THE RURAL-URBAN FRINGE: A REVIEW OF PATTERNS AND DEVELOPMENT COSTS

by

Claude Marchand and Janine Charland

the Intergovernmental Committee on Urban and Regional Research

August 1992

Published by ICURR PRESS
Suite 301, 150 Eglinton Avenue East
Toronto, Ontario
M4P 1E8
Telephone : (416) 973-5629
Fax : (416) 973-1375

The views expressed here are those of the author and do not necessarily represent the official views of ICURR.

Canadian Cataloguing in Publication Data

Marchand, Claude, 1948-
The rural-urban fringe : a review of patterns and development costs

ISBN 1-895469-20-1

1. Cities and towns - Growth. 2. City planning.
3. Cities and towns - Growth - Economic aspects.
4. City planning - Ontario - Toronto Metropolitan Area. I. Charland, Janine. II. Title.

HT371.M37 1992 307.1'416 C92-094792-1

FOREWORD

On behalf of the Intergovernmental Committee on Urban and Regional Research, we are pleased to present this report on the Rural-Urban Fringe: A Review of Patterns and Development Costs.

Rural-urban fringe formation is not a new phenomenon. What is fairly recent, however, is its relatively high pace of development. Further, it appears that most future urban land developments are likely to take place on the fringe of existing urban centres.

The present review of the literature demonstrates that the issue of costs associated with sprawl has been discussed at great length since the early 50s. The review also reveals that engineering estimates present some limitations in predicting variations in costs according to different patterns of development. Urban areas are complex entities and the ability to generalize from an hypothetical as well as from a unique actual situation is limited.

The review of the literature also suggests that our understanding of the major trends that are taking place in Canadian agglomerations regarding the spatial redistribution of residence and employment is incomplete. A later publication based on case studies of six main Canadian urban areas will attempt to bring an understanding of modern growth patterns in the fringe.

Michel Gauvin
Executive Director

Claude Marchand
Research Coordinator

Intergovernmental Committee on Urban and Regional Research
August 1992

BIOGRAPHICAL NOTES

Prior to becoming research coordinator at **ICURR**, Claude Marchand was associate professor of Geography at the University of Montréal from 1979 to 1988. Since 1988, she holds the rank of associate professor (status only) in the Department of Geography at the University of Toronto. She is a graduate of the University of Toronto with a doctorate in Geography. In her capacity as research assistant at **ICURR**, Janine Charland also contributed greatly to this study. She is a graduate of York University where she received her M.A. in Environmental Studies specializing in Urban Sociology. She had previously received a degree in Urban Planning from Université du Québec à Montréal.

TABLE OF CONTENTS

SECTION 1 - INTRODUCTION

There has been an increasing interest in the phenomenon of rural-urban fringe development in Canada over the last 30 years. Rural-urban fringe formation is neither a new phenomenon nor is it limited to North American cities. What is fairly recent, however, is the high rate at which it is taking place[1]. Further, it appears that most future urban land developments are likely to take place on the fringe of urban centres[2].

In the Canadian context, concerns have arisen from the conversion of agricultural lands in the peripheries of urban agglomerations to urban uses. In Canada, it has been estimated that almost 60 percent of the rural land converted to urban uses between 1966 and 1986 was prime agricultural land[3]. Among other issues discussed are the social and economic costs of fringe development including conflicting land uses, costs of servicing discontinuous low density residential developments and the question of inequities between those who pay for and who benefit from the expanded public services put in place to accommodate new development in fringe areas.

The question of whether the typical discontinuous low residential development found in the fringe generates higher costs of development and servicing than do other types of development, has been the subject of much debate. Most of the studies on the subject are based on statistical analyses of actual cities or on engineering estimates of utility and service costs for various hypothetical development patterns[4]. Despite considerable reliance on engineering estimates, recent analyses of alternative scenarios of development based on population growth projections of existing urban agglomerations, can be considered a third category of studies.

This report is a presentation and discussion of major findings pertaining to the patterns of urban development and their associated tangible costs; it comprises three sections. The first part is an introduction to the concepts of regional city and rural-urban fringe. The second section is a broad overview of major forces behind fringe formation. The last section addresses the question of fringe development costs. Although references are made to a number of studies, the emphasis in the latter section is on three studies that are of major importance because of their broader coverage of services than is found in previous studies. Two of these studies were conducted during the 1970s: the first, done in the United States by the Real Estate Research Corporation is entitled The Costs of Sprawl and the second, done by P. A. Stone in England, is entitled The Structure, Size and Costs of Urban Settlements. The third study, prepared for the Greater Toronto Coordinating Committee in 1990, examines the benefits and costs of three alternative development patterns for the Greater Toronto Area.

SECTION 2 - CONCEPTS OF REGIONAL CITY AND RURAL-URBAN FRINGE

2.1 - The Regional City

Urbanization, traditionally defined as the increasing proportion of a country's population concentrated in urban areas, no longer adequately reflects evolving patterns of settlement. With the migration of exurban populations into the countryside, the establishment of commercial complexes and the dispersion of some industrial activities into the peripheries of urban agglomerations, a broader and more complex form of settlement has emerged - a city form that encompasses a concentrated built-up area and its dispersed surroundings.

This new regional city is composed of four major zones: the concentrated city or core built-up area including the suburban area, the rural-urban fringe, the urban shadow and rural hinterland. The various zones of the regional city are regarded as different parts of a continuum of urban influence originating in the urban core and dissipating outwards into the rural hinterland. The fringe is adjacent to the concentrated built-up areas; beyond this zone lies the urban shadow where urban influences on the landscape are much less perceptible than in the fringe area. The external boundaries of the urban shadow correspond to the limits of the main daily commuting zone of the core city. The maximum commuting zone extends beyond the urban shadow into the rural hinterland, the outer edge of the regional city[5].

Within this regional structure, populations are not uniformly distributed. We find populations concentrated in the built-up area of central city cores, residences aggregated in urban nodes of various sizes, settlements gathered in small clusters or scattered on isolated sites in the urban field (i.e., the area encompassing the rural-urban fringe and the urban shadow) and rural hinterland. Four major population components of the regional city have been identified: the concentrated urban population which comprises populations living in the central built-up city core and surrounding cities with a minimum built-up population of 10,000; the urban dispersed population which refers to the population residing in urban nodes of 50 to 10,000 inhabitants; the urban scattered population which corresponds to the rural non-farm population, and the rural farm population[6].

This new regional city, whose urban influences are felt far beyond the concentrated built-up area, also comprises an important rural space. Urban influences can be perceived at a distance of 50 to 60 miles from the city core for major agglomerations such as Toronto, Montréal and Vancouver. Although most population movements are still oriented towards the built-up city core, patterns of flow become more complex as important employment poles and other activity nodes develop in the more dispersed area of this new form of settlement. The overlapping life spaces for different activities (i.e., work, education, shopping and entertainment) constitute an another important feature of the regional city associated with the pattern of multi-directional flows[7].

The regional city is considered the leading form of settlement model since the Second World War. More than three-quarters of the Canadian population and almost 90 percent of the population in Ontario live in regional cities. The vast majority of the residents, 70 to 90 percent, are concentrated in five percent of the regional space while 10 to 25 percent of the population live in the remaining dispersed part of regional cities, which represents 95 percent of the regional space[8]. Population growth in the urban concentrated area of regional cities was relatively important until the mid-seventies. Since then, it has slightly declined as a component of the regional city population. It is in the dispersed part of regional cities that population increased the most significantly, in relative terms, during the same period. The farm population no longer constitutes the majority of residents in this area. Indeed, since the mid-1960s, exurbanites outnumber residents of a rural background in the dispersed area of regional cities.

2.2 - The Rural-Urban Fringe

Presenting features of both country and city, the rural-urban fringe is viewed, within this regional structure, as no longer rural yet not urban[9]. Affected by its contact with the urban edge of the city, the fringe is a zone of transition in terms of land use as well as social and demographic characteristics. The fringe contains a combination of sometimes incompatible urban and rural land use activities. Low-density residential developments typical of the suburbs (i.e, single family dwellings on relatively small lots), commercial and industrial developments, and idle land where will eventually be converted to urban uses are found side by side with agricultural land. Population densities in the fringe are higher than their surrounding rural areas but lower than their urban counterparts. A greater segment of the resident population in the fringe has an urban rather than a rural or rural/urban background. Suburban middle class is the dominant social formation in the fringe. In the Toronto area, for instance, a relatively high proportion of married couples with children live in the fringe compared with the adjacent urban and rural areas. The mean annual income per household is also higher than that of surrounding urban and rural areas[10]. Similarly, households residing in the peripheries of the City of Winnipeg have higher incomes and a greater proportion of household members with a university education[11]. These characteristics are comparable to those found in an appreciable number of fringe communities according to Pryor's review of more than 60 case studies[12].

