PUBLIC TRANSIT'S ROLE IN THE
EVOLUTION OF URBAN MULTI-NODALITY
- A CASE STUDY OF OTTAWA -

by

VERNON RIEDIGER, B.A.

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Carleton University

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ABSTRACT

While the subject of urban multi-nodality has gained considerable attention in the U.S., where the trend is more advanced, the issue has received minimal recognition in Canada. Although the multi-nodal trend within Canada is most detectable in Toronto, a study of the Ottawa urban area is useful in determining whether the trend is present within smaller metropolitan areas. This study reveals that while the Ottawa urban area is still primarily CBD-centred, based on the spatial density patterns of population, employment, transit patronage and transit service, several outlying nodal centres collectively account for an increasing share of urban structural change. In light of the recently approved transitway scheme for the Ottawa urban area, an assessment of the potential use of rapid transit development for concentrating future urban growth at outlying activity or nodal centres, thereby fostering a multi-nodal urban structure, seems appropriate at this time.

ABSTRACT

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CHAPTER ONE

THE CONCEPTUAL FRAMEWORK

1.1 - Scope of Investigation

The close interrelationship between urban land use patterns and transportation flows is a fundamental principle of urban geography. The functional organization of every region is reflected in its networks of transportation, trade and communications (Taaffe & Gauthier, 1973:2). Arguably the most important factor in the structural evolution of an urban region, the transportation system links together all of the functions of an urban area in time and space, including the patterns of population, employment and socio-economic activity. Patterns of urban land use are closely associated with the spatial structure of the transportation system.

During the 1960's, several works connecting land use and transportation pioneered the deductive application of transportation modeling principles to land use modeling. The basic underlying concept in these land use models was the constancy of travel behaviour. Central to land use

modeling were the ideas of location and accessibility, as developed in transportation models. Since the intent of this thesis is to determine the significance of a particular urban phenomenon in the Ottawa urban area, namely the trend toward urban multi-nodality, model development is not particularly relevant for this study; no attempt will be made to comprehensively represent the process of local urban development.

In the systems framework, an equilibrium position of supply and demand between land use and transportation is being sought (Morris, 1977:58). Generally, the greater the concentration and specialization of activity, the greater the level of interaction. Greater interaction naturally results in "...further demands for increased accessibility, greater degrees of locational utility, and transport innovations" (Janelle, 1974:364). The spatial reorganization of urban land uses is perpetuated in an ongoing and accelerating cause and effect cycle. This continuous interplay between nucleation and circulation is summarized in the multiplier effect or positive feedback. The locational specialization and concentration of activities, in combination with the trend towards urban decentralization, introduces the opportunity for significant new nodes or focal points to develop away from the congested Central Business District (CBD), and for activity to intensify at these locations. There is of course a

significant time lag factor involved in all the above-mentioned reactions.

By referring to the hypothetical urban area in Figure 1-1, the process by which improvements in the transportation system, often designed to improve accessibility to the CBD, can encourage the development of new outlying nodes can be explained. Improvements of routes one and two, or increasing transit service along these routes, for the purpose of increasing accessibility to the CBD, also increases the level of accessibility of points A, B and C, and all other points along routes one and two. In order to improve accessibility to trunk routes one and two, arteries three, four and five, which feed into routes one and two, are improved, or transit service along them is increased, thus further improving accessibility to the CBD. These arterial improvements also further increase the accessibility of points A, B and C along routes one and two. Therefore the opportunity for significant new nodal development at these three points is introduced.

Traditionally the location in the urban area with the highest level of accessibility, the highest land values and the most intense land uses has been, and still is, the CBD, which is usually located at or close to the initial point of settlement. Because of these attributes, it also has the highest traffic densities and an extremely high daytime population due to its continued dominance as the major urban

FIGURE 1-1
THE ROLE OF TRANSPORT IN THE
DEVELOPMENT OF URBAN MULTI-NODALITY

Source: Author - 1983.

employment concentration. Most North American CBD's developed when public transit was the dominant transportation mode and are oriented towards the use of that system (Bruton, 1975:174), primarily because of its high-density land use and employment levels. While transit makes high density development possible and is required to service high density areas, it also is most efficient in terms of operation cost and service provided when supplying direct service between origins and destinations which attract and generate large volumes of trips. For this reason, public transit relies heavily upon peak-hour commuting flows, primarily to the CBD.

Historically the North American city has been single-centred with a focus on the CBD. This is more pronounced today in Canadian cities than in U.S. cities where the CBD is commonly rivalled by numerous non-CBD employment subcentres - the large outlying shopping and office complexes developed since World War II (Soberman & Hazard, 1980:133). While the trend toward a multi-nucleated urban spatial configuration is convincingly argued for the U.S. city by many authors (Vance, 1977; Berry & Kasarda, 1977:267,304; Odland, 1978; Huth, 1983), this is much less apparent in Canada with the notable exceptions of Metropolitan Toronto (Griffith, 1981; examples in Appendix D), Montreal and Vancouver, due largely to the smaller average size of the Canadian city. It is strongly suspected

that the extent of urban multi-nodality increases with city size as the friction of distance to the CBD increases. Canadian urban areas, though, should no longer be viewed exclusively as single-centred systems.

Contemporary arguments supporting the development of multi-nodality have been formulated (Huth, 1983:249-251). One is that a multi-nodal urban spatial pattern would provide better service to the entire urban population, provided the new nodes are fully developed, since the newer nodes would be in closer proximity to the predominantly suburban population they are designed to serve. It is of primary importance to provide significant employment opportunities in the new nodes for the surrounding population, however there is no guarantee that the employees working at the new nodes will be drawn from the immediately adjacent residential areas. In addition to lowering congestion levels in the core area, the multi-nodal scheme presents the opportunity to significantly reduce total energy consumption in the intra-urban transportation sector, since the average length of commuting trips would be reduced dramatically. With public transit's heavy dependence on urban commuting flows, the transit service pattern will have to change its almost total focus on the CBD to also include all the newly-developing nodes in the urban area. A more efficient urban structure could potentially be achieved following the multi-nodal scheme.

This thesis addresses itself to the urban multi-nodality issue and the role that public transit plays in this urban transformation process. It is intended to accomplish the following objectives:

1. to determine the relative importance of the spatial density patterns of population and employment, as well as distance to the CBD centre, in accounting for variance in transit patronage and transit service densities within the Ottawa urban area;

2. to determine the extent to which the spatial distributions of population, employment, transit patronage and transit service within the Ottawa area reflect a multi-nodal urban structure;

3. to determine the extent to which Ottawa's major outlying nodal centres have become more employment intensive and more functionally diverse; and

4. to compare the characteristics of the most substantial outlying nodal centres as well as their roles in the present local transit network, and to identify their importance in the proposed transitway system for the Ottawa urban area.

The purpose of this study is to advance understanding of the multi-nodal evolution which, the author feels, is occurring in the Canadian city. The particular significance of public transit in this process, as against transportation in general, will be elucidated in Section 1.2.2.

1.2 - Introduction to the Literature

The relationship of transportation and land use development, a topic of academic enquiry for over a century, is a complex subject. The cyclical nature of the interaction process "...incorporates many factors that make planning for development difficult" (Morris, 1977:84). Reviewing literature in the field of transportation-land use interaction and planning reveals a large gap between "...the professional philosophies of the town planner and transportation engineer" (Blunden, 1971:27). The work of the U.S. Highway Research Board (now the Transportation Research Board) on urban development modeling in the latter half of the 1960's was one of the earliest attempts to close this philosophical gap.

Most of the literature prior to the 1970's tends to base its logic on theoretical urban models which depend on the assumption that cities are and always will be focused on a single centre, the CBD. The development of multi-centre cities attracted relatively little formal attention (Odland, 1978:235) until after the mid-1970's. Today there is a rapidly increasing stock of written material on the subjects of urban multi-nodality, the development of new suburban downtowns, and the function of rapid transit development in fostering the growth of new outlying activity centres.

Also most of the literature has little to say directly about the Canadian urban transportation scene. Literature

on North American cities tends to be biased towards the U.S. urban experience, so one has to guard against making unwarranted continental assumptions regarding urban reality (Mercer, 1979:119-139). Hutton warns that basic urban conditions and trends in Canada and the U.S. differ substantially, and thus caution must be exercised in correctly identifying implications for planning in our cities (1983:55).

The remaining subsections will summarize literature from the many facets of this rather intricate subject. It is believed by the author that an extensive literature review is a necessary foundation if the motivating forces which initiated this study are to be fully grasped. The various component sections of this review serve as logical steps leading to a culminant summary of the function of public transit in the emerging multi-nodal urban area.

1.2.1 - The Interdependence of Transportation and Urban Land Development

At the most elementary level, most Canadian towns and cities are located at points "...where trade routes converge or the transshipment of goods is required. These transportation advantages initiated the growth of urban communities" (Jackson, 1973:145). In 1970, it was estimated that between 35 and 40 percent of all urban land was required for transportation purposes (Creighton, 1970:68).

A city "...comprises a complex system of overlapping

functional areas and of nodes and foci about which human activity is organized" (Garner, 1966:7). The essence of the contemporary urban system is its linkages and interactions, with mutual accessibility of residences and workplaces being of primary importance. Movement within the city and urban focality are intimately connected with the concept of accessibility which "...describes the advantages and attractiveness of a location in terms of its functional proximity to opportunities at other locations" (MacKinnon & Lau, 1973:122). A change in accessibility is the result of either an altered transportation system or a change in the land use pattern, which may have been induced by transportation developments (MacKinnon & Lau, 1973:125). When accessibility is changed, "...the rent gradients change; since land uses and rents for land are tied each to the other by market processes, land use potentials are changed" (Garrison, 1979:523).

"The economic concepts relating land values to differences in accessibility are fundamental to the analysis of the distribution and intensity of land uses within the urban area" (Garner, 1966:7). The most intense competition for land focuses on the most accessible locations, usually centrally located sites, with the advantage of high accessibility reflected in high land values and therefore high rents. Classic location theory states that non-primary land uses arrange themselves spatially according to their

access needs and rent-paying ability. Those land uses that require high accessibility and are able to pay for it are found at the most central and accessible locations. Urban activities generally must make a trade-off between a location's accessibility and site rent. This balance between transportation costs and land costs is an attempt to minimize travel time (or distance) and maximize site space. Thus there is a close interrelationship between the transportation network, land values and land uses.

In theory, accessibility levels, land values and therefore land use intensities peak in the city centre at the peak-value intersection, the point of minimum aggregate travel costs, and fall off inversely with the square of the distance from the CBD. In 1951, Clark found that this exponential decline from the city centre (distance-decay model), which assumes urban monocentricity, was also followed by urban employment and population densities. Clark, who studied the population density gradients for thirty-six cities from Los Angeles to Budapest from 1807 to 1950, found a negative exponential decline from the city centre, however he also detected the emergence of a population density crater in the CBD. A good fit of population density gradients to this pattern was found in all Canadian metropolitan areas in 1971 (Berry, Conkling & Ray, 1976:137).

This generalized urban density and land value gradient

is modified by two additional elements: "main traffic arteries, and intersections of main arteries with secondary centres at regular distances from the CBD" (Haggett, 1975:338). Lesser local land value peaks occur along arterial ribbons, which form ridge lines of relatively greater land value radiating from the CBD apex, at subcentres and at points of particular urban advantage (major intersections). There is a greater tendency for sharper ridges of accessibility to develop along important transit corridors. The minor cones of varying land values found at the intersections of ridges in Berry's overall ribbed cone (Figure 1-2) are usually outlying employment nodes such as business or shopping centres. Brigham has hypothesized that "...land values are negatively related to distance from the CBD and the nearest freeway..." and possibly related to accessibility to employment opportunities (1971:167). Of course other factors like land use zoning, market conditions, and natural site amenities modify the land value surface.

As a land use, transportation facilities clearly influence the usage levels and intensity of other land uses in an urban or rural area (Stopher & Meyburg, 1975:99). Since only accessible land can be effectively utilized, "...transport facilities fulfil a market role in determining the amount of land that is available for development at different levels of accessibility" (Bruton, 1975:25). Urban

Fig. 1-2: General Pattern of Urban Land Values.

Source: Brian J.L. Berry (1963), "General Features of Urban Commercial Structure" (in L.S. Bourne's Internal Structure of the City, New York: Oxford University Press, 1971), p.364.

Fig. 1-3: Hypothetical Land Rent Profile in a Multicentred Urban Area.

Source: Berry, Conkling & Ray; The Geography of Economic Systems (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1976), p.135.

land value, and therefore land use, is determined primarily by accessibility, which is dictated by the transport system.

A comparison of European and North American cities demonstrates that the spatial extent of urban development has historically depended on the speed of travel (Soberman & Hazard, 1980:10). Most European cities tend to be small in area with high densities since they were highly developed before the availability of modern urban transportation systems. Cities in eastern North America developed during a period when transit was available, and are therefore larger and less dense than the European cities. The most highly dispersed and lowest density cities are found in western North America due to their rapid development after 1950 when there was widespread availability of the automobile. The surge of auto ownership and the low-density city came later in Canada than in the U.S., and as a result the development of shopping plazas and expressways in Canadian cities was somewhat delayed and Canadian cities are generally less decentralized (Simmons & Simmons, 1974:14). Thus urban form adapts to the transportation type which dominates it (Pederson, 1980:13) and vice versa.

While access is a necessary condition for development, it is not a sufficient one on its own. Transportation does not cause urban growth and change, it enables it; the causal forces are economic, sociological and political, and they operate on their own without any necessary planned

influence. "The role of transportation and communications has been central to generating this unplanned urban change" (Wheeler, 1974:112).

Since Mitchell and Rapkin's 1953 work, it has been recognized that the transportation system is equally influenced by the location of activities. Traffic flows in an urban area follow predictably from the arrangement and intensity of land uses. Changes in land use mix or density alter traffic flows on particular channels and this will often generate the need for additional physical channels of movement. The characteristic of land use which most affects transportation is density (Blumenfeld, 1969:30), with higher density development encouraging public transit use.

As different transportation modes have different impacts on urban form, different land use types and development forms generate varying amounts and kinds of traffic flows. The spread-out suburb has a vastly different impact on travel patterns than does the concentrated apartment district. Traffic generation is related to: "the type of land use, and the scale or intensity of activity taking place on the land" (Black, 1981:24). "The spatial pattern or distribution of traffic is explained by two factors: the disposition of land use, and the restraints on movement" (Black, 1981:25). The gravity model states that the volume of traffic between urban centres and subcentres is directly proportional to the relative attractiveness of

each subarea, and inversely proportional to distance, measured in travel time (Lowe & Moryadas, 1975:187-189).

Thus the spatial "...pattern of distribution of land use, population and employment, which is the result of transportation, in turn determines the pattern of movement of goods and persons" (Blumenfeld, 1967:125). According to Altshuler, there is little certainty about the strength of the mutual influence between transport and land use relative to other forces that bear upon each, and particularly upon land use. In the short term, travel is predominantly dictated by land use, as trip patterns are dependent on the geographic distribution of activities. Over time though, the transportation system can significantly shape land use and urban form (Altshuler, 1979:374).

1.2.2 - The Role of Public Transit

While the scope of the preceding subsection has been the transportation sector as a whole, it is now appropriate to focus on the role of public transit in the urban development process. While automobile trip patterns spread out into suburban areas beyond the city limits, transit trips occur within a much more confined area, an area which coincides with areas of higher population density (Creighton, 1970:43). Within the public transit sector, bus trip patterns vary markedly from rapid transit trips. Bus trips often crisscross and overlap each other within

relatively small areas, and bus routes do not tend to be as focused to the CBD as rapid transit lines (Yeates & Garner, 1976:352). While both auto traffic and transit volumes peak along major arteries where they intersect with other major collectors and arteries (Berry's model), "the height of the transit access surface is everywhere lower than that of the automobile access surface" (MacKinnon & Lau, 1973:133).

Public and private means of transportation result in substantially different land development forms (Blumenfeld, 1967:309). Developments in public transit have had more intensive, more localized and more central consequences. Developments in auto transportation have had a strong but more diffuse and suburbanizing tendency. The establishment of rapid transit has been given credit for reducing the rate of urban sprawl, centralizing employment and preserving the CBD concentration. For example, the metropolitan areas of Toronto and Montreal are relatively dense by North American standards, and they each support strong central core areas; both cities developed extensive subway systems in the mid-1950's (Toronto) and early 1960's (Montreal) which focus on their respective CBD's.

When mass transit was the most rapid and flexible transportation system available, there was a positive correlation between urban population growth and intensive use of mass transit. The direction of this correlation reversed after World War II when the automobile took over as

the major shaper of urban growth (Berry & Kasarda, 1977:104).

The suburbanization of population and employment since World War II, caused primarily by changes in inter-city and intra-city transport and communications systems, extended the range required of the public transport network. This trend toward low-density and less-concentrated development did not lend itself easily to the provision of economical and efficient bus service (Steiner, 1978:61). The recovery of public transit patronage levels in North America since the early-1970's is largely attributable to the rapid rise in fuel prices after the 1973 'Energy Crisis' which initiated a change in public attitude towards energy conservation.

While movement into and out of the CBD is best served by transit, transit is also best adapted to and most competitive (time and cost-wise) for heavy peak-hour commuter flows to and from the CBD. There is a pronounced peaking of transit trips, as well as service, in both absolute terms and relative to auto trips, during peak-hours. Public transit loads are increasingly concentrated in the morning and afternoon rush hours, accounting for between 50 and 60 percent of all transit rides (Blumenfeld, 1967:131). In Canadian cities, bus systems carry about 20 percent of their one-directional daily load in one hour (Pushkarev & Zupan, 1977:120). The

radial orientation to the CBD exists in all transit systems, regardless of size, but is more pronounced as city size decreases (Soberman & Hazard, 1980:121-124).

Blumenfeld states that efficient public transportation requires a concentration of trips in space and time. For work-trips made to and from high-density workplaces, the absolute cost advantage (for the commuter) still lies with public transit. The greater the volume of potential trips between any two zones, the higher the level of transit service which can be supported. "Thus population density as well as 'attraction' densities (employment, retail floorspace, etc.) are key variables in determining transit demand" (Soberman & Hazard, 1980:133).

New urban transit systems unquestionably assist in shaping the urban centres they serve; they "...affect other modes of transportation, land use patterns and activities, social and economic conditions, and environmental form and quality" (Potter, 1979:45; examples in Section 1.2.4). Rapid transit development emphasizes "...the radial or sectoral growth of the city..." and promotes "...the rise of the area around local transit stations as centres of economic activity" (Yeates & Garner, 1976:192). According to land use theory, there will be gradations of residential construction, land values and population density patterns away from the rapid transit stations. The greatest changes can be observed around those stations farthest from the CBD

(Yeates & Garner, 1976:194).

"The initial effects of a new rapid transit facility are relatively small, though certainly significant", as transit impacts on land development take a rather long time to work themselves out. "The later effects tend to be much larger and involve development that is much more capital-intensive" (Gannon & Dear, 1975:239). Larger transit investments (eg. subway or transitway system) would of course have a great impact on future urban development. It is claimed by some that rapid transit development is inevitably an act of restructuring the city (Figure 1-4).

Increasing concern with pollution, fuel shortages and traffic congestion has shifted the attention of urban planners to the provision of efficient mass transit systems and increasingly the public is recognizing the acceptability and need for improved transit services (Soberman & Hazard, 1980:6). Canada's three largest cities have each experienced major improvements in public transit since the 1950's. In Toronto and Vancouver "...this has occurred at the expense of urban highways and the automobile" (Colcord, 1975:225).

The role of public transport in urban planning can be viewed from either a responsive or an inductive perspective. Historically public transit has followed as a consequence of urban planning, having only a supportive role in the urban planning process. However, it can be used as a catalyst for

Fig. 1-4: Plan showing suggested application of a new public transport system to an existing metropolitan city. Here both radial and circumferential lines are proposed which carry a personal rapid-transit system, and at intersections between these would be generated new activity centres outside the existing centre, surrounded by high density residential development. (Courtesy, Stanford Research Institute)

Source: Brian Richards, *Urban Transportation and City Form* (Futures, March 1969), p.241.

achieving urban development goals (eg. Stockholm's nodal development concept; see Bowes, 1975:237-238). As the cost of private intra-urban travel rises, public transit access will become increasingly important in the future. Investment in public transit systems "...may prove to be a powerful instrument in guiding future population and economic growth into locations within urban regions that optimally serve the public interest" (Huth, 1983:249). The concept of using public transit to encourage a multi-nodal urban configuration will be examined in the four remaining sections.

1.2.3 - Joint Development of Transit and Land Use

Since the 1960's, the emphasis in urban planning has shifted from a simplistic end-state orientation to a more rational concentration on both goals and the process by which goals are achieved. Almost all urban planners acknowledge that land use and transportation must be analyzed, planned and managed, on a metropolitan scale, in a comprehensive, integrated manner if desirable urban form is to be achieved. Not only should transport and land use planning be co-ordinated, but the entire planning process should be continuous, requiring constant amendment and validation (Bruton, 1975:17).

An important objective of planning a land use and transport system is to ensure that transport and land

development be efficiently balanced to avoid undue strain on the transport system due to over-development, and to ensure that transport is available to meet the needs of development.

In the late-1970's, the concept of 'joint development' of transit and land use was rediscovered in the U.S.. Pioneered in New York City during the early decades of this century, joint development "...is a real estate development that is closely linked to public transportation services and station facilities and relies to a considerable extent on the market and locational advantages provided by the transit facility" (U.S. Dept. of Transportation, July 1979:1). Joint development of transit and land use, a cooperative venture involving both public and private sectors, is a logical consequence of successful metropolitan rapid transit planning.

Using transit to lever private investment on land around fixed guideway facilities can benefit both public and private sectors. Developers can increase the returns on their investment and the economic development of the community will receive a boost. Cost efficiencies can be achieved in the construction of both public and private facilities. Joint development would allow a limited recovery of transit capital costs and promote greater use of the transit system. Apart from enhancing urban design, the opportunity to manage and control urban growth would be

presented (U.S. Dept. of Transportation, July 1979:1).

Since the relationship between public transit and high-density development is only permissive, and not causative, successful and effective transit-land use planning requires strict enforcement of land use controls. Without such development controls to help shape land development and encourage complementary land uses, the validity of planned changes in the transport system could be threatened. Soberman stresses that new transit facilities will be profitable "...only if they are integrated with land use decisions that encourage development of activity centres which will support those services" (1975:52).

Based on the joint development experiences in Toronto and Montreal, transit planners in recent decades "...have tended to assume that high-density land use development would automatically spring up where transit stations were constructed" (U.S. Dept. of Transportation, July 1979:1). Successful joint development projects are the result of co-ordinated public and private initiatives, and they are not inevitable consequences of the establishment of transit facilities. Land must be available around transit stations for development of appropriate land uses in appropriate densities. Local zoning and land use planning should be co-ordinated to channel growth toward pedestrian-oriented station areas.

The following set of factors are consistently involved

FIGURE 1-5
in the generation of transit's impacts on land use: land availability, its ease of assembly, social and physical characteristics of the area, general economic conditions, community support, and public land use policies (U.S. Dept. of Transportation, Aug. 1979:4). These factors form an empirical model (Figure 1-5) from which transit's impact on land use can be predicted. Rapid transit's impact on land use in the North American context has ranged in size from nil to dramatically large (the case of Toronto).

The combined experience of cities with rapid transit systems suggests that planners have not given enough attention to implementing joint development, specifically around stations. Since the daily activity patterns of a large number of residents are focused through these transit nodes, station areas become attractive locations for a wide spectrum of consumer, public, professional, retail and possibly higher-order services, as well as high-density housing. Thus transit terminals are potential generators of urban growth, and they often develop into centres of intense activity and development and major generators of intra-urban traffic, based largely on employment opportunities.

