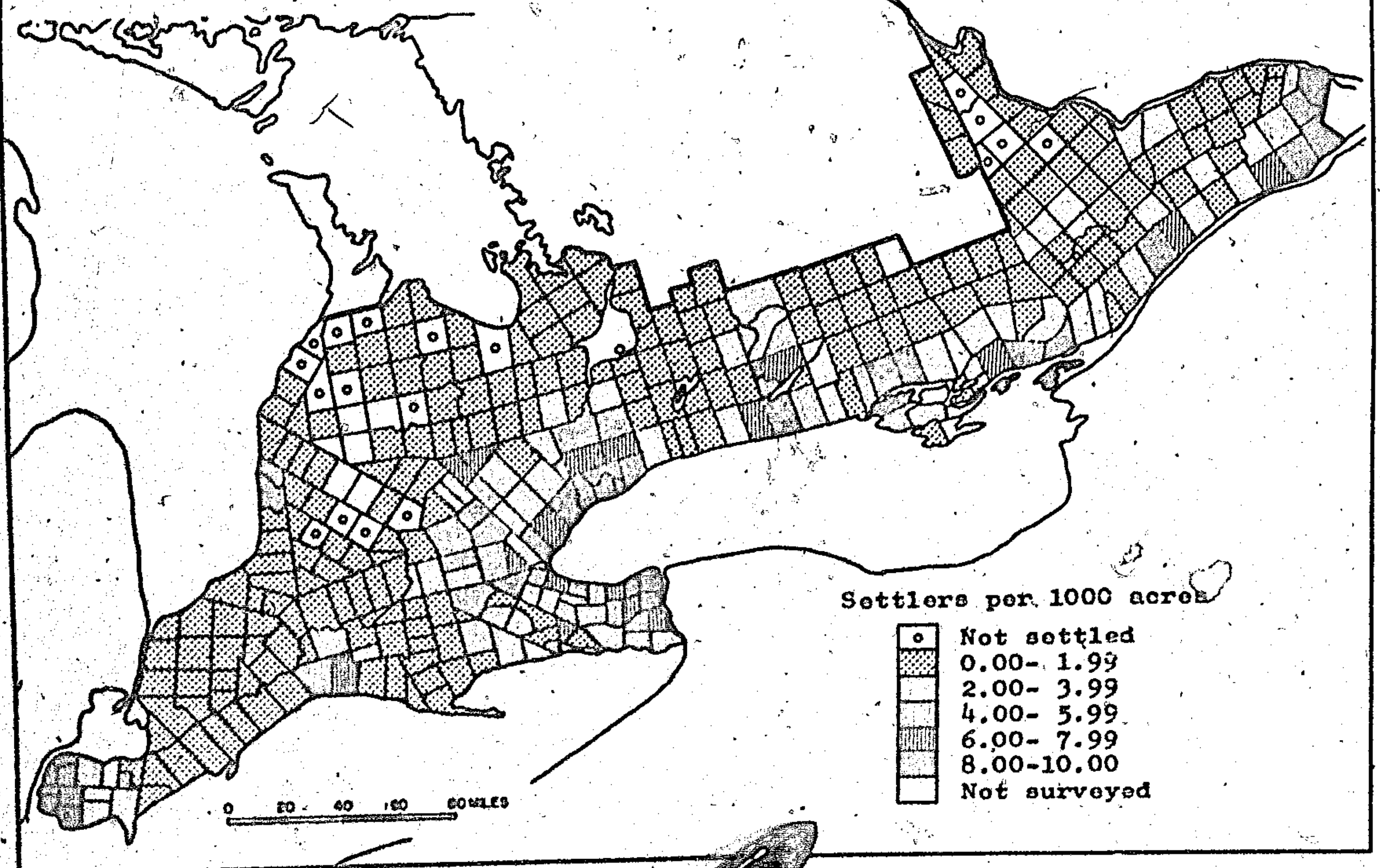
Rapid growth is the dominant feature after 1831. By 1841 there are 312 townships available and only 21 lack settlers (Fig. 26). The pattern develops along already

FIGURE 25: ACTUAL AGRICULTURAL SETTLEMENT, 1831



Source: Upper Canada (1828-40)

FIGURE 26: SIMULATED AGRICULTURAL SETTLEMENT, 1841, RUN 190



established lines; the principal axis of settlement continues to be the Lake Ontario and Saint Lawrence shores and there is a particular emphasis on the west end of the lake.

A general map showing the approximate limit of settlement for the years 1831 and 1841 is provided by Craig (1966, p.127). Comparing the simulated outputs to this map indicates that the model settles a far larger area than that suggested by Craig. For 1831, Craig has only limited settlement in the south west, settlers being located largely in the Lake Erie townships between Niagara and Long Point; there are no settlers north of York and there are substantial empty areas in the east. For 1841, Craig moves the frontier both north and west but again the simulation proposes a far larger settled area.

VII. The Pattern for 1851

During the final decade of the analysis, large numbers of settlers are located by the model in the south west and numbers also increase along the York - Quebec border axis (Fig. 16). Settlement numbers increase throughout the area. Of the 340 townships available by 1851 only one is without settlers.

VIII. Summary

The spread and growth of the simulated pattern may be summarised as follows.

(a) The first settlers locate in the vicinity of entry points, which are also among the few available areas.

(b) Settlement spreads beyond the entry points although the principal feature is a continuing growth near to entry points until 1821; there are many available but unsettled townships.

(c) Finally, during the later generations, the south west receives many settlers and, by mid-century, the York - London axis is important.

The above description based upon the simulated output of Run 190 represents one means by which a surface resembling the actual 1851 surface may have developed. Local inaccuracies are inevitable but it is the overall features of the series of patterns which are pertinent. The important and long lasting effects of entry points are confirmed. Also confirmed is the general idea that early settlement occurred along the lakeshores and the Saint Lawrence, with a subsequent spread both north and west. The simulation model settles the south west relatively late and the York - London axis is not evident by 1841. If the study area is divided into three zones, the east is settled first, the central area next and the west last.

B. Theoretical Expectations

The simulated spread of settlement is now compared to the available theoretical or ideal expectations. Whebell (1968 and 1969) proposes that settlement expansion is related to the existence of cores and corridors. Taking Upper Canada as an example, four initial cores are suggested; the Saint Lawrence shore, the Bay of Quinte, the Niagara Peninsula and the Detroit River. Subsequently, he postulates, the tendency is to spread inland from these four following the most attractive areas, with one major exception, the Rideau military settlements (north east of Kingston). A fifth core develops later at York. After 1791 two additional minor cores are proposed, west of Prince Edward County and at Long Point. These developments are regarded as empirical evidence for notions regarding the influence of cores and corridors.

There is a close correspondence between Whebell's (1968) maps of the location of the early and later cores and the appropriate simulation outputs, particularly with reference to the initial cores. The simulation fails to locate large numbers at either Long Point or west of Prince Edward County by 1811. Further, Whebell (1968, p.103) observes that, "there were of course settlers outside the areas here shown as cores but they were distributed sporadically". The simulation locates settlers outside of the cores. They are sporadic but do represent a substantial portion of the total population. It appears that there is little disagreement as to the location of cores but possibly varying ideas as to their importance in the area.

Using the terms introduced by Hudson (1969), Upper Canada prior to 1851 experienced a continuing process of colonisation, increasing in numbers with time. Spread is also occurring as the colonisation process leaves many empty areas behind the advancing frontier. However, the dominant process is colonisation with the majority of new settlers origininating from outside the area. For the two processes of colonisation and spread the corresponding spatial patterns are concentric circles and nebulae. On the basis of these postulates, the settlement of Upper Canada ought to be characterised by an early diffusion of settlement over a large area, followed by the development of specific cores resulting from the onset of the spread process. (Throughout, of course, Hudson is referring to rural settlement and not simply to the agricultural settlement considered here.) The simulated history of the area, on the basis of Run 190, is first a series of cores and then spread throughout the area. In general, the nebula development occurred first and is related to the process of colonisation, not spread.

To a considerable extent this disagreement is a consequence of the initial government control which restricted settlement to those areas later to become cores. Grossman (1971) discusses this possible sequence of development. Even without government control it is likely that the initial pattern would be one of cores, for reasons of defence. In a frontier area patterns might often assume a form designed to limit encroachment by neighbours. In Upper Canada all of the initial settled areas are along the United States border, and they reflect a desire by the British to establish a separate North American power.

The simulated patterns cannot fairly be compared to the theoretical suggestions of Bylund (1960), nor to the findings of Olsson (1968) as both of these authors are considering settlement by offspring.

C. The Variables

The hypotheses listed in Chapter 1 propose a number of variables responsible in part for the development of the 1851 pattern. These variables are incorporated into the model as input data and the resultant outputs enable an assessment of individual variables to be made. It is recognised that the relevance of variables might change through time and the historical research suggests appropriate time spans which are built into the model. This section, then, considers the role played by individual variables in the simulation runs. One must be aware of the dangers of circular reasoning in this context. The effect of a variable is of course related to the manner in which the variable is incorporated in the first place.

The analysis indicates that the pattern is a response to several variables. Exponent values are estimated and it is shown that the variables vary as regards sensitivity.

Least sensitive of the four variables is that for entry points. As regards the 1851 pattern, this variable is not critical. This is because entry points are not considered after 1821 when most of the settlers are located and because the entry point areas are favoured by the potential variable also. The variable is important, however, for the early stage outputs as it is responsible for the development of the core areas which retain their dominant positions throughout the period. The variable is formulated in such a way that all of the entry points are treated equally; this is an unreal assumption. The historical evidence indicates that the Detroit River entry point is important only at first and is probably the least important of all the proposed entry points. All of the entry points decline in relative importance with time (as entry points). As already noted, the number increases markedly by 1821 when, in fact, the Saint Lawrence and Lake Ontario shore might be regarded as one entry zone; also, as areas adjacent to entry points are settled, they begin to lose significance, and with the steady improvement in communications travel away from entry points is facilitated.

The land quality variable is more sensitive to exponent change. During the early years of settlement Gentilcore (1972b) notes that location was dependent upon the entry points and the availability of surveyed land. The stage outputs for Run 190 indicate that much of the better quality land is settled only after the initial migrations. This supports the view that the relevance of land quality increases through time.

The lot availability variable is the second most sensitive. Formulation of this variable assumes a linear relationship between the available lots and the township attractiveness; the fewer lots, the lower the attractiveness. This is possibly unrealistic as townships with a minimal number of lots remaining might prove very attractive as they represent available land within developed areas.

The potential variable is important to the 1851 outcome and proves the most sensitive variable. It is not included during that period when the entry points variable is operating. The 1851 pattern for Run 190 shows clearly the consequences of the potential variable with areas of high density related to inland market centres.

