RESIDENTIAL DEVELOPMENT IN HAMILTON-WENTWORTH, 1980 TO 1994

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IN

HAMILTON-WENTWORTH, 1980 TO 1994

By

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Abstract

The work presented here is based on data for subdivision applications in the Region of Hamilton-Wentworth between 1980 and mid-1994. The data set contains both spatial and attribute information for each subdivision. The analysis which utilizes this data is divided into three sections. The first is a descriptive examination detailing the pattern of development over space and time. Density is then used as a dependent variable in multiple regression to determine which factors can explain the spatial variation of subdivision densities. The final analysis uses a logit model to test which characteristics of the urban area are important in a subdivision's choice of location among a set of zones representing land available for development.

Most development tends to occur in the form of relatively small subdivisions, and densities appear to increase over time. Yearly subdivision activity displays trends similar to those of various economic indicators. Density is found to be a function of distance from major roadways, the year of plan approval, household sizes and average incomes, and can also be explained using a set of categorical variables for location of development. The logit analysis shows that subdivisions are more likely to locate in areas that have more high-speed roads, more developable land, and greater quantities of previous development. Location probabilities are also higher for zones that are less accessible to employment, have smaller average family sizes, and higher average homeowner payments. Alternative specific density variables are also very important to the logit results.

Acknowledgements

Which of the following headlines sound a little far-fetched?

"Aliens Visit Earth: Replenish Ozone Layer"
"President Resigns, Joins Monastery"
"Elvis to Perform Live on Oprah"
"Masters Student Completes Thesis"

A short while ago, a lot of people would have said all of them, but today they would be wrong. The thesis is actually done! It has been a long road from start to finish, but yes, my friends, it has finally come to an end. There are many people deserving of my appreciation who have helped me along the way.

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The question asked most of me (well, second most in the recent past) has been: "What will I do next?" Countless possibilities lay beyond my door; all I need do is step through it.

M.S.D.
November, 1998

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Introduction

Housing has been an integral part of urbanization since the very beginnings of the process thousands of years ago. The basic physical function of a dwelling is to provide shelter from the environment, but people must also live in close proximity to the city to take regular advantage of any benefit of urban agglomeration. The city creates a demand for dwellings, but the supply of homes also generates demand for goods and services that the city can provide. Housing is therefore much more than just a living space for urban residents.

Typically up to a half of all urbanized land within a city is devoted to dwellings and the lots upon which they are situated. Housing development is thus the primary component of a city's spatial growth. The locations of many other urban features are a function of the changing spatial distribution of those residences. They affect the traffic patterns along road networks, the location of retail establishments, and the placement of public facilities such as schools, recreation centres, parks, hospitals, police and fire departments, and social services. This growth also has non-urban effects because it absorbs land previously devoted to agriculture, open space, or natural areas.

The housing sector is a large component of the economy at the national, provincial, and municipal levels. Dwelling construction creates employment in the building trades through the workers that are required during construction. It also does so indirectly through the physical services that are supplied to each home once it is occupied, and the industries that rely on the purchasing power of the people who live there. The expense of building dwellings requires large investments from public and private sources. Housing is a commodity that is purchased by almost every citizen at some point in their lives, and often more than once; this has given rise to an entire industry devoted to facilitating the buying and selling of homes. It is usually the most expensive purchase the average person will ever make.

Because of the importance of housing, it is also the subject of much regulation. Federal and provincial governments affect the housing sector through investment, and policies which range from construction standards which ensure the safety of the inhabitants, to price controls or affordable housing quotas which ensure that dwellings are available to all strata of society. Municipal governments dictate where they will allow it to be built through planning regulations and the location of infrastructure, and also provide other services once it is occupied.

All of these points underscore the importance of housing-related research. At the same time, they illustrate the broad and complex nature of the topic. This thesis will examine that facet of the subject which centres around new residential development in an urban area. The availability of a data set which contains information regarding individual housing subdivisions, over an extended period of time, has allowed for intensive analysis of the factors which affect both the form and location of development in a specific urban area. This study focuses on the Hamilton-Wentworth region during the period from 1980 to mid-1994.