The fringe is a permanent feature of the regional city but its boundaries change over time and in location. It is a dynamic zone where changes occur on a continual basis and where rural responses, land use competition and the associated transformation of rural structures are prevalent[13]. The mixture in land uses is an important feature of the fringe area. This area differs from the more homogeneous zones of compatible land use found elsewhere in the city[14].

Depending on the perspective adopted, various terms have been used in the literature to designate fringe areas. Russwurm, for instance, refers to the "urban fringe" when discussing the question of fringe development. He argues that fringe formation is mainly the product of urbanization[15]. Lyon prefers the term "urban-rural fringe" to label such areas. She maintains that urbanization, although a major contributor to the development of the fringe, is not the only factor responsible for the fringe phenomenon. There are rural influences to consider in the configuration of the fringe. Rural residents do not passively witness the transition from a rural to an urban society. She writes that "rural-based influences also are involved in the cause-effect relationships, given that rural societies have their own goals and socio-economic concerns apart from those of urban areas"[16].

A similar view is expressed by Troughton who uses the word "rural-urban fringe" to designate the fringe area. He argues that rural-urban fringe is mainly a "process-response system" which results from two opposite and interacting sets of forces, namely the centrifugal and centripetal forces of urbanization. Among centrifugal forces are those related to the urban demand for land which is manifested by the expansion of residential and commercial land uses beyond the suburban areas into the countryside in search of cheaper land and lower property taxes. Centripetal forces are the attraction powers exerted by the city for employment, business, entertainment and other activities. Within this process-response system, "urbanization evokes rural response and transformation as well as creating urban forms"[17]. Taking into consideration that fringe formation is a dynamic phenomenon resulting from the invasion of urban-oriented elements into the countryside, a spatial area initially rural in character, rural-urban fringe is used in the report when discussing this phenomenon. Specific references to rural or urban fringes are made when considering the outer and inner areas of the fringe.

Fringe areas are composed of diversified spatial forms reflecting the various patterns of development in the peripheries of Canadian cities. Fringe development may be the result of concentric accretionary growth adjacent to the built-up areas of cities or may exhibit linear or radial corridor growth along major access routes. Ring formations surrounding London, Ontario provide a Canadian example of the concentric development pattern of the fringe[18]. Fringes in Thunder Bay, Ontario and Brandon, Manitoba exhibit linear and radial corridor expansion along highways. The fringe may also display a discontinuous pattern of development in proximity to particular urbanized nodes that present attractive development features. Spatial forms of fringes are not neatly delineated and may result from overlap. It may, for instance, result from the combination of the fringe of one or more centres or fringes of satellite cities located in the outer fringe or urban shadow of a regional city[19].

The fringe is composed of two spatially discernable areas: the inner and outer fringes, commonly referred to as the urban or rural fringes. These areas are essentially differentiated on the basis of degree of interpenetration of urban built form. Contiguous with the central city built-up area or adjacent to other important urbanized nodes within the regional city, the inner fringe is the area of accretionary development exhibiting an advanced stage of transition from rural to urban uses[20]. Competition for land use is high in the inner fringe and a large proportion of the land is already converted to urban uses or is intended for urban uses. Side by side with rural land, the urban fringe contains a mixture of urban land uses, including residential, commercial and industrial developments, and vacant land which will be converted to urban uses in the foreseeable future[21].

In the outer fringe, pressures for land conversion from rural to urban uses are lower than in the inner fringe. No large scale urban land development is anticipated on the short term in this subzone of the rural-urban fringe. In comparison with the urban fringe, there are fewer urban-related uses in the rural fringe and the types of activities found tend to be more closely associated with the features of the landscape and less dependent on accessibility levels[22]. An important proportion of the land in the outer fringe remains rural in character. Rates of increase in population density and levels of commuting are lower in the rural fringe than in the urban fringe[23].

From the built-up edge of cities, fringe areas may extend from a radius of five miles for cities of 10,000-25,000 inhabitants to 30 miles for large agglomerations of one million inhabitants or more. Boundaries will depend upon the operational definition used to delimit the rural-urban fringe area. Various criteria have been used in the literature to delineate the extent of the rural-urban fringe zone. Russwurm, for instance, used population densities. Based on empirical evidence in the Toronto and Stradford areas, the researcher determined four categories of population density corresponding to the various zones of the regional city: the rural population of the hinterland with a population density of less than 25 persons per square mile; the semi-rural population of the urban shadow zone with population densities varying between 25 to 49 inhabitants; the semi-urban population of the rural fringe area with population densities between 50 and 119 inhabitants, and the urbanizing population of the urban fringe with population densities of 120 persons per square mile or more. The percentage of non-farm population, of non-farm ownership and of non-farm land use are additional criteria suggested by Russwurm which can be used to supplement population density. Ratios of approximately 80 per cent non-farm population or non-farm ownership would apply to the outer fringe and higher ratios to the inner fringe[24]. The proportion of land held by speculators and the average value of land per acre are other criteria mentioned in the literature to delimit fringe boundaries[25].

SECTION 3 - FACTORS AND STAGES OF DEVELOPMENT OF THE FRINGE

3.1 - Major Factors of Development

Urbanization is a primary condition of fringe formation. Pressures exerted by population and employment growth are determining factors of development in the fringe surrounding urban agglomerations. However, urban growth alone is not sufficient to explain the spatial configuration of regional cities and their fringes[26]. At the macro scale level, the development of transportation and communication networks, in combination with technological changes, have made possible the greater dispersal of population and activities into the countryside.

Transportation developments are of critical importance in the fringe formation phenomenon. High levels of personal mobility, associated with private car ownership and the amelioration of highway systems, have facilitated the dispersal of exurbanites into the fringes of regional cities. The extension of transportation networks also has encouraged the spread of commercial and industrial activities into the peripheries of urban agglomerations. Similarly, the improvement of communication systems and technological changes have permitted and encouraged the further dispersal of commercial and industrial activities into the fringes[27].

In addition to increased mobility of individuals, socio-cultural factors have come into play in the dispersal of residents in the fringes of urban agglomerations. The high values attributed to a natural environment, the recreation potential of the countryside, the attractions of a rural life style (for example, hobby farming), the need for a quiet and peaceful environment, the desire for greater privacy and personal space all constitute incentives to move to the fringe[28]. Higher levels of personal affluence and accessibility to the fringe areas have made it possible for individuals to pursue the dream of a rural lifestyle[29].

The spread of industrial activities has been encouraged by a combination of factors. The extension and improvement of transportation networks have been crucial to the dispersion of manufacturing activities within the regional city. The availability of greater space at lower costs in the fringe is an important incentive, especially for land extensive industries. Technological changes in industrial production also have contributed to this trend, with many branches of manufacturing using horizontal plant layouts which require the kind of space more easily available in the peripheries of urban agglomerations. Improvements in communication networks have enabled some firms to locate manufacturing units in the less congested peripheries while maintaining their administrative centre in a more central location. Finally, the dispersion of residents and increased mobility of populations within the regional city, which permitted the development of and access to an adequate labour pool in the rural-urban fringe, are additional factors encouraging the dispersal of manufacturing employment.

Some of the factors which have contributed to the spread of industrial activities have also encouraged the dispersal of commercial activities in the peripheries of urban centres. Transportation developments, lower land cost and greater space availability in the fringe have stimulated the spread of commercial activities in the dispersed parts of the regional city, especially those activities requiring large commercial sites. In the case of retailing, this trend has been stimulated by the presence of a market pool in the fringe areas. The lack of parking facilities in central city areas and the increasing distance between consumers and the urban core, as well as high levels of accessibility to fringe areas, represent definite incentives for consumers residing in the fringe to choose peripheral centres rather than more central areas for shopping[30].

3.2 - Stages of Development

A four stage model has been suggested by Russwurm and Bryant (1981) to describe the formation of the regional city and its fringes. The first step is characterized by the polarization of the space economy engendered by industrialization and urban processes. Within the Canadian context, this period appeared to have persisted until the mid-1960s. The second stage of development is predominated by the dispersal of residential population since the mid-1960s as demonstrated by a greater rate of scattered population growth than concentrated core growth. In the third stage, residential dispersion is followed by the dispersal of industrial and commercial activities in the peripheries of urban agglomerations, particularly in outlying nodes. The dispersion of employment, especially commercial activities, is suggested to have been encouraged by critical population thresholds being reached in the fringe areas. The continuation of these trends may lead, in the final stage of the regional city formation, to the creation of a megapolitan city structure. There is no clear indication in the Canadian context that regional cities have yet reached this hypothesized mature stage of development[31].

The dispersal of residents in the fringes of major Canadian urban agglomerations has been fully documented in the research literature[32]. There is also empirical evidence that this phenomenon has not been limited to the largest urban agglomerations. This is a pervasive phenomenon which has been observed in various sizes of agglomerations in Canada over the last 30 years[33].

The regional city four step model mentioned above suggests that residential dispersion is accompanied by the dispersal of industrial and commercial activities in the subsequent phase of formation. This appears to be the pattern of development observed for the Toronto fringes. While residential development in the Toronto area expanded beyond the 30 mile ring from the city core during the 1961-81 period, the spatial dispersion of manufacturing and commercial activities has been a noticeable trend only since the early 1970s[34].