The sequence of results detailed in Chapter 5 indicates, then, that all four variables are appropriate. Also important are the dates of survey and the inclusion of a limit of one settler per 100 acres.

D. The Effects of Wholesale Squatting

This section discusses the effects of removing the date of survey restrictions and allowing all 347 townships to be settled at all times. Run 190 is repeated (190a) with this change and the resulting r value is 0.6978 and the s.d. is 203. Fig. 27 shows that the distribution of the density classes is very similar to that for Run 190 (Fig. 18). Thus, the essential result appears unaffected by this change to the model input. A comparison of the appropriate 1851 maps follows and serves to emphasise this conclusion.

It is likely, however, that the development of the 1851 simulated patterns is different, although the end products are similar. In order to investigate this possibility, maps are compiled for ten year intervals to be compared to the corresponding maps for Run 190. It is possible, that, by allowing settlement in all townships at all times, the patterns may be equivalent to those which may have developed without any administrative restrictions upon location choice, such as legalised squatting, or with all townships surveyed by 1782.

Fig. 28 shows the resulting pattern for 1791 and although some cores are developing, notably at the Quebec border, the pattern is quite different to that shown by Fig. 20 (Run 190, 1791). More townships are settled and the pattern is quite scattered. This situation is further developed in 1801 with Fig. 29 (Run 190a) indicating many more settled townships than does Fig. 21 (Run 190). This situation continues through until 1821 as indicated by comparisons of Fig. 30 (Run 190a) and 22 (Run 190) for 1811, and Fig. 31 (Run 190a) and 23 (Run 190) for 1821. In 1821 the distribution of core areas and their relative importance

FIGURE 27: HISTOGRAM OF SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 190a