It begins with an outline of the regulatory framework within which development is controlled, and a review of previous research relevant to the subject of housing development. The data set is then studied in detail from various perspectives. Patterns within it are described at an aggregate regional level and by municipality, both spatially and temporally. It is examined in terms of frequency of development approvals, and by the characteristics of the approved subdivisions which included the numbers of dwellings they contain, the area they cover, and their density. The following two chapters look at the subdivision data on a deeper level. Chapter 3 examines factors that can be related to the density of housing. Chapter 4 studies the location in which it is built. It looks at residential growth from the point of view of the individual developer, and uses logit theory to model the location choice of each subdivision.

The research attempts to answer several questions. To begin with, are there any yearly trends evident in the data? Next, what factors can be correlated to the spatial pattern of subdivision densities? Finally, can the choice of location for development be modelled, and what are the characteristics of the areas in which subdivisions are built? If the first question can be related to the "when" of subdivision activity, then the second and third pertain to the "what" and the "where" of housing development. The conclusions drawn in the attempt to answer them will provide a fairly complete picture of the forces which may be influencing development in the Hamilton area.

Chapter One:
Literature Review

1.1 Introduction

Any analysis of housing development would be remiss without an examination of the framework within which it occurs. Residential growth is governed by many factors, but at the most basic level there are two primary influences at work. Market forces provide the impetus for expansion to occur, while planning constraints imposed by governments control and sometimes retard the change in supply. The pair are not mutually exclusive either. There would be little need for planning if there were no stimulus to add to urban land, but without planning guidelines the development forces would function in an environment of chaos.

This review will synthesize the planning and development process in the context of Canada. It begins with an outline of planning ideology. The government participants are then introduced, before focusing on planning tools and regulations. An overview of the development industry is presented, with specific detail regarding historical trends in Canada and the Hamilton area. The last section is a review of modelling literature that details factors influencing development location, and issues regarding the analysis of residential land use.

1.2 Urban Planning

1.2.1 Concepts and Ideologies

Urban planning is a very complex and extensive subject area. Planning occurs on behalf of various levels of government in the regulation of public and private land uses. It also occurs on behalf of the developers in the attempts to conform to or circumvent those regulations. The role of the planner additionally involves consulting for various other public and private bodies, including citizen interests.

There is much debate over what planning is meant to accomplish. There are many differing opinions and points of view on the subject of what planning is, or to be more exact, what it should be. Part of the problem is that planners are caught up in the interests of many different groups - politicians, citizens, private industry, and various public agencies - all of which desire to see the fulfilment of their wants and requirements. To this end, planning can be viewed as the mediator by which the physical outcomes of those needs are satisfied through the act of creating plans. It is the means by which an equitable and efficient solution is reached. However, the optimal result is often not the one that is chosen.

The maximization of a city's economic, physical, and social potential should be the core consideration of the planner, but in practice planners are rarely given a role with this much importance (Kiernan, 1990). They are mostly restricted to controlling physical land use, to reduce the chance that negative externalities of a particular activity will result in undue hardship upon a neighbouring activity. This is in part due to the political ideology of the Canadian municipal system: city government should not play an activist or interventionist role in the development of urban areas. Kiernan (1990) states that this attitude has two effects on planning: it removes resolve and political support of the public sector, and it reduces planning to a "reactive and marginal" role. Local government is viewed as the provider of a limited number of services. There has been a tendency for governments to assume as few responsibilities as possible, and guidelines tend to be interpreted as narrowly as possible (ie. the effort put into satisfying the regulations is minimized). It is also a reality that market pressures often cause planning regulations to be pushed aside or changed in favour of development (Chinitz, 1991). Bourne (1981) questions the consistency of land use controls.

While some academics argue that planning is at best a marginal or erratic system in the process of city building, the development industry tends to have a different view. Many planners think developers regard the approval process as a time consuming, meddling, and superfluous expenditure (Peiser, 1990). Builders have long believed that by restricting development output, planning has forced up prices for dwellings, reducing the ability of many people to buy their own homes (Bramley, 1993a). Developers also feel that planners infringe on their prerogative to build by withholding development permissions (Peiser, 1990). Cutbacks at higher levels of government are creating a larger financial burden for municipalities, which has forced them to rely to a greater extent upon development to bring in revenue and pay for infrastructure. Additionally, there has been an increased awareness of the consequences urban growth has on the environment, generating an anti-development attitude which has resulted in no-growth movements. Developers are as a result being forced to rely more and more on consultants to help them negotiate what has become a very involved process (Peiser, 1990). However, it is also believed that over the long term planning must be responsive to the changing needs of land developers (Chinitz, 1991). Bramley (1993b), discussing the quantity of land available to developers, states that "it is possible to envisage a scenario where planning, by reducing uncertainty, increases supply." Thus the picture of whether planners are making things more difficult for developers is somewhat cloudy.