Office employment has spread into the outlying regional cities of the Greater Toronto Area. However, the dispersal of office employment is fairly recent and a much less marked phenomenon than the other two categories of economic activity[35]. Further, the dispersal of office employment appears, so far, to be more suburban in its growth trend. In the Toronto area, this was initiated by the establishment of small offices serving suburban consumers and small businesses. Sales and head offices of manufacturing companies soon followed as well as small consulting firms which located to the outlying built-up areas. The partial deconcentration of large clerical job pools and the relocation of head offices of companies with a large clerical work force is a recent phenomenon which might gain in importance in the future[36]. However, unlike manufacturing and commercial activities which have expanded into the fringe areas, it is more likely that office employment will continue to spread outward in suburbanized areas.

A study conducted in Philadelphia, which examined the spatiotemporal sequence of the decentralization of residential and economic functions, suggests a similar pattern of development to that observed for the Toronto region. In this study, population was found to be the most spatially expanded function followed by manufacturing industry and retailing. Wholesaling and the service sector were still in a state of suburban growth[37].

In conclusion, the development of the regional city is a dynamic process in which expansion phases of different sectors of activities are interconnected and likely to overlap in time and space. The spread of one activity influences the expansion of other sectors of activities within the regional city. Retailing, for instance, which developed because of the presence of a residential market pool in the fringes, further encouraged the dispersal of populations and commercial activities.

SECTION 4 - THE COSTS OF FRINGE DEVELOPMENT

The relatively fast pace of fringe development in the peripheries of Canadian cities for the last 30 years has raised serious concerns. Most of the rural land that has been converted to urban uses was prime agricultural land. In addition to the loss and fragmentation of agricultural land, development in the fringe has engendered conflicting land uses or "spill over effects" resulting from the combination of sometime incompatible urban and rural land use activities. The costs of servicing low-density scattered development typical of the fringe and the question of inequities between those who pay for and those who benefit from the expanded public services developed to accommodate new development in fringe areas are other important issues discussed in the literature on fringe formation. The focus of this section is on the latter issues, that is, the costs of servicing new development in the fringes of urban agglomerations. Major studies relevant to this question are reviewed and discussed.

Fringe formation is often associated with urban sprawl. Fringe areas are characterized by low-density scattered development and, similar to sprawl, development in the fringe is portrayed as haphazard, disorderly and discontinuous[38]. The Lower Mainland Regional Planning Board in British Columbia was one of the first Canadian planning boards to voice some concerns on the costs of servicing sprawl development typical of the fringe in the mid-1950s. Based on an analysis of utility and servicing costs (i.e., road paving, road and ditch maintenance and water supply costs) of three zones presenting different population densities in the Surrey region, the Board concluded these costs to be significantly higher in sprawl areas than those in the higher density areas. In relation to the benefits received, they also found the tax burden to be unequally shared among the residents with farmers being the most disadvantaged in terms of fiscal inequities[39].

Since then, the question of whether the typical discontinuous low residential development in the fringe does generate higher costs of development and servicing than do other types of development has created a fair amount of discussion. Factors examined in the research literature which are likely to have an influence on the costs of development and servicing include the form and shape of urban agglomerations, the size of urban areas, population density, contiguity of development, population size, extent of clustering and the location of central facilities. Most of the studies on costs of development and servicing are based on statistical analyses of actual cities or on engineering estimates of utility and service costs for various hypothetical development patterns. Although they rely heavily on engineering estimates, recent analyses of different scenarios of development based on population growth projections of existing urban agglomerations constitute a third category of studies.

This section comprises two parts. Findings based on statistical analyses and engineering estimates of hypothetical settlements are first presented. The emphasis is on two particular studies which were conducted during the 1970s by the Real Estate Research Corporation in the United States and P. A. Stone in England. These studies, The Costs of Sprawl and The Structure, Size and Costs of Urban Settlements, are of particular importance because of their broader coverage of services than is found in previous engineering estimates. The focus in the second part, which pertains to the costs of alternative development scenarios based on actual urban agglomerations, is on a study prepared for the Greater Toronto Coordinating Committee in 1990, The Greater Toronto Area Urban Structure Concepts Study. This study examines the benefits and costs of three alternative development patterns in the Greater Toronto Area.

4.1 - Statistical Analyses and Engineering Estimates

Variations in costs for local government services have been examined through statistical analyses for a selected number of independent variables including population size, population density and ratio of central city population to metropolitan area population[40]. The main objective of these studies was to identify variables responsible for intercity variations in costs for the provision of local public services. The studies reviewed are American and have used per capita local government expenditures as a proxy for service costs.

One of the earliest statistical studies on local government service costs was done by Brazer who analyzed data for 462 cities having over 25,000 inhabitants in 1950. Except for highways and recreation, he obtained a positive association between per capita local government expenditures and population density. With the exclusion of police costs, Brazer found, however, no relationship between population size and city expenditures. Concerning the ratio of central city population to metropolitan area population, the results of his study indicated a reverse relationship between this variable and per capita costs. This means that, as the proportion of central city population increases, per capita local government expenditures decrease. Among expenditures considered in Brazer's study were the operation costs of police, fire and recreation; sanitation, including street cleaning, sewers, and sewage and waste collection and disposal; highways, including streets, highways, and related structures, snow and ice removal, and toll highway and bridge facilities[41].

A similar but more recent study was conducted by Bahl, who examined city expenditures for 198 central cities with population of over 50,000. Using regression techniques and the same categories of local government expenditures as those considered by Brazer, Bahl found population density and population size to have a positive and significant influence on per capita expenditures, with the only exception being highway and park expenditures for the population density variable. Similar to Brazer's findings, the results of the study indicated, with the exclusion of local road expenditures, an inverse relationship between city expenditures and the ratio of central city population to metropolitan area population[42].

In the majority of statistical studies and for the majority of services examined, higher density of population is associated with higher per capita local government expenditures[43]. These studies also show that population size has either no influence or a positive influence on per capita costs. In addition, local government expenditures are found to vary in an inverse relationship to the proportion of the central city population living in the metropolitan area.

Studies based on regression techniques are regarded with some reservation because of their limitations in measuring costs, controlling service levels, controlling demand and supply factors and, more importantly, in measuring the influence of different development patterns on servicing and development costs. The regression analyses reviewed are based on public finance data made available by the U.S. Census Bureau. These data better represent the amount spent by cities than spent within city areas. Variations in the degree to which cities finance certain services are not reflected in these data. Census Bureau data are also subject to variations due to differences in reporting procedures between cities[44]. In addition, there is the problem of controlling supply and demand factors. Some of the variables included in regression analyses are likely to affect both the demand and supply of local government services. While often not measurable, differences in service levels between cities are also likely to have an influence on costs of services. Further, statistical studies fail to consider variations in development patterns. Density of population, for example, which is a variable recorded for the city as a whole, does not capture variations in costs generated by different densities within a given city[45].

While the focus of statistical analyses has been on intercity variations of municipal service costs for actual cities, engineering studies have concentrated their efforts on servicing and development costs for hypothetical settlements. Costs of municipal services have been estimated for either hypothetical new residential developments in existing metropolitan areas or for alternative hypothetical cities. The approach adopted in engineering studies allows for a closer examination of the influences of variables pertaining specifically to development patterns than is possible with regression analyses. Variables likely to affect servicing and development costs which are analyzed in engineering studies include residential density, population size, shape and form of settlement, contiguity of development, distance to central facilities and the extent of clustering.

The Cost of Municipal Services in Residential Areas and Municipal Costs and Revenues Resulting from Community Growth were the first two major publications based on engineering estimates which examined variations in costs of municipal services in relationship to different patterns of development. The first study, conducted by William L.C. Wheaton and Morton J. Schussheim in 1955, analyzed the impacts on municipal costs of density, size of settlements and location of new hypothetical developments to accommodate additional residential growth in three Massachusetts cities. In the analysis, capital and operating costs of new residential developments are presented for the following municipal services: streets, water systems, sewers, schools and fire protection[46]. The second study was published in 1956 by Isard and Coughlin[47]. This study differs from the previous one in that it examined costs of provision of services for hypothetical settlements instead of new residential developments in actual cities. Residential densities considered also differ, ranging from one to 16 units per acre in this study compared to 1.5 to four dwelling units per acre in the previous one. In addition, the time period for development was longer, extending over a period of 20 years instead of five years as was used in Wheaton and Schussheim study[48]. With the exclusion of water supply and fire protection, major categories of municipal costs estimated in the study were similar to those considered in the first study[49].