The journey between home and work, the dominant urban traffic flow accounting for between 40 and 60 percent of total daily person-miles (Stopher & Meyburg, 1975:10), is of critical importance from a planning viewpoint. Concentrating many potential trip destinations, particularly

**FIGURE 1-5:
FACTORS INFLUENCING
LAND USE IMPACT**

Source: U.S. Dept. of Transportation (Aug. 1979), p.204.

places of employment, at transit nodes, and increasing the spatial proximity of residences and employment opportunities there could create substantial economies in intra-urban transportation costs, since transit use would be facilitated and auto movement would be reduced. Since the scale of road building and transport facility development is primarily determined by peak period traffic demand (Blunden, 1971:215), additional savings in transportation facility expenditures are possible.

It is logical for new urban transit systems to focus themselves on existing and/or planned major trip generators such as large shopping centres and important employment nodes. Regional shopping centres, predictably located where they are most accessible to the population they serve (usually located at the intersections of radial and circumferential routes), already contain many CBD-like features like office and apartment high-rises. Planned shopping centres, in Canada since 1950, have greatly increased their share of the total retail floorspace and total retail revenues in metropolitan areas (Nader, Vol. I, 1975:79). While outlying regional shopping centres generally have not greatly distorted the land-value surface, they have brought a host of important changes in Canadian urban structure and are becoming more important. Meanwhile, the effect of accessibility to the CBD on land values is not as important as it has been in the past (Yeates & Garner,

1976:222).

According to Lorimer (1978), the new goal of corporate developers is to move from mere regional shopping centres to regional town centres, using the concept of joint development. Examples from the Toronto area include Trizec's "Scarborough Town Centre", McLaughlin's "Square One" in Mississauga, "Bramalea City Centre" in Brampton, and "Sheppard Centre" in North York which is located around the Sheppard subway station near the northern terminal of the Yonge Street line (see Appendix D). Similar to large downtown commercial redevelopment projects, these 'suburban' business nodes are being built up to downtown densities. Thus developers will be able to shift from virtually total reliance on car transportation to obtain public transit service for their centres.

In Edmonton, the 202,400 square metre "West Edmonton Mall", already the largest mall in Canada (Edmonton Journal, August 12, 1983:B1,C8; August 17, 1983:B1), will undoubtedly function as a secondary core area twelve miles from the original downtown core. When the final phase is completed in the fall of 1985, West Edmonton Mall will be the largest shopping mall in North America. With an eventual 368,000 square metres, it will be a covered city of 700 shops, 15 nightclubs, theatres, art galleries, a museum, a public library and a myriad of recreational facilities and tourist attractions (Ottawa Citizen, Dec. 12, 1983:38).

Vancouver's 1975 regional plan proposed four regional 'town centres' for 1986 (Lorimer, 1978:213). "Corporate developers plan...to include every type of central-city activity in new suburban downtowns built on land they own". This would include "...shopping centres, high-rise office towers, high-rise hotels and high-rise apartments with a range of public and cultural facilities" (Lorimer, 1978:213). Presumably these will be linked together by Vancouver's new rapid transit network.

While transport is primarily provided as a service to land development, it is less commonly used to encourage and shape development. This ability to induce urban growth is illustrated by Highway 401 and the Queen Elizabeth Way which have substantially directed and hastened the urbanization of the 'Golden Horseshoe' area at the western end of Lake Ontario. The provision of the appropriate rapid transit service, in association with other positive development controls, can accelerate the land development process, thereby encouraging the desired type of nodal development (Khan, 1974:131). Conversely, land use policies can serve to optimally limit transportation policy choices in favour of rapid transit. The concept of using transit systems to help promote a multi-nodal pattern will now be investigated using specific North American case examples.

1.2.4 - North American Rapid Transit Projects

There are several documented examples of the impact of rapid transit development on land use. This section will focus on some of the past attempts at transit-land use planning in North America. Specifically, rapid transit projects in Toronto, San Francisco-Oakland, Philadelphia, Washington (D.C.), and Atlanta will be examined.

An excellent demonstration of the impact a new transit system can have on land use is found in Toronto. There an "...unparalleled building boom along Yonge Street..." coincided with the 1954 opening of the Yonge Street subway line (Lisco, 1970:57). The focus of Toronto's central area, previously concentrated around Queen and Yonge, was completely shifted by this one line with the rapid increase in non-core high-rise developments at key stations of the subway. Similar commercial and apartment developments have sprung up along the Bloor-Danforth subway line, due to increased accessibility around the stations (Nader, Vol. I, 1975:367). Improvements in public transit tend to concentrate their impact "...near the stations and near surface lines feeding the stations (transfer points), in proportion to the speed and frequency of service on those lines" (Deweese, 1973:54). High property values around '60' stations outside central Toronto emphasize the influence that public transit links have in many outlying transit-oriented communities.

One of the most publicized U.S. transit projects of recent years was the San Francisco-Oakland "Bay Area Rapid Transit" (B.A.R.T.) system, which began operation in 1972. An original principal goal "...was to effect a restructuring of the suburbs served by the transit lines". It was "...hoped that intense commercial and residential land uses would cluster in pedestrian-oriented districts around the stations". This subcentering would mean "...a more efficient, attractive and nucleated suburban form", while healthy core areas were maintained (Dingemans, 1978:289-290). While large-scale station-oriented housing concentrations did not emerge, there was some degree of residential subcentering. "Property values near stations went up in every case, in many cases doubling" (Stone, 1971:87), and station areas tended to "...retain and strengthen their positions as...leading concentrations of commercial land use". Although employment and office development occurred within the designated subcentres, the opportunity to create multi-functional nodes near B.A.R.T. stations was not seized (Dingemans, 1978:301-304). Such desired subcentering may not happen without strong, direct assistance. It is suggested that control over land use developments in transit station areas be secured "...before vast amounts of public funds are spent to construct suburban rapid transit systems" (Dingemans, 1978:306).

An investigation of the Philadelphia-Lindenwold rail

rapid transit facility, run by the "Port Authority Transit Corporation" (see also Johnson, 1975:79), has revealed its "...dual impact upon commercial office development and employment". The CBD has been consolidated as a prime office location but "...an impetus...for increased suburban office development and employment..." has developed especially along the transit corridor, and primarily concentrated near the stations (Gannon & Dear, 1975:229). Thus a rapid transit system, or other transportation link between the suburbs and the CBD, can reinforce land values and growth in the city centre or can act primarily as a catalyst for new growth points in the shape of satellite business centres outside the old city centre.

Washington D.C.'s metro-rail system, in operation since 1976, has been relatively successful in concentrating and intensifying development around stations. Market forces combined with W.M.A.T.A. (Washington Metropolitan Area Transit Authority) and local government policies have induced new commercial development at stations in Washington's downtown core and in the older suburbs, with joint development projects increasingly commonplace. While development projects around stations are primarily commercial, office or hotel projects, there has been a lack of residential development projects. If the dispersion of population is allowed to continue, the use of cars for commuting will continue to increase, thereby diminishing the

role of rapid transit in future urban development. Since the W.M.A.T.A. subway lines run radially from the suburbs to downtown, the system is ill-equipped to service suburb-to-suburb commuting, the fastest growing commuting pattern in the Washington area between 1970 and 1980 (Baker, 1983:30). The dramatic suburbanization of residences and places of employment, particularly to the outer suburbs, between 1970 and 1980, have created transportation needs that a fixed rail system cannot easily accommodate.

The use of rail transit as a tool for multi-nodal development was attempted with Atlanta's new Metropolitan Atlanta Rapid Transit Authority (M.A.R.T.A.) system, which was opened in 1979. Planners there encouraged the reconstruction of the urban area around the new transit framework with a number of M.A.R.T.A. stations becoming logical nuclei for future urban development. Two major land use needs were identified:

1. the need to serve existing concentrations of residential, commercial and industrial development; and
2. the need to intensify future land use development in appropriate locations along M.A.R.T.A. lines (Potter, 1979:49).

The specific objectives of the rapid transit system were:

1. stabilization of the CBD;
2. encouragement of commercial development around certain passenger stations, creating nodes or employment centres that commuters can reach easily without personal transportation; and
3. slowing down of...urban sprawl, and stimulation of a larger share of the region's future growth within the central city (Potter, 1979:48).

There are already several excellent examples of joint development projects including hundreds of millions of dollars in new office building and hotel construction in downtown Atlanta (Potter, 1979:57). Several large developments have also materialized around suburban Decatur's new transit station, which is located in the central core of the city (Potter, 1979:58-60). Higher floor-area ratios have been permitted in transit-station areas to encourage high-density 'nodal development' therein.

This renewed interest in using rapid transit development as a tool for redirecting urban growth coincides with an apparent trend towards urban multi-nodality. Perhaps the development of new rapid transit systems can be instrumental in fostering a new multi-centred urban structure, should such a pattern be a desirable goal. Instead of allowing the trend toward multi-nodal urban form to continue largely uncontrolled, urban planners may wish to consciously direct this process of change using the techniques of joint development.

1.2.5 - The Development of Outlying Nodal Centres

It is widely conceded that "...models and theories, held to be fundamentally sound until comparatively recently, are now...inadequate for describing or evaluating (all) aspects of urban development" (Hutton, 1983:51). As early as 1943, Harris and Ullman's 'Multiple Nuclei Theory'

(Berry, Conkling & Ray, 1976:139) suggested that the CBD was not the only focal point of urban development, and recognized the existence of several nuclei within the city around which growth occurred. The urban monocentricity assumption is no longer justified based on "...contemporary processes of decentralization which apparently favour the development of dispersed or multi-centre patterns of employment and interaction" (Odland, 1978:234).

Since 1945, CBD's in the U.S. have been experiencing a relative decline in their dominance, especially in retailing, and have been evolving into central office and financial districts. Berry claims that conventional CBD-dominated urban concentration is waning; "...the multi-node, multi-connection system is (now) the rule, with the traditional multi-functional core simply a specialized one among many" (Berry & Kasarda, 1977:267).

While office decentralization is not occurring quite as rapidly as retail, industrial and population decentralization, the rate is still great enough to give considerable credibility to regional planners' claim that the multi-nodal city concept is consistent with relatively long-term urban land use trends (Huth, 1983:250).

The emerging multi-nodal urban patterns fall into two categories. The Los Angeles style multi-centric city has no one centre which "...contains markedly more activity than any of several others" (Pederson, 1980:25). The second type of multi-centricity, the Chicago style, "...has a dominant centre encircled by a series of subdominant clusters of

economic activity". In this case, none of the outlying centres "...comes close to matching the size and importance of the Loop, but together the subdominant centres contain a large fraction of Chicago's economic and cultural life" (Pederson, 1980:26).

Several factors have contributed to the development of concentrated suburban land use clusters and corridors. These include the locational tendencies of specific land uses, transportation system characteristics, historical factors and timing of development, social and demographic patterns, local government actions, and entrepreneurial prerogative (Baerwald, 1982:9,11).

Employment opportunities in urban areas are becoming increasingly dispersed spatially, both relatively and absolutely, resulting in substantially modified journey-to-work patterns. Suburban and exurban employment growth is more evident in the U.S., while CBD losses and erosion are occurring at significantly lower rates in Canadian cities (Mercer, 1979:129). However, "...non-CBD trips in Canadian urban areas...represent the great majority of trips, usually over 80 percent of all regional trips" (Soberman & Hazard, 1980:365). "Trips between peripheral residential and central work areas account for only a small and decreasing proportion of all trips in a large metropolitan area" (Blumenfeld, 1967:119-120). There is a tendency for the number of persons entering and leaving the

CBD to become stabilized, even in cities with well-developed public rapid transit systems, with the emergence of outlying business centres, and the increasing percentage of 'cross-commuting'. By the mid-1970's in the U.S., the volume of intra-suburban commuting, measured in numbers of commuters, was double that of the familiar suburb to central city movement (Hutton, 1983:52). Reverse commuting from the central city to the suburbs is also on the rise. By 1975, almost 20 percent of the labour force residing in U.S. central cities travelled to suburban workplaces (Hutton, 1983:52).

The situation in Toronto lends support to these trends. "Since 1948 the number of persons counted between 6:30 and 10:00 a.m. as crossing a cordon line encircling the CBD of Toronto has remained constant" (Blumenfeld, 1979:28). Since 1953, Toronto's CBD employment has been stable in absolute terms, but has declined in its proportional share of total employment. CBD employment in 1979 was less than 18 percent of the metropolitan total (Blumenfeld, 1979:297-298). In Metropolitan Toronto, the number of 'crosstown' work trips exceeds the number of all 'inbound' trips, which include "...all trips going from the outskirts to the intermediate ring, in addition to those going to the centre" (Blumenfeld, 1979:313).

Griffith's study of Toronto between 1971 and 1976 revealed that no transformation from monocentricity to

polycentricity was yet detectable, based on the spatial distribution of urban population densities (Griffith, 1981:189). By 1976 however, the dominance of the CBD seemed to be declining, since it accounted for a lower percentage of the variation in population density distribution than in 1971 (Griffith, 1981:193). This is because the population density at a given location results from the layering of influences generated by several centres. Planning efforts in Metro Toronto have been focused in an attempt to stabilize the influence of the CBD and to cultivate the influences of nine designated subcentres. This strategy is aimed at equalizing or redistributing urban development (Griffith, 1981:191-193).

Traditionally offices have concentrated in the CBD in order to facilitate easy access to other offices. Due to "...the emergence of much improved electronic communications systems, ...the possibility exists to substitute information transmission for physical movement of people" (MacKinnon, 1974:255). The 'communications revolution' has had a centrifugal effect on the location of business and industry within U.S. urban areas (Hutton, 1983:53). Not all offices have chosen to fully utilize this new technology yet. However, since offices are no longer wholly dependent on a core location, many are free to suburbanize, and indeed firms have been suburbanizing faster than households (Mills, 1972). While "...the dominant process in land use change is

suburbanization, the second in importance is nucleation..." or concentration of land use change (Bourne & Doucet, 1973:100). The resultant subcentres may cause local rent peaks to form in the suburbs, and their existence may also "...cause households to relocate in response to the new spatial pattern of employment opportunities" (White, 1976:324).

Since the early 1960's, the dispersal of high-rise apartments throughout the urban area has paralleled the decentralization of office and retail functions. Burrows' 1978 study found that population density in the Ottawa urban area did not decline evenly or regularly in any direction from the CBD, with pockets of higher densities located rather far from the central area. Anomalies appeared "...due to the presence of other important nodes such as Bayshore..." or natural amenities such as the Ottawa River (dense population along the Western Parkway) and Hog's Back (Burrows, 1978:40). She also found that proximity to Ottawa's CBD had "...a limited impact on (local) residential apartment rent and land values" (1978:37). Thus suburban development reflected a combination of many factors such as land costs, site availability, zoning regulations and market opportunities" (Burrows, 1978:41). Not surprisingly, the simple distance decline pattern of land values is becoming less evident (Burrows, 1978:20-22).

The urbanization of suburbia is supported by a growing

demographic diversity, the development of a multi-functional environment within suburbs and changing suburban lifestyles. "This transformation involves a shift from the tightly focused single-core urban region of the past to the widely dispersed multi-nodal metropolis of today" (McCauley, 1979:7). The list of land uses found in many large suburban concentrations is an inventory of traditional downtown activities. During the last few decades, these "...new suburban 'downtowns' have evolved in response to changes in the metropolitan circulation system" (Baerwald, 1982:7). The attraction power of regional-level shopping malls, today's suburban community centres, transcends their basic function as retailing nodes.

The two U.S. urban areas which have made the greatest progress in implementing the multi-nodal city concept exemplify the apparent advantage of regional level planning, which is more commonly practiced in Canadian urban areas. Metropolitan planning agencies in Denver and Minneapolis-St. Paul have successfully been promoting the establishment of major diversified centres outside the respective urban core areas. In the Minneapolis-St. Paul urban area, which has an active and powerful metropolitan government, the best example of an outlying nodal cluster is Southdale Center, which evolved from the construction of a 760,000 square-foot shopping centre in the mid-1950's. Opened in 1956 as the first enclosed shopping mall in the U.S., the centre soon

began attracting a variety of land uses to its periphery, thereby elevating its status to that of a major diversified centre. Further diversified clustering around the mall has occurred since it was expanded to 1.1 million square feet in 1972 (Baerwald, 1982:8).

Another example of the emergence of an outlying activity centre within a metropolitan region is the downtown area of Bellevue Washington outside of Seattle. Originally centred around a community-scale shopping centre built in the mid-1940's, the CBD area of Bellevue employed about 12,000 people by 1981. Unfortunately, few people use transit to travel to and from the CBD because it is poorly served by the regional transit system which is radially oriented to downtown Seattle from outlying communities. Civic leaders want to transform their suburban automobile-oriented CBD into a diversified people-oriented urban activity centre by co-ordinating land use regulations with transportation incentives. Land use zoning techniques will be applied to the CBD area to encourage higher employment and development densities. While the CBD parking supply will be reduced, transit service will be improved (Noguchi, 1982:1-6).

It must be noted that the natural maturing of outlying business and employment centres, such as planned shopping centres or town centre projects, could receive a powerful impetus from the energy conservation movement of the past

decade. By intensifying development along rapid transit corridors and around transit stations, urban decentralization could significantly reduce total energy consumption in the urban transportation field. As an alternative to shifting development back to the city core, new subcentres along transit corridors, if properly planned and developed, could potentially reduce the volume of intra-urban movement, especially long-distance commuting to the city's CBD. This is because the new outlying satellite centres within the city will necessarily be in closer proximity to the urban population. Movements between them could be efficiently served by rapid transit, particularly if high-density residential development occurs around them.

1.2.6 - Summary:--Transit in the Multi-Nodal City

Despite the interplay of many other forces, transportation remains "...an area of key decision-making in the shaping of both urban form and environment" (Dickey, 1975:78). While major changes in urban transportation technologies and infrastructure patterns have historically been very influential in the evolution of urban form, there is far less certainty about the ability of major new rapid transit improvements to generate or encourage desirable changes in contemporary urban land development. This thesis focuses on the potential of public transit as a force in shaping today's increasingly multi-centred cities.

Recent major rapid transit and commuter rail improvements have played a key role in inducing intensified development near transit stations both in CBDs and in outlying areas, although only when supported by other favourable forces. These essential factors include land use controls, availability of land, attractiveness of surroundings, and regional demand (U.S. Dept. of Transportation, Dec. 1979:2). The prospect for future joint development projects around rapid transit stations appears bright provided that "...public officials implement land use and transit planning decisions which exploit transit as a development tool..." and "...private developers and public officials are willing and able to work together to consummate the necessary deals" (U.S. Dept. of Transportation, July 1979:14).

Contemporary trends support the contention that the fundamental focus of urban spatial structure is the workplace, not the CBD (Getis, 1969:55-59). The decentralization of urban employment opportunities has led to an improved balance between the resident labour force and jobs within a local area. To support a good public transit system, this decentralization of urban activity should concentrate in high-density suburban clusters or secondary downtowns, within reasonable proximity of any part of the metropolitan area. "If transit is to serve even a modest proportion of this (non-CBD) market, a multi-destination

network which is oriented to both CBD and non-CBD trips is required" (Soberman & Hazard, 1980:365).

To summarize, continuing improvements in transit service can lead to significant nodal clustering of activities and residential land uses at major transit stations. In turn, this adjusted land use pattern will generate easy-to-serve transit trips. This more efficient rearrangement of urban land uses and the provision of an appropriate transit service could potentially reduce travel times and decrease fuel consumption (given sufficient ridership) and the consumption of other resources. Most urban mass transit systems still focus on downtown, and few have been reoriented to providing better service to the emerging outlying destinations (Huth, 1983:245). The potential of co-ordinating land use planning policies and the layout of new or future transit routes is obvious.

CHAPTER TWO

ORIENTATION TO THE OTTAWA STUDY AREA

Before this study's hypotheses are presented, it is necessary to orient oneself with the Ottawa study area. In order to attain the objectives outlined in Section 1.1, it is essential to have a reasonable familiarity with local conditions. The stress in this chapter will be on regional aspects of public transit with a secondary emphasis on regional employment. This secondary focus on employment can be attributed to the third objective, and is justifiable based on the extensive literature reviewed in the previous chapter. A considerable number of factors influence local transit service and employment patterns, both directly and indirectly, and these will be dealt with in the following sections.

2.1 - Study Area's Characteristics

The study area for this thesis essentially coincides with the OC (Ottawa-Carleton) Transpo service territory which encompasses almost 100 percent of the urban area of

the RMO. This area extends from the Ottawa River in the north, to Leitrim in the south, Orleans in the east and Kanata in the west (see Figure 2-1). It includes the whole of the Cities of Ottawa and Vanier and the Village of Rockcliffe, and large parts of the Cities of Nepean, Gloucester and Kanata, as well as portions of the Township of Cumberland (Orleans area). Since OC Transpo's 'commuter service' runs (routes 200, 210, 211 and 220) were not included in any calculations, the predominantly rural townships of Goulbourn, Osgoode, Rideau and West Carleton were completely excluded from the study area.

Ottawa has a rather atypical transit and employment situation among large Canadian cities. One peculiarity arising out of the fact that Ottawa is Canada's capital is that a single employer, the Federal Government, employs a large majority of the people in the region, especially in the central area. Because of this dominance, concepts such as staggered work hours are much easier to implement in the CBD (Bowes, 1975:241). The existence of federal employment on both sides of the Ottawa River has created a need for cooperation and coordination with respect to public transit service between the Ottawa and Hull core areas. The two sides form an entity in terms of transportation needs and so the NCC has, in the past at least, subsidized the interprovincial bus system.

Another element of local urban structure is the traffic

congestion at bridge crossings across the Rideau River and Rideau Canal. Within Ottawa, there are nine crossing points across the Canal and ten across the Rideau River, and this limited number of bridges has a funnelling effect on traffic in general. The large traffic volumes at Billings Bridge, Confederation Heights and Carleton University, for example, are at least partially attributable to this funnelling effect.

The remaining sections of this chapter will investigate the involvement of the regional and federal governments in local urban planning and development. The author believes that these two governmental levels exercise the most influence in determining local urban form. Because of this study's emphasis on public transit, a summary of the Regional Municipality of Ottawa-Carleton's (RMOC's) transitway plans will follow. The transitway scheme is relevant to the fourth objective.

2.2 - The N.C.C.'s Greber Plan

The direct involvement of the Federal Government in the planning of Ottawa, via its planning agency, the National Capital Commission (N.C.C.), is unique in Canada. Mandated to plan for and assist in the development of the National Capital Region (N.C.R.), the NCC has undoubtedly been "...the most important factor in shaping the post-1950 character of the (Ottawa) metropolitan region"

(Nader, Vol. II, 1975:172). The Federal Government's plans for the NCR are found in the Greber Plan of 1950, which has been largely implemented since the mid-1950's. Three major elements of Greber's Plan are relevant for this thesis:

1. the development of a greenbelt around the city of Ottawa;
2. the relocation of a number of railway lines in the city; and
3. the decentralization of government offices from the central area. (Nader, Vol. II, 1975:175).

The containment of urban development by the greenbelt, the only complete application of this planning concept to a North American city, was the guiding concept of the Greber Plan. Established during the years 1959 to 1965, the federally-owned greenbelt surrounded the then existing urban area, however two islands of land, Blackburn Hamlet and Bells Corners, were left unabsorbed. The area beyond the greenbelt was to remain rural in character, with the exception of limited and controlled self-sufficient satellite cities (i.e. Kanata, Orleans and Barrhaven). The greenbelt has been relatively successful "...both in checking sprawl and in increasing building density" (Nader, Vol. II, 1975:177). Developable land was removed from the market, thus increasing the scarcity value of the remaining land. The resultant general rise in the cost of land meant that higher densities were required for an economic return on investment (Nader, Vol. II, 1975:177). This study will determine whether these higher urban densities distributed themselves in a multi-nodal fashion.