Planning is also believed to be a technical exercise. This tends to obscure the fact that it does involve debatable value judgements, with results that are rarely equitable. It also strengthens emphasis on the physical aspects of planning, maintaining a deficiency in tools which would allow interest in a wider range of social and economic issues (Kiernan, 1990).

This view of planning as a rational, technical field also pervades the planning legislation (Makuch, 1983). Government mandates assume that if a problem is thoroughly studied and analyzed, the right solution will become evident. They also tend to use ambiguous terms such as "orderly", "economic", and "beneficial" in their text, assuming that these have understood meanings. The allocation of the plans is also isolated from the political process to support this rationality. For example, the *Ontario Planning Act (1983)* empowers municipal governments to provide for the creation of a plan, and also provides for the creation of a planning advisory committee to devise it. However, this assumption of rationality is incorrect. Politics are the essence of planning - there are no absolutes; no distinct rights or wrongs. Values tend to change through time, and as the history of planning shows, they have shifted from a "pro-growth" mentality of the '50s and '60s to a more socially oriented conservationist agenda today. Prior to the recession of the early 1980s, the common perspective planners took towards development was a critical and negative one - they could afford to be choosy during prosperous periods - but with the economic downturn their emphasis shifted to the encouragement of new development (Kiernan, 1990). The planning process is not a technical process at all, but a "war" among competing interests (Makuch, 1983).

In practice, planners tend to be regulators. Seldom do they actually create the plans (Perks &

Jamieson, 1991). The Canadian situation echoes this sentiment - planning is mainly the control of land uses (Makuch, 1983). The actual process of planning is what is important because decisions affect the circumstances of individuals. Access to information and adequate notification of the plans are necessary to ensure a fair outcome. For these reasons, one of the most important themes in planning is the need for formal systems of review. Since property rights are at stake, planners tend to leave the decision making to the politicians, who are better suited to handle it (Makuch, 1983).

Hodge (1991) notes that there are actually two processes at work in planning: a normative and a technical. The normative process is undertaken by the community government to determine its objectives, needs, and courses of action. This phase involves the establishment of "norms" which attempt to satisfy the ideals and values of the various interests, and is thus given to much debate. The technical process is the actual designing of the plan and determination of the instruments to be used, and mainly involves the planners.

There seems to be a definite need for community planning. This need exists for several reasons, which are outlined by Hodge (1991). The necessity of planning arises because people desire to improve their environments, and not strictly because of the formal structures they erect. Thus, two things lie at the heart of the need for planning: community aspirations, and problems which accompany development. Neither one is exclusive of the other.

Planning actions are taken to achieve community objectives, ie. the "achievement of a community's preferred future physical environment" (Hodge, 1991). This aspect of the need is based on the concept of idealism - planning is meant to help the community attain what is considered to be the "ideal". This view has roots which extend deep into the history of civilization. The early Mesopotamians, Chinese, Greeks, and Romans all recognized the utility of planning their urban living spaces, and aspired to create cities which were aesthetically pleasing or functionally efficient. Planning to achieve the ideal involves creating an image or vision of a possible community environment, something which many modern communities have undertaken or provided for within their official plans and policy guidelines (Hamilton-Wentworth's *Vision 2020* policy statement is a prime example).

Planning is also necessary to solve problems associated with a community's development (Hodge, 1991). The definition of what constitutes a "problem" is a function of the concerns and conditions which are prevalent at a particular time. Many problems arise due to the differences between the interests of the developer and the interests of the community, and can include the external effects of development which is only being proposed - thus it is possible to avoid an expected problem before it becomes a reality. Since the externalities may not always be known, some prediction may be required. The planning should provide a solution which makes the community situation at least as good or better than it was expected to be before the problem became apparent.