Wheaton and Schussheim found that service costs of water supply, sanitary sewers and streets, tend to decrease as density of residential population increases. The reverse relationship between density and municipal costs is attributed to a reduction in length of streets and utility lines per dwelling. Density is also found to affect costs by influencing the level and standards of municipal services provided. The location of new residential developments within a community may contribute to variations in costs of services. The study suggests that major savings can be realized by locating new residential developments in areas where existing service capacity and addition to capacity can be fully achieved. This factor is, therefore, of importance in partly built-up and partly serviced areas. It has much less impact on costs in underdeveloped and unserviced towns and in built-up and extensively serviced cities. In reference to the influence of size of residential development, the study indicates that some economies of scale can be realized for elementary schools, trunk sewers, water mains and fire stations[50].

The subsequent study, by Isard and Coughlin, examined the influence of density on municipal service costs for roads, sewage treatment plants, sanitary and storm sewers and elementary and secondary schools. Their findings are similar to those of Wheaton and Schussheim. They found costs of municipal services to be affected by both residential density and levels of services provided, with the latter factor varying with density[51].

Based on engineering estimates, these studies present a similar problem to the one encountered in statistical studies. They have not succeeded in isolating the influence of density on service costs. In both studies, levels and standards of services provided are found to vary with density. The study conducted by Wheaton and Schussheim also presents the weakness of considering a relatively small range of densities and sizes of residential developments. Sizes of new developments varied from 100 to 1000 housing units. The limited range of densities considered confined the study to an examination of areas with single-family detached dwellings[52].

A significant number of engineering studies have been realized since the publications of these studies in the mid-1950s[53]. Two of these studies are presented in the report. The Costs of Sprawl and The Structure, Size and Costs of Urban Settlements are detailed cost analyses covering particularly wide ranges of services and parameters of development patterns.

4.2 - The Costs of Sprawl - Detailed Cost Analysis (RERC, 1974)[54]

Sponsored jointly by the U.S. Council on Environmental Quality, the Department of Housing and Urban Development, and the Environmental Protection Agency, The Costs of Sprawl is the most well known study using engineering estimates[55]. The main objective of the engineering study was to analyze the impact of densities and contiguity of development on costs. The study examined costs of alternative development patterns for six communities of 10,000 housing units designed to house 33,000 persons per community and six neighbourhoods of 1,000 dwelling units with population ranging from

2,825 to 3,525 in each neighbourhood. Cost analyses were, therefore, carried out at two different scales of development (i.e., neighbourhood and community levels).

The hypothetical communities consisted of different combinations of the 1000 dwelling-unit neighbourhoods. Communities selected differed in development growth patterns: sprawl vs planned development. The prototypes consisted of one high density, planned community, two low density communities differing in development growth patterns (planned vs sprawl), and three intermediate density communities varying in degree of planning. The size of the community area was 6000 acres. The categories of neighbourhoods considered for analysis varied in densities and housing type compositions (i.e. single-family conventional, single family clustered, townhouse clustered, walk-up apartment, and high-rise apartment). The acreage for the prototype neighbourhoods varied from 100 to 500 acres depending on their density and housing type compositions. In the RERC study, residential densities ranged from three to 30 dwelling units per net acre. At the community level, the average density of occupation was maintained at 3.3 persons per dwelling unit while at the neighbourhood level it varied from 2.8 to 3.5 persons per household depending on housing types. The time period for development was established at 10 years.

Among servicing and development costs analyzed in The Costs of Sprawl are the capital and operating costs of utilities, including sewers, water supply, storm drainage, gas, electricity and telephone; costs of public facilities and services, including police, fire and solid waste collection; costs of transportation, including streets, roads and school busing; costs of elementary and high school education, including school construction and instruction; and recreation and health care costs. The research took into account housing expenditures, a major component of overall costs comprising capital costs of residential structures, paving, parking and landscaping. Privately borne, these residential costs are excluded from discussion in the report. In their study, the authors have also considered some environmental effects in non-monetary terms.

Based on their estimates of development costs, the researchers found that planned, more compact development is less costly than unplanned, sprawl development and this holds true for all densities of communities investigated. Costs differences are particularly significant for expenditures borne by local governments, including capital costs of transportation (i.e., roads and streets) and utilities (i.e, sanitary sewerage, storm drainage, water supply, electricity and telephone). In relative terms, cost savings are more important for utilities than transportation, with savings in capital costs ranging from 15 percent to 30 percent for utilities and approximately 12 percent for transportation. The reduction in costs found in planned communities is attributed, according to the authors, to costs of road and utility connection between neighbourhoods. Operating and maintenance costs of most public services and utilities are more a function of population size than of development pattern. The researchers concluded that "on going operation and maintenance costs of most public and semi-public services -- education, recreation, sewage treatment, water supply, police and fire protection -- are largely based on population size rather than development pattern or even housing type. For utilities (sewer, water, electricity, telephone) ongoing costs are largely based on consumption of resources and production of wastes; maintenance of pipe and cables is a comparably small proportion of total costs"[56].

While cost savings can be obtained by planning more compact communities, density is found to be a more influential determinant of costs than contiguity of development. Total local government capital expenditures can be cut down by as much as 60 percent in denser developments mainly because of the lower costs of roads and public utilities. In relative terms, cost savings are more important for utilities than transportation, with savings in capital costs ranging from 85 percent for sanitary sewerage to almost 135 percent for storm drainage, in comparison with 50 percent for transportation. Significant reductions in public operation costs can also be achieved by increasing the density of development. Operation costs per unit for electricity can be reduced by more than 70 percent and operation costs of transportation by almost the same percentage. Estimated costs of solid waste collection were approximately 30 percent less in high density developments than in low density residential communities. By contrast, fire protection services were found to be 20 percent more expensive in high density areas than in lower density agglomerations. Operating and maintenance costs for schools, sewage disposal, and water supply, were found to be more a function of size of population than density of residential development. Using RERC data, Paul B. Downing and Richard D. Gustely examined, at the neighbourhood level, variations in public costs for different housing types. Their findings were in accordance with those obtained by the authors of The Costs of Sprawl, presented above at the community level of analysis. Capital costs for single-family housing were substantially greater than for high-rise apartments, especially for water supply, storm drainage and sanitary sewers. Differences in operating costs between the two extremes in housing types were lower than for capital costs differentials. Similar to the findings of the Real Estate Research Corporation (which found education costs to be more a function of population size than of density), school expenditures did not appear to vary significantly with housing types[57].

In their analysis, the authors have also considered some non-monetary environmental impacts including: air pollution from residential natural gas consumption and private automobile utilization; water pollution from sewage effluent, storm run-off, sanitary landfill leachate and erosion (sedimentation).

Air pollution from automobile use was found to be 20 to 30 percent less in a more compact, planned community than in an unplanned sprawl development. Energy consumption associated with automobile travel was also eight to 14 percent lower in planned than in sprawl developments. Density is even a more influential factor of pollution and energy consumption than the growth development pattern. Indeed, in high density areas, energy consumption and air pollution resulting from auto transportation, space heating and cooling requirements were more than 40 percent lower than in low density residential developments. Similarly, water consumption was reduced by approximately 35 percent in high density communities. Concerning sedimentation and water pollution from storm water run-off, the researchers noted that it can be reduced by as much as 80 percent by increasing the density of development. However, concentration levels of pollution are expected to be somewhat greater.

Although The Costs of Sprawl with its detailed costs analysis is viewed as a landmark document in the field of urban planning, the engineering estimates raised some criticisms on methodological grounds. One of the major critics of The Costs of Sprawl, Alan Altshuler, argued that the RERC study failed to isolate the influence of density on costs from other sources of variations in servicing and development costs. He stated that the authors of the study did not consider the effects of density on demand levels of services. In addition, the estimated environmental impacts, in terms of pollution and energy consumption levels, are likely to have been overestimated for low-density communities because of greater floor area per household allocated for single-family dwelling units than in high-rise building units. Referring to typical housing development standards found for different types of housing, the researchers had assumed an average floor area per household of 900 square feet for high-rise buildings in comparison with 1600 square feet for single-family detached houses. Taking into consideration the varying composition in housing types, this is translated, at the community level, by a total floor area 35 percent lower in high density communities than in low density ones[58]. Empirical support for Alan Altshuler's assertion that environmental costs for low-density communities were overstated has been provided by Duane Windsor who also concluded that, by using different floor area sizes, not only have the authors failed to control the influence of this factor on costs, but they have also introduced another source of variations of costs - the level of development standards[59].

Calculations of environment-related costs of transportation represent another weakness of the study. Estimates of energy consumption levels were based on the number of trips made locally. Intraneighbourhood trips, however, constitute, at most, one-fifth of annual household auto mileage. In addition, some assumptions made concerning the substitution of mass transit use for automobile travel were not empirically supported by estimates of modal shift or transit vehicle mileage[60].