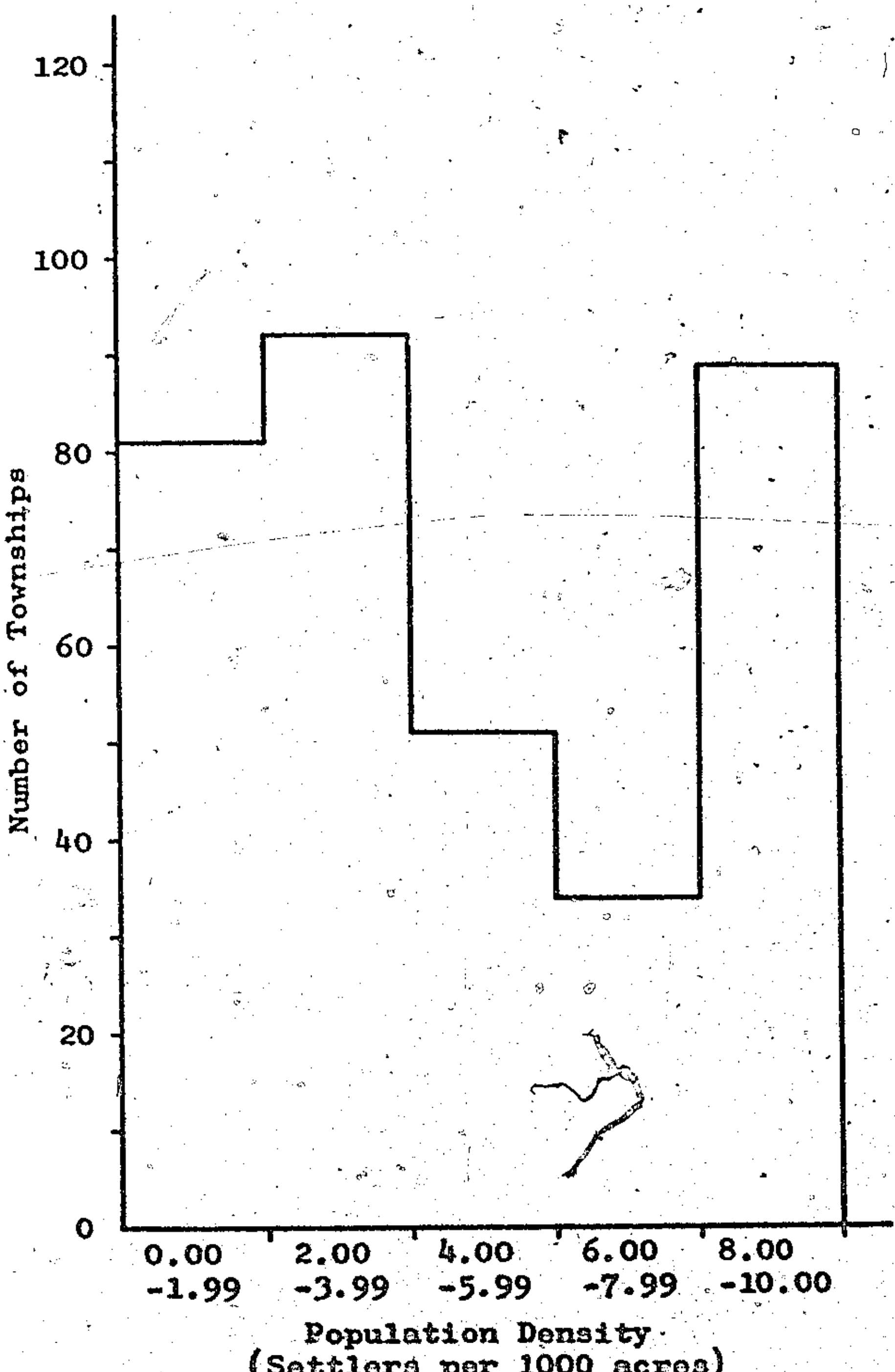


FIGURE 28: SIMULATED AGRICULTURAL SETTLEMENT, 1791, RUN 190a

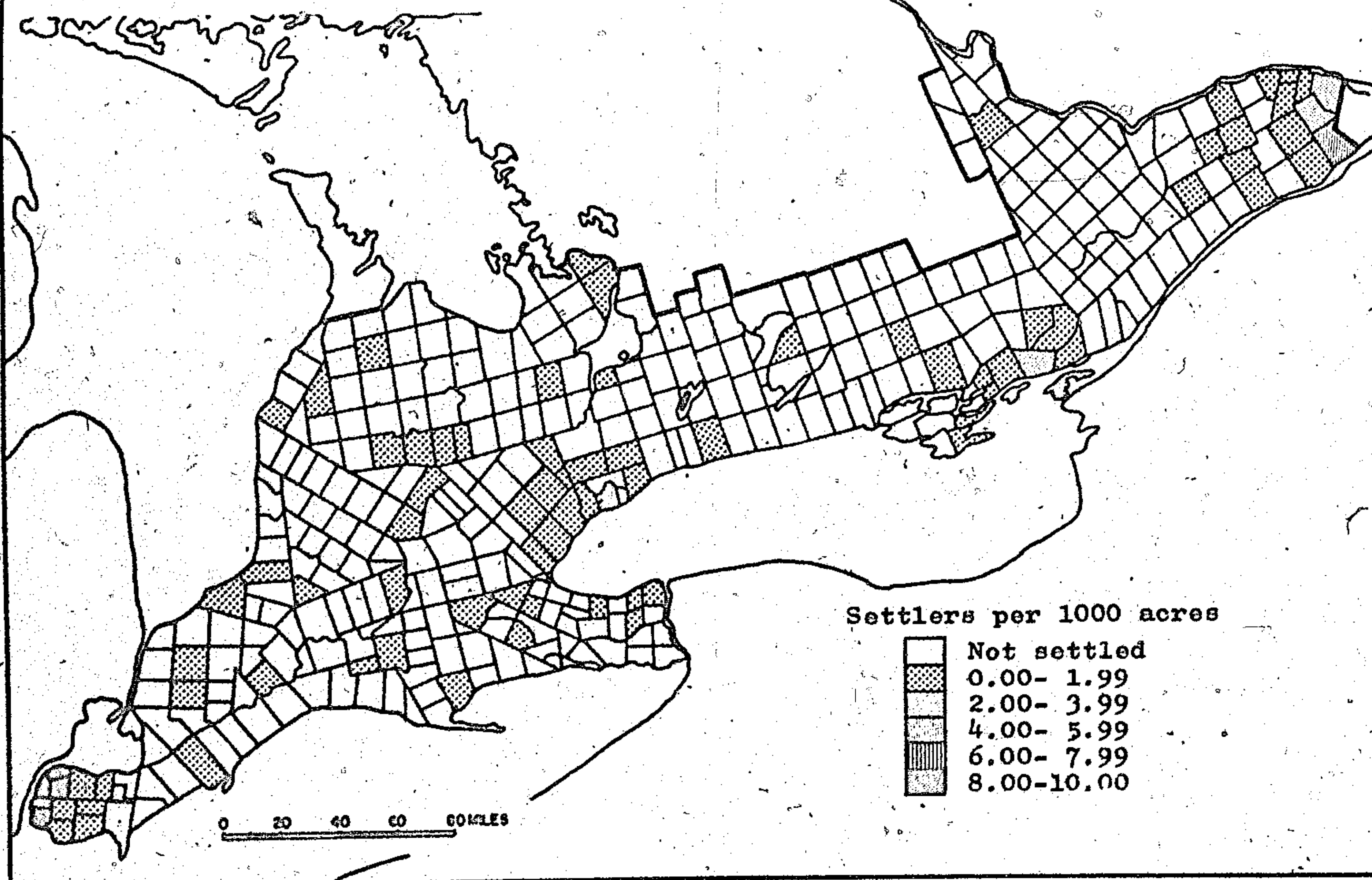


FIGURE 29: SIMULATED AGRICULTURAL SETTLEMENT, 1801, RUN 190a

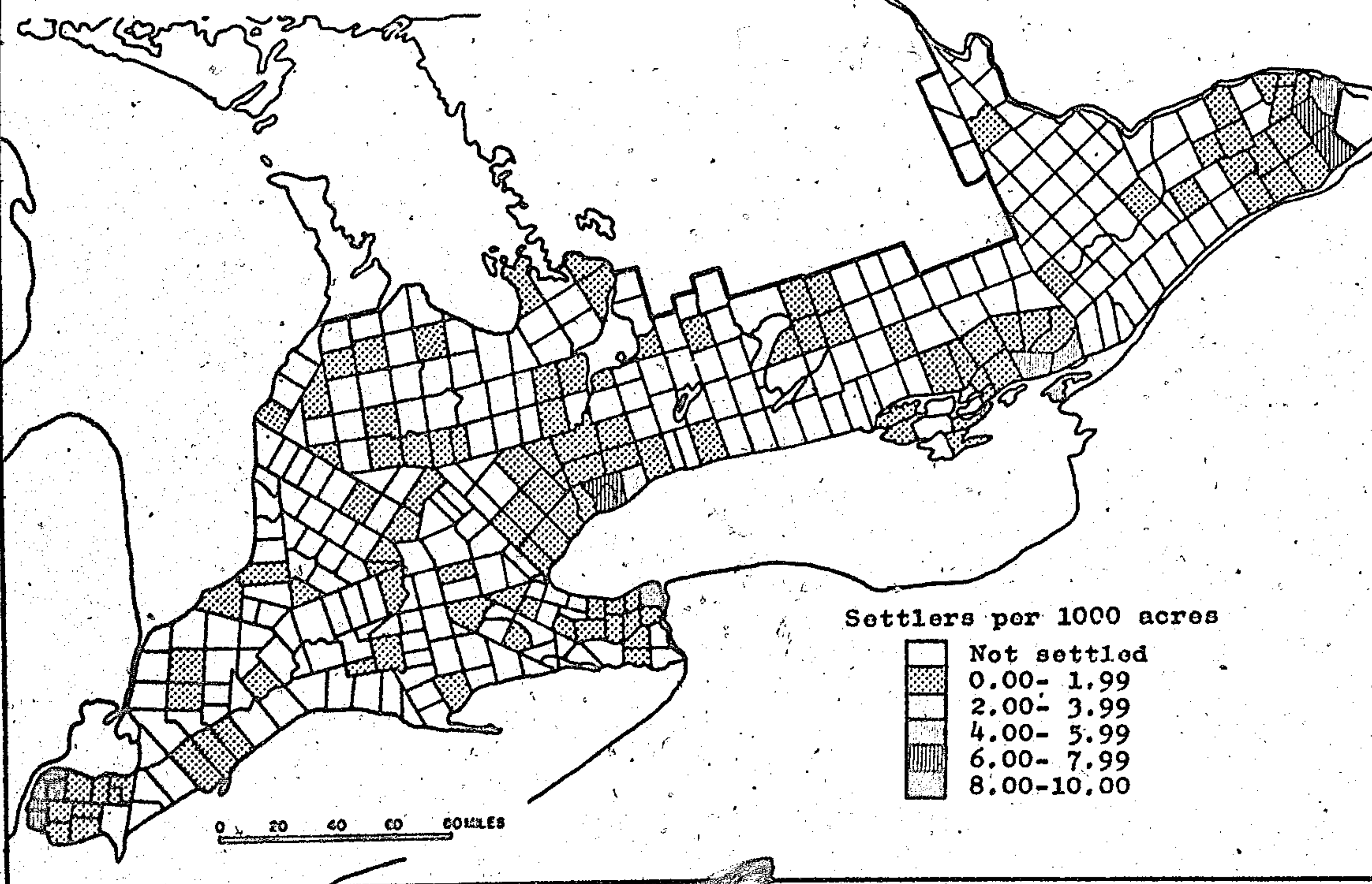


FIGURE 30: SIMULATED AGRICULTURAL SETTLEMENT, 1811, RUN 190a

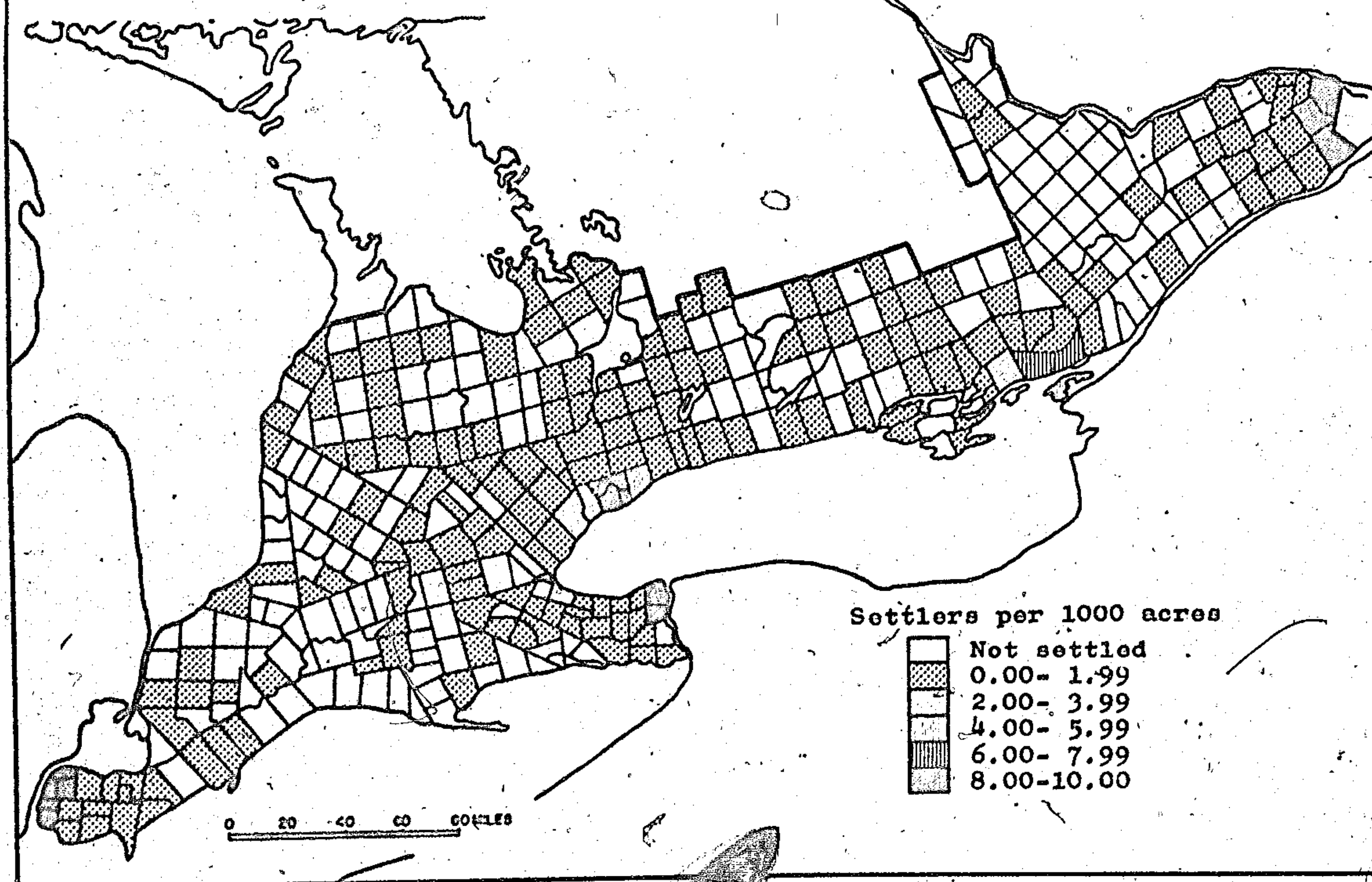
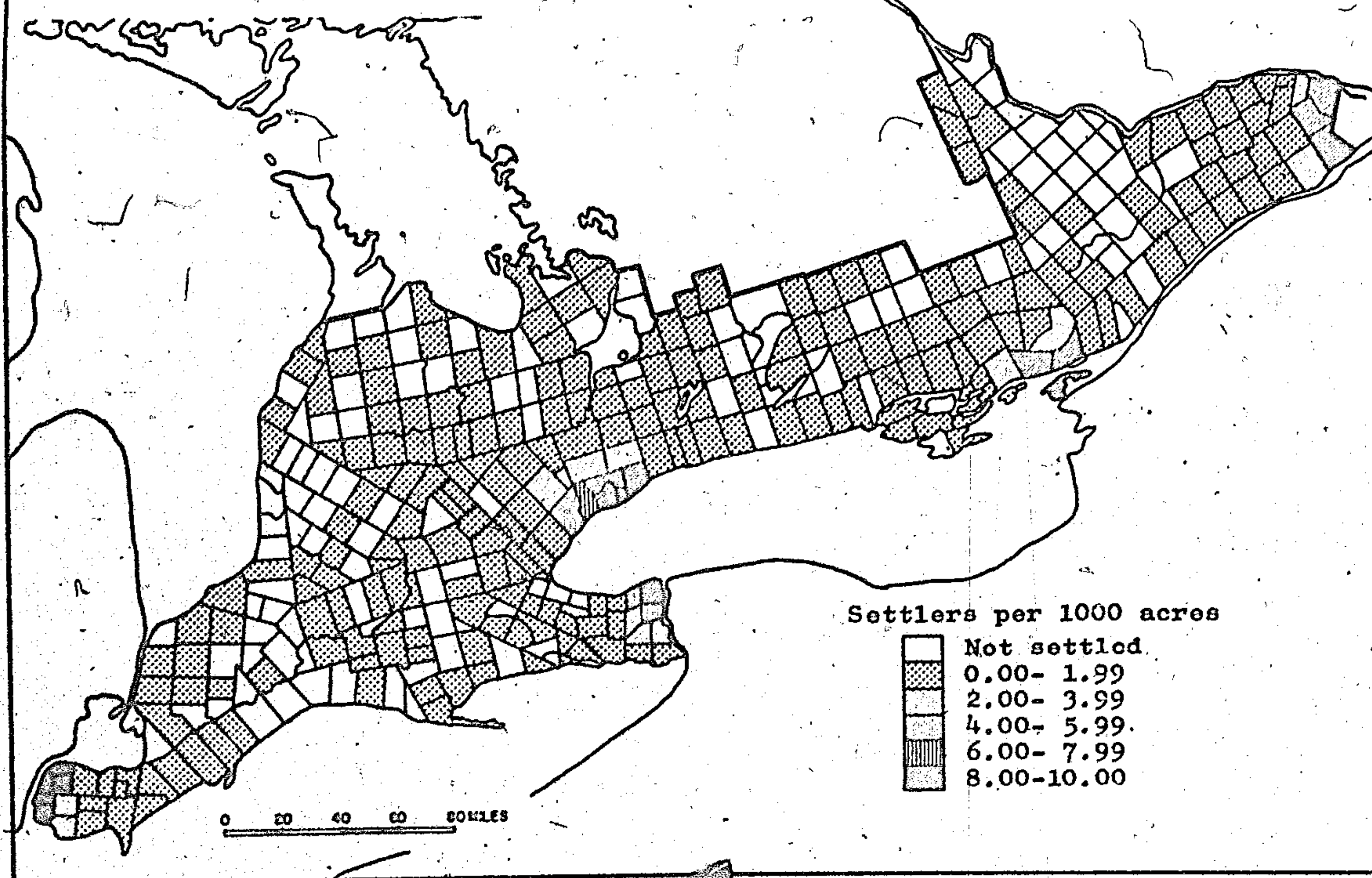


FIGURE 31: SIMULATED AGRICULTURAL SETTLEMENT, 1821, RUN 190a



are quite similar but the location of settlers outside of these cores remains dissimilar with Run 190a indicating a much more general development.