1.2.2 The Participants in the Process of Planning

1.2.2.1 The Federal Government

There is no unifying national urban policy in Canada, such as a federal planning act, but the highest level of government can still exert its influence both directly and indirectly. For example, federal programs in housing (eg. the establishment of the Canada Mortgage and Housing Corporation) directly affect the development process. The federal government is also the single largest owner of land in Canada, and its management of those lands includes planning for them. For example, airports, which are federally owned, affect land use in surrounding areas by limiting the height of buildings on runway approaches, taking precedent over local by-laws (Rich, 1993). Indirectly, influence over development is felt through federal employment, the tax system, transfer payments, and policy on economics and immigration (Cullingworth, 1987). For example, by introducing the GST, housing costs were increased, placing housing out of the reach of more people, and creating pressure on provincial and municipal governments to alleviate the added burden (Rich, 1993). Also of note is the effect of the Constitution. This document provides for the civil rights of citizens of the nation. Since planning pertains to the regulation of private property, the Constitution has some influence in the way municipalities can go about handling issues which are related to development on privately owned lands.

1.2.2.2 The Provincial Government

This section will focus mainly on the Ontario situation, but many of the ideas apply to the other provinces as well. The provinces are given responsibility for municipal institutions under the Constitution. Thus, they are concerned not only with establishing municipal governments, but also providing for the regulation of the affairs of those governments (Rich, 1993). The main justification for the provincial involvement in local planning is that local decisions can sometimes have impacts which are experienced over wider regional areas (Makuch, 1983). In Ontario, the *Planning Act* is administered through the Ministry of Municipal Affairs, which has three functions in local planning: to advise, to supervise, and provide a forum for appeal (Rich, 1993).

Debate in Ontario during the late '70s over the role of the province resulted in the passing of a planning act in 1983. The catalyst for definition of provincial responsibilities was the 1977 Comay Committee Report. Comay argued that provincial involvement should not go beyond formally defined provincial interests, which was not the case during the 1970s. The province had been acting in a complete supervisory role, reviewing almost all planning decisions and actions at the municipal level. Comay felt that this was not necessary, and that instead the province should only make sure that its interests are not violated by local plans. Municipalities had also tended to allow the provincial government to handle the difficult or contentious issues; they would sometimes take the easy way out of a problem knowing that the province would change their decision if necessary (Cullingworth, 1987). The areas of provincial interest proposed by Comay included:

- implementation of provincial policy and programs in economic, social, and physical development; protection of the natural environment and management of natural resources; equitable distribution of social and economic resources;
- maintenance of the provincial financial well-being;
- ensuring civil rights and natural justice in the administration of municipal planning;
- ensuring the coordination of planning activities of municipalities and other public bodies; resolution of intermunicipal conflicts.

According to Comay, the province shouldn't worry about whether municipalities engage in "good" planning, and instead restrict its focus to whether local planning adversely affects provincial interests. Comay also recommended that official plans be dropped from the list of items requiring provincial approval.

The report was rejected by the province on the basis that its recommendations allowed for too much local autonomy (Cullingworth, 1987), but the province did agree that more powers of approval could be delegated to the municipalities, and accepted the need to formally define provincial interests. The 1983 Ontario Planning Act set the following as being matters of provincial interest:

- protection of the natural environment, including the agricultural base and management of natural resources;
- protection of features of significant natural, architectural, historical, or archaeological interest;

- the supply, efficient use of, and conservation of energy;
- the provision of major communications, servicing, and transportation facilities;
- the equitable distribution of education, health, and other social facilities;
- the coordination of municipal planning activities with other public bodies;
- the resolution of conflict between municipal and other public bodies;
- the health and safety of the population;
- the protection of the financial and economic well-being of the province and its municipalities.

The Act also provided for the publication of policy statements dealing with municipal planning matters of provincial interest, in order to allow municipalities to have a clearer understanding of provincial policy (Cullingworth, 1987). The Act stipulates that all matters of provincial interest are to be approved by the Lt. Governor of the province, and grants the minister responsible for planning authority to require municipal amendments to serve provincial interests (Makuch, 1983). Ontario planning legislation also provides for the creation of an approved development plan in a defined area. Once approved, the plan prevents both changes of a structural nature and the passing of by-laws which are in conflict with the plan. The development plan prevails over local provisions in the event of a conflict. The purpose of these plans is to provide a direction for municipal planning policy. Some, however, criticize them because there is no regulation on how specific such plans need to be, meaning that the possibility of conflicting by-laws can be small. There is also criticism of this emphasis on development control - it is said to lead to a negative image of planning, and the number of ministries involved increases the time for decision making and makes coordination among participants difficult (Rich, 1993).