Finally, the RERC study does not include in its calculations of expenditures the costs for facilities outside of the 10,000 person community. This means, according to James A. Frank, "that the costs of roads [leading] to employment centres, transmission lines to sewage treatment, transmission lines from the water source, and storm drainage ditches, culverts, and other flood central works between the development and the receiving body of water were ignored"[61]. The significance of transportation costs to travel to employment centres has been documented by P. A. Stone in his study The Structure, Size and Costs of Urban Settlements. Major features of the study are described in the following paragraphs of this report. Estimates of distance-related costs of major public facilities provided by Paul B. Downing and Richard D. Gustely document the importance of this factor on servicing and development costs. Using data from the RERC study, the researchers calculated variations in costs per mile between the location of a prototype neighbourhood of 1000 dwelling units and the locations of a central water source, a sewage treatment plant, and the receiving body of water. Costs for central public facilities were found to vary significantly with distance, with water supply costs being the most sensitive to distance, followed by operating costs of sanitary sewers and of storm sewers[62].

4.3 - The Structure, Size and Costs of Urban Settlements[63]

Published in England at almost the same time as the Costs of Sprawl in the United States, The Structure, Size and Costs of Urban Settlements is a complex study whose main contribution lies in its analysis of transportation costs, a relatively weak area of study in The Costs of Sprawl. Another important characteristic of the study conducted by P.A. Stone is the examination of costs as a function of various aspects of urban forms including, settlement size, settlement shape and degree of employment concentration.

The study analyzed transportation costs for model settlements of 50,000, 100,000 and 250,000 inhabitants. Prototype settlements were sufficiently large to reflect self-sufficient communities. In his analysis, P. A. Stone considered three different shapes of agglomerations: rectangular, star-shaped and linear. The model communities were spatially organized to reflect three different forms of employment concentration: centralized, decentralized and partly centralized. Most shops, offices and service establishments were located in one central area in centralized settlements while, in decentralized ones, neighbourhood centres provided these central facilities needed on a daily or weekly basis by approximately 10,000 inhabitants, with the rest of services located in the central area. In partly centralized communities, district centres provided all services for about 25,000 persons except those community level services which are located in the town centre. Comparisons were also made between single settlements of 250,000 inhabitants and settlements spatially organized in various types of clusters of 50,000 persons. The types of settlement clusters considered in the analysis included: linear block (in one or two strands), linear line, cross, and necklace.

Capital costs of construction and development were estimated for model neighbourhoods of 2,930 dwelling units housing 10,000 inhabitants. The demographic composition of the residential population, by sex, age and marital status, was determined for a model neighbourhood at a maturity stage of development (i.e., at the end of a planned migration period). These characteristics were determined based on an examination of population data for settlements with various rates of growth and patterns of migration in order to reflect a realistic population composition in a model settlement. The neighbourhoods considered for analysis varied in densities and housing type compositions. Residential densities ranged from nine to 29 dwelling units per acre and the average density of occupation was maintained at 3.4 persons per household, an average value similar to the one used in the RERC study. The area size of a prototype neighbourhood of 10,000 persons was 557 acres, with residential sites varying in size from 100 to 333 acres depending on their density and housing type compositions. Neighbourhood models were designed to incorporate different land uses that are normally found in urban areas, including residential, commercial, industrial, recreational and institutional uses. Estimates of housing and other needs were determined in relation to the characteristics of the population in the model neighbourhood.

Cost analyses were carried out at two different scales of development. (i.e., neighbourhood and community scales). Capital costs of construction and development of housing and other facilities were estimated at the neighbourhood scale. A significant portion of these costs are privately borne and are, therefore, not discussed in the report. Only costs of public utilities are considered for discussion at this level of analysis.

Estimates of transportation costs at the community level constitute this study's main contribution to the understanding of the effects of urban form on costs. P. A. Stone provided a detailed analysis of variations in transportation costs as a function of settlement size, settlement shape and degree of employment concentration. The author used a traffic network simulation model to calculate these costs. Transportation costs examined fell into two categories: roads and travelling costs, with the latter category including costs of vehicle and travelling time[64].

Capital costs of providing electricity and gas were not found to vary significantly with size and form of settlements, with variations ranging from only three to five percent. Costs for sewerage and drainage were higher for settlements of 1,000 individuals than for 5,000. However, decreases in costs with population size were not substantial for communities of 50,000 to 250,000 inhabitants, suggesting that economies of scale for utilities are exhausted before reaching a settlement size of 50,000 persons. Results obtained for water supply were similar. Concerning the impact of density on costs, the author found that operation costs of electricity, gas, sewerage, telephones and water declined as density rose. Fire and police protection, however, were found to increase with density of development.

In his study, P. A. Stone found capital costs of roads to be affected by the size of settlement and degree of centralization of employment. In comparison with a settlement of 50,000 inhabitants, per capita costs of roads were 50 percent higher in a community of 250,000 persons. However, the study indicates that per capita road costs increase but at a declining rate as the size of settlement increases. For every size and shape of settlement examined in the study, costs were significantly higher in centralized settlements than in decentralized ones, with variations in costs reaching on average almost 20 percent. Concerning the effect of shape on costs, main roads were found to be least expensive for rectangular settlements and most costly for star-shape agglomerations, with a difference in per capita cost of 17 percent between these two extremes. Changes in residential density did not appear to generate significant variations in capital costs of roads per person. Finally, comparisons in costs for different communities of 250,000 inhabitants spatially organized in clusters of five equal settlements of 50,000 indicated that the more constituent settlements are dispersed, the more expensive the main road network is.

Travelling costs were more influenced by settlement size than were road construction costs. Average travelling costs per person for communities of 250,000 inhabitants were 75 percent above to more than twice the costs per capita of settlements of 50,000 people. However, the rate of increase in per capita costs declined with size, a pattern of variation in costs similar to the one found for road costs. Of less importance than the size of settlement, the shape of communities appears to have an impact on travelling costs, with the rectangular form being the least expensive and the linear form the most costly. An average difference of 23 percent in travelling costs per person was found between the linear and rectangular shapes. The association between travelling costs and the degree of employment concentration is not as clear as with size and shape of settlement. According to the author, the overall impact of centralization on costs is relatively small. Similarly, the effect of density on costs does not appear to be significant.

Finally, comparisons between communities presenting different arrangements of constituent clusters indicate much less variation in per capita travelling costs between these forms of settlement than were found for capital costs of roads.

To sum up, studies on servicing and development costs of alternative development patterns present significant similarities or consistencies. Studies based on engineering estimates suggest that public costs of utilities decrease with increases in density of residential development[65]. Capital costs of utilities for water supply, sanitary sewerage and storm drainage costs were found to be lower in denser residential developments than in lower density areas. While most studies indicate a negative relationship between the costs of transportation and density, P. A. Stone, who provided a detailed analysis of costs through the use of a traffic network simulation model, obtained no significant variations in costs in relation to density. However, Stone's study revealed construction costs of roads to be affected by both the size of settlement and the degree of centralization of employment, with larger settlements and more concentrated forms of employment presenting higher costs than smaller agglomerations with less centralized forms of employment. Unlike transportation costs, capital expenditures on utilities did not appear to vary significantly with size of settlement, suggesting that economies of scale for utilities are exhausted before reaching a settlement size of 50,000 inhabitants.

Although less important than density, the degree of contiguity of development was found to have an impact on utility and transportation costs. In <u>The Costs of Sprawl</u>, capital costs of water supply, sanitary sewerage, storm drainage, electricity and telephone services were lower in planned contiguous developments than in unplanned sprawl developments. Similarly, capital costs of transportation were lower in planned areas than in unplanned sprawl areas. Differences in costs, however, were relatively less significant for roads than for utilities. Estimates provided by Paul B. Downing and Richard D. Gustely of costs related to the location of major public facilities indicate these costs vary significantly with distance, with water supply costs being most affected, followed by sanitary sewers and storm sewers. Comparisons of capital costs of transportation between different shapes of settlements suggest circular and rectangular settlements to be the optimal shapes with respect to road construction costs.

Concerning operation and maintenance costs of public services and utilities, the studies showed less consistency in relation to urban form than was found for capital costs of services and utilities. These costs are, according to the authors of The Costs of Sprawl, more a function of population size than of development patterns. Education, recreation, fire and police protection are public services largely based on population size. Similarly, operation costs of sewers, water supply, electricity and telephone are more a function of consumption of resources and production of wastes than of a form of development. Electricity and fire protection are exceptions. Although a function of population size, operation and maintenance costs of electricity and fire protection were found, in the studies conducted by the Real Estate Research Corporation (RERC) and by P. A. Stone, to vary with density. Operation and maintenance costs of electricity decrease with density while fire protection service costs increase with density. Findings in the P. A. Stone study regarding the costs of water supply, sewerage and telephone suggested, unlike the RERC study, that these costs vary with density, with higher densities generating lower costs per person than in low density areas.

Based on detailed estimates of servicing and development costs, engineering studies have contributed to a better understanding of variation in costs in relation to different aspects of urban form including, residential density, population size, shape or form settlement, contiguity of development, distance to central facilities and the extent of clustering. Unfortunately, in most of these studies, costs of municipal services have been estimated for hypothetical settlements, not for actual cities. Population growth is more likely to take place in actual urban agglomerations than in towns newly created for absorbing this urban growth. These model settlements represent a notable departure from real situations. In addition, the effect of density on levels of demand for services has been overlooked in engineering studies.