This situation continues through until 1831 (Fig.32, Run 190a and Fig. 24, Run 190). By 1841 the two patterns are beginning to approach each other (Fig. 33, Run 190a and Fig. 26, Run 190). Finally, in 1851, it is not possible to make any significant comparisons; Figs. 34 of Run 190a and 16 of Run 190 are quite similar and might very well have been the outcome of identical model formulations with only different random numbers causing distinctions.

This result suggests that, given complete freedom as to location the intermediate outputs are quite different to those with spatial restrictions imposed. For Upper Canada it is known that the 1791 pattern of settlement is closely related to the available surveyed land, but it is possible that, after the introduction of fees and the cancellation of free supplies, appreciable squatting did occur. Because the assumption of free location choice is known to be unreal, the result of Run 190a represents the consequences of a counter-factual argument.

It is important to recognise that this result might also apply to other model formulations. An analysis of runs producing 1851 outputs similar to the 1851 pattern for Run 190 might show analogous results, that is, the stage patterns varying from those of Run 190. For example, Run 110, may have a similarly 1851 pattern to that of Run 190, yet this does not imply that the patterns produced by the two runs are similar throughout the development of the theoretical pattern.

FIGURE 32: SIMULATED AGRICULTURAL SETTLEMENT, 1831, RUN 190a

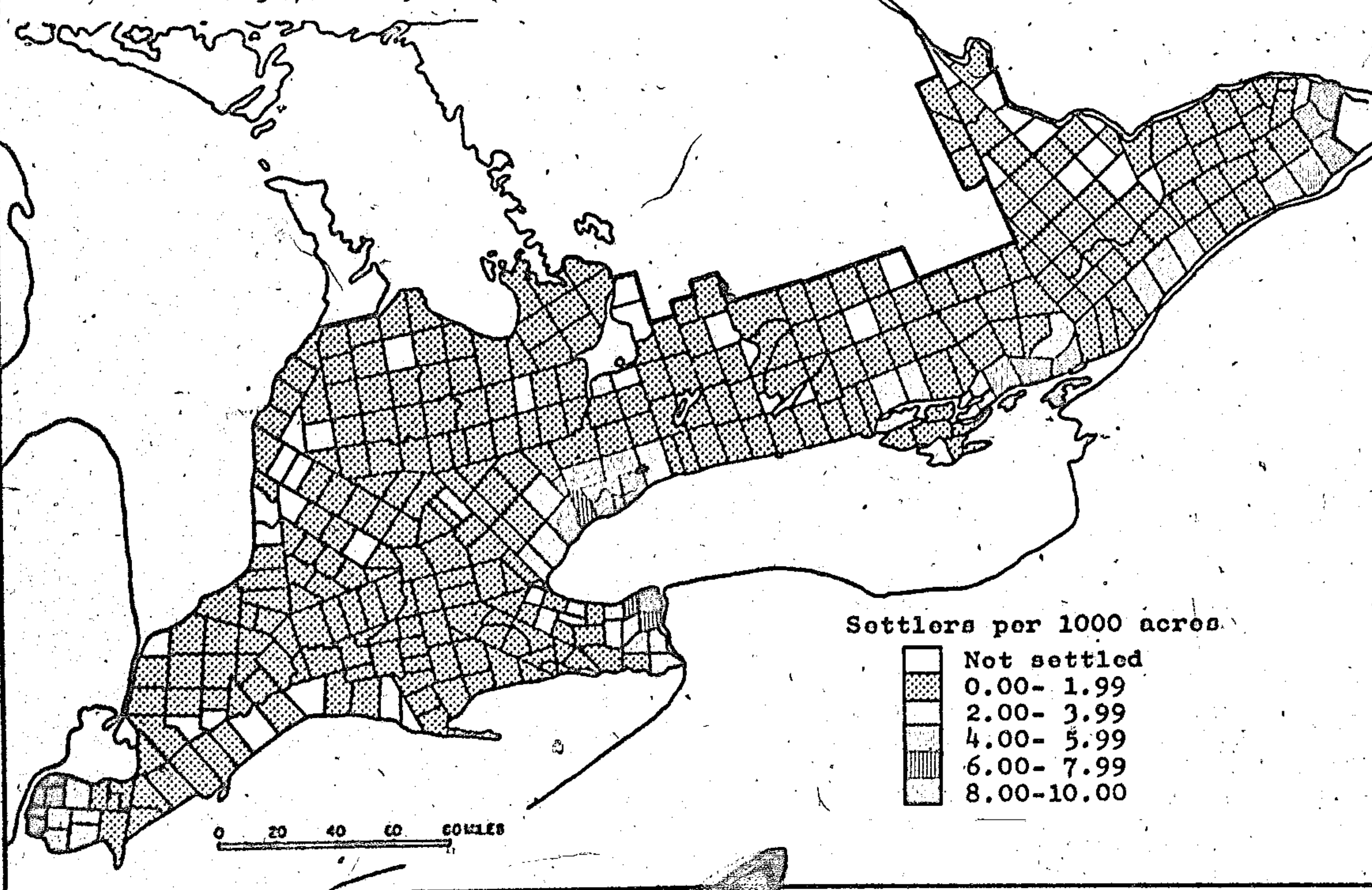


FIGURE 33: SIMULATED AGRICULTURAL SETTLEMENT, 1841, RUN 190a

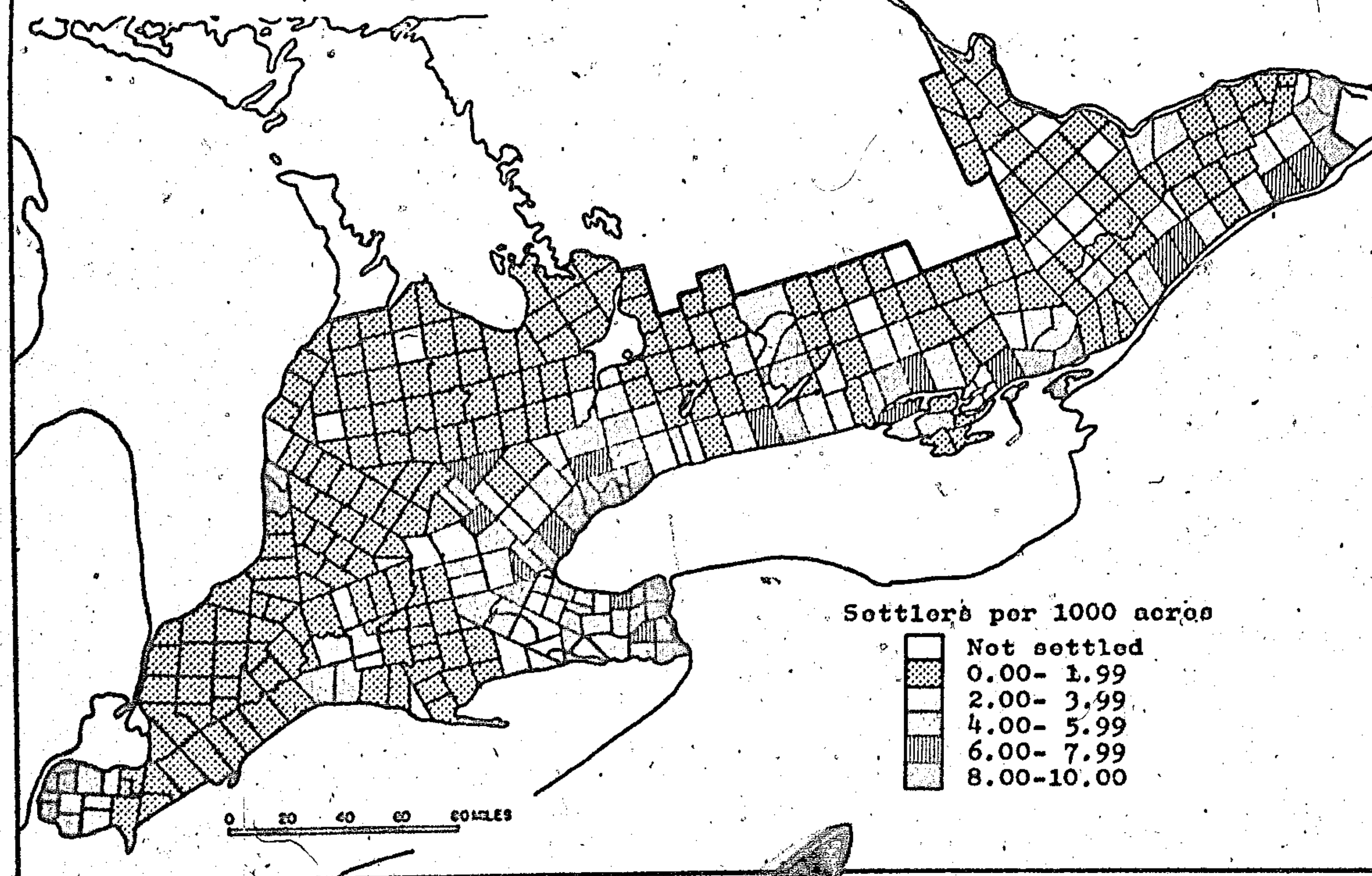
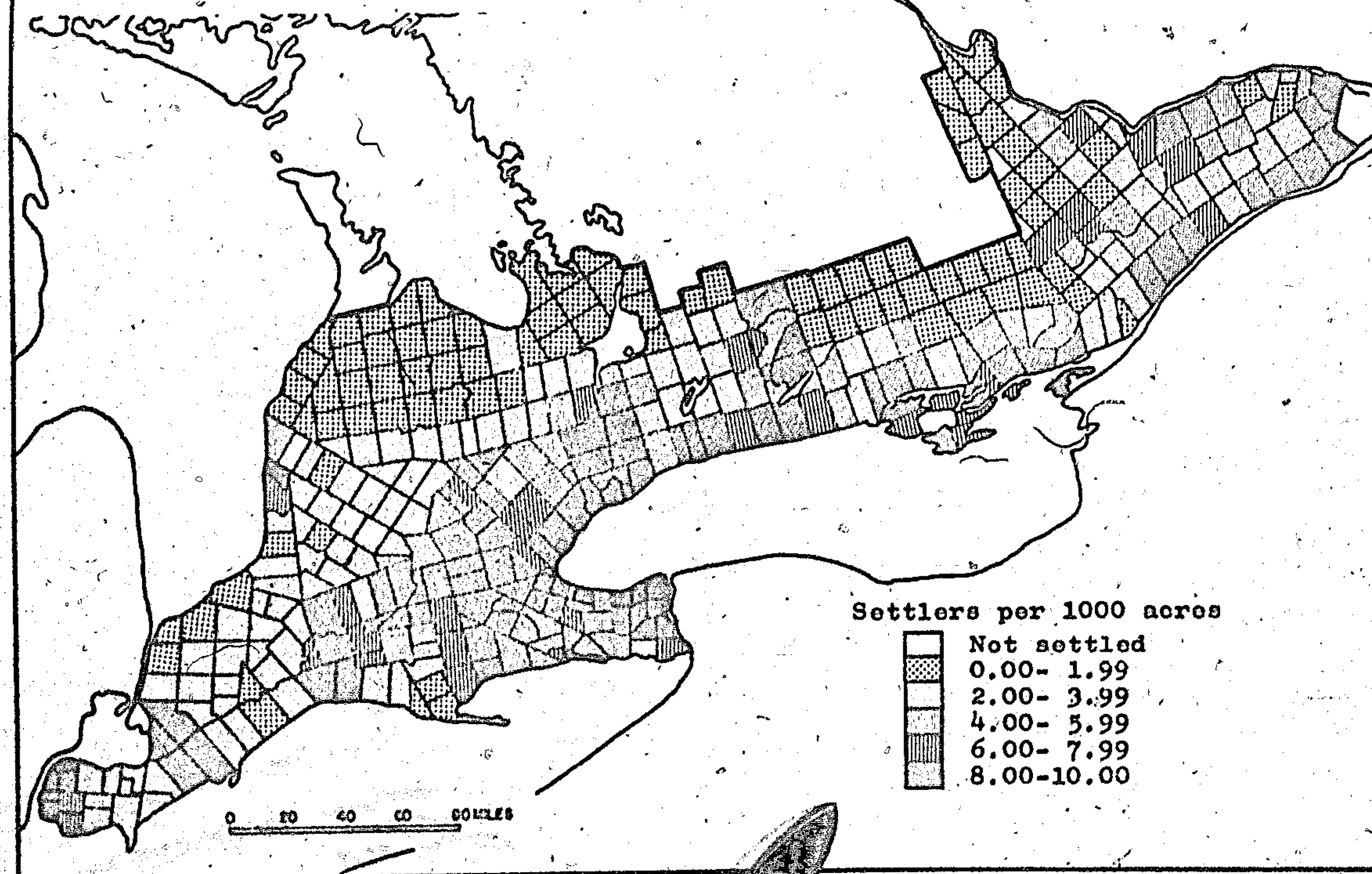