1.2.2.3 The Ontario Municipal Board

The OMB originated in 1906 as the *Ontario Railway and Municipal Board*, but later had planning functions allocated to it. The Board serves, or is meant to serve, as an impartial mechanism for the appeal and judgement of contentious planning decisions. It is a provincially appointed tribunal, and has adopted an adversarial approach in the way with which appeals are dealt, much like a court. Opposing views are put forth, supported by expert testimony and evidence. Decisions are made based solely on the information presented during the appeal, and it is rare for the Board to ask for additional information. The OMB is also not bound by the precedents it sets, but it tends to accept arguments based on earlier decisions in order to remain consistent (Rich, 1993).

The OMB is thus quite a powerful body, and the fact that it enters the planning process at a late stage makes it important for planners to consider a plan from many points of view, to account for possible opposition and reduce the risk of a negative ruling by the Board. Its strengths are its support of the public interest expressed by citizens, and its independence from other ministries (Cullingworth, 1987). The OMB has been criticized on the basis that full representation in an appeal can be expensive, deterring the average person from contesting an issue. It is also criticized for being too subjective in its views, and it has a tendency to ignore the fact that there is often more than one "right" resolution (Rich, 1993). Suggestions for reform of the OMB include classification of the types of municipal actions which require review - given that some issues should not be reviewed the same way as others (Cullingworth, 1987), and the suggestion that it adopt a system of mediation instead of absolute rulings to recognize the multiplicity of solutions (Rich, 1993). Other provinces have similar bodies which provide a forum for appeal.

1.2.2.4 The Municipalities

Local governments are traditionally seen as non-political agencies concerned mainly with the delivery of services (Cullingworth, 1987). Their responsibilities include fire protection, local roads, waste disposal, sewage, taxation of land and buildings, and the regulation of local land use. The common element of those responsibilities is property - therefore many people view municipal government as the unit of government concerned with the regulation, taxing, and servicing of the built environment (Sancton, 1991). Demand for services, both quantity and quality, has increased over time. Municipal decisions are increasingly seen to have a greater impact on the environment - socially, economically, and physically. Cities are also facing problems over which they have little control. The combination of those trends has resulted in a policy-oriented role for local government, following the reorganization of local governments to provide for better service delivery (Cullingworth, 1987). Such reformation of the local governing structure has created a two-tier system of regional government in many places, but there are problems which arise in such situations (Sancton, 1991). If there is a strong or dominant central city with a weaker outer region (eg. Hamilton-Wentworth), the outlying suburbs will feel that the regional government primarily serves the central city's interests. If the suburbs are strong (eg. Winnipeg), the central city feels that its needs are secondary. If boundaries extend far into the countryside (eg. Ottawa-Carleton), then there are conflicts between rural and urban interests. These types of conflicts are part of the reason why provinces have control over local planning powers.

Authority typically granted to municipalities includes the ability to pass zoning and planning by-laws, practice development control, regulate the subdivision of land, assemble and lease land for development, create local housing authorities, and recycle money raised through development levies to generate further development (Kiernan, 1990). However, the provinces dictate which powers may be used and generally have a say in how they may be used. This creates a tension between municipal and provincial interests, one of the underlying themes in Canadian urban planning (Kiernan, 1990).

City governments are allowed to organize their planning departments as they see fit. They are generally split into two partitions: forward planning (dealing with both long-range/city-wide plans, and short-term/small-area plans), and a division responsible for the daily administration of current planning situations (Kiernan, 1990).

Municipalities, as stated previously, are allowed to create development plans under provincial legislation. Such plans are meant to be the basis of all planning decisions by setting out goals and policies. They generally focus on land use control, but can include social and economic concerns as well. They may contain vague generalizations or precise and detailed statements, but in Ontario cannot include conditional requirements (ie. the allowance of a land use given that the developer meets some prerequisite). They also tend to include maps setting out the desired land use patterns. In Ontario, these documents are termed *official plans* and have legal status once they are approved by the province. In practice they are little more than statements of intention (Makuch, 1983), because municipalities are under no obligation to carry out projects stated within the plan. This makes them relatively ineffective in restricting land use. Bossons (1993) points out that an official plan may only provide more certainty concerning future development if it constrains site-specific regulatory decisions. Municipalities can still exercise powers of land control without an official plan, but in the presence of such a plan, land use regulations become the instruments by which the plan is realized. Official plans are more of a means of controlling municipal action by prohibiting certain developments which are in conflict with the plan, rather than dictating the exact pattern that future development will take (Makuch, 1983).