4.4 - The Greater Toronto Area Urban Structure Concepts Study[66]

Prepared for the Greater Toronto Coordinating Committee (GTCC), The Greater Toronto Area Urban Structure Concepts Study[67] differs from previous engineering studies in that it is based on an actual urban region, the Greater Toronto Area (GTA). The region comprises Metropolitan Toronto, the regional cities of Durham, Halton, Peel and York, and the 30 municipalities within these five regions. Three alternative development patterns were examined and compared in terms of capital and operation costs of transportation systems and utilities including water supply, sanitary sewerage and solid waste disposal. Capital costs of health, education, and recreational facilities and of protection services were also included in the study. Operation costs of most human services were discussed in qualitative terms. The costs of environmental impacts on areas surrounding the three alternative development concepts included those associated with the loss of agricultural land and other natural resources, the disposal of contaminated soil, stormwater drainage, air pollution and energy consumption levels resulting from transportation.

The overall employment and population growth projected for the three patterns are identical, only their spatial distribution within the Greater Toronto Area differs. Population and employment projections for the study horizon year of 2021 were estimated at 6.02 million people and 3.44 million jobs. This represents an increase in population of 50 percent relative to 1990 levels. Population and employment projections are based on an implicit assumption that present demographic trends, social values and immigration policies will persist over the next 30 years. Population forecasts were determined on the assumption that population increase is expected to decline in the future partly due to the aging of the population. Natural population growth as a source of population increase will steadily decline. Migration into the Greater Toronto Area from the rest of Ontario, from the rest of Canada and from abroad is expected to become an increasingly important component of population growth. The trend toward smaller household sizes is also expected to persist in the future but at lower rates of decline than those experienced within the past 20 years. The employment rate in the Greater Toronto Area, estimated at 55.7 percent in 1986, is expected to reach 57.1 percent by 2021. These projections are based on the assumptions that the overall activity rate will increase until 2011 as a result of the continuing growth of the number of women working outside the home. It will then fall because of the rising proportion of people reaching retirement age. Estimated projections are also based on the implicit assumption that the Greater Toronto Area will continue to be the leading financial, commercial and industrial centre of Canada.

The three urban structure concepts examined in the study include the spread model (Concept 1), the central concept (Concept 2) and the nodal scenario (Concept 3). Developed to manage the anticipated population growth of the next 30 years, the three models differ in their spatial distribution of population and employment within the Greater Toronto Area. In the spread and nodal models, new population is largely distributed outside the existing central built-up areas while in the central model, future population growth takes place for the most part within the existing central built-up areas. The nodal and spread models present a similar proportion of population residing in the four regions surrounding Metropolitan Toronto, with the difference, however, that in the nodal concept more people live and work in compact communities than in the spread model.

The major characteristics of the three concepts are summarized in Background Report No. 1 as follows:

Spread concept:

> "A status quo concept, representing a continuation of existing trends, characterized by substantial population growth in the suburban regions at relatively low density, with continuing concentration of office development downtown and in various subcentres in Metro and the four adjacent regions (designated as **Concept 1, Spread)**

Central concept:

a concept in which substantial additional population growth/intensification occurs within Metro Toronto, and other "mature" urbanized areas adjacent to Metro along with further intensification of employment activities, such that the rate of urbanization occurring beyond Metro boundaries would be significantly reduced (referred to as **Concept 2, Central**)

Nodal concept:

an intermediate concept in which residential and employment growth occurs primarily in and around various existing communities in a compact form, resulting in reduced consumption of undeveloped land relative to Concept 1 (referred to as **Concept 3, Nodal**)."[68]

In Concept 1, gross population density for Metro Toronto slightly increases to 19 persons per acre over a 30 year period but is maintained at the density level of 1986 for the Greater Toronto Area as a whole. Defined as total population divided by gross residential acres (including streets, parks, schools, etc.), gross population densities for Metropolitan Toronto and the entire Greater Toronto Area were estimated at about 18 and nine persons per acre respectively in 1986. In Concept 2, gross population density jumps to 30 persons per acre in Metropolitan Toronto which is slightly higher than the density level of the City of Toronto in 1986. Under this urban structure concept, the overall density for the regions adjacent to Metropolitan Toronto stays the same but increases to 17 persons per acre for the entire Greater Toronto Area because of significantly higher densities in the Metropolitan Toronto region. This represents a gross population density for the Greater Toronto Area as a whole that is similar in value to the current gross density in the Metropolitan Toronto region. Concept 3 presents densities that fall between the values obtained for the spread and central models, with gross population densities of 22 persons per acre in Metro Toronto and 15 persons per acre for the entire Greater

Toronto Area. However, the overall gross density of 12 persons per acre for the areas adjacent to Metropolitan Toronto is higher than the suggested densities for the corresponding area under the spread and central concepts.

Under Concept 1, Metropolitan Toronto witnesses a greater increase in jobs in relation to people than is currently the case. With the exception of Durham, the surrounding regions experience a relatively small increase in the ratio of employment to population. Under Concept 2, significant population and employment growth in Metropolitan Toronto result in a better balance between population and employment within Metropolitan Toronto and the surrounding regions than is suggested for the two other models. Employment and population levels for the different regions under Concept 3 fall between those estimated for the spread and central concepts.

The three urban structure concepts also differ in terms of the amount of rural land used for development. Under Concept 1 (spread model), urbanized areas increase by a factor of 60 percent by the year 2021 while under Concept 2 (central model), developed areas grow by 23 percent in comparison to the areas urbanized in 1986. Concept 3 (nodal model) is between the two other models, with a 39 percent expansion relative to the size of areas urbanized in 1986. About 21 percent of the total Greater Toronto Area land area was already urbanized in 1986. By the year 2021, it is estimated that developed areas will correspond to 34 percent of the Greater Toronto Area land under the spread concept, 26 percent under the central model and 29 percent under the nodal scenario.

A comparison of public service costs among the three urban structure concepts in the Greater Toronto Area indicated no significant differences in capital costs given the absolute size of the cumulative costs and the level of precision of the estimates. Indeed, figures based on The Greater Toronto Area Urban Structure Concepts Study showed overall variations in capital costs of less than 10 percent among the three concepts. Major capital costs considered for analysis included: transportation systems, utilities (including water supply, sanitary sewerage and waste disposal), health, education and recreational facilities and protection services. Capital costs of acquisition of passive open space were also included in the study. Capital costs of transportation and human services constituted about 34 to 36 percent and 36 to 39 percent respectively of the overall estimated capital costs. Capital costs of utilities represented approximately 16 to 25 percent of capital expenditures. Costs associated with the appropriation of passive open land comprised four to ten percent of total capital expenditures.

An examination of the major capital costs components revealed no significant differences in capital costs for transportation and human service provision. However, important variations in capital costs of utilities were found among the different models. The overall annual capital costs of utilities in terms of trunk water and sewerage systems, solid waste disposal systems and capital site-related utility costs for land development and redevelopment differed on average by more than 50 percent among the three concepts, with the spread model displaying the highest average annual capital expenditures per person and the central model the lowest average per capita costs. Indeed, the average annual capital cost of transportation per person (public transit and major roads) varied by less than six percent between the different scenarios of development. Estimates of transportation costs in The Greater Toronto Area Urban Structure Concepts Study were based on the transportation network requirements derived from a detailed analysis of differential demand of transportation associated with the three patterns of development using a computerized travel demand model. Similar relative differences in capital costs were found for human services, with less than a six percent difference in per capita capital expenditures on human services among the three concepts. The GTA study examined capital expenditures on the following services: cultural and recreational facilities, hospitals, elementary and high schools, colleges and universities.

Solid waste disposal and transportation costs were among operation costs estimated in the Greater Toronto Area study. Because of time limitations, most of the operating costs associated with the provision of human services were treated qualitatively. These costs are described in detail in Background Reports Numbers 6 and 7. Regarding operation costs estimated in quantitative terms, a comparison of the three patterns of development indicated no significant difference in solid waste disposal costs. By contrast, an almost 20 percent variation in operation costs of transportation was found among the three development scenarios, with the spread model being the most costly and the central concept the least expensive. However, transportation operation costs considered in the GTA study included the following public and private costs: public transit and road operating costs (freeways, arterial and major collectors), auto user costs in terms of total annual vehicle and ownership costs, school busing costs, and handicapped transit operation costs. Auto user costs, a major component of costs, comprise more than 85 percent of the overall operation costs of transportation. If these privately borne costs are excluded from the total operating costs of transportation, the difference in operation costs among the three development scenarios falls from 20 percent to seven percent. As expected, figures obtained revealed road operating costs to be the highest and public transit costs the lowest for the spread model. Conversely, road operating costs were found to be the lowest and public transportation costs the highest for the central model of development.

Other aspects of transportation costs, including travel time and trip length, were taken into consideration in the comparison of the three concepts of development. In terms of these costs, the central model rated the highest. In the central model, average travel time and commuting distance were, respectively, 11 percent and 15 percent shorter than in the spread concept. These results are attributable to a better balance in the central concept between population and employment than is found in the spread and nodal concepts.