FIGURE 34: SIMULATED AGRICULTURAL SETTLEMENT, 1851, RUN 190a



CHAPTER 7

CONCLUSION

The merits of a temporal explanation of past spatial patterns are evident. Any study of the farming settlement pattern of Upper Canada cannot be satisfactorily accomplished by reference only to the conditions prevailing at the time. It is not essential to refer to the ultimate origins of the pattern, although such an approach is valuable for this study which considers a sufficiently short span of time.

In this research a specific historical problem is examined - the isolation of variables related to the settlement process and the construction of settlement patterns. A model is developed and used to simulate patterns which are then compared to the real pattern for 1851. The model is a technique, a method of approach, that permits the following aims to be pursued: first, the principal variables are isolated; second, exponent values are estimated for each variable and the variables are ranked in terms of sensitivity; third, patterns for years between 1782 and 1851 are presented and possible sequences of development outlined;

fourth, the patterns resulting from particular processes are outlined. A principal advantage of this approach is the ease with which the consequences of alternative assumptions are indicated. An intensive historical study may provide greater detail of the settlement process but would be oriented rather differently. If the principal concern had been the recognition of as many variables as possible and the production of local detail, such an approach would have been appropriate.

A. Summary Remarks Relating to the Variables

Inevitably the 1851 pattern of actual settlement is not fully explained. There remain areas of discrepancy between the real pattern and the best approximations to the real pattern. Much of this difference is related to the multitude of local variables and conditions which the model, as a simplification of the process, cannot consider. Statistically, with a maximum mean r value of 0.7012, 49.2 per cent of the variation between the real and simulated 1851 patterns is "explained". Given the few variables employed and the recognition that many local variables were important, this is a satisfactory result. In addition, the visual comparison of simulated and real maps indicates that reasonable approximations of the real pattern are achieved. The analysis in Chapter 5 permits the following conclusions.

1. The following ranking of exponents is possible:

Variable	Exponent Value
Entry points	b = 1.5
Land quality	c = 1.5
Availability	a = 1.0
Potential	d = 1.5

Use of these four values as input to the simulation model results in the highest mean r value (Run 190). Comparison with other high mean r values confirms this ranking and shows that b, the exponent for the entry point variable, is quite inconsistent.

2. With respect to sensitivity, the variables are ranked as follows:

Rank	Exponent	Variable
first	d	Potential
second	a	Lot availability
third	c	Land quality
fourth	b	Entry points

3. Distance from market, the potential variable, is assumed to be relevant from 1822 onwards. Proximity to market is significant although it may be several years before a settler is able to produce a surplus and, at first, this surplus may be sold to recent settlers located nearby.

4. The lot availability variable appears to be relevant throughout.

5. Land quality is a variable influencing location and it appears that the relevance of this variable increases through time.

6. Entry points are important at first with initial settlement occurring in their immediate vicinity. However, as these are the only available (surveyed) lands and, as the entry points also represent markets, the early patterns reflect several factors.

B. Agricultural Settlement Patterns, 1782-1851

1. Initial settlement reflects the availability of townships (Fig. 20).

2. The pattern begins as a series of cores and subsequently develops throughout the area, emphasising several of the early cores (Figs. 21, 22 and 23).

3. Patterns are simulated for 1821 and 1831 which correspond generally to those derived from available data. This suggests that the sequence of development outlined is appropriate.

4. The simulated pattern for 1841 (Fig. 26) suggests that the York - London axis did not develop until the final decade.

5. Speculation aside, the data for township survey suggest that ample land was available at all times. The stage outputs for Run 190 indicate a surplus of locations given the number of settlers.

C. Outcome of Alternative Processes

Several of the results reported represent the consequences of unrealistic assumptions regarding the settlement process. Generally, the resulting patterns are unrealistic as, for example, when all of the exponents are 0.0 (Run 1). In one instance it is shown that similar patterns result from different processes. The simulated 1851 pattern resulting from a model which includes only available townships (Run 190) and the pattern from a model including all townships throughout (Run 190a) are similar. This does not apply to the earlier patterns.

D. Some Limitations of the Analysis and Suggestions for Further Research

This model based approach to a problem in historical geography necessarily has some deficiencies. The settlement process is related to a few conditions. No attempt is made to include any local or minor variables which far ranging historical research might discover. However, many of the local variables serve to locate people within townships which is not a consideration in this study where the unit of analysis is the township itself.

The model is not always able to distinguish between variables. It is possible that the entry point variables included reflect the attraction of a market. Again, the attraction of one town, York, is related not only to the entry point and the town itself, but to its role as the capital of Upper Canada, a factor not included in the model.

The existence of a second institutional control -

the selection of first surveyed lands - compels the entry points to be important early areas. The choice of surveyed land, in turn, reflects the previous location of military establishments.

The role played by varying perceptions of townships is unclear. It appears that, if a township is publicised, it is by definition in a well settled area and, therefore, already favoured in the model structure. A fuller consideration of the whole question of the perceived world of the settler is required. Given the plight of many settlers on arrival in Upper Canada, perception is bound up closely with a desire for a home and land; the location is not considered. The failure to include group settlement schemes in the model results in the simulated 1821 and 1831 patterns (Figs. 23 and 24) not replicating the settlement of the area north east of Kingston in the vicinity of the Rideau Canal.

Despite some deficiencies, the model presented in this study merits application elsewhere. Although the specific model structure (see Appendix 2) is related to Upper Canada, the basic form is sufficiently general to warrant application elsewhere and for other time periods. The conclusions regarding exponent values require testing elsewhere. The model is suited to problems involving a span of time during which settlement is occurring, prior to the availability of adequate data sources for historical reconstruction. It may be possible to amend the model in order to consider all rural settlement. Further analyses of the type embodied in this study might eventually contribute to the formation of a valid theory of rural settlement location.

APPENDIX 1

DATA SOURCES

A. Canada Company Papers

Registers of Land. 18 volumes (1-18).

Vol. 1-3: Canada Company. Topographical Register of the Huron Tract. These volumes include descriptions and registers of town and township lot sales, 1827-1923. Give the location, acreage, date of sale and price. Record of the disposal of the company lands.

Vol. 13: Canada Company, Register of Lands, Eastern, Ottawa, Johnstown, Midland, No. 1. Gives acreage of crown and clergy reserves, 1827-1880.

Vol. 14: Bathurst, Home, Western (same as Vol. 13).

Vol. 15: Newcastle, Gore, Niagara, London (same as Vol. 13).

Registers of Contracts. Volumes 19-28.

Vols. 24-26: Canada Company. Register of Contracts. These volumes give crown reserve sales, 1827-82.

Registers of Leases. Volumes 29-41.

Vol. 29: Register of Leases. Huron Tract. 1842-68.

Vol. 34: Canada Company. Register of Leases. Crown Reserves. 1843-53.

Registers of Undisposed Land. Volumes 111-114.

Vol. 112: Register of Lands Undisposed, 31st Dec. 1845. All lands.

B. Crown Land Papers

Series A.

A-I. 4. Vol. 2: Letter Book Regarding Emigration, 1832-33.

A-I. 4. Vol. 9: Letter Book Regarding Crown Lands, 1836-40.

A-I. 7. Box 10: Military grants and settlement.

A-I. 7. Box 11: Regulations and orders regarding grants and sales.

A-I. 7. Boxes 16-18: Settlement.

A-I. 7. Box 19: Squatters.

A-II. 1. Vol. 8: Reports to Commissioner of Crown Lands, 1830-36.

A-II. 1. Vol. 11: Sundry Reports, 1788-1831.

A-II. 2. Vol. 1: Reports on petitions for land grants, 1832-35.

A-II. 3. Vol. 1: Appendix to the report on Owen Sound Settlement, 1845.

A-II. 6. Vol. 1: Statement of leases, 1811.

A-II. 6. Vol. 4: Returns of lands sold and granted, 1823-38.

A-II. 6. Vol. 7: Statement of clergy reserves sold, 1829-41.

A-II. 6. Vol. 8: Ungranted lands, 1829-34. Annual Reports.