Hodge (1991) lists the steps which must be taken to prepare the average plan. First, municipal council must decide to prepare a plan. An advisory committee is asked to recommend a course of action, and this involves public input as well as background data collection and analysis provided by planning staff. The result is the preparation of a *draft plan by-law*, which is presented at a public hearing. The advisory committee then presents the plan to council. The plan is openly debated: if council defeats it, the plan is either abandoned or reworked; if passed, the plan is submitted to the province along with any public objections. The province then decides on the by-law. If there are legitimate objections, the plan can be referred to an appeal body, which can either ratify the plan or refer it back to council to make changes based on the objections. If there are no objections, the province may approve the plan. While the appeals process is important, there are limitations placed upon it to maintain fairness and alleviate unnecessary delay. For example, no appeal may be made until the by-law has actually been passed by the local government, and there is usually a 30 day limit for appeal after by-law approval. If the appeal is considered trivial, the appeal body or minister has the right to dismiss it. In Ontario, revised by-laws may be subject to objection only by those who were party to the original decision, thus eliminating the problem of new objectors appearing in the midst of revision, saving time and political energy.

1.2.3 Land Use Regulation

1.2.3.1 Planning Instruments

There are many ways in which municipalities are able to influence and exert control over urban land use. The most important and well-known is *zoning*. The basic premise of zoning is the separation of conflicting land uses. Zoning was originally developed as a tool to help cities govern development years in advance of development pressures, minimizing state intervention at the actual time of growth. It seeks to provide certainty and predictability in the land use system with a minimum of discretion on behalf of local governments (Makuch, 1983). The zoning by-laws attempt to define precisely what uses are permitted (Cullingworth, 1987).

Zoning is related to the concept of *nuisance*, or more specifically, nuisance avoidance. Traditional remedies for nuisance are sought in the court system, and occur after the physical interference has been created. Nuisance is also a subjective term which varies from situation to situation. Zoning is a method of replacing the court's values about nuisance with those of the community, and is a preventative measure for the avoidance of nuisance before it can ever take place (Makuch, 1983).

However, basic zoning is widely criticized as being too restrictive and inflexible to the needs of a changing development system. Since development patterns are somewhat unpredictable, in part due to exogenous economic influences, it is necessary for planning policies to work with market forces, and this idea conflicts with the concepts of predictability and certainty which zoning was originally meant to provide (Cullingworth, 1987). Some view zoning as unnecessary because of the belief that economic forces will ensure a "fair" outcome without government interference. Zoning is also prone to political corruption, and can affect the actions of land owners if they expect a zoning change to occur. Cities may also "over-zone" for certain categories of land use which yield large financial returns, leaving other public land use needs with a smaller supply of land (Pacione, 1990). An even harsher criticism is levelled by Perks & Jamieson (1991), who state that zoning has "denied and progressively destroyed the traditional intermingling of work, manufacturing, home, play, leisure activity, and retail trade which gave coherency, social meanings, and a sense of stability and place to urban communities".

Makuch (1983) lists other reasons for the inadequacy of zoning in its original form. It did not allow for phased development, which would allow services to be provided gradually. Zoning did not have regard for special cases and situations. It only controlled for the type of development, and not its "quality". It could not impose conditions or positive obligations on developers because of its prohibitive nature. Zoning also did not allow for the establishment of temporary controls, it provided for a lack of variety within land use classifications, and its minimum standards often became maxima because developers had no incentive to exceed them. Thus zoning simply prevents the worst, but inhibits the better (Makuch, 1983). These problems were the impetus for the creation of other tools which try to remove the limitations of early zoning practices.

Most of the reforms on regulation are simply variations on the zoning theme. For example, the *variance* evolved as a means of allowing an alteration to zoning in specific cases where a by-law results in unnecessary hardship on a land owner, so long as the terms of the variance are not contrary to the interest of the public (Cullingworth, 1987). Ontario legislation allows for the creation of independent committees of adjustment which may grant minor variances so long as the general intent and purpose of the zoning by-laws remain intact, and the official plans are maintained.