"The railway relocation program, the largest undertaken in a Canadian city, was begun in 1955 and was largely completed by 1967" (Nader, Vol. II, 1975:179). This program left many vacant rights-of-way, including the east-west artery now occupied by the 'Queensway', the backbone of the present road system. Blumenfeld believed that "...the elimination of the central railroad station and the tracks leading to it..." made future establishment of rail rapid transit as the backbone of an efficient urban transit system much more difficult (1979:77). While the relocation of the freight railroad system was a positive move, the benefits of eliminating the central passenger station are debatable.

The decentralization of federal employment is in conformity with Greber's Plan which proposed a systematic distribution of new federal complexes throughout the area at distances from Parliament Hill ranging from two to eight miles. Their pleasant green surroundings are offset by "...the absence of shopping facilities and restaurants..." (Blumenfeld, 1979:77). Federal employment distribution between the Quebec and Ontario parts of the NCR was to approximate the proposed proportional distribution of population. Federal locational decisions were to give priority to Hull Island and Rideau Centre, with new office space concentrated at the points of greatest transit access (Lawless, 1980:6). The Federal Office Redistribution Program began in February 1969, with an eventual aim to have

36,000 public service employees on the Quebec side of the NCR. The job relocations from Ottawa to Hull have not however been accompanied by corresponding household relocations to the Hull side (Lawless, 1980:45).

Movement was to be "...greatly reduced by the planned decentralization of employment and the planned 'nucleation' of communities and neighbourhoods". Greber saw the future NCR "...essentially as a conglomeration of relatively self-contained villages, embedded in and encircled by green, grouped around a centre" (Blumenfeld, 1979:74-75). Although municipalities have generally disregarded the Greber Plan in their official plans, with the exception of the RMOC, the Federal Government, being the major landowner, employer and source of funds in the NCR, has faithfully followed the plan. "The most salient features of the plan have been or are being carried out" (Blumenfeld, 1979:75).

The NCC readily acknowledges the importance of public transit in achieving their goals. It is proposed that the development of peripheral lands be shaped by access to public transit, firstly by extending public transit into undeveloped areas to encourage growth and secondly by matching the level of transit service to the desired intensity of development. The NCC's plan demonstrates how the provision of transportation facilities can be used to guide urban development.

2.3 - The R.M.O.C.'s Official Plan

Since 1972, transportation planning has been the responsibility of the Planning Department of the RMOC (established in 1968). Transit planning is the responsibility of the Planning Department of the Transit Commission (OC Transpo), which is appointed by the RMOC. Long-range transit planning is closely integrated with the overall transportation system, as both are, in large part, dependent on the same urban road system. Transportation planning is integrated with land use planning mainly through the Regional Official Plan which outlines the long-range development objectives of the RMOC.

In the Official Plan, urban growth is to be accommodated in the remaining vacant land available for development inside the inner limit of the greenbelt, as well as in three urban communities outside the greenbelt, each with an eventual population of between 75,000 and 100,000. This is large enough to generate a level of jobs and social, commercial and cultural services for a considerable degree of self-sufficiency. After considering a number of factors and a range of locations, three satellite sites were chosen: Kanata (West Urban Community), Barrhaven/Gloucester South (South Urban Community) and Orleans (East Urban Community). While all three communities began prior to their official selection, their designation as outlying satellites has certainly spurred their development.

The distribution of employment proposed in the Official Plan is fundamental to attaining other aspects of the plan, notably the attainment of a public transit oriented transportation system and the creation of viable urban communities outside the greenbelt (RMOC Official Plan, 1980:2.39). New employment areas are provided for inside the inner greenbelt limit as well as in the three new urban communities outside the greenbelt. Locations were selected that could be well-served by public transit. The central area is to remain the area with the highest employment but it will grow more slowly than other employment areas. This shift in the location of new jobs could potentially help reduce the length of work trips for many and eliminate the need for costly road expansion.

The locations of regional-level shopping centres, which are important employment and activity centres and therefore major traffic generators, are identified in the Official Plan as being St. Laurent, Bayshore, Carlingwood and South Keys, with a fifth to be located in the South Urban Community. District centres are also proposed at five locations inside the inner limit of the greenbelt and additionally as centres of the new urban communities outside the greenbelt. Departure from this plan though, would not be precedent-setting. As focal points for substantial new employment and a full range of uses including community and cultural facilities, office space, apartments, retailing and

Source: RMO Planning Dept., 1981.

recreation facilities, these activity centres are to be linked, where possible, by rapid transit so as to encourage maximum use of the proposed transit system. The creation of Federal Government jobs within these activity nodes is crucial, although no substantial federal employment growth is foreseen at these outlying centres. No federal commitments to the location of federal employment centres in the proposed new urban communities beyond the greenbelt have been made. Excluding the relocation of some federal employment outside the NCR, continued centralization within the Ottawa-Hull core area is most likely.

The major goal of the regional transportation plan is "...to develop a safe, convenient, efficient and publicly oriented transportation system which optimizes accessibility for all persons and goods, with minimum disruption to the environment" (RMOC, Official Plan Summary, 1981:VII). Because of its potential for focusing employment, population and special activities, and generally structuring the growth of new communities (see Section 1.2.2), rapid transit is an indispensable part of the Region's development plan for the future. With public transit expected to carry an increasing share of total regional travel, priority is "...being given to rapid transit over road widenings and new road construction" (RMOC, Feb.1976:I.3).

The volume of trips to and from the central area, as well as other major activity nodes, depends primarily on the

amount of employment located there. The Official Plan acknowledges that if a large majority of work-trips are to be made by public transit, most job locations must be capable of being served by public transit and preferably by rapid transit. Major employment centres should therefore be located in close proximity to stations on rapid transit routes. Although a new rapid transit system must fit into the existing urban structure without causing excessive disruption, it must serve as many of the important activity centres as possible. The system should use readily available rights-of-way wherever possible so as to minimize costs and disruption, but the need to maximize ridership by maximizing the level of service, stressing quick and direct (origin-destination) service, is equally important. To realize the economies and benefits of rapid transit, the number of routes is to be limited.

The RMOC believes that, until the population level reaches 750,000, the most cost-effective strategy to meet the transportation objectives set out in the Official Plan, is the construction of a system of transitways, or arteries built strictly for transit. The transitway strategy has been applied in thirty European cities and over fifty urban areas in the U.S. (Miller, 1982:225), including Los Angeles and Washington (Vuchic, 1979:80; Dickey, 1975:371). The new transitways will stress service to a strong central core and eventually to the new outlying communities. In the downtown

Figure 2-4

Source: DeLCan-Dillon-IBI Group (March 1981), Ottawa-Carleton Rapid Transit Development Programme (Volume 8), p. 15.

Source: DeLCan-Dillon-IBI Group (March 1981), Ottawa-Carleton Rapid Transit Development Programme (Volume 8), p. 17.

Source: DeLCan-Dillon-IBI Group (March 1981), Ottawa-Carleton Rapid Transit Development Programme (Volume 8), p. 19.

Figure 2-7

Source: DeLCan-Dillon-IBI Group (March 1981), Ottawa-Carleton Rapid Transit Development Programme (Volume 8), p. 21.

area, priority on surface streets will be given to transit. As demand warrants, the transitways are eventually to be extended to the outer urban communities (outside the greenbelt) which are proposed to be strongly tied to the regional rapid transit system. The transitway network is to connect the many outlying concentrated and transit-oriented activity centres, namely the district centres, major shopping centres and major institutions.

The RMOC's Official Plan assumes that rapid transit development in itself will naturally influence the distribution of employment in the desired directions, thereby guiding urban growth. This is a valid assumption based on the cyclical interaction of the transportation system and urban land uses. The region's 'corridor-satellite concept', based on high-speed transit corridors, is also planned for energy and transportation efficiency.

2.4 - The Local Public Transit System

Until 1948, Ottawa's transit service was privately operated. From 1948 to 1972, public transit was owned by the City of Ottawa through the Ottawa Transportation Commission (O.T.C.). With suburban growth beyond Ottawa city limits, the need for a regional level service necessitated the takeover by the RMOC in 1972 (Bureau of Management Consulting, 1977:5).

After World War II, there was a severe decline in annual transit trips per capita, followed by a no-growth period in the 1960's and early 1970's. However by 1976, ridership had returned to its immediate post-war level (see Appendix E). The trend now is steady growth, with most of the growth within peak periods on weekdays (Bureau of Management Consulting, 1977:6-10).

OC Transpo expanded the local public transit system from 320 buses in 1972 to over 500 in 1975 (Bowes, 1975:239), and by 1981 the system had 755 buses in operation. A key feature of the "...expansion program was the development of regional transit focal points in suburban areas", typically major activity centres such as the large shopping centres. Between these outlying nodal centres and the CBD, fast and frequent regular and express transit services operated. From these focal points, "...feeder routes and dial-a-bus services (Tele-Transpo) fanned out to cover low density suburban areas" (Bowes, 1975:239). Tele-Transpo, which has operated since August 1973 and runs only when and where there is a specific, immediate demand for service (Cartwright, 1976), is gradually being phased out.

There has been a vast expansion of the level of transit service throughout the region since 1972. Exclusive with-flow and counter-flow bus lanes, as well as downtown bus-only streets, have been introduced during peak commuting

TABLE 2-1

Selected OC Transpo Service Area and Operating Statistics
1967 to 1981^a

	1967	1970	1973	1976	1981	1976 to 1981 percentage change
Population of Service Area	366,000	353,000	425,000	463,000	493,000	+ 6.5%
Employment ^b within service area (207 Traffic Zones)	-	-	-	243,950	260,328	+ 6.7%
Service Area (hectares)	14,245	14,245	21,497	25,900	38,000	+46.7%
Vehicle km's of service operated annually (excluding charter and sightseeing service)	12,969,920	13,708,960	18,787,750	33,472,000	46,049,017	+37.6%
Total Passengers Carried	36,693,300	41,471,100	53,096,100	76,534,500	78,884,183	+ 3.1%

^aOC Transpo did not exist until 1972, so the statistics for 1967 and 1970 are for the O.T.C.
(See Section 2.3)

^bSource: RMOC, 1979 and 1982. (Employment Surveys)

*Source for other 1967, 1970, 1973 and 1976 statistics: Soberman & Hazard (1980:732)

*Source for other 1981 statistics: OC Transpo ("Good Day", Vol. 2, #4 - April 1982)

hours. In 1973, 11.2 kilometres of peak flow bus lanes were created on arterial streets, and in 1974, 7.2 kilometres of parkway were devoted exclusively to express buses during peak periods. By 1981, there were 10.3 kilometres of reserved transit lanes on city streets and 14.5 kilometres of reserved parkway lanes. Other enforced bus priority measures include priority turns, priority traffic signals and signing, and new special access (bus-only) roads. More recently there have been major improvements at the major outlying focal points in the city such as at major shopping centres. This indicates the increasing importance of the outlying nodes within the urban transit network. With all of these improvements, OC Transpo "...achieved the highest per capita transit ridership for any all-bus system in North America..." in 1979 (Rolfe, Ross & Shrubsole, 1979:1). In 1980, Ottawa-Carleton residents took 149 transit trips per year per capita, the highest for an all-bus system in Canada (RMOC, 1981:Info-Card Ottawa-Carleton).

The level of transit service to the CBD has been substantially upgraded. The Region has been using several strategies to reduce peak hour traffic congestion in the CBD. Firstly, it has attempted to divert a high percentage of trips to public transit, and indeed it has been very successful with peak period transit patronage accounting for nearly 80 percent of all trips to and from the downtown core during rush-hours by the late 1970's (Rolfe, Ross &

Shrubsole, 1979:1). This success is due primarily to the introduction of fast and extensive express and limited-stop bus service during peak periods (since March 1974). A second strategy has been to disperse employment to district centres and industrial areas in order to reduce work-trip lengths. A third tactic has been the promotion of flexible work hours in highly congested areas, especially in the CBD, to distribute work trips over an extended peak period (since March 1974). As a result of this measure, OC Transpo got "...up to twice as many runs out of the express bus system as was obtained before the operation was put into effect" (Bowes, 1975:241).

While OC Transpo's service generally follows population shifts, mainly serving demand, there is some evidence of attempted growth guidance. For example, the use of transit service to induce land use growth and therefore travel demand (via employment growth) is illustrated in the service growth to Kanata Town Centre (see Section 4.2), where the level of bus service has gone from non-existent prior to September 1977 to the highest of all nodes within Kanata by 1981. It is questionable whether existing demand dictates this high level of transit service based on the 1977 and 1981 OC Transpo passenger surveys.

In order to fulfill the changing requirements brought about by constantly shifting population concentration and public transportation needs, OC Transpo regularly modifies

its routes. The Region reviews subdivision plans to ensure that transit accessibility and therefore ridership are maximized within them, and stresses the provision of a high level of transit service from their initial stages through to their final development. It is required that activity centres, such as large shopping complexes, and higher-density development, such as high-rise apartments, be placed as close as possible to transit service, thus minimizing average walking distances to transit. Lands developed beyond a maximum walking distance should be limited to low-density development. The goal is to minimize the number of streets in which transit service is provided, and then concentrate as many transit routes and as much development as possible on a few streets. Transit service is then maximized on these collectors. From the discussion above, it appears that OC Transpo fully recognizes the importance of integrating public transit with the land use pattern.

Since transportation planning is under Regional jurisdiction, a limited amount of region-wide control over land uses is established. A node-to-node regional transit system, such as the proposed transitway network, can be an active regional land use planning tool. "By specifying station locations (on rapid transit lines) throughout the region", focal points are designated for activities in each area (Stone, 1971:83). Keeping this in mind, the importance

and potential of the new transitway system for shaping future urban structure is clear.

In 1980, the RMOC chose a program of exclusive transitways as its rapid transit option as opposed to light rail or subways. RMOC officials argued that regional population densities were not high enough for an Articulated Light Rail Transit (ALRT) system, or the Urban Transportation Development Corporation's (UTDC's) rapid transit system, which is designed for cities needing something between subways and buses (Ottawa Citizen, July 31, 1981:35). A 30 kilometre \$160 million above-ground transitway network, connected to a bus-only transit mall along Albert Street, is to be completed by 1991.

During peak periods, buses will flow through the transitway network at a rate of 200 vehicles per hour. The new system, as projected, is to cut passengers' travel time by 25 percent during peak hours, with the potential for even greater savings at other hours. Waiting time will be drastically reduced to about 20 seconds during peak hours and one to two minutes during other times of the day, once the transitways are in place (Ottawa Citizen, May 11, 1981:1,33). The \$160 million capital cost of the transitway construction, 75 percent of which is subsidized by the Province of Ontario, will be offset by both capital and operating savings within five to ten years. This does not take into account the anticipated increase in ridership, an

inevitable result of a faster, more convenient transit system.

By separating private and public transportation modes, the Regional transitway system should eliminate many problems, especially during peak hours. By decreasing transit commuting time "...to a level comparable with that by automobile, public transportation gains a great deal of competitive power" (Soliman & Manastersky, 1973:14-15). In Ottawa's case, this competitive advantage for commuting by transit will apply primarily to trips to and from the CBD, as the transitway network will not be oriented to direct crosstown travel.

It should be noted that the Region's choice of buses over rail transit was challenged by some groups, including 'Transport 2000 Ottawa/Outaouais', who questioned whether busways were really cheaper than L.R.T. systems such as those in Edmonton and Calgary (Ross & Shrubsole, 1981). There is considerable evidence to support the view that passengers prefer rail transit. Shifting from buses to rail transit systems invariably leads to higher ridership, and L.R.T. systems apparently have lower operating costs, significantly lower labour costs, and slightly lower energy and maintenance costs (Ross & Shrubsole, 1981:3-4). They also argue that the station spacing on the Region's busway system will be too infrequent to benefit the large majority of urban area residents, and that only long-distance

commuters will reap any savings in mainline travel time to the CBD (Ross & Shrubsole, 1981:7). Taking into account RMOB cost overruns on the transitway scheme and provincial subsidy payments, an L.R.T. system may cost less than the busway system. This thesis does not intend to resolve this controversy, and only the approved regional transitway scheme will be dealt with.

The importance of rapid transit in the emerging multi-nodal urban pattern has been discussed in Section 1.2.6. Clearly the transitway network can play an indispensable role in fostering such a multi-nodal pattern in the Ottawa urban area.

CHAPTER THREE

METHODOLOGY AND HYPOTHESES

The four major objectives of this thesis, as introduced in Section 1.1, deal with the interrelationship of transportation, specifically urban public transit, and land use, as reflected in the spatial patterns of urban employment and population, and the emergence of a multi-nodal urban structure. The purpose of this chapter is to present the hypotheses that will be tested in order that the objectives may be achieved, and to outline the methodologies for testing these hypotheses. Initially it is necessary to outline the general methodological qualifications for this study, thereby averting definitional and conceptual conflicts. Following this, each of the four objectives will be dealt with separately so as to facilitate a logical progression of thought.

3.1 - Methodological Qualifications

The goal of this thesis is to explore the interrelationship between public transit and the development

of outlying business centres in the Ottawa urban area. According to Taaffe and Gauthier, when examining the transportation network, a geographer considers the following:

1. the linkages and flows between centres, their nature and size;
2. the centres, or nodes, themselves, especially their size, function and accessibility to the rest of the network; and
3. the structure of spatial dominance and competition among the nodes within each network of linkages and flows (Taaffe & Gauthier, 1973:2).

In a study analyzing public transit and outlying nodal development, it is necessary to accumulate a considerable amount of basic movement and land use data.

Initially it was intended that this study would focus on the contiguous urban area of Ottawa-Hull, but with two regional jurisdictions and two transit systems, the potential of problems in data comparability increases. RMO data does not include the Quebec side of the NCR, thus making inclusion of the Hull side of the urban area cumbersome. Therefore the study area has been restricted to the Ontario side of the urban region, however limited contrasts of federal employment nodes on both sides of the interprovincial border are included where appropriate. More specifically this thesis focuses on the OC Transpo transit area, defined earlier in Chapter two. The stress in this study will be on the developing non-CBD areas of the Ottawa urban transit area.

Bus services have, in the past, been acceptable as an

accurate representation of short-distance vehicular movement in the city (Johnston, 1966:33), particularly over distances of less than ten miles. As one moves farther out, buses are less representative of overall traffic levels since public transit is usually restricted to the limits of denser settlement, while car traffic is more dispersed and relatively unbounded. There is little reason to expect that public transit services operated are no longer representative of total intra-urban traffic flows.

Population, employment and transit patronage statistics are available by RMOC traffic zones which are tailored to the particular needs of transportation planning. Traffic zones are "...formed to keep zone size roughly equal in numbers of trips generated and somewhat homogeneous as to the kind of trip". The zones are smaller than census tracts "...in areas of high trip generation, such as the CBD..." and the major outlying subcentres (Dickey, 1975:264). Although the traffic zones are not ideally suited for realistic delimitation of all nodal centres, OC Transpo transit patronage data was only available by traffic zones.

For the purposes of this thesis, the CBD of Ottawa will be the area within RMOC traffic zones 1 to 17. Traffic zones 1 to 35 comprise the Greater Central Area while the Central Planning District includes traffic zones 1 to 40. Distance to the CBD centre for any traffic zone will be from the centre of that zone to the point of peak transit service

Figure 3-1
RMO Traffic
Zone System

Note: The areas of Traffic Zones 84 and 140 have been reduced to reflect the respective shopping centres only, to conform with the other traffic zones containing shopping centres.

LEGEND

.....TRAFFIC ZONE BOUNDARY

211.....TRAFFIC ZONE NUMBER

——..TRAFFIC DISTRICT BOUNDARY

FIGURE 3-2

CENTRAL AREA TRAFFIC ZONES

Source: RMOC, Dec. 1978.

which in 1981 was the block on Bank Street between Albert and Slater. The Bank and Albert intersection will be used as the CBD centre since Albert Street is slated to become a two-way transit mall.

Originally it was intended that the study would focus on the years since 1976, the earliest year for which transit service and employment data were available from the RMO. By using a series of years, any trend towards urban multi-nodality could have been more accurately determined. However, 1981 is the only year for which transit service, transit patronage, employment and population data are available by traffic zones. Therefore this thesis will focus on the year 1981; it will be necessary, however, to use both 1976 and 1981 data for measuring changes in employment intensity and diversity and growth in transit service at the study nodes.

Since the majority of transit riders are commuters, restricting study to working-day (weekday) transit trips is not a serious limitation. Weekend transit service is generally lower than weekday service since most employment nodes, with the notable exception of commercial (shopping) centres, are not in full operation on the weekend. In determining the level of public transit service for a given traffic zone or node in the transit network, only OC Transpo's regular, peak period and express routes were used; 'early bird', 'special' and 'commuter' (routes 200, 210, 211

▲Figure 3-4
**OC TRANSP0'S
 SUPPLEMENTARY PEAK SERVICE**
 - JUNE 1981 -

LEGEND

- EXPRESS ROUTE PREMIUM FARE (GREEN NUMBERS ON BUS STOP)
CIRCUIT EXPRESS, TARIF PRIME (CHIFFRES VERTS SUR ARRÊT)
- PEAK-ONLY REGULAR FARE ROUTE (RED NUMBERS ON BUS STOP)
SERVICE DE PONTE, TARIF REGULAR (CHIFFRES ROUGES SUR ARRÊT)
- PEAK-HOUR EXTENSION OF REGULAR ROUTE
PROLONGEMENT DE CIRCUIT REGULAR, HEURES DE PONTE
- CLOSED-DOOR SECTION OF ROUTE
SECTION DU CIRCUIT SANS ARRÊT
- OC TRANSP0 ZONES
LES ZONES OC TRANSP0

and 2203 services were excluded since they were not considered to be of a level of service which would be acceptable to the urban transit area.

Although graph theory is used in this study, the concept of networks consisting of nodes and routes, or links, is applicable. Nodes are defined as locational origins and/or destinations of spatial interactions which

CHANGES TO FIGURES 3-3 AND 3-4 EFFECTIVE SEPTEMBER 8, 1981

Route Change: Route 102 is cancelled and replaced by an extension of Route 44, which continues to serve the NRC, and now also provides service to the Carson Staff Development Centre and to the Rockcliffe Airport.

New Service: Route 155 is introduced to service Industrial Avenue in peak hours. Seven trips in the a.m. peak are provided, running from Alta Vista at the Queensway, via Alta Vista and Industrial Avenue to St. Laurent Blvd.; and eight trips in the p.m. peak are provided, running in the opposite direction.

and 220) services were excluded since they contribute only minimally to the level of service within the contiguous urban transit area.

Although graph theory is not used in this study, the concept of networks consisting of nodes and routes, or links, is applicable. Nodes are defined as locational origins and/or destinations of spatial interaction, which are occupied by people and objects, and connected to other nodes by routes. While nodes come in a variety of functional specialties, each functions as either an originator, receiver or relay of movement. For the purposes of this study "node" will only refer to major focal centres, or large attractors and generators of public transit flows, as defined in Section 3.2.3.

Public transit service will be used as a measure of the accessibility of zones to the remainder of the urban area. Burrows notes that the number of bus routes available within a reasonable walking distance is "...a measure of accessibility,...not necessarily reflecting accessibility to the CBD" (Burrows, 1978:24). Traffic zones will be weighted according to the level of weekday transit service within that zone. This service level equals the number of OC Transpo buses which stop within or along traffic zone limits each weekday. If a route passes through a traffic zone without stopping, for example along a closed-door, limited-stop section or along a limited-access roadway, it

is not considered to be contributing any transit service to that zone and is therefore excluded from the measure of transit service.