A-II. 6. Vol. 17: Crown Lands sold in Upper Canada, up to 1841.

A-II. 6. Vol. 18: Clergy reserves sold in Upper Canada, up to 1841.

A-IV. Vol. 27: Vacant crown lands, 1861.

A-IV. Vol. 31: Lands located and sold in Seymour township, 1823-32.

A-IV. Vol. 45: Vacant lands, various districts and countries, 1828-68.

A-IV. Vol. 50: Vacant lots for sale, 1833-50.

A-IV. Vols. 53-54: Crown lands in Upper Canada, c.1837.

A-IV. Vol. 56: Lands in Upper Canada. Contents of each township of crown and clergy reserves, quantity granted and vacant, 1838.

A-IV. Vol. 61: School lands, 1841.

A-IV. Vol. 65: Squatters in Erin township, 1850.

A-V. Box 17: Miscellaneous.

A-VI. Inspection and Valuation reports, 1822-1913.

A-VII. Vol. 43: Township index, Canada West, 1851.

Series B.

B-III. Vol. 14: Statement of clergy land sold and cash received, 1829-35.

B-III. Vol. 15: Statement of crown land sold and cash received, 1829-32.

B-III. Vol. 20: Crown lands sold in Brock district, 1833-41.

B-III. Vol. 25: Statements on sales of school land, 1840.

B-III. Vol. 35: Lands leased and sold up to 1853.

Series C.

C-I. 1. Vols. 65-66: Registers of applications for specific lots, 1828-42.

C-I. 2. Vol. 8: Orders in Council.

C-I. 4. Vols. 1-4: Registers of locations, 1800-19.

C-I. 4. Vol. 5: Schedule of locations, 1816-28.

C-I. 4. Vol. 6: Register of locations, 1835-37.

C-I. 7. Vol. 3: Index to description.

C-III. 1. Vol. 5: Collection of notices of land sales, 1828-72.

C-III. 2. Vol. 4: Applications for crown lands in Thorah and Eldon townships, 1830.

C-III. 4. Vol. 3: Sale of crown lands in Tyendaga township, 1833-35.

C. C.O. 42, Canada, Original Correspondence, 1700-1909

Vol. 82: Quebec, 1791, June-July.

Vol. 320: Upper Canada, 1795-96.

Vol. 338: Upper Canada, 1805, August Enclosures.

Vol. 460: Upper Canada, 1839, June despatches.

Vol. 377: Upper Canada, 1826, January-June despatches.

Vol. 411: Upper Canada, 1832, despatches.

Vol. 391: Upper Canada, 1830, despatches.

Vol. 418: Upper Canada, 1834, January-April despatches.

Vol. 423: Upper Canada, 1834, August-December despatches.

Vol. 429: Upper Canada, 1836, January-April despatches.

Vol. 420: Upper Canada, 1834, Returns of sales of clergy reserves and crown lands, 1828-32.

Vol. 421: Upper Canada, 1834, Returns of patents for clergy reserve lands, 1823-33.

Vol. 422: Upper Canada, 1834, Returns of grants and appropriations of crown lands without purchase, 1823-33.

D. Records of the Society for the Propogation of the Gospel. The Journals, 1701-1850.

Vols. 1-50, with appendices A-D.

Appendix A: Includes (a) Number of Protestants in Canada, 1783. (b) Account of Canada by J. Doty, 1783. (c) A Report of the Special Committee regarding Canada and Nova Scotia.

Appendix D: Religious statistics for Upper Canada, 1837.

E. Journals of the Legislative Assembly

Census material available, 1824-50 in appendices.
Assessment material available, 1825-48 in appendices.
(omissions in both sources)

APPENDIX 2

APPLICATION OF THE SIMULATION MODEL

1. Division of the study area into areal units.

2. Division of the time period into generations. Immigration data are necessary for each generation.

3. Statement of variables to be incorporated into the model. Data are required for each variable for each areal unit.

4. Calculation of a measure of attractiveness for each areal unit on the basis of the hypothesised variables.

5. If desired, the number of areal units in each generation can be determined prior to the calculation of attractiveness values.

6. Calculation of a single probability for each areal unit. This is based upon the attractiveness values and is interpreted as the likelihood of an areal unit receiving a settler.

7. The probabilities are cumulated to equal one.

8. Corresponding random numbers are assigned to each areal unit.

9. Random numbers are now generated, as many as there are settlers, and locations in the appropriate areal units occur.

10. The simulated pattern is recorded at the end of each generation.

The procedure of attractiveness and probability calculation is incorporated into one computer program. The program proceeds to simulate patterns and to produce the results of statistical comparison between final simulated and actual patterns. Additional features are easily incorporated into this one program; such as a maximum permissible density. The program used by the author is written in Fortran IV and copies are available on request.

APPENDIX 3

DETAILS OF THE 256 SIMULATION RUNS

Run	Exponent Values				Classes					r	s.d.
	a	b	c	d	0.00 1.99	2.00 3.99	4.00 5.99	6.00 7.99	8.00 +		
1	0.0	0.0	0.0	0.0	21	104	104	48	70	.4157	77
2	0.0	0.0	0.0	0.5	97	70	35	23	122	.6570	200
3	0.0	0.0	0.0	1.0	131	45	21	13	137	.6320	256
4	0.0	0.0	0.0	1.5	144	29	20	12	142	.6178	266
5	0.0	0.0	0.5	0.0	18	95	117	40	77	.4228	79
6	0.0	0.0	0.5	0.5	97	70	38	20	122	.6653	207
7	0.0	0.0	0.5	1.0	134	41	22	13	137	.6266	257
8	0.0	0.0	0.5	1.5	143	27	23	10	144	.6296	268
9	0.0	0.0	1.0	0.0	32	89	101	45	80	.4389	96
10	0.0	0.0	1.0	0.5	95	70	37	22	123	.6727	211
11	0.0	0.0	1.0	1.0	132	42	24	12	137	.6327	256
12	0.0	0.0	1.0	1.5	140	37	15	10	145	.6281	269
13	0.0	0.0	1.5	0.0	37	84	94	48	84	.3827	109
14	0.0	0.0	1.5	0.5	96	76	37	12	126	.6738	214
15	0.0	0.0	1.5	1.0	128	44	21	20	134	.6377	253
16	0.0	0.0	1.5	1.5	140	39	10	12	146	.6303	271
17	0.0	0.5	0.0	0.0	20	107	101	47	72	.3991	85
18	0.0	0.5	0.0	0.5	98	74	30	28	117	.6642	207
19	0.0	0.5	0.0	1.0	131	42	27	11	136	.6196	257
20	0.0	0.5	0.0	1.5	142	37	15	6	147	.6254	269
21	0.0	0.5	0.5	0.0	17	106	105	48	71	.5109	84
22	0.0	0.5	0.5	0.5	99	72	33	22	121	.6661	209
23	0.0	0.5	0.5	1.0	139	32	24	12	140	.6339	259
24	0.0	0.5	0.5	1.5	142	31	21	9	144	.6419	269
25	0.0	0.5	1.0	0.0	30	95	90	49	83	.4477	99
26	0.0	0.5	1.0	0.5	106	64	33	15	129	.6681	216
27	0.0	0.5	1.0	1.0	129	45	21	12	140	.6384	258
28	0.0	0.5	1.0	1.5	141	40	13	8	145	.6369	268
29	0.0	0.5	1.5	0.0	39	80	101	47	80	.4219	109
30	0.0	0.5	1.5	0.5	101	63	41	19	123	.6646	215
31	0.0	0.5	1.5	1.0	132	42	24	9	140	.6402	256
32	0.0	0.5	1.5	1.5	140	36	16	7	148	.6227	271
33	0.0	1.0	0.0	0.0	17	121	93	33	72	.3985	87
34	0.0	1.0	0.0	0.5	102	71	29	22	123	.6494	214
35	0.0	1.0	0.0	1.0	133	45	19	12	138	.6311	258
36	0.0	1.0	0.0	1.5	145	31	14	12	145	.6347	270
37	0.0	1.0	0.5	0.0	17	110	98	47	75	.4493	89
38	0.0	1.0	0.5	0.5	98	73	32	21	123	.6784	211
39	0.0	1.0	0.5	1.0	133	46	18	11	139	.6368	258
40	0.0	1.0	0.5	1.5	145	30	17	10	145	.6352	269
41	0.0	1.0	1.0	0.0	33	95	88	50	81	.4421	100
42	0.0	1.0	1.0	0.5	99	69	37	15	127	.6537	215

Run	Exponent Values a	b	c	d	Classes 0.00–1.99	2.00–3.99	4.00–5.99	6.00–7.99	8.00 +	r	s.d.
43	0.0	1.0	1.0	1.0	134	43	20	11	139	.6323	259
44	0.0	1.0	1.0	1.5	141	38	13	7	148	.6373	271
45	0.0	1.0	1.5	0.0	37	95	84	51	80	.4052	111
46	0.0	1.0	1.5	0.5	102	64	41	13	127	.6641	215
47	0.0	1.0	1.5	1.0	138	33	22	15	139	.6411	257
48	0.0	1.0	1.5	1.5	140	37	16	6	148	.6348	273
49	0.0	1.5	0.0	0.0	18	116	105	34	74	.3802	87
50	0.0	1.5	0.0	0.5	98	68	36	23	122	.6562	209
51	0.0	1.5	0.0	1.0	130	46	21	11	139	.6363	259
52	0.0	1.5	0.0	1.5	141	35	21	5	145	.6237	270
53	0.0	1.5	0.5	0.0	21	109	101	39	77	.3941	94
54	0.0	1.5	0.5	0.5	106	60	37	20	124	.6652	213
55	0.0	1.5	0.5	1.0	133	46	18	12	138	.6336	258
56	0.0	1.5	0.5	1.5	141	34	17	9	146	.6324	270
57	0.0	1.5	1.0	0.0	34	102	86	43	82	.4092	109
58	0.0	1.5	1.0	0.5	102	66	33	24	122	.6640	213
59	0.0	1.5	1.0	1.0	139	38	18	9	143	.6301	262
60	0.0	1.5	1.0	1.5	142	38	9	11	147	.6349	272
61	0.0	1.5	1.5	0.0	40	88	93	41	85	.4083	117
62	0.0	1.5	1.5	0.5	100	70	36	10	131	.6695	219
63	0.0	1.5	1.5	1.0	137	39	17	15	139	.6535	257
64	0.0	1.5	1.5	1.5	145	34	12	7	149	.6359	273
65	0.5	0.0	0.0	0.0	4	93	172	56	22	.4662	92
66	0.5	0.0	0.0	0.5	84	86	41	39	97	.6535	210
67	0.5	0.0	0.0	1.0	118	67	22	16	124	.6456	255
68	0.5	0.0	0.0	1.5	142	33	24	13	135	.6315	267
69	0.5	0.0	0.5	0.0	14	86	153	69	25	.5445	92
70	0.5	0.0	0.5	0.5	90	71	55	26	105	.6819	206
71	0.5	0.0	0.5	1.0	126	52	23	22	124	.6472	256
72	0.5	0.0	0.5	1.5	143	33	22	12	137	.6347	267
73	0.5	0.0	1.0	0.0	15	95	134	67	36	.4749	103
74	0.5	0.0	1.0	0.5	91	74	52	23	107	.6877	208
75	0.5	0.0	1.0	1.0	129	54	24	13	127	.6484	254
76	0.5	0.0	1.0	1.5	139	39	17	12	140	.6336	269
77	0.5	0.0	1.5	0.0	28	84	124	72	39	.4809	110
78	0.5	0.0	1.5	0.5	85	79	51	27	105	.6916	208
79	0.5	0.0	1.5	1.0	132	43	29	16	127	.6518	255
80	0.5	0.0	1.5	1.5	138	41	15	14	139	.6389	270
81	0.5	0.5	0.0	0.0	2	106	154	60	25	.4769	94
82	0.5	0.5	0.0	0.5	83	89	41	37	97	.6470	204
83	0.5	0.5	0.0	1.0	124	57	25	16	125	.6422	253
84	0.5	0.5	0.0	1.5	140	35	25	9	138	.6387	267
85	0.5	0.5	0.5	0.0	2	110	144	66	25	.5329	94
86	0.5	0.5	0.5	0.5	85	82	49	28	103	.6998	207
87	0.5	0.5	0.5	1.0	133	43	25	22	124	.6479	255
88	0.5	0.5	0.5	1.5	138	39	17	15	138	.6395	269
89	0.5	0.5	1.0	0.0	17	93	136	59	42	.5367	105