In The Greater Toronto Area Urban Structure Concepts Study, non-monetary environmental impacts were also considered, including consumption of rural land, ease of disposal and potential for clean-up of contaminated soil, quality of stormwater drainage, and air pollution from and energy consumption of transportation. In terms of consumption of rural land, significant variations were found among the three concepts, with the spread model exhibiting urban encroachment areas that were more than twice the size of rural land developed in the central model. The amount of urbanized rural land falls between the two extremes in the nodal concept of development. Because of a substantially greater amount of redeveloped land in the central concept than in the other development scenarios, it rates lowest in terms of ease of elimination of contaminated soil. On the other hand, higher densities and greater levels of redevelopment in the central model render the clean-up of contaminated soil more economically feasible than in the other concepts. The central concept demonstrates, therefore, the greatest potential for clean-up as well as for improving quality of stormwater drainage. Levels of gas emissions resulting from transportation were twice as high in the spread model than for the central concept of development. Energy consumption by transportation was also higher in the spread than in the central concept, with a difference of 25 percent between the two. In terms of energy consumption and gas emissions from transportation, values estimated for the nodal concept fall between the central and spread model of development.

In brief, a comparison of the costs of development and services associated with three different concepts of development in the Toronto region over a period of 30 years indicated similar overall capital costs for the three alternative development patterns. Taking into consideration the level of accuracy of the estimates, variations in capital costs of transportation and human services were not considered significant among the models. However, substantial differences were found for capital costs of utilities, with the central model displaying the lowest capital costs and the spread model the highest levels of capital expenditures. Operation costs of transportation differed significantly among the different concepts examined. If privately borne costs are excluded from the overall operating costs of transportation, variations in costs become less important. Noticeable differences in travel time and distance were found among the three concepts, with the central model being the most advantageous. As expected, the spread concept rated the lowest and the central concept the highest among the three concepts in terms of levels of air pollution generated from vehicle use and energy consumption associated with transportation.

SECTION 5 - CONCLUSION

The question of whether typical discontinuous low residential development in the fringe does generate higher costs of development and servicing than do other types of development has created a fair amount of discussion. While the focus of statistical analyses has been on intercity variations of municipal service costs for actual cities, engineering studies have concentrated on servicing and development costs for hypothetical settlements. The approach adopted in engineering studies has allowed for a closer examination of the influences of variables pertaining specifically to development patterns than was possible with regression analyses.

Studies on servicing and development costs of alternative development patterns present significant similarities or consistencies. Studies based on engineering estimates indicate that public costs of utilities decrease with increased residential density. Capital costs of utilities, including water supply, sanitary sewerage and storm drainage costs were found to be lower in denser residential developments than in lower density areas. Although less important than density, the degree of contiguity appears to have an impact on utility and transportation costs. In The Costs of Sprawl, capital costs of water supply, sanitary sewerage, storm drainage, electricity and telephone services were lower in planned contiguous developments than in unplanned sprawl developments. Similarly, capital costs of transportation were lower in planned areas than in unplanned sprawl areas. Differences in costs, however, were relatively less significant for roads than for utilities. Costs related to the location of major public facilities were found to vary significantly with distance, with water supply costs being most affected, followed by the costs of sanitary and storm sewers.

The influence of urban form on transportation costs appears to be relatively complex. While most studies indicate a negative relationship between the costs of transportation and density, P. A. Stone, who provided a detailed analysis of costs through the use of traffic network simulation model, obtained no significant variations in costs in relation to density. Similarly, in the GTA study, differences in capital costs of transportation among the three concepts of development were not significant. However, notable differences in the overall operating costs of transportation were found between the different patterns of development in the latter study.

These conflicting findings on transportation costs documented in studies based on hypothetical developments and those based on an actual urban region illustrate some of the limitations of engineering estimates in predicting variations in costs according to different patterns of development. This demonstrates the advantage of relying on concrete situations to investigate the impacts of various strategies of development on public costs. Engineering studies have contributed to a better understanding of variation in costs in relation to different aspects of urban form. However, these studies do not capture the entire picture of development costs. Urban agglomerations are complex entities and various factors influence the costs of development and services. Based on an existing urban region, <u>The Greater Toronto Area Urban Structure Concepts Study</u> demonstrates the relevance of considering actual situations rather than hypothetical urban agglomerations in investigating the fiscal consequences of various development scenarios. Unlike most engineering studies which attempt to isolate the influence of particular aspects of urban forms on costs, the approach favoured by the GTA study was a comparative analysis in terms of advantages and disadvantages of various concepts of development that are conceivable in a particular urban area within a certain time frame.

The main conclusion to be drawn from the review of the literature on public costs of development and services is that urban agglomerations are complex entities presenting features that are specific to particular urban regions. For this reason, it becomes necessary to analyze the impacts of development according to the specific conditions of a given urban area.

A review of the literature also reveals that our understanding of the major trends in spatial distribution of employment occurring in Canadian urban agglomerations is incomplete. Spatial changes in employment distribution have been documented, so far, for the Toronto region for the 1961-81 period[69]. This phenomenon of deconcentration of employment has also been documented for the Montréal region for the 1970s[70]. However, none of the studies reviewed documents this phenomenon for the 1980s. In addition, the dispersal of economic activities has been documented for Central Canada only. It becomes imperative that a better knowledge of the economic trends taking place in major Canadian cities be developed in order to better anticipate major factors affecting the development of the fringe. Changes in spatial distribution of employment have tremendous implications indeed for urban development patterns. A better understanding of these changes is a prerequisite for urban planning in the fringe.

NOTES

1. Lyon, Deborah M. 1983. The Development of the Urban-Rural Fringe: A Literature Review. Winnipeg: Institute of Urban Studies, University of Winnipeg.

2. Russwurm, Lorne H. 1980. "Land in the Urban Fringe: Conflicts and their Policy Implications". Edited by Preston, Richard E. and L. H. Russwurm. Essays on Canadian Urban Process and Form II. Waterloo, Ontario: Department of Geography, University of Waterloo.

3. Estimates based on land use changes in 70 Canadian cities with populations of more than 25,000. More than two-thirds of the Canadian population in 1986 lived within these 70 urban-centred regions. Warren, C. L., Kerr, A. and Turner, A.M. 1989. Urbanization of rural land in Canada, 1981-86 - A State of the Environment Fact Sheet. Ottawa: Environment Canada, Minister of Supply and Services Canada.

4. Fisher, Peter S. 1983. Public Service Provision on the Urban Fringe: A Case Study of Development Patterns and Infrastructure Staging. Oakdale, Iowa: University of Iowa, Institute of Urban and Regional Research.

5. Bryant, Russwurm and McLellan, The City's Countryside - Land and its Management in the Rural-Urban Fringe.

6. Bryant, "L'évolution de la ville régionale en Amérique du Nord: le cas de Toronto".

7. Bryant, C. R., L. H. Russwurm and A. G. McLellan. 1982. The City's Countryside - Land and its Management in the Rural-Urban Fringe. New York: Longman Group Limited.

8. Estimates are based on population living within a distance of 30 miles (40 miles for Toronto, Montréal and Vancouver) from the urban core of regional cities in 1981. With the exception of Charlottetown, Chilliwack and Granby, all agglomerations with an urban core of 40,000 inhabitants or more in 1976 were considered regional cities. Bryant, Christopher, R. 1986. "L'évolution de la ville régionale en Amérique du Nord: le cas de Toronto". Annales de géographie no 527: 26-42.

9. Reeds, Lloyd G. 1982. "Rural-urban Fringe Studies: A Critical Review". Edited by Beesley Ken B. and Chris Cocklin. Perspectives on the Rural-urban Fringe. Guelph: University of Guelph, Department of Geography.

10. Walker, Gerald. Forthcoming. The Rural-Urban Fringe: City and the Countryside.

11. Bryant, Russwurm and McLellan, The City's Countryside - Land and its Management in the Rural-Urban Fringe.

12. Pryor, Robin J. 1968. "Defining the Rural-Urban Fringe". Social Forces vol. 47: 202-212.

13. Troughton, M. J. 1981. "The Rural-urban Fringe: A Challenge to Resource Management?". Edited by Beesley, Ken B. and Lorne H. Russwurm. The Rural-urban Fringe - Canadian Perspectives. Toronto: York University, Department of Geography.

14. Everitt, John and Christoph Stadel. 1988. "The Urban Fringe". Edited by Welsted John, John Everitt and Christoph Stadel. Brandon - Geographical Perspectives on the Wheat City. Canada: D. W. Friesen and Sons Ltd.

15. Russwurm, Lorne H. 1971. "Urban Fringe and Urban Shadow". Edited by Krueger, Ralph R. and R. Charles Bryfogle. Urban Problems: A Canadian Reader. Toronto: Holt, Rinehart and Winston of Canada, Limited.