In the case of zones where transit routes originate and/or terminate, the number of inbound and outbound buses are totalled, since the transit service level is intended as a measure of the total number of one-directional passes made by OC Transpo buses. The mere fact that a route originates or terminates within a given zone indicates that the zone is a more important node than most along the route in terms of attraction and generation of transit flows; typically it is a major activity centre. Not totalling inbound and outbound buses at route terminals would essentially give all zones between the two route terminals a double-weighting.

Logically access time to and from transit routes has a major impact on usage. Typically "...the transit service area includes at least the area within walking distance of stations..." (or stops), which is considered to be 400 metres, since "...data on bus travel indicates that only a very small fraction of bus trips either originate or terminate more than this distance from bus stops" (Anderson, 1978:137-138). However, applying this 400 metre radius to the traffic zones when calculating transit service would have proven impractical since, in some cases, zones expanded by 400 metres around the periphery would completely engulf other zones. Thus routes passing within 400 metres of a

zone but not directly servicing that zone are excluded from the transit service totals. It is rare though for a route to service zones near a major activity centre without servicing the activity centre itself.

The relative magnetism of the various nodes within the urban area can be determined by reference to traffic origin-destination (O-D) surveys. Transit patronage, as opposed to transit service, more directly reflects the attractiveness of the transit system to the local transit-riding market. The 1981 level of transit patronage for each traffic zone equals the aggregate number of weekday transit trips attracted and generated, and is based on OC Transpo's weekday O-D survey of 560,880 one-directional trips taken between February 23rd and March 2nd, 1981. Since the density of people in the transit service area is of utmost importance in determining transit patronage, the major outlying activity centres, where total daytime person density can be many times the resident population and employment density, are expected to stand out as substantial nodal areas for the developing non-central urban area. OC Transpo's O-D passenger surveys of 1977 and 1981 will be used in combination with RMOC's 1976 and 1981 employment surveys to identify ten (an arbitrary number) major urban transit trip generators outside the Central Planning District (Traffic Zones 1 to 40).

The trip generation capacity of land use varies with

the intensity of use, and one of the commonest ways of measuring the density of land use is to count the number of people using it. By measuring the density and diversity of employment at a particular node, the density and diversity of land use at that location will be adequately estimated. A more complete intensity measure for land use would generally comprise the densities of floor area, employment, residential population and any other uses. Originally land use within a 400 metre radius of selected nodes was to be surveyed, however the intended type of land use survey did not take land use density into account whereas an employment survey does. Therefore in this thesis, changes in employment totals and types from 1976 to 1981 (RMOC study dates), for the selected study nodes, will be used as surrogates for changes in land use intensity and diversity. Residential land use change will not be considered since traffic zones incorporating major activity nodes exclude any residential lands.

The intent of this section has been to avert any conceptual problems which may arise during the formulation of the hypotheses. It is necessary now to elaborate on the four objectives outlined in Chapter one, and to create relevant hypotheses.

3.2 - Formulation of Hypotheses

Now that the methodological framework has been established, it is necessary to deal specifically with how the thesis objectives will be attained. This section will focus on each objective in a logical sequence and formulate a satisfactory hypothesis for each. The hypotheses, therefore, will also follow in a logical sequence; they will be tested in the next chapter.

Initially it is important to define the relationship between the local public transit system and local urban structure. Since this thesis is addressing the urban multi-nodality issue, the second hypothesis will deal with the multi-nodality of the local public transit system and local urban structure, as reflected in the spatial density patterns of population and employment. Following this, some of the outlying nodal centres, the non-CBD components of multi-nodal urban structure, will be investigated for evidence of increasing ascendance within the multi-nodal network. Finally, the role of public transit in the evolving multi-nodal pattern will be put into a local perspective.

3.2.1 - The Interrelationship of Public Transit and Urban Structure

The first objective deals with the relative significance of certain variables in accounting for variance

in transit patronage and transit service densities. More specifically, the following hypothesis will be tested:

H1: The spatial density patterns of employment and population, as opposed to distance to the CBD centre, account for most of the variance in transit patronage and transit service densities within the OC Transpo service area.

If the Ottawa urban area is still extremely CBD-centred, as opposed to being somewhat multi-nodal, distance to the CBD centre will account for most of the variance in the transit densities. Densities for each of the four variables will be used to account for variation in RMO traffic zone areas.

Although transit patronage densities and transit service densities are highly independent, the two variables do not measure the same phenomenon. Therefore both transit patronage densities and transit service densities are being used as the dependent variables in separate multiple regressions. Clearly most transit service is geared to transit patronage levels which are based largely on the magnitude of both residential population and employment in a given traffic zone. While transit patronage is only possible in the presence of transit service, the latter is also highly dependent on patronage levels. Logically transit service alone, without the presence of either residential population or employment concentrations, accounts for a minimal amount of the variance in transit patronage densities. It is redundant and unrealistic therefore to include transit service as an independent

variable in the regression of transit patronage; similarly, since transit patronage would not exist without residential population and employment densities, transit patronage is excluded as an independent variable in the regression of transit service.

For this first hypothesis, stepwise multiple regressions involving the four density variables and distance to the CBD, will attempt to explain variance in transit patronage and transit service densities within the traffic zones for 1981. The regressions will approximate the relative importance of the relationships among the five variables. While it is generally accepted that travel time to the CBD, as opposed to direct linear distance, more accurately reflects proximity to the core, travel time by public transit cannot be accurately calculated for all traffic zones since not all traffic zones have continuous direct public transit links to the CBD, although most have peak hour links. Since peak hour links tend to be quicker than regular links, using a mix of both route types to determine travel time to the CBD would distort proximity values. Thus physical distance to the CBD will be used instead of travel time to the CBD. The importance of this variable is found in the distance decay model, which assumes that distance to the CBD is responsible for all variation in urban densities.

With the dominance of the commuter in urban transit

flows, the distribution of residential population should theoretically account for as much of the variance in transit patronage and service densities as the spatial distribution of employment, since the home base is typically one of the terminals in peak period trips. In fact, "...between 80 and 90 percent of all journeys have either a beginning or an end in the home" (Bruton, 1975:86). However, it is expected that only the spatial density patterns of transit service, transit patronage and employment will be significantly correlated in this study. Population is not expected to be as highly correlated to transit service and transit patronage as employment, since the traffic zones incorporating major employment and activity nodes, such as the CBD and the major outlying nodes, have been delimited by the RMOC to exclude adjacent residential populations. Population distribution patterns are also relatively continuous compared to the spatial distribution patterns of employment and transit service, which are clustered in a relatively limited number of well-defined business districts, including the CBD. For these two reasons, population is not expected to account for as much of the variance in transit patronage and service densities in the outlying urban area as employment.

3.2.2 - The Emergence of Urban Multi-Nodality

Objective two, dealing with the multi-nodality of the public transit network, requires a simple hypothesis:

H2: The spatial distribution of population, employment, transit patronage and transit service within OC Transpo's service area reflects the emergence of a multi-nodal urban structure.

While Ottawa's CBD still plays the dominant role in determining the local urban structure and therefore local transit patronage and service, since it is the major employment node in the RMO, the outlying business and activity centres are gaining in relative importance and it is believed that they collectively account for an increasing share of urban density patterns. This scenario resembles the Chicago style of multi-nodality (see Section 1.2.5). Showing that the density patterns of population, employment, transit patronage and transit service cannot be fully explained by the CBD-centred distance decay function may indicate that some degree of urban multi-nodality exists within the Ottawa urban area.

Berry's 'ribbed cone' model of land values (Section 1.2.1) represented a significant modification of the hypothetically smooth distance decay surface of urban densities. A multi-nodal urban structure is one logical extension of the Berry model, if one assumes continuing change caused by the cyclic interaction of transportation and land use. There may indeed be a 'fine line' between the

point where a multi-nodal urban model becomes relevant and the point where Berry's 'ribbed cone' model remains adequate. The urban development process is a dynamic one, under the constant influence of changing conditions and circumstances, and so it is entirely conceivable that the urban pattern described in Berry's model will evolve into a multi-nodal pattern. The possibility of this urban transformation is based on the cyclical interplay of transportation and land use as well as the urban decentralization process.

Testing the second hypothesis will involve scattergrams of the 1981 densities of population, employment, transit patronage and transit service against distance from the CBD centre (in kilometres), based on the assumption of distance decay from the downtown core. Most of the outlying nodal centres to be studied in Section 3.2.3 will appear as large positive residuals on the scattergrams. The degree to which each density curve is inversely correlated with distance to the CBD centre may approximate the degree to which that variable is CBD-centred.

This method of estimating the degree to which the urban structure is CBD-centred does not lend itself easily toward the development of a statistical measure of urban multi-nodality. A measure quantifying the amount of urban development, within a given urban region, attributable to the non-central urban area, and specifically to the numerous

outlying nodal centres would merely be a measure of the degree to which the non-CBD areas account for urban structure. The development of a comprehensive methodology to quantify levels of urban multi-nodality, a complex task by any standard, could potentially assist the urban planning process.

3.2.3 - Employment Growth at the Outlying Nodal Centres

The third objective deals with the increasing employment density and functional diversity of the outlying subcentres. In this study, employment density and diversity are used as surrogates to approximate land use density and diversity. The following hypothesis will be tested:

H3: The major outlying subcentres within the Ottawa urban area, taken collectively, have increased their absolute employment levels and their functional diversity between 1976 and 1981.

While some of the major outlying subcentres may be static or in decline, it is believed that collectively they account for an increasing share of the urban area's total employment, thereby gaining relative importance vis-a-vis the CBD. The functional diversity of the outlying nodes will be based on the employment mix found at the subcentres, and it is expected that, over time, the subcentres are becoming increasingly multifunctional. Increasing multifunctionality is important for an outlying node because in order to acquire and maintain major subcentre status, the node must function more completely as an important activity

centre, both during the workweek and during weekends, similar to the CBD.

Selection of ten study cases was based on the following criteria:

1. only nodes within the OC Transpo service area outside the Central Planning District will be considered;
2. the node must be an easily identifiable focal point that is relatively compact in area;
3. the node must employ at least 1000 people as of 1981; and
4. the node must attract and generate (aggregate total) at least 2500 public transit trips per weekday as of 1981.

The employment data is from the RMO's 1981 employment study, while the public transit trip data is found in OC Transpo's 1981 origin-destination passenger survey. While the cut-off points for criteria three and four are rather arbitrary, together they conveniently separate the ten dominant outlying traffic zones (based on employment and transit patronage) from the other non-central zones. In his study of regional employment centres within the Washington D.C. area, Dunphy decries the lack of accepted criteria for defining regional employment centres, specifically outside the CBD. He delineated areas of non-residential land use for each potential centre using three basic criteria, which unfortunately were not suitable for the Ottawa study area.

In order to determine if a trend toward increasing absolute and relative (vis-a-vis the CBD) size of outlying nodes exists in the Ottawa study area, percentage changes, from 1976 to 1981, in absolute employment totals and in

relative regional employment shares (based on the RMOC's employment surveys of 1976 and 1981) will be calculated. It is expected that most of the proportional shift from CBD to non-CBD employment within the RMOC will be accounted for within the ten major outlying centres. The employment mix for the ten study nodes will be studied for the two years, again using the RMOC's employment surveys, in order to determine if there is any trend towards increasing functional diversity.

3.2.4 - The Role of the Outlying Nodes in the Transit Network

Objective four is to compare the characteristics of the selected outlying nodal centres and to identify their roles in both the present and proposed transit networks for the Ottawa urban area. It is meant as a summary of the interdependence of local urban transit and the emerging outlying nodes. The characteristics of the ten selected subcentres and the roles they play in the present transit system will be reviewed in a qualitative manner. While it is physically possible to link all ten study nodes, a tradeoff between maximization of the transitway system's connectivity and minimization of physical community disruption must be made.

Because of the interdependence of public transit and employment patterns, both the present transit system and the new transitway network predictably focus on the CBD;

however, the importance of the outlying subcentres is increasing steadily and must be recognized. By designating an outlying node as a station along the new transitway system, its role in encouraging a more efficient multi-nodal urban structure is magnified. If the ten major outlying subcentres are at least to maintain their relative importance in the urban transit area, a location along or in close proximity to the new transitways would be desirable. Likewise, if the new transitway system being built in Ottawa-Carleton is to achieve its full potential, it must serve as many of the major outlying subcentres as economically and politically possible besides servicing the CBD core area.

3.3 - Summary of Hypotheses

To recap, three hypotheses have been formulated for testing. The first hypothesis suggests that most of the variance in transit patronage and transit service densities within the OC Transpo service area can be accounted for by the spatial density patterns of employment and population. The second hypothesis, the most difficult to test quantitatively, postulates that the spatial distribution of population, employment, transit patronage, and transit service within OC Transpo's service area reflects the emergence of a multi-nodal urban structure. The third hypothesis alleges that the major outlying nodal centres

within the Ottawa urban area collectively increased their absolute employment levels and their functional diversity between 1976 and 1981. Chapter four will attempt to resolve these hypotheses and provide some useful insight into the function of outlying nodes in Ottawa's public transit network.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

To meet the objectives of this thesis necessitated the collection of considerable volumes of quantitative data and qualitative information. A major part of the data accumulation process involved quantifying OC Transpo's public transit network to produce accurate measures of transit service for each of the 207 traffic zones. While OC Transpo supplied passenger survey data for 1977 and 1981 as well as bus stop information, the RMO's Transportation Planning Department supplied all transit service data and RMO's Planning Department supplied all employment and population information for 1976 and 1981. Data analysis will be divided into four major parts to correspond to the four objectives outlined in chapter three.

4.1 - Accounting for Transit Patronage and Service Densities

The first hypothesis postulated that the spatial density patterns of employment and population account for most of the variance in transit patronage and transit

service densities within the OC Transpo service area. Distance to the CBD centre was not expected to be as significant a variable in accounting for the variance in light of the trend toward multi-nodality. Stepwise multiple regression analyses were performed on the densities of transit patronage and transit service (the dependent variables) to help determine which independent variables were statistically most significant in this regard.

The following five variables were used for each of the 207 traffic zones in the multiple regressions:

1. the September 1981 density of daily transit service (buses per hectare);
2. the 1981 density of daily transit patronage (trips per hectare);
3. the 1981 employment density (jobs per hectare), with part-time employment receiving half-weight;
4. the 1981 population density (persons per hectare); and
5. distance, in kilometres, from the CBD centre (Bank and Albert intersection).

The measurement of these variables has been described in Section 3.1, and the values for each zone are summarized in Table 4-1. To ensure a normal distribution of data and linearity of relationships, it was necessary to use the common logarithms (logs) of all variables.

The first multiple regression analysis was to account for the variance in transit patronage densities across the urban transit area. Using the common logs of all independent variables, employment density accounted for 57.9 percent of the variance in transit patronage densities. Population density accounted for an added 8.6 percent of the

TABLE 4-1

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
1	0.5	0.0	140.4	111.4	60.6
2	0.5	0.0	157.4	52.1	15.9
3	0.5	0.0	622.1	1,086.8	553.9
4	0.3	0.0	448.5	844.4	528.5
5	0.1	0.0	807.6	1,325.4	527.9
6	0.1	0.0	1,407.3	2,015.0	487.3
7	0.4	39.2	945.1	913.1	188.5
8	0.7	84.7	57.0	203.3	149.7
9	0.4	58.4	306.1	360.3	249.9
10	0.1	10.4	680.0	1,717.7	616.3
11	0.1	10.4	1,176.7	1,491.3	616.3
12	0.3	10.4	1,444.5	930.0	408.8
13	0.5	17.9	503.8	1,143.0	451.1
14	0.7	0.0	44.2	211.3	196.1
15	1.0	7.7	196.9	460.4	179.0
16	1.1	6.7	263.5	337.6	94.6
17	1.2	51.5	33.3	53.9	25.3
18	1.5	70.5	29.5	39.6	21.1
19	1.3	20.1	45.0	22.7	16.4
20	2.0	0.0	100.0	111.3	16.4
21	2.0	37.2	12.0	35.9	27.8
22	2.1	107.6	46.7	92.6	40.1
23	2.0	89.7	37.3	122.3	27.0
24	2.0	67.1	9.8	64.7	7.8
25	2.1	22.8	3.1	8.1	8.1
26	1.4	22.9	80.0	241.8	33.9
27	1.0	159.4	127.2	80.2	31.3
28	1.3	94.2	6.6	45.8	18.8
29	0.5	146.6	421.2	401.5	32.0
30	1.1	69.0	64.1	132.9	23.5

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
31	0.5	117.7	190.7	380.6	63.0
32	1.1	46.4	91.7	127.1	40.9
33	0.8	102.1	13.7	99.3	23.6
34	1.3	80.3	26.5	56.0	24.9
35	1.3	0.0	470.0	566.7	260.0
36	1.5	95.6	12.4	78.3	23.4
37	1.0	68.3	116.0	53.3	115.7
38	1.3	0.2	8.3	2.2	12.3
39	1.5	78.6	20.3	63.4	45.2
40	1.9	47.2	28.7	90.6	22.9
41	2.3	31.3	41.8	44.2	35.9
42	2.0	50.1	150.5	171.9	34.4
43	2.4	23.7	5.6	31.6	34.3
44	1.7	50.1	37.3	56.5	34.0
45	2.1	50.4	16.2	130.7	25.6
46	2.6	67.8	4.9	35.7	15.5
47	1.7	41.8	14.5	59.7	21.2
48	2.2	81.3	23.0	69.7	19.9
49	2.6	0.0	1.3	16.6	15.7
50	2.3	38.6	11.7	38.7	6.9
51	2.2	32.3	3.5	46.5	4.7
52	3.2	39.8	4.0	40.2	12.3
53	3.3	39.6	8.3	34.0	11.2
54	3.8	0.2	50.4	161.9	9.5
55	4.3	0.2	6.1	4.2	3.8
56	6.5	0.0	7.0	16.3	8.3
57	5.4	64.1	11.9	45.9	8.5
58	4.9	64.7	3.6	41.5	9.3
59	4.7	0.0	38.0	79.9	19.7
60	4.2	0.8	36.3	36.6	22.9
61	3.7	43.0	11.9	77.2	32.1
62	3.4	15.9	335.4	252.9	83.2

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
63	2.8	36.1	6.1	21.0	11.6
64	2.5	65.1	37.2	51.9	15.0
65	3.0	1.7	104.1	70.8	152.7
66	2.6	78.1	13.2	50.3	27.2
67	2.5	11.4	4.3	5.7	8.2
68	3.3	0.0	138.7	110.2	23.6
69	4.0	13.9	0.6	15.7	6.8
70	3.6	42.4	25.3	71.8	27.8
71	3.8	40.5	9.3	46.3	15.6
72	4.7	30.2	9.3	24.0	8.9
73	4.9	22.1	17.5	30.2	3.8
74	5.5	39.2	8.0	40.4	9.7
75	6.2	11.6	28.2	21.4	8.8
76	6.3	31.5	3.1	31.7	5.2
77	6.5	22.2	7.0	11.2	8.0
78	7.2	52.0	3.1	22.9	17.6
79	7.5	23.2	1.0	16.6	9.0
80	7.7	0.0	73.1	309.3	55.7
81	8.0	76.6	11.9	40.7	14.6
82	8.1	32.4	8.8	28.8	22.1
83	8.6	29.6	6.0	18.5	13.2
84	9.1	0.0	35.3	285.9	158.6
85	9.3	33.8	5.0	23.9	5.7
86	9.7	31.4	0.6	21.7	8.6
87	10.7	34.8	3.9	13.9	9.6
88	10.8	46.3	2.4	27.7	9.9
89	11.8	82.1	1.8	48.1	20.9
90	11.6	0.0	129.4	493.2	100.0
91	11.7	28.7	4.3	14.0	4.3
92	12.7	4.0	99.5	62.0	47.1
93	12.0	26.7	3.3	10.5	7.8
94	10.4	8.6	0.2	5.0	3.8

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
95	9.7	35.1	1.6	21.8	6.0
96	10.0	0.0	49.7	10.7	17.1
97	10.0	0.0	29.5	3.6	10.0
98	8.0	41.2	1.7	28.6	5.5
99	6.3	0.0	28.0	5.5	7.2
100	7.0	49.4	0.1	16.1	4.6
101	8.1	24.4	2.2	9.3	6.0
102	8.9	0.0	21.0	60.2	46.5
103	9.1	0.0	71.6	259.0	39.2
104	9.0	37.0	1.3	13.6	12.2
105	9.2	24.5	0.8	10.2	3.3
106	8.2	0.0	45.8	47.7	12.4
107	8.5	0.0	10.1	0.8	1.7
108	7.9	20.9	1.9	10.2	1.7
109	7.2	40.6	1.0	31.4	4.5
110	7.1	0.0	48.0	57.8	26.8
111	6.5	39.8	2.4	15.2	4.5
112	5.6	43.3	2.4	37.6	7.4
113	6.5	17.1	2.5	14.3	2.4
114	7.2	12.6	0.4	5.1	5.3
115	7.0	21.6	0.9	18.6	4.8
116	5.8	0.0	0.9	3.8	15.9
117	5.9	43.8	8.5	45.1	7.1
118	6.7	16.3	0.2	12.6	4.1
119	5.9	19.2	0.3	8.9	5.4
120	5.8	0.0	33.9	73.7	26.7
121	5.2	41.7	10.5	21.7	9.9
122	4.9	0.0	91.5	42.6	17.7
123	4.7	0.0	0.0	4.4	9.1
124	4.3	0.0	3.0	4.4	13.2
125	4.1	0.0	114.5	366.0	91.0
126	3.5	0.1	34.1	45.3	46.5

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
127	4.0	29.1	5.9	19.9	15.5
128	4.9	28.3	7.2	24.8	20.4
129	5.7	22.2	7.6	76.7	14.6
130	6.6	34.5	6.0	30.5	5.4
131	6.1	66.5	1.7	77.5	18.0
132	7.1	0.0	3.6	1.8	1.6
133	5.7	33.0	0.6	27.2	5.0
134	4.8	22.2	0.4	14.4	4.1
135	3.9	2.4	5.8	13.9	8.4
136	3.1	28.4	1.0	10.9	7.3
137	3.7	33.7	1.5	37.4	10.6
138	5.0	24.1	20.2	23.3	6.6
139	6.2	38.7	1.7	36.1	4.2
140	6.4	0.0	47.8	428.0	170.6
141	7.2	49.8	5.1	27.9	4.1
142	7.0	0.2	14.8	1.8	1.3
143	6.3	2.5	11.5	1.9	2.5
144	4.7	0.0	22.1	8.2	6.5
145	4.6	14.6	33.5	14.5	18.6
146	3.7	0.0	1.9	26.3	64.5
147	3.0	0.0	0.1	4.6	20.8
148	3.7	0.0	67.0	13.4	17.8
149	4.8	0.0	69.4	291.3	84.6
150	5.4	25.1	12.2	14.2	9.6
151	5.1	41.7	8.5	39.7	14.1
152	4.3	57.6	4.0	24.1	11.0
153	4.5	47.8	7.6	37.7	19.8
154	3.2	28.5	2.4	13.4	2.3
155	3.8	81.8	14.7	48.9	12.6
156	3.0	55.4	57.0	80.0	24.0
157	3.1	53.8	13.4	29.2	19.8
158	4.2	36.0	3.5	15.4	5.4

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
159	3.1	67.8	6.7	48.1	13.7
160	2.7	16.3	2.2	15.5	2.7
161	3.6	7.3	2.3	8.3	1.9
162	4.2	10.2	0.1	6.0	3.3
163	5.1	42.2	1.0	26.2	3.5
164	5.1	52.1	6.0	41.0	12.6
165	5.6	0.0	47.7	36.3	24.8
166	6.0	0.0	7.2	3.2	1.1
167	6.2	22.7	6.2	8.7	2.9
168	6.2	21.7	3.3	17.8	2.4
169	6.4	16.0	0.2	5.5	4.1
170	7.3	27.3	1.1	13.8	1.1
171	7.1	0.0	0.0	0.6	5.3
172	7.1	0.0	17.4	7.6	4.1
173	8.2	22.6	1.1	9.8	1.5
174	8.5	44.0	2.1	22.0	5.4
175	8.3	39.7	2.7	35.5	4.1
176	7.7	0.0	14.6	41.1	29.3
177	10.1	0.0	0.5	0.5	1.3
178	10.7	4.4	0.3	1.9	0.2
179	8.2	0.0	4.1	1.1	0.7
180	8.1	8.7	0.8	5.8	0.5
181	9.6	3.6	1.8	0.5	0.2
182	9.7	14.1	1.3	4.5	0.5
183	8.1	4.1	0.4	2.9	8.5
184	12.5	0.0	0.6	0.2	0.1
185	9.8	6.1	0.4	2.4	0.4
186	7.8	21.2	0.3	8.7	1.7
187	8.3	12.5	0.7	7.4	0.9
188	9.6	0.6	5.5	0.5	0.5
189	11.0	10.7	0.8	3.2	0.4
190	10.1	0.0	22.4	3.1	1.7

Traffic Zone	Distance to CBD Centre (km.)	1981 Population Density ^a	1981 Employment Density ^b	1981 Transit Patronage Density ^c	Sept. 1981 Transit Service Density ^d
191	11.0	9.0	2.1	5.2	0.8
192	10.9	0.0	2.7	48.8	19.6
193	11.3	21.7	1.0	9.8	1.5
194	12.8	16.5	1.2	4.9	0.8
195	13.8	0.1	0.1	0.0	0.1
196	14.4	23.2	4.4	10.0	1.4
197	15.5	31.4	5.5	12.1	2.0
198	14.6	5.6	20.1	8.8	2.7
199	13.4	14.4	6.1	5.9	0.3
200	13.7	0.0	0.9	4.2	1.1
201	15.6	0.1	0.1	0.1	0.1
202	19.3	5.3	4.8	2.3	0.2
203	19.6	6.8	0.9	1.6	0.9
204	19.6	11.0	1.0	3.6	0.4
205	17.0	4.8	0.3	1.3	0.1
209	14.8	11.2	1.0	3.6	0.2
212	13.0	0.3	0.3	0.0	0.0

*All densities are per hectare; traffic zone areas from RMOC, 1981.