Run	Exponent Values				Classes					r	s.d.
	a	b	c	d	0.00 1.99	2.00 3.99	4.00 5.99	6.00 7.99	8.00 +		
90	0.5	0.5	1.0	0.5	96	67	50	26	108	.6935	210
91	0.5	0.5	1.0	1.0	127	50	28	12	130	.6485	254
92	0.5	0.5	1.0	1.5	138	39	22	12	136	.6459	267
93	0.5	0.5	1.5	0.0	33	76	116	79	43	.4851	114
94	0.5	0.5	1.5	0.5	95	75	47	23	107	.7000	213
95	0.5	0.5	1.5	1.0	136	42	27	18	124	.6527	257
96	0.5	0.5	1.5	1.5	146	29	20	15	137	.6406	270
97	0.5	1.0	0.0	0.0	3	110	161	44	29	.4178	100
98	0.5	1.0	0.0	0.5	92	77	44	30	104	.6542	214
99	0.5	1.0	0.0	1.0	123	58	25	11	130	.6452	257
100	0.5	1.0	0.0	1.5	142	39	17	10	139	.6465	270
101	0.5	1.0	0.5	0.0	7	104	154	51	31	.4885	102
102	0.5	1.0	0.5	0.5	93	74	48	29	103	.6788	212
103	0.5	1.0	0.5	1.0	130	51	20	19	127	.6518	257
104	0.5	1.0	0.5	1.5	142	37	22	8	138	.6417	271
105	0.5	1.0	1.0	0.0	23	82	146	66	30	.5382	108
106	0.5	1.0	1.0	0.5	91	80	44	23	109	.6845	213
107	0.5	1.0	1.0	1.0	133	44	25	16	129	.6527	257
108	0.5	1.0	1.0	1.5	138	45	11	11	142	.6491	271
109	0.5	1.0	1.5	0.0	28	79	131	72	37	.4968	117
110	0.5	1.0	1.5	0.5	95	76	39	27	110	.6982	213
111	0.5	1.0	1.5	1.0	126	51	24	16	130	.6562	258
112	0.5	1.0	1.5	1.5	139	41	14	10	143	.6439	272
113	0.5	1.5	0.0	0.0	4	108	159	49	27	.4208	102
114	0.5	1.5	0.0	0.5	90	75	47	38	97	.6743	206
115	0.5	1.5	0.0	1.0	123	58	20	18	128	.6487	258
116	0.5	1.5	0.0	1.5	141	39	20	10	137	.6428	268
117	0.5	1.5	0.5	0.0	5	116	142	51	33	.4981	106
118	0.5	1.5	0.5	0.5	98	70	48	27	104	.6882	211
119	0.5	1.5	0.5	1.0	134	40	28	21	124	.6626	257
120	0.5	1.5	0.5	1.5	142	37	17	9	142	.6464	271
121	0.5	1.5	1.0	0.0	19	89	143	57	39	.5020	110
122	0.5	1.5	1.0	0.5	101	66	42	30	108	.7002	214
123	0.5	1.5	1.0	1.0	137	40	19	20	131	.6576	259
124	0.5	1.5	1.0	1.5	143	37	16	11	140	.6554	270
125	0.5	1.5	1.5	0.0	32	91	117	63	44	.4918	120
126	0.5	1.5	1.5	0.5	94	67	54	23	109	.6859	216
127	0.5	1.5	1.5	1.0	133	41	24	20	129	.6584	259
128	0.5	1.5	1.5	1.5	140	34	21	13	139	.6434	272
129	1.0	0.0	0.0	0.0	2	107	221	16	1	.3582	134
130	1.0	0.0	0.0	0.5	80	87	66	37	77	.6594	211
131	1.0	0.0	0.0	1.0	122	61	33	21	110	.6384	255
132	1.0	0.0	0.0	1.5	135	46	26	12	128	.6356	269
133	1.0	0.0	0.5	0.0	3	106	210	25	3	.4280	125
134	1.0	0.0	0.5	0.5	73	98	58	39	79	.6676	205
135	1.0	0.0	0.5	1.0	126	59	30	19	113	.6588	254
136	1.0	0.0	0.5	1.5	134	53	15	14	131	.6459	269

Run	Exponent Values				Classes					r	s.d.
	a	b	c	d	0.00 1.99	2.00 3.99	4.00 5.99	6.00 7.99	8.00 +		
137	1.0	0.0	1.0	0.0	9	94	196	47	1	.4408	127
138	1.0	0.0	1.0	0.5	78	89	62	34	84	.6802	207
139	1.0	0.0	1.0	1.0	121	64	26	25	111	.6523	254
140	1.0	0.0	1.0	1.5	133	51	16	19	128	.6422	270
141	1.0	0.0	1.5	0.0	19	81	184	63	0	.4252	137
142	1.0	0.0	1.5	0.5	78	85	64	30	90	.6812	208
143	1.0	0.0	1.5	1.0	125	53	34	18	117	.6530	253
144	1.0	0.0	1.5	1.5	141	40	18	20	128	.6462	269
145	1.0	0.5	0.0	0.0	3	105	209	28	2	.3670	132
146	1.0	0.5	0.0	0.5	82	86	63	36	80	.6429	210
147	1.0	0.5	0.0	1.0	126	55	40	21	105	.6556	255
148	1.0	0.5	0.0	1.5	132	46	28	12	129	.6394	267
149	1.0	0.5	0.5	0.0	4	103	207	29	4	.4502	124
150	1.0	0.5	0.5	0.5	74	94	66	29	84	.6799	205
151	1.0	0.5	0.5	1.0	123	58	30	27	109	.6597	255
152	1.0	0.5	0.5	1.5	137	42	23	19	126	.6507	269
153	1.0	0.5	1.0	0.0	11	93	196	41	6	.4303	128
154	1.0	0.5	1.0	0.5	81	84	63	36	83	.6891	207
155	1.0	0.5	1.0	1.0	123	59	31	18	116	.6529	255
156	1.0	0.5	1.0	1.5	140	42	19	20	126	.6556	269
157	1.0	0.5	1.5	0.0	27	79	177	59	5	.4556	139
158	1.0	0.5	1.5	0.5	76	91	61	36	83	.7057	201
159	1.0	0.5	1.5	1.0	121	54	32	23	117	.6606	256
160	1.0	0.5	1.5	1.5	142	38	17	20	130	.6458	268
161	1.0	1.0	0.0	0.0	1	124	190	20	12	.3784	135
162	1.0	1.0	0.0	0.5	83	90	57	42	75	.6535	208
163	1.0	1.0	0.0	1.0	121	59	36	19	112	.6546	256
164	1.0	1.0	0.0	1.5	140	45	15	21	126	.6476	270
165	1.0	1.0	0.5	0.0	4	109	204	18	12	.4441	131
166	1.0	1.0	0.5	0.5	75	97	62	32	81	.6880	207
167	1.0	1.0	0.5	1.0	126	52	37	18	114	.6579	258
168	1.0	1.0	0.5	1.5	137	44	20	16	130	.6491	271
169	1.0	1.0	1.0	0.0	11	101	185	36	14	.4371	131
170	1.0	1.0	1.0	0.5	79	97	46	46	79	.6822	211
171	1.0	1.0	1.0	1.0	124	54	37	15	117	.6621	257
172	1.0	1.0	1.0	1.5	137	43	23	14	130	.6544	270
173	1.0	1.0	1.5	0.0	21	94	171	50	11	.4557	143
174	1.0	1.0	1.5	0.5	89	81	56	36	85	.7026	210
175	1.0	1.0	1.5	1.0	125	51	32	23	116	.6698	255
176	1.0	1.0	1.5	1.5	140	40	18	20	129	.6496	272
177	1.0	1.5	0.0	0.0	1	118	198	16	14	.3837	139
178	1.0	1.5	0.0	0.5	81	90	56	44	76	.6555	208
179	1.0	1.5	0.0	1.0	125	58	28	22	114	.6456	256
180	1.0	1.5	0.0	1.5	133	43	28	17	126	.6476	269
181	1.0	1.5	0.5	0.0	2	111	199	23	12	.4541	134
182	1.0	1.5	0.5	0.5	78	100	53	31	85	.6779	208
183	1.0	1.5	0.5	1.0	117	65	33	20	112	.6644	257