16. Lyon, The Development of the Urban-Rural Fringe: A Literature Review.

17. Troughton, "The Rural-urban Fringe: A Challenge to Resource Management?".

18. Troughton, M. 1981. "Aspects of Employment and Commuting in the Fringe zone of London, Ontario". Edited by Beesley Ken B. and Lorne H. Russwurm. The Rural-Urban Fringe - Canadian Perspectives. Toronto: York University, Department of Geography.

19. Gertler, Leonard O. and Ronald W. Crowley. 1977. Changing Canadian Cities: The Next 25 Years. Toronto: McClelland and Stewart.

20. Russwurm, Lorne H. 1977. "The Urban Fringe as a Regional Environment". Edited by Russwurm, Lorne H., Richard E. Preston and L. R. G. Martin. Essays on Canadian Urban Process and Form I. Waterloo: University of Waterloo, Department of Geography. See also Statistics Canada. 1986. Census Metropolitan Areas and Census Agglomerations: A 1986 and 1981 Comparison. Catalogue 99-105E. Ottawa: Ministry of Supply and Services Canada.

21. Pryor, "Defining the Rural-Urban Fringe".

22. Bryant, Russwurm and McLellan, The City's Countryside - Land and its Management in the Rural-Urban Fringe.

23. Pryor, "Defining the Rural-Urban Fringe".

24. Russwurm, "The Urban Fringe as a Regional Environment".

25. Reeds, "Rural-Urban Fringe Studies: A Critical Review".

26. Bryant, Russwurm and McLellan, The City's Countryside - Land and its Management in the Rural-Urban Fringe.

27. Bryant, Christopher R. 1988. "Economic Activities in the Urban Field". Edited by Coppack, Philip M., Lorne H. Russwurm and Christopher R. Bryant. Essays on Canadian Urban Process and Form III - The Urban Field. Waterloo: University of Waterloo, Department of Geography.

28. Lyon, The Development of the Urban-Rural Fringe: A Literature Review. See Bryan, Russwurm and McLellan, The City's Countryside - Land and its Management in the Rural-Urban Fringe.

29. Wardwell, J. M. 1980. "Toward a Theory of Urban-Rural Migration in the Developed World". Edited by Brown, D. L. and J. M. Wardwell. New Directions in Urban-Rural Migration. New York: Academic Press.

30. Bryant, "Economic Activities in the Urban Field".

31. Russwurm, Lorne H. and Chris R. Bryant. 1981. "Regional Differences in the Evolution of the Canadian City, 1941 to 1976". Paper presented at the annual meeting of the Canadian Association of Geographers, Corner Brook, Newfoundland, August 1982.

32. Russwurm, Lorne H. and Philip M. Coppack. 1988. "Population in the Urban Field". Edited by Coppack, Philip M., Lorne H. Russwurm and Christopher R. Bryant. Essays on Canadian Urban Process and Form III - The Urban Field. Waterloo: University of Waterloo, Department of Geography.

33. Lépine, Yolande and Yves Brunet. 1984. "Les variations spatiales de la présence ex-urbaine en milieu rural québécois: description et hypothèses d'explication". Edited by Bunce Michael F. and Michael J. Troughton. The Pressures of Change in Rural Canada. Toronto: York University, Department of Geography.

34. Bryant, "Economic Activities in the Urban Field". See also Gertler, Meric S. 1985. "Industrialism, Deindustrialism and Regional Development in Central Canada". The Canadian Journal of Regional Science 8(3): 353-375.

35. Bryant, "Economic Activities in the Urban Field".

36. Gad, Gunter. 1985. "Office Location Dynamics in Toronto: Suburbanization and Central District Specialization". Urban Geography 6(4): 331-351.

37. Kellerman, Aharon and Shaul Krakover. 1986. "Multi-Sectorial Urban Growth in Space and Time: An Empirical Approach". Regional Studies 20(2): 117-129.

38. Russwurm, Lorne H. 1977. The Surroundings of our Cities: Problems and Planning Implications of Urban Fringe Landscapes. Ottawa: Community Planning Press.

39. The Lower Mainland Regional Planning Board. 1956. Urban Sprawl. New Westminster, British Columbia.

40. Proportion of population of the Standard Metropolitan Statistical Area (SMSA) living in the central city area.

41. Brazer, Harvey E. 1959. City Expenditures in the United States. New York: National Bureau of Economic Research.

42. Bahl, Roy W. 1969. Metropolitan City Expenditures - A Comparative Analysis. Lexington: University of Kentucky Press.

43. Fisher, Peter S. 1983. Public Service Provision on the Urban Fringe: A Case Study of Development Patterns and Infrastructure Staging. Iowa City: Institute of Urban and Regional Research, the University of Iowa.

44. Bahl, Roy W. 1969. Metropolitan City Expenditures - A Comparative Analysis. Lexington: University of Kentucky Press.

45. Fisher, Public Service Provision on the Urban Fringe: A Case Study of Development Patterns and Infrastructure Staging.

46. Wheaton, William L. C. and Morton J. Schussheim. 1955. The Cost of Municipal Services in Residential Areas. Washington: United States Government Printing Office.

47. Isard, Walter and Robert E. Coughlin. 1956. "Municipal Costs and Revenues Resulting From Community Growth". APA Journal vol. 22(1): 239-251.

48. There are also variations in levels of service considered for analysis within the same category of municipal services. For storm sewers, for example, minor and major collectors are included in the Wheaton and Schussheim study while only minor collectors are computed in the Isard and Coughlin study.

49. There are also variations in service levels within the same category of municipal services. For instance, only local street costs are included in the Wheaton and Schussheim study while costs of both local and collector streets are considered in Isard and the Coughlin study. Variations are also found for sanitation and storm drainage. In Frank, James E. 1989. The Costs of Alternative Development Patterns - A Review of the Literature. Washington, D.C.: The Urban Land Institute.

50. Wheaton and Schussheim, The Cost of Municipal Services in Residential Areas.

51. Isard and Coughlin, Municipal Costs and Revenues Resulting from Community Growth.

52. Frank, The Costs of Alternative Development Patterns.

53. In The Costs of Alternative Development Patterns, James A. Frank has summarized and discussed major findings of these engineering estimates of costs of alternative development patterns.

54. Real Estate Research Corporation. 1974. The Costs of Sprawl. Detailed Cost Analysis. Washington, D.C.: U.S. Government Printing.

55. Fisher, Public Service Provision on the Urban Fringe: A Case Study of Development Patterns and Infrastructure Staging.

56. Real Estate Research Corporation, The Costs of Sprawl, p. 8

57. Downing, Paul B. and Richard D. Gustely. 1977. "The Public Service Costs of Alternative Development Patterns: A Review of the Evidence". Edited by Paul B. Downing. Local Service Pricing Policies and Their Effect on Urban Spatial Structure. Vancouver: University of British Columbia Press.

58. Altshuler, Alan. 1977. "Review of The Costs of Sprawl". Journal of the American Institute of Planners vol. 43(2): 207-209.

59. Windsor, Duane. 1979. "A Critique of The Costs of Sprawl". APA Journal vol. 45(3): 279-292.

60. Altshuler, "Review of the Costs of Sprawl".

61. Frank, The Costs of Alternative Development Patterns p. 30.

62. Downing and Gustely, "The Public Service Costs of Alternative Development Patterns: A Review of the Evidence".

63. Stone, P. A. 1973. The Structure, Size and Costs of Urban Settlements. Cambridge, England: Cambridge University Press.

64. The author included vehicle costs in the estimates of travelling costs, of which an important portion is privately borne.

65. Studies based on statistical analyses suggest the opposite:
public costs were found higher in denser developments than in lower density areas. It is argued, however, that the approach adopted in engineering studies allowed for a closer examination of the influences of variables pertaining specifically to development patterns than was possible with regression analyses.

66. IBI Group. 1990. Greater Toronto Area Urban Structure Concepts Study: Summary Report. Prepared for the Greater Toronto Coordinating Committee. Ontario, Toronto.

67. The documents published on the Greater Toronto Area Urban Structure Concepts Study comprise a summary report that is accompanied by the following background reports:

(1) Description of Urban Structure Concepts
(2) Minimal Growth Options
(3) Transportation Systems
(4) Water, Sewers and Solid Waste
(5) Greening/Environment
(6) Human Services
(7) Comparison of Urban Structure Concepts

68. IBI Group. 1990. Greater Toronto Area Urban Structure Concepts Study: Background Report No. 1 - Description of Urban Structure Concepts. Ontario, Toronto.

69. Bryant, "Economic Activities in the Urban Field". See Gertler, "Industrialism, Deindustrialism and Regional Development in Central Canada". See also Gad, "Office Location Dynamics in Toronto: Suburbanization and Central District Specialization.

70. Lamonde, Pierre and Mario Polèse. 1985. Le déplacement des activités économiques dans la région métropolitaine de Montréal de 1971 à 1981. Etudes et documents No 45. Montréal: INRS-Urbanisation.