^aSource: RMOC, 1982.

^bSource: RMOC, 1982.
Full-time employment given full-weight; part-time employment given half-weight.

^cSource: OC Transpo, 1981.
Based on total weekday transit trips attracted and generated.

^dSource: OC Transpo, Sept. 1981.
Based on total number of weekday OC Transpo buses serving traffic zone.

variance, while distance to the CBD contributed another 3.0 percent. Altogether employment, population and distance to the CBD accounted for 69.5 percent of the variance in transit patronage densities (Table 4-2).

An analysis of residuals reveals that the largest positive residuals are typically shopping centres (Figure 4-1). In fact, the four largest positive residuals were shopping centres, and six of the eight largest positive residuals matched six of the largest outlying shopping centres within the RMOC. Other variables which may account for additional variance in transit patronage densities include automobile ownership rates for zones originating transit flows and traffic zone drawing power (as a destination), exclusive of employment and residential population densities, which reflects total utilization of that zone.

The second multiple regression analysis was to account for the variance in transit service densities across the urban transit area, again using the common logs of all independent variables. Employment density accounted for 57.7 percent of the variance in transit service densities, while distance to the CBD accounted for an additional 8.2 percent. Population density was not a significant variable in this regression analysis. In total, the two significant variables accounted for 66.0 percent of the variance in transit service densities (Table 4-3). Residual analysis in

**▲FIGURE 4-1:
Non-Central Traffic Zones with
Large Positive Residuals for
Transit Patronage Densities**

Source: Author - 1984.

TABLE 4-2

SUMMARY OF THE REGRESSION ANALYSIS OF TRANSIT PATRONAGE DENSITIES (1981)

Dependent Variable: the common log of the 1981 transit patronage density for a given traffic zone.

Step	Variable Entered	Multiple 'r'	r ²	F Statistic	Significance Level	r ² Change	Beta Value
1	LEMD	.7610	.5792	282.122	».001	.5792	.7610
2	LPND	.8157	.6653	202.790	».001	.0862	.2942
3	LDKM	.8337	.6950	154.192	».001	.0297	-.2418

Variable Key:

LEMD: common log of 1981 employment density.

LPND: common log of 1981 population density.

LDKM: common log of distance to the CBD centre.

TABLE 4-3

SUMMARY OF THE REGRESSION ANALYSIS OF TRANSIT SERVICE DENSITIES (1981)

Dependent Variable: the common log of the 1981 transit service density for a given traffic zone.

Step	Variable Entered	Multiple 'r'	r ²	F Statistic	Significance Level	r ² Change	Beta Value
1	LEMD	.7597	.5771	279.773	».001	.5771	.7597
2	LDKM	.8121	.6595	197.541	».001	.0824	-.3901

Variable Key:

LEMD: common log of 1981 employment density.

LDKM: common log of distance to the CBD centre.

this case, did not reveal any clear trends, although four of the eight largest positive residuals were shopping centres. Other variables which may account for additional variance in transit service densities include traffic zone proximity to major transit trip attractors and generators, and local planning preferences regarding the spatial distribution of urban growth.

The common log of the employment density variable was highly correlated with the common logs of the transit patronage and transit service variables, with simple 'r' values of .76 and .76 respectively (Table 4-4). This can be explained by the influence of the CBD and the outlying transit terminals where higher transit service levels are needed to satisfy higher transit demand levels caused by higher employment and overall activity levels. Of course, distance to the CBD was inversely correlated to transit patronage and transit service (using common logs) with simple 'r' values of -.69 and -.73 respectively (Table 4-4). Population density is the variable least related to the other density variables when using RMO traffic zones as the unit of measurement of urban densities. The low correlation of population densities with the other densities was not entirely unexpected since the spatial distribution pattern of population is relatively continuous whereas employment opportunities tend to cluster in a relatively limited number of well-defined business districts, similar to the densities

TABLE 4-4

SIMPLE CORRELATION OF THE VARIABLES
IN THE REGRESSION ANALYSES

	LPND	LEMD	LTPD	LTSD	LDKM
LPND	1.000	-.064	.244	.069	-.139
LEMD	-.064	1.000	.761	.760	-.677
LTPD	.244	.761	1.000	.871	-.692
LTSD	.069	.760	.871	1.000	-.726
LDKM	-.139	-.677	-.692	-.726	1.000

VARIABLE KEY

LPND: common log of 1981 population density.

LEMD: common log of 1981 employment density.

LTPD: common log of 1981 transit patronage density.

LTSD: common log of 1981 transit service density.

LDKM: common log of distance to the CBD centre.

of transit patronage and transit service (compare scattergrams in Section 4.2).

In summary, when determining transit patronage density, the most important variable is employment density. Population density was also a significant variable, however distance to the CBD was least significant in determining transit patronage density. Employment density was also the most significant variable when determining transit service density. Distance to the CBD was also important, however population density was not a significant variable in determining transit service density. The apparently lower significance of population density, as compared to employment density, in explaining variance in transit patronage and transit service densities can be largely attributed to the delimitation of RMOC traffic zones. Otherwise, these results support the literature in Section 1.2.2; the relative lack of significance of distance to the CBD in the regression analyses, again as compared to employment density, may indicate a shift towards multi-nodality in the Ottawa urban area.

4.2 - Evidence of Urban Multi-Nodality in the Ottawa Area

It is speculated in hypothesis two that the Ottawa area's population, employment, transit patronage and transit service patterns reflect multi-nodal density surfaces. The fact that the highest densities for employment, transit

patronage and transit service occur in the CBD area (traffic zones 1 to 17; see Table 4-1) is evidence in support of traditional distance decay theory. Although the highest population density does not occur within the CBD, it is found within the Greater Central Area (traffic zones 1 to 35; see Table 4-1). Only a tiny fraction of land in the CBD of most cities is residential, even though housing is a major user of urban land (Pederson, 1980:16).

The suburbanization of employment opportunities and residential population, caused primarily by the increasing friction of distance to the central area as measured in travel time, tend to support each other. Between 1971 and 1976, close to 100 percent of the RMO's population growth occurred outside of Ottawa, Vanier and Rockcliffe Park; since 1976, all population growth has occurred in the suburbs, and some of this growth was the result of suburbanization of residences from Ottawa and Vanier (City of Ottawa, 1979:7). The urbanization of suburbia is demonstrated by the fact that the number of jobs available in Bells Corners exceeded the number of employed residents in 1979 (McCauley, 1979:81-82).

By using the RMO's traffic zones as the units for data measurement, the significance of population density as a factor in determining major nodal centres is diminished. This is because the majority of major traffic attractors and generators in the Ottawa study area, such as the large

office and/or commercial complexes, do not co-exist with dense apartment complexes within the same traffic zone, even though such dense population concentrations often exist immediately adjacent to such large office and/or commercial zones. For example, conspicuous clusters of residential high-rises exist in close proximity to Bayshore, Carlingwood, Billings Bridge and the three federal employment nodes, however they are not located within the respective traffic zones. Perhaps if population within a 400 metre radius of the major activity centres were available, the importance of population could be properly assessed, however, such data does not exist.

Since the population within major activity sites in the Ottawa urban area is typically zero, based on the traffic zone delimitations, this thesis focuses on the existence of major nodal centres in the non-central urban area where the densities of employment, transit patronage and transit service substantially exceed typical suburban levels based on traditional distance decay theory which assumes urban monocentricity. It should be noted that multi-use zoning, which allows for a mix of residential and other land uses on individual sites and within individual buildings, is becoming increasingly common in urban planning and is likely to encourage the development of diversified subcentres in the suburbs. This trend may also increase the importance of population density in explaining urban transit patronage and

service densities in the future if traffic zones are used for data measurement.

Generally population has a more continuous distribution than employment, with the pattern of employment concentration being more sporadic and clustered. The following employment trends can be derived from Table 4-5. While the CBD is still the most important employment node, its dominance is declining with the rise of the outlying nodal centres. The proportion of the RMO's total employment contained within Ottawa's CBD (roughly defined by traffic zones 1 to 17) declined from 25.4 percent to 24.1 percent between 1976 and 1981. In 1973, it was estimated that only about 16 percent of all Metropolitan Toronto jobs were located in the CBD, "...a not atypical figure for large North American cities" (Deweese, 1973:11). The City of Ottawa's share of RMO employment decreased from 80.5 percent to 79.9 percent over the 1976 to 1981 period, with a corresponding relative gain in employment in the non-CBD area of the municipality. This latter area's employment share rose slightly from 55.2 percent to 55.8 percent. With the growth of the three urban communities outside the greenbelt (Section 2.3), the share of total employment beyond the greenbelt limits rose from 4.5 percent to 6.6 percent, while the share of total employment within the outer limits of the greenbelt slipped from 95.5 percent to 93.4 percent between 1976 and 1981. While the CBD accounted

TABLE 4-5
RMOC EMPLOYMENT CHANGES
1976 to 1981^a

	1976-(% share)	1981-(% share)	1976- 1981 Change
Total Employment ^b	249,723 (100.0)	266,114 (100.0)	+ 6.6%
<u>BY TYPE:</u>			
Primary	761 (0.3)	603 (0.2)	- 20.8%
Secondary	27,485 (11.0)	28,705 (10.8)	+ 4.4%
-High Technology	8,700 (3.5)	16,600 (6.2)	+ 90.8%
Tertiary & Quaternary	221,480 (88.7)	236,811 (89.0)	+ 6.9%
-Public Administration & Defence	106,015 (42.5)	100,779 (37.9)	- 4.9%
-Federal Government	96,071 (38.5)	88,281 (33.2)	- 8.1%
<u>BY AREA:</u>			
CBD (Traffic Zones 1-17)	63,316 (25.4)	64,130 (24.1)	+ 1.3%
Non-CBD area	137,821 (55.2)	148,395 (55.8)	+ 7.7%
-City of Ottawa			
City of Ottawa (excludes Vanier & Rockcliffe Park)	201,137 (80.5)	212,525 (79.9)	+ 5.7%
Non-CBD inside outer Greenbelt limits	175,180 (70.1)	184,302 (69.3)	+ 5.2%
Total inside outer Greenbelt limits	238,496 (95.5)	248,432 (93.4)	+ 4.2%
West Urban Community (Kanata)	2,260 (0.9)	6,853 (2.6)	+203.2%
East Urban Community (Orleans)	1,061 (0.4)	1,971 (0.7)	+ 85.8%
South Urban Community (Barrhaven)	192 (0.1)	273 (0.1)	+ 42.2%
Rural	7,708 (3.1)	8,581 (3.2)	+ 11.3%
Total outside Greenbelt limits	11,221 (4.5)	17,678 (6.6)	+ 57.5%

^aSource: RMOC, Employment in Ottawa-Carleton (1976-1981), February 1982.

^bMeasured in full-time equivalents (part-time employment given half-weight).

Employment Areas for Table 4-5

for less than 5.0 percent of the total employment increase in the RMOC, 69.5 percent of regional employment growth occurred in the City of Ottawa. Thus the non-CBD area of Ottawa contained 64.5 percent of all employment growth. Kanata, with its growing high-technology base, accounted for 28.0 percent of RMOC employment growth between 1976 and 1981.

The Federal Government has the greatest physical and economic impact on the NCR since it is the dominant owner as well as tenant of offices in the planning area. Until the mid-1970's, federal employment growth was "...the prime generator of population growth..." in the RMOC (Smith & Co., 1972:13). Public administration is therefore the single most important industry in the RMOC. In 1976, public administration and defence accounted for 42.5 percent of regional employment, but by 1981 this share had dropped to 37.9 percent (Table 4-5), indicating increasing diversification with growth in the high-technology sector and reflecting the relocation of about 12,000 federal jobs to the Hull side of the NCR (RMOC, 1982:iii). With this Federal Government dominance of the Ottawa employment scene, it is appropriate to focus on the distribution of federal employment in the NCR.

Although the NCC's definition of the core area differs from the RMOC's (Figure 4-3), the locational shifts of federal government employment within the NCR (Table 4-6) are

TABLE 4-6

Federal Government Employment in the N.C.R.
(Distribution by Place of Work)

	1973-(% share)	1976-(% share)	1979-(% share)
Ottawa - core	44,807 (48.5)	50,844 (49.5)	42,537 (41.3)
Ontario non-core	41,748 (45.2)	44,763 (43.6)	41,592 (40.4)
Total Ontario	86,555 (93.7)	95,607 (93.1)	84,129 (81.7)
Hull - core	4,242 (4.6)	6,118 (6.0)	17,387 (16.9)
Quebec non-core	1,544 (1.7)	981 (1.0)	1,464 (1.4)
Total Quebec	5,786 (6.3)	7,099 (6.9)	18,851 (18.3)
Total Core	49,049 (53.1)	56,962 (55.5)	59,924 (58.2)
Total non-core	43,292 (46.9)	45,744 (44.5)	43,056 (41.8)
Federal Office Locations ^a	-	286	274
Total Federal Employment	92,341 (100.0)	102,706 (100.0)	102,980 (100.0)

^aBuildings occupied in whole or in part by the Federal Government.

*Source: NCC, Federal Government Employment Study, August 1979.

still relevant. Even though federal employment became increasingly core-oriented within the NCR between 1973 and 1979, this is attributable primarily to the Federal Government's policy of redistributing jobs from Ottawa to the Hull core area. The Quebec side's share of the NCR's federal employment rose from 6.3 percent in 1973 to 18.3 percent in 1979, accounted for primarily by the "Place du Portage" and "Les Terrasses de la Chaudiere" federal office projects in downtown Hull. The outlying federal office complexes on the Ontario side of the NCR were developed prior to the major federal employment developments in Hull. Already by 1971, almost one-third of federal employment in the metropolitan area had decentralized outside the downtown area (Nader, Vol. II, 1975:180). By 1973, Tunney's Pasture had 7500 federal employees while Confederation Heights had 6000 (Nader, Vol. II, 1975:181).

Table 4-6 illustrates that when observing the Ontario side of the NCR in isolation, the non-core area has gained only slightly relative to the core area, increasing its share from 48.2 percent in 1973 to 49.4 percent in 1979. While the Ontario non-core area's share of federal employment slipped to 46.8 percent in 1976, it regained a substantial 2.6 percent share by 1979. In fact, within the NCR, seven of the eleven established federal non-core employment concentrations experienced growth in employment in the 1976 to 1979 period. Four locations - Tunney's

Pasture, Confederation Heights, the Experimental Farm and Booth Street - each exhibited growth of between 6 and 13 percent (NCC, 1979).

Because of the emergence of such outlying nodal areas, the proportion of urban trips oriented towards non-CBD areas continues to grow. Within the Ottawa-Hull area in 1972, it was estimated that the number of daily trips destined for areas other than downtown (non-CBD trips) was about "...two-thirds of all work trips, ...three-quarters of all family business trips, ... (and) four-fifths of all pleasure trips" (RMOC, 1972:20). The downtown's retail dominance over local markets, at least prior to the 1983 opening of the Rideau Centre project, has shown a remarkable decline since 1961, in conformity with the general North American trend. Only 35 percent of all retail purchases occurred in suburban shopping centres in 1961, but by 1971 this proportion had risen to 65 percent, and by 1977 it was up to 75 percent (Lorimer, 1978:188-189).

Although Richmond Road, Montreal Road and Bank Street (Metcalf Road) form the foundation on which Ottawa was built (RMOC, 1972:70), the construction of the Queensway between 1962 and 1967 has unquestionably encouraged the east to west development of the Ottawa urban area besides facilitating both CBD-oriented and crosstown (or non-CBD oriented) movement. With the addition of other improvements in crosstown transportation corridors and the growth of

outlying business centres, Ottawa's public transit system has changed from an almost totally CBD-oriented system with virtually no crosstown transit routes in 1955 (W. Smith & Associates, 1955), to one with a considerable number of crosstown, non-CBD oriented transit routes. This gradual transformation of the public transit network, while still primarily CBD-oriented, has coincided with the emergence of major outlying business centres (within the urban area), the majority of which are being used by OC Transpo as transit terminals. It should be noted that the dramatic growth in bus transit service (Table 2-1) occurred soon after the RMOC took over responsibility for local public transit and may have been spurred on by the 'gas crisis' of 1973, which probably reinforced the multi-nodal tendency already promoted by the new transit routes.

The growth of 'suburbia' can be traced through the growth of both non-central transit patronage and the level of non-central transit service. Since the methodologies used in OC Transpo's 1977 and 1981 origin-destination passenger surveys differ, their results cannot be directly compared. Taken separately though, the two surveys yield relevant findings. They will be used to determine the ten special study cases in Section 4.3 since it is felt that the transit patronage levels most accurately reflect the attraction and generation potentials of various nodal areas.

Using the 37.6 percent growth in vehicle kilometres of

service operated by OC Transpo between 1976 and 1981 (Table 2-1) as a measure of the average growth in transit service for the Ottawa urban transit area, the growth in service for any point or area is classified as either below average, average, or above average. From Table 4-7, it can be seen that there has been a very marked increase in transit service to the three developing urban communities outside the greenbelt, especially to Kanata. The most remarkable growth in transit service since 1976, and especially since 1980, has been at Kanata Town Centre, which until September 1977 had no service at all. The complex was not completed until about 1981; however, it is clear that this Town Centre development, located conveniently along the Queensway, is being planned and developed as the main transit and commercial focus of the Western Urban Community. It is highly probable that this development is the beginning of a core area for Kanata.

Orleans has also experienced major growth in transit service (Table 4-7), and it is expected that the level of transit service will have risen substantially by 1986 with the considerable amount of development occurring at present (1983). The growth of the Western and Eastern Urban Communities has overshadowed development in the South Urban Community, but the rate of transit service growth in Barrhaven was still two-and-a-half times the average between 1976 and 1981 (Table 4-7). Most of the increases in service

TABLE 4-7

The Growth in Weekday OC Transpo Service^a

	Sept. 1976	Sept. 1980	Sept. 1981	Sept. 1982	1976 to 1981 Change
Kanata- Eagleson & Highway 7	63	241	313	315	+396.8%
Kanata- Kanata Town Centre	0	93	477	504	Undefined
Bell's Corners- Moodie & Highway 7	176	250	273	355	+ 55.1%
Barrhaven- Greenbank & Malvern/Foxfield	59	115	115	197	+ 94.9%
Nepean- Meadowlands & Merivale	358	504	478	546	+ 33.5%
Ottawa- Elmvale Shopping Centre	1 057	939	1 092	1 099	+ 3.3%
Gloucester- Leitrim Road & Highway 31	55	91	91	98	+ 65.5%
Blackburn Hamlet- Innes & Bearbrook	159	210	212	231	+ 33.3%
Orleans- Place de Orleans	146	193	256	265	+ 75.3%
Orleans- St. Joseph & Jeanne D'Arc	73	269	280	292	+283.6%

^aThese figures exclude service by "commuter", "early-bird", and "special" routes.

Figure 4-4

Transit Nodes for Table 4-7

Scale
1:200,000

Source: Author, 1983.

beyond the greenbelt are attributable to the introduction of new routes and the extension of old routes. While the growth in transit service is less dramatic inside the greenbelt, several nodes have exhibited above average growth, and some of these may have the potential to become important urban subcentres. Section 4.3 will examine the extent of this trend inside the greenbelt, with supporting employment, transit patronage and transit service figures for ten study cases.

Simple bivariate correlation of each density variable with distance from the CBD (Bank and Albert Streets), using non-transformed figures (Figures 4-5, 4-6, 4-7 and 4-8), reveals that the density patterns of employment, transit patronage and transit service are highly correlated. The three curves all generally follow a distance decay function. There are several exceptional deviations from this model in the non-central urban areas, especially when dealing with transit patronage and transit service densities, and these are labelled on the scattergrams. Section 4.3 will focus on several of these cases, however this section only seeks to establish the possible existence of some degree of urban multi-nodality based on the spatial density patterns of employment, transit patronage and transit service.

Since an urban area can only be either multi-nodal or monocentric, a statistical measure of multi-nodality for the urban area is rather intangible; clearly the extent of urban

multi-nodality can range from non-existence, in which case the city is totally CBD-centred, to total presence, in which case the urban structure could be classified as multi-nodal. Most of the large positive residuals from the regression analyses, where employment, transit patronage and transit service densities significantly exceed expected suburban levels, indicate the presence of the outlying transit terminals which are predictably located at the major outlying shopping centres. Some of the positive deviations, though, are caused by the exceptionally compact delimitation of certain traffic zones which tends to magnify the relative significance of several minor nodes (eg. traffic zones 35 and 65). The ten most important of the outlying nodes will be dealt with in the next section. While the Ottawa urban area is still primarily CBD-centred, it is conceivable that the limited degree of urban multi-nodality is evolving into a Chicago-style multi-nodal pattern (Section 1.2.5).

4.3 - Selection and Analysis of Outlying Nodes

This section involves the selection and study of ten candidates for "outlying nodal centre" status from the non-central urban area (excludes traffic zones 1 to 40). An analysis of the positive residuals from the two multiple regressions in Section 4.1 does not yield a clear set of major outliers. This can be largely explained by the inconsistency in delimiting RMO traffic zones, which often

leads to exaggeration of the relative importance of minor nodes contained within areally small zones. The larger shopping centres, however, tend to be large positive outliers in both regressions. Because of traffic zone inconsistencies, other criteria have to be used to select the outlying nodal centres. These have been outlined in Section 3.2.3.