Run	Exponent Values				Classes					r	s.d.
	a	b	c	d	0.00 1.99	2.00 3.99	4.00 5.99	6.00 7.99	8.00 +		
184	1.0	1.5	0.5	1.5	138	43	23	12	131	.6508	269
185	1.0	1.5	1.0	0.0	11	101	186	38	11	.4700	134
186	1.0	1.5	1.0	0.5	83	86	58	36	84	.6938	206
187	1.0	1.5	1.0	1.0	126	48	36	19	118	.6694	257
188	1.0	1.5	1.0	1.5	136	42	20	16	133	.6565	269
189	1.0	1.5	1.5	0.0	21	97	165	49	15	.4488	143
190	1.0	1.5	1.5	0.5	81	90	50	40	86	.7097	210
191	1.0	1.5	1.5	1.0	130	51	27	22	117	.6753	258
192	1.0	1.5	1.5	1.5	145	37	11	18	136	.6525	273
193	1.5	0.0	0.0	0.0	10	123	206	8	0	.2854	177
194	1.5	0.0	0.0	0.5	68	103	74	56	46	.6100	211
195	1.5	0.0	0.0	1.0	118	64	45	17	103	.6393	255
196	1.5	0.0	0.0	1.5	136	45	37	18	111	.6433	269
197	1.5	0.0	0.5	0.0	8	119	211	9	0	.3156	169
198	1.5	0.0	0.5	0.5	69	103	74	44	57	.6421	206
199	1.5	0.0	0.5	1.0	115	68	43	21	100	.6580	252
200	1.5	0.0	0.5	1.5	138	43	30	20	116	.6417	270
201	1.5	0.0	1.0	0.0	15	114	192	26	0	.3567	165
202	1.5	0.0	1.0	0.5	72	97	71	44	63	.6476	708
203	1.5	0.0	1.0	1.0	123	62	38	20	104	.6589	253
204	1.5	0.0	1.0	1.5	133	45	32	19	118	.6451	269
205	1.5	0.0	1.5	0.0	23	102	184	38	0	.3717	167
206	1.5	0.0	1.5	0.5	75	93	70	46	63	.6693	204
207	1.5	0.0	1.5	1.0	122	54	48	19	104	.6581	253
208	1.5	0.0	1.5	1.5	136	44	26	22	118	.6551	269
209	1.5	0.5	0.0	0.0	7	121	207	12	0	.3045	175
210	1.5	0.5	0.0	0.5	72	98	68	59	50	.6325	213
211	1.5	0.5	0.0	1.0	121	59	45	22	100	.6425	253
212	1.5	0.5	0.0	1.5	137	50	27	17	116	.6379	270
213	1.5	0.5	0.5	0.0	8	123	202	14	0	.3304	166
214	1.5	0.5	0.5	0.5	67	108	67	51	54	.6436	206
215	1.5	0.5	0.5	1.0	121	63	41	22	100	.6699	253
216	1.5	0.5	0.5	1.5	131	52	29	17	118	.6546	269
217	1.5	0.5	1.0	0.0	16	113	188	30	0	.3889	162
218	1.5	0.5	1.0	0.5	68	101	75	46	57	.6548	206
219	1.5	0.5	1.0	1.0	113	67	45	19	103	.6642	254
220	1.5	0.5	1.0	1.5	138	45	26	21	117	.6583	270
221	1.5	0.5	1.5	0.0	27	101	177	42	0	.3848	170
222	1.5	0.5	1.5	0.5	75	95	69	50	58	.6811	208
223	1.5	0.5	1.5	1.0	119	54	48	22	104	.6653	254
224	1.5	0.5	1.5	1.5	134	51	19	28	115	.6544	268
225	1.5	1.0	0.0	0.0	10	126	193	10	8	.2992	177
226	1.5	1.0	0.0	0.5	73	98	73	57	46	.6234	212
227	1.5	1.0	0.0	1.0	120	64	37	27	99	.6497	255
228	1.5	1.0	0.0	1.5	138	46	24	23	116	.6496	271
229	1.5	1.0	0.5	0.0	7	118	205	9	8	.3479	169
230	1.5	1.0	0.5	0.5	69	110	64	49	55	.6533	208

Run	Exponent Values				Classes					r	s.d.
	a	b	c	d	0.00 1.99	2.00 3.99	4.00 5.99	6.00 7.99	8.00 +		
231	1.5	1.0	0.5	1.0	115	73	35	20	104	.6529	253
232	1.5	1.0	0.5	1.5	130	58	17	25	117	.6506	271
233	1.5	1.0	1.0	0.0	15	116	185	23	8	.3772	162
234	1.5	1.0	1.0	0.5	74	99	66	47	61	.6602	211
235	1.5	1.0	1.0	1.0	119	61	49	13	105	.6594	253
236	1.5	1.0	1.0	1.5	130	56	22	22	117	.6605	269
237	1.5	1.0	1.5	0.0	22	109	177	33	6	.3837	169
238	1.5	1.0	1.5	0.5	79	91	66	45	66	.6819	209
239	1.5	1.0	1.5	1.0	124	53	45	21	104	.6664	254
240	1.5	1.0	1.5	1.5	137	47	20	20	123	.6570	271
241	1.5	1.5	0.0	0.0	7	146	171	12	11	.3150	179
242	1.5	1.5	0.0	0.5	77	92	78	50	50	.6095	215
243	1.5	1.5	0.0	1.0	119	65	39	21	103	.6419	256
244	1.5	1.5	0.0	1.5	132	51	27	17	120	.6486	272
245	1.5	1.5	0.5	0.0	9	140	176	11	11	.3456	174
246	1.5	1.5	0.5	0.5	73	100	69	43	62	.6577	209
247	1.5	1.5	0.5	1.0	117	74	33	20	103	.6529	255
248	1.5	1.5	0.5	1.5	137	43	27	21	119	.6585	270
249	1.5	1.5	1.0	0.0	17	122	178	20	10	.3871	164
250	1.5	1.5	1.0	0.5	78	103	56	50	60	.6645	212
251	1.5	1.5	1.0	1.0	121	60	41	19	106	.6597	255
252	1.5	1.5	1.0	1.5	134	52	21	18	122	.6566	270
253	1.5	1.5	1.5	0.0	26	114	166	30	11	.3828	171
254	1.5	1.5	1.5	0.5	75	97	64	44	67	.6766	210
255	1.5	1.5	1.5	1.0	124	53	47	16	107	.6732	254
256	1.5	1.5	1.5	1.5	136	45	25	21	120	.6591	270

APPENDIX 4

RUNS REQUIRED FOR CALCULATION OF MEAN r VALUES

Run	Exponent Values a	b	c	d	Classes 0.00–1.99	2.00–3.99	4.00–5.99	6.00–7.99	8.00 +	r	s.d.
78	0.5	0.0	1.5	0.5	89	77	49	28	104	.6827	211
"		"			82	85	48	27	105	.6922	209
"		"			87	77	53	26	104	.6895	211
"		"			88	77	47	27	108	.6851	210
"		"			92	73	49	23	110	.6910	212
"		"			85	79	51	27	105	.6916	208
"		"			90	75	47	27	108	.6889	210
"		"			88	89	35	25	110	.6942	210
86	0.5	0.5	0.5	0.5	92	80	37	35	103	.6931	208
"		"			87	81	52	19	108	.6831	207
"		"			89	80	44	31	103	.6916	210
"		"			95	81	36	32	103	.6862	210
"		"			87	81	43	35	101	.6905	207
"		"			85	78	53	32	99	.6925	208
"		"			93	74	45	32	103	.6820	207
"		"			92	74	47	31	103	.6894	209
90	0.5	0.5	1.0	0.5	91	79	43	26	108	.6963	209
"		"			90	73	53	25	106	.6728	209
"		"			87	85	39	33	103	.7088	210
"		"			86	81	52	21	107	.6822	210
"		"			90	75	47	33	102	.6815	207
"		"			93	80	44	24	106	.6810	210
"		"			90	75	55	17	110	.6848	209
"		"			87	86	41	29	104	.7038	209
94	0.5	0.5	1.5	0.5	94	76	39	28	110	.6864	211
"		"			91	77	44	27	108	.6939	212
"		"			87	78	52	19	111	.7022	211
"		"			88	80	45	31	103	.6962	211
"		"			95	67	54	21	110	.6882	213
"		"			92	76	49	20	110	.6961	208
"		"			94	74	47	28	104	.6947	211
"		"			86	86	41	21	113	.6803	212
110	0.5	1.0	1.5	0.5	83	90	43	26	105	.6850	213
"		"			92	81	43	18	113	.6979	211
"		"			89	82	47	21	108	.6984	212
"		"			96	73	46	23	109	.7045	213
"		"			88	79	46	26	108	.6976	212
"		"			96	71	50	20	110	.6960	214
"		"			91	79	45	25	107	.7030	213
"		"			95	74	47	18	113	.6968	212

Run	Exponent Values (a b c d)	Classes 0.00–1.99	2.00–3.99	4.00–5.99	6.00–7.99	8.00 +	r	s.d.
122	0.5 1.5 1.0 0.5	94	75	43	25	110	.6801	212
"	"	98	64	51	28	106	.6920	212
"	"	97	71	44	28	107	.6877	214
"	"	93	75	48	27	104	.7022	210
"	"	92	73	46	28	108	.6830	208
"	"	95	78	41	28	105	.7137	209
"	"	90	79	43	28	107	.6983	210
"	"	96	73	47	29	102	.6945	215
158	1.0 0.5 1.5 0.5	83	85	59	36	84	.6969	207
"	"	82	79	65	35	86	.6874	207
"	"	87	74	62	45	79	.7016	207
"	"	84	79	61	39	84	.7037	207
"	"	78	83	64	36	86	.7039	209
"	"	81	83	66	30	87	.6984	209
"	"	87	79	55	42	84	.6905	208
"	"	86	79	58	36	88	.6893	210
174	1.0 1.0 1.5 0.5	81	85	58	35	88	.6969	207
"	"	78	88	58	35	88	.7033	209
"	"	79	89	59	34	86	.6916	208
"	"	93	69	59	38	88	.6890	211
"	"	79	87	62	31	88	.6894	207
"	"	77	90	59	37	84	.6942	208
"	"	84	87	47	38	91	.6951	211
"	"	85	83	57	29	93	.6822	211
186	1.0 1.5 1.0 0.5	80	88	59	34	86	.6861	208
"	"	77	93	57	38	82	.6954	208
"	"	86	79	64	37	81	.7073	209
"	"	78	95	51	39	84	.6956	210
"	"	82	89	56	36	84	.6991	205
"	"	83	89	50	40	85	.7038	207
"	"	76	91	61	39	80	.6909	208
"	"	87	85	53	34	88	.7005	208
190	1.0 1.5 1.5 0.5	82	90	50	37	88	.6983	207
"	"	86	83	58	36	84	.7021	210
"	"	81	85	60	33	88	.7152	208
"	"	83	85	63	29	87	.6936	210
"	"	84	87	54	31	91	.6963	208
"	"	85	86	54	34	88	.7013	209
"	"	85	83	59	37	83	.7045	207
"	"	81	91	51	32	92	.6984	209

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