The ten nodes which met the set of criteria in 1981, were also the top ten transit trip attractors and generators outside the central planning district in both the 1977 and 1981 OC Transpo surveys. The ten nodes designated for "outlying nodal centre" status are, in order of transit patronage attracted and generated in 1981:

1. CARLETON UNIVERSITY - Traffic Zone 54;
2. CARLINGWOOD MALL - Traffic Zone 80;
3. TUNNEY'S PASTURE - Traffic Zone 68;
4. ST. LAURENT MALL - Traffic Zone 149;
5. BILLINGS BRIDGE PLAZA - Traffic Zone 125;
6. BAYSHORE MALL - Traffic Zone 90;
7. BOOTH-CARLING GOVERNMENT COMPLEX - Traffic Zone 42;
8. ALGONQUIN COLLEGE (on Woodroffe) - Traffic Zone 103;
9. CONFEDERATION HEIGHTS - Traffic Zone 122; and
10. CIVIC HOSPITAL - Traffic Zone 62.

Several additional nodes may satisfy the four criteria by 1986; for example, Elmvale Mall in 1981 satisfied all but the employment criterion.

Since Algonquin College (on Woodroffe) and Shopper's City West are immediately adjacent to each other, it was felt that figures for Shopper's City West (Traffic Zone 102) should be included in Table 4-8. It is notable that Traffic Zone 80 contains Carlingwood Mall, as well as Fairlawn Plaza

TABLE 4-8: Relevant Characteristics of Ten Study Cases

STUDY NODE (Traffic Zone)	1976 Employ- ment ^a	1981 Employ- ment ^a	1976 to 1981 Em- ployment Change	1977 Transit Patronage ^b	1981 Transit Patronage ^b	Sept. 1976 Transit Service ^c	Sept. 1981 Transit Service ^c	1976 to 1981 Growth in Transit Service
Algonquin College (103)	1 228.5	1 117.5	- 9.0%	3 007	4 040	399	611	+53.1%
-with Shopper's City West (102 and 103)	(1 772)	(1 536.5)	(-13.3%)	(3 935)	(5 244)	(674)	(929)	(+37.8%)
Bayshore (090)	1 486	1 553	+ 4.5%	4 604	5 918	785	1 200	+52.9%
Billings Bridge (125)	1 461	2 015	+37.9%	3 936	6 441	1 191	1 601	+34.4%
-with western corner of T.Z. 127 (125 and pt. 127)	(1 855)	(2 594)	(+39.8%)	-	-	(1 191)	(1 601)	(+34.4%)
Booth-Carling (042)	3 868	4 093	+ 5.8%	4 195	4 675	896	937	+ 4.6%
Carleton University (054)	1 800.5	4 579	+154.3%	11 201	14 700	798	862	+ 8.0%
Carlingwood (080)	1 987	1 753.5	-11.8%	5 766	7 422	1 215	1 336	+10.0%
Civic Hospital (062)	3 462	3 756	+ 8.5%	2 985	2 832	770	932	+21.0%
Confederation Heights (122)	4 717	7 647	+62.1%	4 588	3 561	990	1 479	+49.4%
St. Laurent (149)	1 228	1 582	+28.8%	2 248	6 642	690	1 930	+179.7%
Tunney's Pasture (068)	7 791.5	8 875	+13.9%	6 746	7 054	1 018	1 513	+48.6%
TOTALS for 10 Traffic Zones	29 029.5	36 971	+27.4%	49 276	63 285	8 752	12 401	+41.7%
Share of RMOG Totals	11.6%	13.9%	+48.5%	10.0% ^d	11.3% ^d	-	-	-

^aFull-time employment given full-weight; part-time employment given half-weight.

^b1977 and 1981 figures not comparable since different methodologies were used.

^cThese totals exclude service by "commuter", "early-bird", and "special" OC Transpo routes.

^dCollective share within total OC Transpo Service Area (includes Hull).

Figure 4-9

Location of Ten Study Nodes

NODE KEY

- 1 - Algonquin College
- 2 - Bayshore Mall
- 3 - Billings Bridge
- 4 - Booth-Carling
- 5 - Carleton University
- 6 - Carlingwood Mall
- 7 - Civic Hospital
- 8 - Confederation Heights
- 9 - St. Laurent Mall
- 10 - Tunney's Pasture

Scale
1:200,000

Source: Author, 1983.

and the commercial strip on the south side of Carling Avenue between Fairlawn and Woodroffe. Using this same logic, employment in part of Traffic Zone 127 (extreme western corner) will be added to Billings Bridge employment in the table since there is a considerable amount of nodal-type development around the Bank Street-Riverside Drive intersection (Figure 4-10). These additions to traffic zones 103 and 125 will not be incorporated into the final results and their inclusion is meant only to illustrate that the region's delimitation of traffic zones does not lend itself ideally to the realistic definition of major outlying nodal areas.

Concerning Carleton University, it must be stated that the values for the four density variables are somewhat deceiving since 53.9 percent of the land in traffic zone 54 is open space, thus unrealistically lowering densities. Also Carleton University was the largest single attractor and generator of transit passengers outside the Central Planning District in both 1977 and 1981, so it is an important transit node. Other study cases whose density figures may be similarly underrated because of large areas of open space, are Traffic Zone 125 (Billings Bridge) which is 59.1 percent open space, Traffic Zone 122 (Confederation Heights) which is 39.5 percent open space and Traffic Zone 68 (Tunney's Pasture) which is 38.1 percent open space. The converse holds true for Traffic Zone 62 (Civic Hospital) and

FIGURE 4-10
The Billings Bridge Nodal Area

Top left: view from the east

Top right: view from the west

Bottom left: view from the south

These photos, taken in July 1983, clearly indicate the development of an outlying nodal centre.

Traffic Zone 103 (Algonquin College) where 100 percent of the land is classified as employment area. Not surprising then is the fact that, outside the Central Planning District, Traffic Zone 62 containing the Civic Hospital has the highest employment density. Because of these inconsistencies in traffic zone delimitation, it can be understood why selection of study nodes was not based solely on the density data in Section 4.1.

Table 4-8 illustrates that, between 1976 and 1981, the ten major outlying centres (using ten traffic zones only) collectively experienced a 27.4 percent growth in employment, more than four times the regional rate of employment growth. Their share of the RMOC's total employment grew from 11.6 percent in 1976 to 13.9 percent in 1981. This can be compared with Ottawa's CBD (Traffic Zones 1 to 17) which experienced a meagre 1.3 percent growth in employment while its regional share dropped from 25.4 percent in 1976 to 24.1 percent in 1981. The ten outlying centres also accounted for an increasing share of transit trips attracted and generated, rising from 10.0 percent in 1977 to 11.3 percent in 1981. Based on the growth between 1976 and 1981 in the annual vehicle kilometres of service operated by OC Transpo, which was 37.6 percent (see Table 2-1), the ten outlying centres collectively experienced above average growth in transit service with a 41.7 percent increase. To understand more clearly the roles of the ten

study nodes, they will be studied in three groups according to their dominant employment category and/or land use characteristic.

The first group includes the four dominant outlying commercial centres: St. Laurent Mall, Bayshore Mall, Carlingwood Mall and Billings Bridge Plaza. The viability of retailing operation is heavily dependent on location and transport availability, which dictates market size and consumer access. All four retailing nodes are located on major arterial routes and within close proximity of large residential populations. The market areas for both St. Laurent and Bayshore Malls have been substantially enlarged by their location on the Queensway (Highway 417), the principal east-west traffic artery in the Ottawa urban area. Accessibility can significantly affect the scale of retail operation. The use of shopping centres as local transit terminals by OC Transpo prompted a 1980 survey by the RMOC's Transit Planning Branch (1981).

The 1980 survey revealed that Billings Bridge, Carlingwood and Bayshore attracted substantial transit clientele. Billings Bridge, with the highest daily volume of transit passengers (including shoppers, people transferring or riding-through), had the highest volume of transit riding shopping clientele (alighting transit passengers destined to the centre) as well as the highest modal split in favour of transit (of auto riders and transit

passengers destined to the shopping centre). Carlingwood was second in all three categories. Bayshore had the highest proportion of transit riders destined to the shopping centre, followed closely by Carlingwood. St. Laurent, the eastern focus for many OC Transpo buses, had the highest daily volume of transit passengers boarding and alighting, with a very high volume of transferring passengers. With the lowest proportion of passengers riding-through the terminal, St. Laurent was the most efficient terminal with respect to route structuring, followed closely by Bayshore (RMO Transit Planning Branch, 1981; refer to Table 4-9).

The employment data in Table 4-10 indicates that the outlying commercial (shopping centre) nodes are becoming slightly more diverse primarily due to the increasing share of community, business and personal services which rose from 7.6 percent in 1976 to 12.1 percent in 1981. The share of trade employment (retail and wholesale), the category which gives the four nodes their predominant character, dropped from 66.1 percent in 1976 to 62.5 percent in 1981, indicating increasing functional diversity at the four shopping centre nodes. While employment in the finance, insurance and real estate, and public administration and defence categories grew between 1976 and 1981, their relative shares of employment at the four shopping nodes remained relatively stable. Billings Bridge Plaza accounted

TABLE 4-9

1980 Use of Shopping Centre Transit Terminals
(Percentages of all transit passengers entering shopping centre transit terminal)

NODE	SHOPPING	TRANSFERRING	RIDING-THROUGH
St. Laurent	10.0	67.1	21.0
Bayshore	22.1	43.6	25.0
Carlingwood	20.6	25.9	51.0
Billings Bridge	12.8	30.2	55.0

Source: RMOC, Transit Planning Branch, July 1982.
("1980 Shopping Centre Transit Terminal Survey")

TABLE 4-10

A Comparison of Employment within the Shopping Centre Nodes,
the CBD and the RMOC - 1976 and 1981

EMPLOYMENT CATEGORY	Four Shopping Centre Nodes (Traffic Zones 80, 90, 125 & 149)		CBD (Traffic Zones 1 to 17)		Total RMOC	
	1976-(% share)	1981-(% share)	1976-(% share)	1981-(% share)	1976-(% share)	1981-(% share)
Primary	1 (0.02)	0 (0.00)	14 (0.02)	0 (0.00)	761(0.30)	603(0.23)
Manufacturing	46 (0.75)	30 (0.43)	647 (1.02)	253 (0.39)	16368(6.55)	19704(7.40)
Construction	44 (0.71)	13 (0.19)	193 (0.30)	329 (0.51)	11117(4.45)	9001(3.38)
Transportation and Communications	19 (0.31)	31 (0.45)	1554 (2.45)	2166 (3.38)	10335(4.14)	11537(4.34)
Trade	4075 (66.12)	4314 (62.48)	4244 (6.70)	4547 (7.09)	33180(13.29)	35643(13.39)
Finance, Insurance and Real Estate	356 (5.78)	388 (5.62)	4156 (6.56)	5168 (8.06)	11070(4.43)	11873(4.46)
Community, Business and Personal Services	465 (7.55)	836 (12.11)	9456 (14.93)	11228 (17.51)	60880(24.38)	76979(28.93)
Public Administration and Defence	1157 (18.77)	1293 (18.73)	43052 (68.00)	40439 (63.06)	106015(42.45)	100779(37.87)
TOTAL	6163 (100.00)	6905 (100.00)	63316 (100.00)	64130 (100.00)	249723 ^a (100.00)	266114 ^a (100.00)
Regional Share of Employment	2.47%	2.59%	25.35%	24.10%	-	-
Share of Transit Trips Attracted & Generated (1977)	3.34%	4.71%	-	16.58%	-	97.02%
Average Level of Transit Service/ Traffic Zone	970.25	1516.75	-	2272.35	-	-

^aFigures may not add up to totals due to rounding caused by half-weighting of part-time employment.

for a very large majority (almost all) of this public administration employment.

Overall total employment at the four nodes has increased by 12.0 percent between 1976 and 1981, while total CBD employment grew by only 1.3 percent over the same time period (Table 4-10). The regional employment growth rate was 6.6 percent. The four centres slightly increased their share of regional employment from 2.5 percent in 1976 to 2.6 percent in 1981. The 1983 opening of the Rideau Centre in Ottawa's CBD must be balanced with the expansions at St. Laurent, Bayshore and Carlingwood (the three outlying regional-level malls) since 1981. The four shopping centres accounted for an increasing share of transit trips attracted and generated, rising from 3.3 percent in 1977 to 4.7 percent in 1981. Transit service growth between 1976 and 1981 averaged 56.3 percent at the outlying shopping centre nodes, due probably to their designation as local transit terminals. Most of this growth in service took place at St. Laurent, which experienced a 179.7 percent increase, and Bayshore, which had a 52.9 percent increase (Table 4-8).

The second group of outlying nodes includes the three largest federal employment centres outside the Central Planning District: Tunney's Pasture, Confederation Heights and the Booth-Carling federal office complex. These older federal nodes have not been allowed to evolve under natural market conditions because of federal controls on surrounding

lands. This is especially true for Tunney's Pasture and Confederation Heights, which are completely unbalanced nodes with respect to employment and land use mix. While the earlier federal decentralization projects on the Ontario side of the NCR act primarily as monofunctional employment centres, the newest federal employment nodes, "Place du Portage" (completed in 1975) and "Les Terrasses de la Chaudiere" (completed in 1977), both in Hull's core area, are considerably more integrated into the local urban environment. Place du Portage, in particular, acts as a multifunctional focus for downtown Hull.

Nonetheless, the three older federal nodes continued to experience employment growth despite their monofunctionality. While public transit usage at Confederation Heights has declined markedly, Tunney's Pasture is heavily dependent on public transit for carrying employees. These two federal nodes are the most significant employment concentrations outside the central area. The Booth-Carling complex, the third largest outlying federal node, is relatively compact in area probably because of its earlier development and its location adjacent to the Central Planning District where space is at more of a premium. Overall, the three federal nodes increased their share of RMO C employment, rising from 6.6 percent in 1976 to 7.8 percent in 1981 (Table 4-11).

The three federal employment nodes have not become more

TABLE 4-11

A Comparison of Employment within the Federal Employment
and Institutional Nodes - 1976 and 1981

EMPLOYMENT CATEGORY	Three Federal Employment Nodes (Traffic Zones 42, 68 & 122)		Three Institutional Nodes (Traffic Zones 54, 62 & 103)	
	1976-(% share)	1981-(% share)	1976-(% share)	1981-(% share)
Primary	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Manufacturing	7 (0.04)	2 (0.01)	0 (0.00)	0 (0.00)
Construction	16 (0.10)	18 (0.09)	0 (0.00)	0 (0.00)
Transportation and Communications	510 (3.11)	2 (0.01)	12 (0.18)	0 (0.00)
Trade	25 (0.15)	258 (1.25)	0 (0.00)	0 (0.00)
Finance, Insurance and Real Estate	78 (0.48)	131 (0.64)	30 (0.46)	35 (0.37)
Community, Business and Personal Services	318 (1.94)	614 (2.98)	6 441 (99.21)	9 411 (99.56)
Public Administration and Defence	15 423 (94.17)	19 591 (95.03)	9 (0.14)	7 (0.07)
TOTAL	16 377 (100.00)	20 616 (100.00)	6 492 (100.00)	9 453 (100.00)
Regional Share of Employment	6.56%	7.75%	2.60%	3.55%
Share of Transit Trips Attracted & Generated	3.14% (1977)	2.73%	3.47% (1977)	3.85%
Average Level of Transit Service/ Traffic Zone	968.00	1 309.69	655.67	801.67

multifunctional between 1976 and 1981, and in fact the proportion of jobs in public administration and defence increased from 94.2 percent to 95.0 percent over the five year span (Table 4-11). For all intents and purposes, the federal nodes are monofunctional and will likely remain that way. The only notable employment increases, however small, occurred in the trade and community, business and personal services categories. It is highly unlikely that these will ever gain any substantial share of the employment totals at the federal nodes. Most of the employment outside the public administration sector is found in the Booth-Carling zone which includes areas to the north and east of the Federal Government office towers on Booth Street.

Overall employment growth between 1976 and 1981 at the three federal nodes averaged 25.9 percent which is almost four times the RMO's rate, and more than double the growth rate of the shopping centre nodes. Surprisingly the three nodes collectively experienced a decline in their share of transit trips attracted and generated between 1977 and 1981. This decline from 3.1 percent to 2.7 percent can primarily be attributed to the unexplained drop in transit patronage at Confederation Heights. Transit service increases averaged 35.3 percent, which is near the regional average of 37.6 percent. Service grew by 49.4 percent at Confederation Heights, despite the unexplained decline in patronage, and by 48.6 percent at Tunney's Pasture between 1976 and 1981.

(Table 4-8).

The third group of outlying nodes includes the three largest institutional centres outside the Central Planning District: Carleton University, Algonquin College (Woodroffe campus) and the Civic Hospital. Almost all employment at these nodes falls into the community, business and personal services category. With both the institutional and the large commercial nodes, the number of people using the centres is more important than the numbers employed there. For educational institutions, which are not in full operation during the summer months, student enrollment is more important than employment. A university campus forms the "...nucleus for a quasi-independent community" (Harris & Ullman, 1970:100). Hospitals, on the other hand, are 24-hour full-time operations; this necessitates a higher number of employees, and results in more uniform traffic flows.

The employment data for the three nodes reveals that they are even more monofunctional than the federal employment nodes. The proportion of jobs in the community, business and personal services category rose from 99.2 percent in 1976 to 99.6 percent in 1981 (Table 4-11), while what employment exists in other categories seems to be disappearing altogether. This extreme monofunctionality is somewhat tempered by the fact that the community, business and personal services category embraces some degree of

functional diversity in itself. The apparent lack of diversity can also be partially attributed to the tight definition of the traffic zones containing Algonquin College and the Civic Hospital, which eliminates any employment nearby - for example, Shopper's City West adjacent to Algonquin College. While the Civic Hospital will open a new main floor concourse of shops this year (1983), it is not expected that the number of jobs in the trade category will be substantial. In the case of Carleton University, all of the vacant land just west of Bronson Avenue is under university control which prohibits the natural development of complementary land uses.

Collectively employment growth at the three centres averaged 45.6 percent, which is greater than at either the commercial or federal employment nodes. The three institutional nodes increased their share of regional employment, rising from 2.6 percent in 1976 to 3.6 percent in 1981 (Table 4-11). Most of this apparent growth can be attributed to the reclassification of teaching assistants at Carleton University in 1980, which has inflated the 1981 employment figures for the university. If Carleton University is excluded, employment growth at the two other institutional nodes averaged a meagre 3.9 percent, which is less than employment growth in the CBD. The share of transit patronage attributed to the three nodes rose from 3.5 percent in 1977 to 3.9 percent in 1981. Most of these

trips were destined for, or originated from, Carleton University, which was the largest single attractor and generator of transit traffic outside the central area in both 1977 and 1981. Transit service growth at the institutional nodes averaged 22.3 percent, the lowest rate among the three groups studied. In general, transit service at these nodes, especially at the educational centres, is considerably below what would be expected based on the levels of patronage which exist there.

To summarize, employment growth for all three groups of nodes was at a rate above the regional average, and markedly higher than employment growth in the CBD. While employment at two nodes actually declined (at Carlingwood-Fairlawn and Algonquin College's Woodroffe campus) between 1976 and 1981, taken collectively, the ten nodes accounted for an increasing share of regional employment. Employment increased the most at the institutional nodes, followed by the federal nodes. However, only the shopping centre nodes exhibited a growth in employment diversity. Federal employment and institutional nodes exhibited increasing monofunctionality. The shopping centre nodes had the largest rise in share of total transit patronage levels, as well as the largest increase in transit service levels at 56.3 percent (Table 4-10). Service growth at the federal nodes was average despite their declining share of transit patronage levels, while service growth at the institutional

nodes was below average. Compared to the CBD, the outlying nodes are considerably less dependent on public transit service because of their overall lower densities.

Therefore, while all three groups of nodes generally became more employment intensive (eight of ten nodes experienced growth), only the shopping centre nodes became more functionally diverse. A more multifunctional node is much more likely to attract and generate greater volumes of trips based on a greater diversity of trip purposes; this is the case with most CBD's. Based on this study, it would seem that the four outlying commercial nodes hold the greatest potential for developing into full-fledged outlying subcentres to the CBD. Most of this potential is probably attributable to private sector control over land use at the commercial nodes; this can be contrasted with public sector control over land use at the federal employment and institutional nodes.

4.4 - The Role of the Outlying Nodes in the Public Transit System

This brief section summarizes the characteristics and roles of the outlying nodes in both the present and proposed transit system. Presently the shopping centre nodes play the most dominant role in the OC Transpo transit system outside the central area. St. Laurent and Bayshore are the most important outlying transit terminals. The four commercial study nodes accounted for the greatest increase

in the share of regional transit patronage, and transit service growth there, which is the highest of the three nodal groups investigated, reflects this shift. The mere designation of most shopping centres as local transit terminals indicates OC Transpo's recognition of their increasing relative importance in the transit area.

The federal nodes, while not exhibiting any signs of increasing multifunctionality, are nonetheless growing in absolute employment levels. While their share of regional transit patronage is declining, transit service growth was only slightly below average, and in fact above average at Confederation Heights and Tunney's Pasture. The institutional nodes, which are the most monofunctional in nature, experienced the lowest level of employment growth when the reclassification of teaching assistants at Carleton University is accounted for. Transit service growth at the three institutional nodes was below average, reflecting the meagre employment growth and the modest increase in their share of regional transit patronage.

Overall the shopping centre nodes have the most significant function in the local transit system and their importance is likely to increase as they evolve into major outlying nodal centres. The role of the federal nodes in local transit is strictly geared to peak hour commuting flows based on their high employment levels. As for the institutional nodes, their role is not fully recognized as

the transit service levels indicate, despite the high levels of transit patronage they attract and generate.

Because of the involvement of both private and public sectors in land development at the shopping centre nodes, the potential for joint development projects there is considerably higher than at the federal employment and institutional nodes where little private sector involvement is evident. Public sector involvement at the shopping centres exists in the form of transit facilities (terminals, special bus ramps and roadways, pedestrian bridges and walkways, etc.), and in the case of Billings Bridge, federal office employment. The opportunity exists for both public and private sectors to collaborate on more intensive land use development at the major commercial nodes in the transit network. Such projects could benefit both sectors if properly planned and developed (Section 1.2.3), and could be instrumental in encouraging multi-centred urban growth.

Of the four commercial nodes, only Carlingwood will not be directly served by the transitway scheme at the time of its completion. It would be rather difficult to link the three nodes on Carling Avenue and Carleton University without constructing a transitway along Carling itself and south from Carling along Bronson or the CPR tracks (under Dow's Lake) to Confederation Heights. While a busway could not be accommodated in the Carling Avenue median, it is a superior L.R.T. route option (Ross & Shrubsole, 1981:5).

Any outlying nodes which will not be linked by the transitways, such as Carlingwood Mall and Carleton University, will likely remain as major transit nodes provided they are still well-served by regular public transit routes. While a transitway link may be highly desirable at these nodes, as well as at the Civic Hospital and the Booth-Carling Government Complex, it is by no means a prerequisite for nodal development.

The approved transitway scheme linking six of the ten outlying centres will not involve many complications since existing rights-of-way will be utilized. Provided no other incentives develop for outlying nodal development, the six nodes to be linked, with the possible exception of the two federal nodes, will inherit the greatest potential to develop into more dominant outlying nodal centres.

CHAPTER FIVE

CONCLUSIONS

5.1 - Toward a Multi-Nodal Pattern in the Ottawa Urban Area

The emergence of the multi-nodal city is certain to attract increasing attention if the trends currently occurring in the Canadian city continue. While this study has concentrated on the role of public transit in this evolution, and has focused on a rather atypical urban area, some insight has been gained into the processes involved in this transformation. What follows is a summary of this study's major findings.

Spatial density patterns of employment, transit patronage and transit service in the Ottawa urban area are significantly correlated with each other, although the population density pattern exhibits a low level of correlation with the other variables. The apparent lack of correlation between population density and the employment and transit density variables stems primarily from the methodology used to delimit traffic zones. The exclusion of

peripheral residential areas from zones with high trip generation rates, such as the CBD and the major outlying nodes, naturally biases against the influence of residential population in determining transit patronage and transit service densities. By using larger zones that would incorporate all development surrounding major nodes, much higher correlation values for population density would probably be obtained. Also, the outlying nodes could then be more realistically contrasted with the CBD.

In the multiple regressions, employment density accounted for the largest share of variation in both transit patronage and transit service densities. This is based primarily on the dominance of peak hour work trips in urban transit flows. While the pattern of transit patronage is logically based on the spatial pattern of employment and population densities, the employment pattern is more clustered than that of residential population. Hence, while the demand for transit service originating from residential areas is relatively continuous, the demand for service originating from the employment centres is more spatially clustered.

The second major conclusion is that while the Ottawa urban area is primarily CBD-centred, as reflected in the scattergrams of the four density variables against distance from the CBD centre, there are a considerable number of deviations from the distance decay model in the developing

non-central areas. A multi-nodal urban pattern is proposed in this thesis as the logical consequence of continuing decline in the CBD's dominance as the single urban control point. Although Ottawa's CBD is the most important node within the local urban area, its dominance has declined with the development of outlying employment and retailing nodes. Even though no single outlying node comes close to the CBD in accounting for variation in local urban density patterns, the evidence supporting the notion of the CBD as the only important focal point is somewhat questionable.

It was discovered that central and outlying peaks in the population density pattern often do not coincide with peaks in the employment, transit patronage or transit service density patterns (compare population scattergram with other scattergrams). This again is at least partially attributable to the delimitation of the traffic zones used in this study. Larger traffic zones incorporating development within, for example, a 400 metre radius of activity centres would certainly increase the correlation of the population density pattern with the other three density surfaces.

In response to the third hypothesis, the outlying nodal centres collectively have become more employment intensive, making gains relative to the CBD, although only the shopping centre nodes show any trend towards increasing functional diversity. Thus, it appears that only the commercial nodes

are evolving into more CBD-like focal points. Again if the zones for data measurement were large enough to encompass peripheral land uses around major activity nodes, most outlying nodes would become more functionally diverse.

Clearly proximity to the CBD explains a decreasing share of the variation in population, employment, transit patronage and transit service densities. Collectively the ten outlying nodes (ten traffic zones) studied account for at least 13.9 percent of total regional employment (in 1981) compared with a 24.1 percent share for the CBD (covering 17 traffic zones). They also accounted for 11.3 percent of local transit trips in 1981, while the CBD was the origin or destination of 16.6 percent of transit trips. While the average traffic zone in the CBD was serviced by 2272.4 OC Transpo buses per weekday (as of September 1981), the outlying nodal centres averaged 1240.1 buses per weekday. Due to their designation as transit terminals, the level of service at the four shopping centre nodes averaged 1516.8 buses per weekday in September 1981. While the CBD is still growing in its absolute levels of employment, transit patronage attracted and generated, and transit service, it is losing its dominance over the urban area relative to the evolving outlying subcentres, and especially to the four largest outlying shopping centre nodes, which exhibit the most potential for obtaining substantial nodal status.

Finally, the potential of the four shopping centre

nodes for developing into major urban subcentres is based largely on their present and future roles in the urban public transit system. It is hardly conceivable that their utilization as transit terminals is an accident or coincidence. The RMOC's Official Plan specifies that the regional and district activity centres are to be linked, where possible, by rapid transit, thereby encouraging maximum utilization of the transitway network (Section 2.3).

The City of Ottawa has designated the area bounded by Bank Street, extensions of Johnston Road and Cahill Drive, and the CPR tracks, for the development of a major activity centre, namely the "South Keys Regional Centre". This integrated development, which is to serve a surrounding regional population, is to include a regional shopping centre, offices, community facilities, housing, a cultural and recreation centre, open space, a hotel, a fire station, as well as a fully-integrated regional rapid transit station (City of Ottawa, 1977; see Appendix C). The approved transitway system provides for a station at Hunt Club which is at the proposed site of the "South Keys Regional Centre".

This example indicates that local planning officials recognize the need to link major activity centres with the new transitway system. If the transit projects in Toronto, Philadelphia and Atlanta are any indication (Section 1.2.4), Ottawa's developing transitway network may act primarily as a spur to the development of satellite business centres

outside the CBD. Six of the ten study nodes will be linked by the transitways and three of the four shopping centre nodes (all except Carlingwood Mall) will eventually be integrated into the network, using only available rights-of-way. It would not be physically possible to connect all ten nodes with the transitways without causing considerable disruption to existing urban development.

Both public and private transportation can play important roles in the emerging multi-nodal city. Modal interchange from cars to public transit can be easily accommodated at outlying shopping centres because of the relatively abundant parking space there. Walk-in trade is also important for evolving nodal centres and therefore high-density residential complexes are desirable adjacent to the various outlying nodes. In light of the energy conservation movement, further development of such complexes near outlying nodes may be anticipated.

Logically, the length of commuting trips would be shortened if major employment centres would locate in closer proximity to urban residences, the majority of which are now suburban, and certainly non-central. In 1971, Dale concluded that CBD journey to work trips in Ottawa were generally longer than peripheral journey to work trips (1971:24). While new outlying 'town centre' type projects, fully-integrated with rapid transit development, are not occurring in the Ottawa urban area to the extent that they

are in the Toronto urban region (see Appendix D), this is probably due to the difference in the sizes of the two cities. 'Town centre' developments of this nature are currently favoured by major developers as discussed in Section 1.2.6.

While it may be undesirable for a city to completely lose a single primary focus, such as the traditional CBD, it may be beneficial to redirect growth into several outlying subcentres in order to avoid overdevelopment of the core area. The RMO's Official Plan provides for the development of regional and district centres within the greenbelt and three major urban communities outside the greenbelt. While the urban satellites beyond the greenbelt seem to be developing as significant urban concentrations, particularly Kanata and Orleans, the emergence of identifiable outlying nodal centres within the greenbelt is more subtle. Perhaps a multi-nodal urban pattern, while it may be emerging gradually on its own, should be more actively encouraged for the Ottawa urban area in order that an economical and efficient urban structure can be more quickly attained.

5.2 - Suggestions for Further Research

Since comparable 1976 data was not available for all the variables, it may be opportune to test these hypotheses again in 1986, using the results of this thesis as a base. Although some might argue that a five year time span is not

long enough to detect long-term trends, such an update would at least reveal short-term trends and any changes in the relationships between the variables used in the regression procedures. Of course a comparable 1986 study could only be accurately done if data for all four variables was available in identical or very similar formats. For example, OC Transpo would have to conduct another origin-destination passenger survey in 1986 using the same methodology as in 1981. A 1986 update would be enlightening since most of the new transitway system would be in operation by then, and it is logical that the stations along the transitway lines (outside the central area) may gain relative dominance over the surrounding urban area as major outlying business nodes.

It would also be desirable to develop some methodology whereby the degree of urban multi-nodality present within a city could be accurately measured. Such a measure, for example, could be used by local planners in determining the spatial allocation of various urban services and facilities. The development of this measure would have to take into account, among numerous other factors, the spatial variation in urban land values, urban traffic volumes, as well as population and employment densities. Should the development of such a comprehensive measure be possible, given the extreme complexity of factors involved in the urban development process, it would seem to involve subjective judgements regarding the weighting of components to be

included within the aggregate index of multi-nodality.

In his study of regional employment centres within the Washington D.C. area, Dunphy emphasizes that there are no standard definitions of non-central employment centres comparable with those of CBD's. There is a need for studies of employment centres to "...develop new geographic units rather than being limited by the same census tract boundaries frequently used in studies of population concentrations" (Dunphy, 1982:13). Several reasons are given for identifying and analyzing employment centres in urban regions:

1. such centres could serve as a major focus for transit service in the suburbs;
2. improved knowledge of the location and function of current employment centres will make it possible to develop better forecasts of growth in existing centres and identify the location of future centres;
3. they can be used to target special transportation policies (eg. ridesharing and carpooling); and
4. prior knowledge of the locations of major employment clusters in a region will focus data-collection efforts for special surveys (Dunphy, 1982:13).

Finally, this type of study would be better suited to the Metropolitan Toronto region, where several 'town centre' projects already exist or are under development in the suburban areas, and there is a true recognition of the need to integrate these outlying subcentres into the rapid transit system (eg. Scarborough Town Centre; Sheppard Centre in North York - see Appendix D). The trend toward urban multi-nodality is of course more noticeable as the size of

the city increases. Since Toronto has a subway system, the influence of public transit on urban development patterns is much more dramatic.

Many other possibilities exist for research in the field of urban multi-nodal development as the subject matter covers numerous facets of urban geography. Current and future energy constraints are likely to make the topic of growing future relevance. The largest research barriers seem to be availability of usable data and the accurate measurement of relevant urban phenomena. Nonetheless, the subject of urban multi-nodality is one that should be given serious attention by our urban planners. While both public and private transportation are involved in this trend, private transport's potential in stimulating multi-nodal development diminishes as outlying nodes become more intensely developed. The pivotal role that public transit plays in this evolutionary process should not be underestimated.

APPENDIX_A: DEFINITIONS

Accessibility: a relative concept which denotes the relative position of individual nodes vis-a-vis other nodes (Lowe & Moryadas, p.75).

Commuter: one who travels back and forth regularly, usually to and from a place of employment.

Joint development: a real estate development that is closely linked to public transportation services and station facilities and relies to a considerable extent on the market and locational advantages provided by the transit facility (U.S. Dept. of Transportation, July 1979, p.1).

Land rent: payment to an owner to use his land (Berry, Conkling & Ray, p.126).

Land value: price paid to purchase land; land rent capitalized at current rate of interest (Berry, Conkling & Ray, p.126).

Modal split: proportionate division of the total number of person-trips between different methods or modes of travel (Bruton, p.169).

Node: locational origin and/or destination of spatial interaction, which is occupied by people and objects, and connected to other nodes by routes; each functions as either an originator, receiver or relayer of movement (Section 3.1).

Rapid transit: transportation system where vehicles travel at relatively high speeds within an exclusive right-of-way.

Transit: process of transporting people and goods within urban areas by public conveyances (Anderson, p.1).

Urban system: set of fixed activity nodes which are interconnected and supported by flows of goods, people and information (Nader, Vol. I, p.356).

Urban transportation: totality of movement within an urban area by public and private means, even though private conveyances must almost always move on publicly financed roadways (Anderson, p.1).

APPENDIX B

SCATTERGRAMS FOR REGRESSION ANALYSES ILLUSTRATING NORMAL DISTRIBUTIONS OF DATA AND LINEARITY OF RELATIONSHIPS

Multiple regression analysis requires normal distributions of data and linearity of relationships between independent variables and the dependent variable. These qualifications for the two regression analyses in Section 4.1 are illustrated in the following scattergrams using the common logs of all variables by traffic zones. The row of zero values in the scattergrams involving the common log of population densities represent traffic zones which are underbounded; if one ignores these aberrations, which have been explained in Sections 3.2.1 and 4.1, the data distributions are fairly normal and the relationships are reasonably linear.

STATISTICS..

CORRELATION (R) -	.06930	R SQUARED -	.00480	SIGNIFICANCE -	.16054
STD ERR OF EST -	.78286	INTERCEPT (A) -	.93156	SLOPE (B) -	.07077
PLOTTED VALUES -	207	EXCLUDED VALUES -	0	MISSING VALUES -	0

STATISTICS..

CORRELATION (R)-	.76103	R SQUARED -	.57916	SIGNIFICANCE -	.00000
STD ERR OF EST -	.59317	INTERCEPT (A) -	-.36544	SLOPE (B) -	.71493
PLOTTED VALUES -	207	EXCLUDED VALUES-	0	MISSING VALUES -	0

STATISTICS..

CORRELATION (R)-	.75969	R SQUARED -	.57712	SIGNIFICANCE -	.00000
STD ERR OF EST -	.59461	INTERCEPT (A) -	.02135	SLOPE (B) -	.90396
PLOTTED VALUES -	207	EXCLUDED VALUES-	0	MISSING VALUES -	0

STATISTICS..

CORRELATION (R)-	-.69206	R SQUARED	-.47895	SIGNIFICANCE	-.00000
STD ERR OF EST -	.54898	INTERCEPT (A) -	2.12369	SLOPE (B) -	-1.17344
PLOTTED VALUES -	207	EXCLUDED VALUES-	0	MISSING VALUES -	0

STATISTICS..

CORRELATION (R)-	-.72574	R SQUARED	-	.52670	SIGNIFICANCE	-	.00000
STD ERR OF EST -	.52836	INTERCEPT (A) -		1.75589	SLOPE (B)	-	-1.24865
PLOTTED VALUES -	207	EXCLUDED VALUES-		0	MISSING VALUES -		0

STATISTICS..

CORRELATION (R)-	.87118	R SQUARED	-	.75895	SIGNIFICANCE	-	.00000
STD ERR OF EST -	.37728	INTERCEPT (A) -	-	-.24287	SLOPE (B)	-	.88024
PLOTTED VALUES -	207	EXCLUDED VALUES-	0		MISSING VALUES -	0	

APPENDIX_C

SOUTH KEYS REGIONAL CENTRE, OTTAWA

The following three illustrations depict accessibility and land use aspects of Ottawa's plan for the South Keys Regional Centre in the southern part of the city. Although these plans are now over six years old, they demonstrate that Ottawa planners recognize the benefits of integrating rapid transit and high-density nodal centre development. South Keys will be the last station along the southeast corridor of the RMOC's approved transitway scheme.

Source: City of Ottawa, Jan. 1977.

Source: City of Ottawa, Jan. 1977.

Source: City of Ottawa, Jan. 1977.

APPENDIX_D

EXAMPLES OF TOWN CENTRE DEVELOPMENT IN THE TORONTO REGION

The purpose of this appendix is to focus on town centre developments in the Toronto urban region. The following projects, located on the map below, will be highlighted: "Bramalea City Centre" (Brampton), "Square One" (Mississauga), "Sheppard Centre" (North York) and "Scarborough Town Centre" (Scarborough). It is notable that "Sheppard Centre" is situated around the Sheppard subway station near the northern terminal of the Yonge Street line. "Scarborough Town Centre" will be linked to the Bloor-Danforth subway line by rail transit by late 1984. Clearly rapid transit plays an integral role in the development of outlying nodal centres within urban areas.

BRAMALEA CITY CENTRE (BRAMPTON)

Since the City of Brampton already has a downtown core area in the established urban area to the west of Bramalea City Centre, this town centre development is somewhat unique in the Toronto regional context. The town centre projects in Mississauga, North York and Scarborough are more similar in that they are being developed in the absence of other municipal core areas. Maximum permitted uses within the commercial core area of Bramalea City Centre include 1.2 million square feet of commercial uses, 1 million square feet of business office space and non-retail commercial uses, 910,000 square feet of high-density residential apartments (1000 dwelling units) and 350,000 square feet of hotel space and convention facilities.

[Source: City of Brampton, 1981.]

Existing Official Plan Designations

..... **Bramalea City Centre Study Area**

Scale: 1:9600

Date: 1981 05 15

City of Brampton
Planning and Development

PEDESTRIAN CIRCULATION : ULTIMATE PLAN

BRAMALEA CITY CENTRE

James Murray & Murray Marshall
architects & planning consultants

237 Mather Drive Toronto Ontario

DATE: 1987

PROJECT: BRAMALEA CITY CENTRE

SCALE: 1" = 100'

DATE: 1987

PROJECT: BRAMALEA CITY CENTRE

SCALE: 1" = 100'

DATE: 1987

PROJECT: BRAMALEA CITY CENTRE

SQUARE ONE (MISSISSAUGA)

Since the City of Mississauga was formed by amalgamating several smaller urban and semi-urban municipalities - namely the towns of Mississauga, Port Credit and Streetsville, and the urbanizing townships of Toronto and (part of) Toronto Gore - no significant core area existed for the new city. The development of "Square One" is changing this situation. Land use within this developing city centre area is to include 353,000 square metres of gross leasable retail space, 1,180,800 square metres of gross office space, 7610 housing units, 54,000 square metres of community facilities and 2000 hotel rooms.

[Source: City of Mississauga, 1981.]

Transit

The transit system will expand gradually as the City Centre is developed; bus service will be the predominant transit mode for a considerable period of time. Bus routing within the City Centre will be determined to support its physical development.

The existing transportation terminus adjacent to Square One will serve the City Centre for the next few years. However, as City Centre development intensifies a larger more efficient terminal will be required. This plan retains the northwest corner of Hurontario Street and Burnhamthorpe Road as a possible location for a new transit terminal. However, it is possible that future development and study will determine a more suitable location for a transit terminal in which case an appropriate transfer of land uses will be made without amendment to this Plan.

Any study to determine the location of the transit terminal will consider possible integration with the following:

- the City-wide transit network;
- the internal City Centre people-mover system;
- the pedestrian system, major office concentrations, and major cultural uses.

As the area develops and traffic volumes increase, preferential transit lanes should be provided in the City Centre. The preferential lanes will consist of a single curbside lane in each direction intended to serve transit vehicles and right-turning vehicles. Their initial use would be during peak periods only with possible expansion to exclusive lanes. Preferential transit and service lanes should be provided within the City Centre along Burnhamthorpe Road and possible preferential transit lanes are provided along Hurontario Street.

For the immediate future, bus service will be the primary transit service to the City Centre. The need for a high capacity transit service, such as a fixed guideway system, will be dependent upon achieving the ultimate density of the City Centre as well as increasing the density in the main transit corridors. If the fixed guideway system becomes feasible, it may be able to utilize the right-of-way of the preferential transit lanes.

Existing Conditions

..... Service Tunnel

▬▬▬▬▬ Pedestrian Malls

▨▨▨▨▨ Roads and Parking

▩▩▩▩▩ Potential for Future Expansion

▩▩▩▩▩ Vegetation

Scale 1:10000

Source: City of Mississauga - Nov. 1981.

SHEPPARD CENTRE (NORTH YORK)

The most fully-developed of the outlying town centres in the Toronto urban region is undoubtedly "Sheppard Centre" in North York. This high-density node, located at the Sheppard station of the Yonge Street subway line, is also a diversified activity centre which could easily serve as North York's CBD. It is no coincidence that this outlying node is highly accessible by both private and public modes of transportation within Metropolitan Toronto. Metro Council has designated the area along Yonge Street stretching from Highway 401 to north of Finch Avenue as one of only two subcentres slated for concentrated growth. The City Centre project, a 250 million-dollar office, hotel, shopping and library complex, is to be developed around Metro Toronto's newest subway station at Park Home Avenue, and is to function as the focal point of "Downtown North".

[Source: Financial Post; Oct. 22, 1983; pp. A1-A12.]

"Sheppard Centre" in North York, Ontario
(photos taken in April 1983)

Top: from the northwest

Bottom: from the southeast

This well-developed node is situated near the northern terminal of Toronto's Yonge Street subway line. North York's City Hall is to the left of the top photo (northwest side of the node).

SCARBOROUGH TOWN CENTRE

Similar to Mississauga and North York, Scarborough emerged primarily as an extension of Toronto and therefore did not develop with its own CBD. The Official Plan provides for a major concentration of urban central area type uses, including about 40,000 office jobs, at the Town Centre development. This multi-use urban centre, which will include a variety of land uses, is intended to function as a downtown core for Scarborough - the governmental, cultural, business, retail and transportation focus for the eastern Metropolitan area. The use of public transit is being promoted for access to the Town Centre so that the centre develops as a major transit interchange and focus for Scarborough transit service. Land uses, their densities and their distribution, are being carefully planned to optimize access between land uses and the transit system. At least 55 percent of the Centre's office workers are to arrive by transit when a level of development sufficient to accommodate 40,000 jobs has been reached.

[Source: Borough of Scarborough, 1982.]

TOWN CENTRE DEVELOPMENT PLAN

PROJECT	FLOOR SPACE		USE	PROJECT	FLOOR SPACE		USE
	m ²	ft ²			m ²	ft ²	
EXISTING:				UNDER CONSTRUCTION:			
A - State Farm Insurance	6 870	74,000	Office	F - Government of Canada	35 850	386,000	Office
B - Scott House	460	5,000	Restaurant	G - Canada Life Centre	20 700	223,000	Office
C - Shopping Centre	107 000	1,150,000	Retail	H - Consilium Phase I	34 500	370,000	Office
D - Bell Canada	23 440	250,000	Office	I - ICTS Transit Stations			
E - Civic Centre	27 870	300,000	Office	- McCowan/Town Centre			Transit
TOTAL				TOTAL	91 050	979,000	
PROPOSED:							
J - Trizec	44 100	475,000	Office				
K - Eatons	65 000	700,000	Office				
L - Government of Canada	30 000	323,000	Office				
M - YMCA	13 000	140,000	Recreational				
			Residential (312 units)				
N ¹ - Tankos Yarmon Office	31 000	334,000	Office				
P - Tankos Yarmon Hotel			Hotel (400 units)				
Q - Consilium - Phase II	48 000	517,000	Office				
			Residential (468 units)				
R - Consilium - Phase III	70 000	750,000	Office				
			Residential (480 units)				
			Hotel (200-400 units)				
S - Provincial Court House	15 500	167,000	Court House				
TOTAL							
	316 600	3,406,000					
Total Existing, Under Construction & Proposed							
	573 290	6,164,000					

For further information, contact the Urban Design & Graphics Section of the Planning Department at 296-7338.

APPENDIX_E

RECENT TRENDS IN PUBLIC TRANSIT OPERATION IN OTTAWA

The following graphs are included as a brief summary of recent trends in public transit operation in the Ottawa urban area. Included are graphs of transit ridership growth between 1948 and 1976, growth in average daily ridership between 1972 and 1976, changes in the hourly distribution of average weekday ridership between 1963 and 1975, and changes in per-mile transit and auto usage costs between 1961 and 1975. Although the information from these graphs is not central to this thesis, it provides a useful insight into local public transit.

Source: Bureau of Management Consulting (1977), The Ottawa Bus-Pass System: An Examination of Effects, p. 9.

Source: Bureau of Management Consulting (1977), The Ottawa Bus-Pass System: An Examination of Effects, p. 11.

Source: Bureau of Management Consulting (1977), The Ottawa Bus-Pass System: An Examination of Effects, p. 12.

Source: Bureau of Management Consulting (1977), The Ottawa Bus-Pass System: An Examination of Effects, p. 63.

SELECTED BIBLIOGRAPHY

Altshuler, Alan (1979). The Urban Transportation System: Politics and Policy Innovation. Cambridge, Mass.: MIT Press.

Anderson, J. Edward (1978). Transit Systems Theory, Ch. 6. Lexington, Mass. and Toronto: D.C. Heath and Co..

Baerwald, Thomas J. (1982). "Land Use Change in Suburban Clusters and Corridors", Transportation Research Record 861 (Transportation and Land Use Impacts on Major Activity Centers), pp. 7-12.

Baker, Carole (1983). "Tracking Washington's Metro", American Demographics, November, pp. 30-35, 46.

Beauchemin-Beaton-Lapointe Inc.; DeLeuw Cather Canada Ltd.; M.M. Dillon Ltd.; and the IBI Group (1976). Rapid Transit Appraisal Study. Ottawa: prepared for the RMOC.

Bellefeuille, Bruce (1976). "Transportation Policy Making for the Urban Area." B.A. Thesis, Carleton University (Ottawa).

Benedetti, Sandra M. (1975). "High-rise Apartments and Bus Routes - Ottawa Study Area." B.A. Thesis, Carleton University (Ottawa).

Berry, Brian J.L. (1963). "General Features of Urban Commercial Structure." In Internal Structure of the City, pp. 361-367. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

----- (1967). Geography of Market Centres and Retail Distribution. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Berry, Brian J.L.; Conkling, Edgar C.; and Ray, D. Michael (1976). The Geography of Economic Systems. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Berry, Brian J.L., and Gillard, Quentin (1977). The Changing Shape of Metropolitan America. Cambridge, Mass.: Ballinger Publishing Co..

Berry, Brian J.L., and Kasarda, John D. (1977). Contemporary Urban Ecology. New York: MacMillan Publishing Co. Inc..

Black, John (1981). Urban Transport Planning: Theory and Practice. London: Croom Helm Ltd..

Blumenfeld, Hans (1961). "Transportation in the Modern Metropolis." In Internal Structure of the City, pp. 231-239. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

----- (1964). "Criteria for Urban Form." In Internal Structure of the City, pp. 434-436. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

----- (1967). The Modern Metropolis. Montreal: Harvest House.

----- (1975). "Myths and Realities of the Urban Transit Problem." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 2-11. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

----- (1979). Metropolis...and Beyond (Selected Essays). Edited by Paul D. Spreiregen. New York: John Wiley and Sons.

Blunden, W.R. (1971). The Land Use/Transport System. Oxford, England: Pergamon Press.

Blurton, Michael (1975). "Myths and Realities of the Urban Transit Problem." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 12-30. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Boal, Frederick W. (1968). "Technology and Urban Form." In A Geography of Urban Places, pp. 73-80. Edited by R.G. Putnam, F.J. Taylor and P.G. Kettle. Toronto: Methuen, 1970.

Bonsall, Peter; Dalvi, Quasim; and Hills, Peter J. (1977). "The Broad Perspective." In Urban Transportation Planning, pp. 3-5. Edited by Bonsall, Dalvi and Hills. Kent, U.K.: Abacus Press.

Bourne, Larry S., and Doucet, M.J. (1973). "Components of Urban Land Use Change and Physical Growth." In The Form of Cities in Central Canada: Selected Papers, pp. 83-103. Edited by Larry S. Bourne, R.D. MacKinnon and J.W. Simmons. Toronto: University of Toronto Press.

Bowes, R. Wayne (1975). "Planning the Urban Future with New Transit Systems." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 227-242. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Boyce, Ronald R. (1966). "The Edge of the Metropolis: The Wave Theory Analog Approach." In Internal Structure of the City, pp. 104-111. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

Brigham, Eugene F. (1965). "The Determinants of Residential Land Values." In Internal Structure of the City, pp. 160-169. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

Bruton, Michael J. (1975). Introduction to Transportation Planning. 2nd ed.. London: Hutchinson and Co. (Publishers) Ltd..

Bureau of Management Consulting (1977). Ottawa Bus-Pass System: An Examination of Effects. Ottawa: prepared for the Urban Transportation Research Branch.

Burrows, B.A. (1978). "An Investigation of Residential High-rise Location and Rental Patterns in Ottawa." B.A. Thesis, Carleton University (Ottawa).

Burton, Ian (1963). A Restatement of the Dispersed City Hypothesis. Toronto: University of Toronto.

Cartwright, D.W. (1976). "A Geographical Analysis of the Dial-a-bus System as a Response to Canada's Urban Public Transportation Needs." B.A. Thesis, Carleton University (Ottawa).

Catton, Dawson (1975). "Transit Systems: Case Studies of Success." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 54-68. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Colcord, Frank A. (1975). "Planning the Urban Future with New Transit Systems." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 218-226. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Cooley, C.H. (1974). "The Theory of Transportation." In Transportation Geography: Comments and Readings, pp. 15-29. Edited by Michael E. Elliot Hurst. New York: McGraw-Hill Inc., 1974.

Cornehls, James (1977). "The Automobile Society: Urban Design and Environment", Traffic Quarterly, XXXI(4), pp. 571-590.

Creighton, Roger J. (1970). Urban Transportation Planning. Chicago: University of Illinois Press.

Dale, L.M. (1971). "A Comparison of Central and Peripheral Journeys to Work - A Case Study of Ottawa." B.A. Thesis, Carleton University (Ottawa).

Dayani, Jarir; Egan, M. Michael; and McElroy, Marjorie B. (1975). "The Redistributive Impact of the Atlanta Mass Transit System", Southern Economic Journal, XLII(July), pp. 49-60.

DeLCan-Dillon-IBI Group (1978-1981). Ottawa-Carleton Rapid Transit Development Programme, Volumes 1 to 8.

DeLeuw Cather and Co. of Canada Ltd. Consulting Engineers (1965). Ottawa-Hull Area Transportation Study. Ottawa: DeLeuw Cather and Co..

Derbyshire, Andrew, and Brown, Henry (1979). "Urban Structure." In Urban Planning and Public Transport, pp. 16-33. Edited by Roy Cresswell. Lancaster, England: the Construction Press.

Deweese, D.N. (1973). The Impact of Urban Transportation Investment on Land Value (Research Report No. 11). Toronto: University of Toronto.

Dickey, John (1975). Metropolitan Transportation Planning. Washington: Scripta Book Co..

Dingemans, Dennis J. (1978). "Rapid Transit and Suburban Residential Land Use", Traffic Quarterly, XXXII(2), pp. 289-306.

Dunphy, Robert T. (1982). "Defining Regional Employment Centers in an Urban Area", Transportation Research Record 861 (Transportation and Land Use Impacts on Major Activity Centers), pp. 13-15.

Edmonton Journal (Aug. 12, 1983). "Triple Five has more plans in works", p. B1. "Countdown's on for mall-orama", p. C8.

Edmonton Journal (Aug. 17, 1983). "Champagne chic opens mall addition as thousands arrive for sneak preview", p. B1.

----- (Aug. 18, 1983). "Sales pitch stole the show", p. F6.

Financial Post (October 22, 1983). "North York", pp. A1-A12.

Gannon, Colin A., and Dear, Michael J. (1975). "Rapid Transit and Office Development", Traffic Quarterly, XXIX(2), pp. 223-242.

Garner, Barry J. (1966). "Aspects and Trends of Urban Geography." In A Geography of Urban Places, pp. 4-10. Edited by R.G. Putnam, F.J. Taylor and P.G. Kettle. Toronto: Methuen, 1970.

Garrison, W.L. (1979). "Urban Transportation and Land Use." In Public Transportation: Planning, Operations and Management, pp. 515-526. Edited by George E. Gray and Lester A. Hoel. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Gertler, Leonard O. (1976). Making Man's Environment - Urban Issues. Toronto: Van Nostrand Reinhold Ltd..

Getis, Arthur (1969). "Residential Location and the Journey from Work." Proceedings of the American Association of Geographers, (1), pp. 55-59.

Godlund, Sven (1956). "The Function and Growth of Bus Traffic Within the Sphere of Urban Influence", Lund Studies in Geography, Series B(18), pp. 1-72.

Griffith, Daniel A. (1981). "Evaluating the Transformation from a Monocentric to a Polycentric City", Professional Geographer, XXXIII(2), pp. 189-196.

Haggett, Peter (1975). Geography - A Modern Synthesis. 2nd ed.. New York: Harper and Row Publishers.

Hall, Mark D. (1979). "Spatial and Temporal Changes in Urban Non-residential Land Use at Freeway Interchanges." B.A. Thesis, Carleton University (Ottawa).

Hansen, Walter G. (1959). "How Accessibility Shapes Land Use", Journal of the American Institute of Planners, XXV(2), pp. 73-76.

Huth, Gary J. (1983).
Structure, 1983.
245-263.

Harris, Chauncy D., and Ullman, Edward L. (1945). "The Nature of Cities." In A Geography of Urban Places, pp. 91-101. Edited by R.G. Putnam, F.J. Taylor and P.G. Kettle. Toronto: Methuen, 1970.

Hatfield Research Co. (1978). Economic Analysis - Potential for Regional Shopping Centres in the RMO. Ottawa: prepared for the Planning Dept., RMO.

Hayes, Charles R. (1976). The Dispersed City - The Case of Piedmont, North Carolina (Research Report No. 173). Chicago: University of Chicago.

Highway Research Board (1968). Urban Development Models (Proceedings of a Conference held June 26-30th, 1967, at Dartmouth College - Hanover, New Hampshire). Washington.

Hilton, George W. (1975). "Economic Perspectives on Mass Transit Policies." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 189-196, 202-203. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Hodge, Gerald (1972). "The Emergence of the Urban Field." In Urban Systems Development in Central Canada - Selected Papers, pp. 234-243. Edited by Larry S. Bourne and R.D. MacKinnon. Toronto: University of Toronto Press.

----- (1974). "The City in the Periphery." In Urban Futures for Central Canada: Perspectives on Forecasting Urban Growth and Form, pp. 281-301. Edited by Larry S. Bourne, Ross D. MacKinnon, Jay Siegel and James W. Simmons. Toronto: University of Toronto Press.

Hurst, Michael E. Eliot (1974). "Land Use/Travel Movement Relationships." In Transportation Geography: Comments and Readings, pp. 474-482. Edited by Michael E. Eliot Hurst. New York: McGraw-Hill Inc..

Hutchinson, B.G. (1974). Principles of Urban Transport Systems Planning. Washington: Scripta Book Co..

Hutchinson, B.G., and Shortreed, J.H. (1973). Lecture notes for a first course in Urban Transport Planning. Waterloo, Ont.: University of Waterloo.

Hutchinson, Pat. Marketing Manager, West Edmonton Mall (Edmonton, Alberta). Interview on CHEZ (106 FM-Ottawa) "News at Noon", Aug. 19, 1983.

Huth, Mary Jo (1983). "Toward a Multi-Nodal Urban Structure", Transportation Quarterly, XXXVII(2), pp. 245-262.

- Hutton, Thomas A. (1983). "Prospects for Planning: An Economic Perspective", Plan Canada, XXIII(2), pp. 51-58.
- Jackson, John N. (1973). The Canadian City - Space, Form, Quality. Toronto: McGraw-Hill Ryerson Ltd..
- Janelle, D.G. (1974). "Spatial Reorganization: A Model and Concept." In Transportation Geography: Comments and Readings, pp. 358-376. Edited by Michael E. Eliot Hurst. New York: McGraw-Hill Inc..
- Johnston, R.B. (1975). "Transit Systems: Case Studies of Success." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 69-82. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.
- Johnston, R.J. (1966). "An Index of Accessibility and Its Use in the Study of Bus Services and Settlement Patterns", Tijdschrift Voor Economische en Sociale Geografie, LVII, pp. 33-38.
- Kain, John F. (1970). "Transportation in Metropolitan Areas." In Metropolitan Problems, pp. 77-92. Edited by Simon Miles. Toronto: Methuen.
- Khan, A. (1974). "Land Use and Transport Interaction: Policy and Planning Implications", High Speed Ground Transportation Journal, VIII(1), pp. 125-151.
- Koski, Robert W. (1979). "Bus Transit." In Public Transportation: Planning, Operations and Management, pp. 120-141. Edited by George E. Gray and Lester A. Hoel. Englewood Cliffs, N.J.: Prentice-Hall Inc..
- Lawless, Kevin E. (1980). "The Effect of Office Relocation on the Retail Sector in the National Capital Region." B.A. Thesis, Carleton University (Ottawa).
- Leisch, Jack (1970). "A Plan for Co-ordination of Transportation with Land Use and Urban Development", Traffic Engineering, May, pp. 14-22.
- Lisco, Thomas E. (1970). "Mass Transportation: Cinderella in our Cities", The Public Interest, Winter (18), pp. 52-74.
- Lorimer, James (1978). The Developers, Ch. 10. Toronto: J. Lorimer and Co. Publishers.
- Lowe, John C., and Moryadas, S. (1975). The Geography of Movement. Boston: Houghton Mifflin Co..

McCauley, David (1979). "Bells Corners: A Study of Urbanizing Trends in the Suburban Environment." B.A. Thesis, Carleton University (Ottawa).

McCleary, D. (1971). "Transportation Systems for the Future Ottawa." B.A. Thesis, Carleton University (Ottawa).

Mackinnon, Ross D. (1974). "Urban Transportation in the Future." In Urban Futures for Central Canada: Perspectives on Forecasting Urban Growth and Form, pp. 236-265. Edited by Larry S. Bourne, R.D. Mackinnon, Jay Siegel and J.W. Simmons. Toronto: University of Toronto Press.

Mackinnon, Ross D., and Lau, R. (1973). "Measuring Accessibility Change." In The Form of Cities in Central Canada: Selected Papers, pp. 120-137. Edited by Larry S. Bourne, R.D. Mackinnon and J.W. Simmons. Toronto: University of Toronto Press.

Mayer, Harold M. (1970). "Making a Living in Cities: The Urban Economic Base." In A Geography of Urban Places, pp. 125-142. Edited by R.G. Putnam, F.J. Taylor and P.G. Kettle. Toronto: Methuen.

Mercer, John (1979). "On Continentalism, Distinctiveness, and Comparative Urban Geography: Canadian and American Cities", Canadian Geographer, XXIII(2), pp. 119-139.

Meyer, J.R.; Kain, J.F.; and Wohl, M. (1965). The Urban Transportation Problem. Cambridge, Mass.: Harvard University Press.

Miller, G. Tyler, Jr. (1982). Living in the Environment. 3rd ed., pp. 223-227. Belmont, Cal.: Wadsworth Publishing Co..

Mills, Edwin S. (1972). Studies in the Structure of the Urban Economy. Baltimore: John Hopkins Press.

Mississauga, City of (Nov. 1981). City Centre Secondary Plan.

Mitchell, Robert B., and Rapkin, Chester (1954). Urban Traffic: A Function of Land Use. New York: Columbia University Press.

Mok, K.S. (1973). "Ottawa-Carleton Regional Transportation Study: Towards the Year 2000." B.A. Thesis, Carleton University (Ottawa).

Morris, R.E. (1977). "An Investigation of the Interaction of Land Use and Transportation in Planning Urban Areas, Case Example, Stuttgart." B.A. Thesis, Carleton University (Ottawa).

Nader, George A. (1975). Cities in Canada - Volume I: Theoretical, Historical and Planning Perspectives. Toronto: Macmillan of Canada.

----- (1976). Cities in Canada - Volume II: Profiles of Fifteen Metropolitan Centres, pp. 172-183. Toronto: Macmillan of Canada, Maclean-Hunter Press.

National Capital Commission (1979). Federal Government Employment Study - 1979. Ottawa: NCC.

Noguchi, Tomoki (1982). "Shaping a Suburban Activity Center through Transit and Pedestrian Incentives: Bellevue CBD Planning Experience", Transportation Research Record 861 (Transportation and Land Use Impacts on Major Activity Centers), pp. 1-6.

Nutt, Ronald J. (1972). "The Relative Influence of Accessibility to Place of Work upon Residential Location: A Case Study of Ottawa." B.A. Thesis, Carleton University (Ottawa).

Odland, J. (1978). "The Conditions for Multi-Center Cities", Economic Geography, LIV, pp. 234-244.

Ottawa, Planning Board (1970). Official Plan of the Ottawa Planning Area.

Ottawa (1977). Major Activity Centre Urban Design Guidelines.

Ottawa, Dept. of Community Development (1977). Retail/Commercial Policy Report.

----- (1977). Scale and Structure of Growth.

----- (1977). Transportation Efficiency and Development Form in the Ottawa-Carleton Region.

----- (1979). Demographic and Housing Changes in Ottawa-Carleton.

Ottawa, Urban Space Futures (1980). Consumer Attitudes and Shopping Patterns, Vol. I - Summary Analysis, Urban Part - Ottawa-Hull CMA.

OC Transpo (1976). Local Weekday Stopping Service, and Weekday Express Service. (September 1976 headways).

OC Transpo (1981). Zone Trip Attractions and Generations for all Purposes by Time Period.

----- (1981). Daily Headways, and Express Headways. (September 1981 bookings).

----- (1982). "Good Day - Bonjour", Vol. 2, No. 6.

----- (1983). OC Transpo Transitway.

OC Transpo, Public Relations and Marketing Services (1979). Your Bus Guide.

Ottawa Citizen (May 11, 1981). "Area transit much more rapid by 1983", p. 1. "Bus every 20 seconds promised by transit planners", p. 33. "How new bus system will develop", p. 33.

----- (July 31, 1981). "Rapid transit (now made in Ontario)", p. 35.

----- (Oct. 5, 1981). "Rapid transit choice queried", p. 8.

----- (Dec. 5, 1981). "Bus mall gets go-ahead", p. 3.

----- (Dec. 14, 1981). "Centres shop for a conscience", p. 8.

----- (Dec. 15, 1981). "Transpo touts propane system", p. 18.

----- (March 17, 1982). "Regional council rejects a freeze on transitways", p. 40.

----- (July 14, 1982). "Shopping centres won't be required to justify expansion", p. 15.

----- (Dec. 12, 1983). "Mall to include indoor fantasy land", p. 38.

Owen, Wilfred (1972). The Accessible City. Washington: Brookings Institution.

Pederson, Eldor Olin (1980). Transportation in Cities. New York: Pergamon Press Inc..

Potter, Paul E. (1979). "Urban Restructuring: One Goal of the New Atlanta Transit System", Traffic Quarterly, XXXIII(1), pp. 45-60.

Pushkarev, Boris S., and Zupan, Jeffrey M. (1977). Public Transportation and Land Use Policy. Bloomington, Ind.: Indiana University Press.

RMOC, Planning Dept. (1972). Progress Report - Transportation Study.

----- (1976). Regional Shopping Centre Location Study.

----- (1979). Employment Survey of RMOC for the year 1976.

----- (1980). Official Plan: Ottawa-Carleton Planning Area.

----- (1981). Data Handbook.

----- (1982). Employment in Ottawa-Carleton (1976-1981).

RMOC, Transit Planning Branch (1981). 1980 Shopping Centre Transit Terminal Survey.

RMOC, Transportation Dept. (1981). Transit Servicing of New Urban Areas - Guidelines for Development.

Reynolds, D.J. (1975). "Economic Perspectives on Mass Transit Policies." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 181-188. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Richards, Brian (1969). "Urban Transportation and City Form", Futures, I, pp. 239-251.

Roads and Transportation Association of Canada (1977). Urban Transportation Planning Guide. Toronto: University of Toronto Press.

Rolfe, Jim; Ross, Greg; and Shrubsole, Charles (1979). Discussion Paper on the Reorganization of Regular OC Transpo Routes. Ottawa: prepared for Transport Ottawa.

Ross, Greg, and Shrubsole, Charles (1981). Busways or LRT? Ottawa: prepared for Transport 2000 Ottawa/Ontario.

Scarborough, Borough of (Aug. 1982). Scarborough Official Plan - Town Centre Plan.

Sharpe, C. (1969). "Shopping Centres as Trip Generators." B.A. Thesis, Carleton University (Ottawa).

Silverleaf, A. (1979). "Introduction." In Urban Planning and Public Transport, pp. 7-13. Edited by Roy Cresswell. Lancaster, England: the Construction Press.

Simmons, James and Robert (1974). Urban Canada. 2nd ed.. Toronto: Copp Clark Publishing.

Smerk, George M. (1975). "Myths and Realities of the Urban Transit Problem." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 31-37. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

----- (1979). "The Development of Public Transportation and the City." In Public Transportation: Planning, Operations and Management, pp. 4-21. Edited by George E. Gray and Lester A. Hoel. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Smith, Frederick A. (1971). "Kanata: Its Relationship to the Urban Growth of Ottawa." B.A. Thesis, Carleton University (Ottawa).

Smith, Walter A. and Co. Ltd. (1972). A Study of the Development of Retail Facilities in the Ottawa-Hull Region. Ottawa: prepared for the RMOC.

Smith, Wilbur and Associates (1955). Traffic and Transportation Plan for Ottawa, Canada. New Haven, Conn..

Soberman, Richard M. (1975). "Transit Systems: Case Studies of Success." In Mass Transit: the Urban Crisis of North America (Proceedings of the 17th Annual Seminar on Canadian-American Relations), pp. 45-53. Edited by J. Alex Murray. Windsor: University of Windsor, 1976.

Soberman, Richard M., and Hazard, Heather A., editors (1980). Canadian Transit Handbook. Toronto: University of Toronto - York University.

Soliman, A.H., and Manastersky, R.A. (1973). An Integrated Public Transportation System for Middle-Sized Urban Areas (Research Report No. 14). Winnipeg: Centre for Transportation Studies, University of Manitoba.

Statistics Canada (1982). Passenger Bus and Urban Transit Statistics - 1980. (Catalogue 53-215 Annual). Ottawa: Minister of Supply and Services Canada.

----- (1982). Travel to Work: 1976-1980. (Catalogue 87-503 Occasional). Ottawa: Minister of Supply and Services Canada.

Steiner, Henry Malcolm (1978). Conflict in Urban Transportation. Lexington, Mass. and Toronto: D.C. Heath and Co..

Stern, E. (1979). "Inter-Nodal Association of Bus Services", GeoJournal, III(1), pp. 89-96.

----- (1980). "A Cognitive Scalar for the Public Transport Connection Matrix", Professional Geographer, XXXII(3), pp. 326-334.

Stone, Tabor (1971). Beyond the Auto - Reshaping the Transportation Environment. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Stopher, Peter R., and Meyburg, Arnim H. (1975). Urban Transportation Modeling and Planning. Lexington, Mass. and Toronto: D.C. Heath and Co..

Taaffe, Edward J., and Gauthier, Howard L., Jr. (1973). Geography of Transportation, Chs. 4 & 5. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Turabian, Kate L. (1973). A Manual for Writers of Term Papers, Theses, and Dissertations. 4th ed.. Chicago: University of Chicago Press.

U.S. Dept. of Transportation (July 1979). Joint Development: Making the Real Estate-Transit Connection (Executive Summary). Washington: Urban Land Institute.

----- (Aug. 1979). Land Use Impacts of Rapid Transit - Implications of Recent Experience (Final Report). Washington.

----- (Dec. 1979). Land Use Impacts of Rapid Transit - Implications of Recent Experience (Executive Summary). Washington.

----- (Jan. 1981). Planning and Development of Public Transportation Terminals. Washington.

Vance, James E., Jr. (1977). This Scene of Man, Ch. 8. New York: Harper and Row Publishers.

Voorhees, Alan M. (1963). "Transportation Planning and Urban Development." In A Geography of Urban Places, pp. 192-200. Edited by R.J. Putnam, F.J. Taylor and P.G. Kettle. Toronto: Methuen, 1970.

Vuchic, Vukan R. (1979). "Urban Passenger Transport Modes." In Public Transportation: Planning, Operations and Management, pp. 68-98. Edited by George E. Gray and Lester A. Hoel. Englewood Cliffs, N.J.: Prentice-Hall Inc..

Webster's New Collegiate Dictionary (1979). Toronto: Thomas Allen & Son Ltd..

Weissman, Ernest (1970). "Planning and Development of the Metropolitan Environment." In Metropolitan Problems, pp. 411-450. Edited by Simon Miles. Toronto: Methuen.

Wheeler, James O. (1974). The Urban Circulation Noose. North Scituate, Mass.: Duxbury Press.

----- (1981). "Long, Long Trail to Work", The Geographical Magazine, LIII(May), pp. 511-516.

White, Michelle J. (1976). "Firm Suburbanization and Urban Subcenters", Journal of Urban Economics, III, pp. 323-343.

Winterhalt, William H.. Policy Planner, City of Brampton (Ontario). Interview, April 20, 1983.

Wolforth, John (1965). "The Journey to Work." In Internal Structure of the City, pp. 240-247. Edited by Larry S. Bourne. New York: Oxford University Press, 1971.

Wolforth, John, and Leigh, Roger (1971). Urban Prospects. Toronto: McClelland and Stewart Ltd..

Yeates, Maurice, and Garner, Barry (1976). The North American City. 2nd ed.. New York: Harper and Row Publishers.