Zoning by-laws can be amended under legislation, a recognition of the fact that the by-law cannot exist forever. Other types of zoning include *spot zoning*, which is the re-zoning of an individual plot of land. *Bonus zoning* or *bonusing* is the granting of an allowance above the zoning regulation in exchange for some additional requirement (usually the provision of a public amenity; also known as *incentive zoning*). *Mixed-use zoning* allows the development of compatible uses on a particular plot of land. *Cluster zoning* is a means of allowing the developer to concentrate construction on one part of a site, leaving the remainder as public open space. This method is still subject to an average density requirement, but the compact nature of development allows for lower cost servicing (Cullingworth, 1987). *Inclusionary zoning* requires the inclusion of some specific feature in the development (for example, a park, or affordable housing). *Performance zoning* sets standards for physical conditions which can be measured (such as specific levels of sunlight, noise, or vibration).

There are also methods of preventing or delaying development from taking place. These tools go by many names: *holding zones*, *interim ordinances*, *holding by-laws*, etc.. Their main purpose is to limit development until the project can be given more intense scrutiny by municipal staff. The 1983 Ontario Planning Act empowers municipalities to "hold" a zoning designation to allow control over the phasing of development. It requires that the official plan contain adequate explanation and justification for the practice. The legislation also allows the placement of a "development freeze" of up to one year in duration (with possible extension to two years) to allow the municipality time to prepare land use policy. However, development can also be delayed by imposing an agricultural zoning by-law, the continuance of obsolete existing zoning, or the downsizing of allowable densities to uneconomic levels (Cullingworth, 1987).

A relatively new idea is the *transfer of development rights* (TDR). The development rights can be considered the owner's license to build on or develop a site. TDR allows the separation of development rights from one site and their sale or transfer to another (ie. the first site loses its capacity for development, which is then passed to the second). It was used initially in the preservation of historic buildings, allowing municipalities to keep such properties from being demolished. Development rights become marketable, allowing the owner of rights in a restricted area to gain some return on investment through their sale. The Ontario government considers the concept too complex to legislate, but allows municipalities to experiment with the idea.

Planned unit developments are another type of innovation. They relax regulation on use and type of buildings on a site, allowing for a mixture of building types, thus creating a greater variety in the built environment. The regulations governing PUDs conform to the development as a whole (Cullingworth, 1987). Hodge (1991) states that TDRs and PUDs offer positive incentives for development, probably through the flexibility they offer the developer.

Development control or *site plan control* is a method which has gained popularity in recent years. The municipality is allowed to impose conditions and require agreements with developers concerning those conditions. The controls were legislated in Ontario in 1973, and allowed for schemes to be approved on a case by case basis without the need to pass by-laws approving a development. Municipalities can designate site plan control areas within their official plans. Development within those areas is prohibited until the developer provides plans showing the location of all buildings, service facilities and works, and elevations and cross-sectional views for each commercial and industrial building, as well as each residential building with over 25 units. Municipalities may also require provision for street widening, access to the lots, off-street parking and loading, traffic circulation, pedestrian access, lighting, grading and landscaping, waste storage, and easements for water and sewage. They may require the developer to enter into agreements regarding the above matters. The agreements may be registered to make them binding to subsequent land owners. Zoning is not abandoned under this type of control; height and density are covered by zoning by-laws (Makuch, 1983).

Developers are also affected by *discretionary planning controls*, where the owner's right to develop is controlled by special planning authorities and not zoning by-laws. There are examples in Ontario, the most well known and influential of which is the *Niagara Escarpment Commission* (created in 1973 by the *Niagara Escarpment Planning and Development Act*). All development within a specified area around the escarpment is subject to the control and approval of the NEC, which may impose terms and conditions on development. Failure to comply with the NEC or contradiction of the Act may result in fines. The NEC also has the power to order the demolition of offending structures. Another example is the northern region of Ontario: the Ministry of Natural Resources issues permits for building on Crown lands, which puts much of that part of the province under ministry jurisdiction (Cullingworth, 1987).

In general, there has been a shift away from limited zoning toward more complex and flexible forms of planning control which are at the discretion of local planning bodies. The view that the "certainty" of zoning is superior to the uncertainty of discretionary control still exists, but practical experience has shown that the two can be integrated into more manageable and powerful tools for planning (Cullingworth, 1987). In many cases, undeveloped areas are not regulated by zoning bylaws or municipal plans until a development application has been submitted, allowing a municipality to avoid prematurely committing an area to a particular form of development (Bossons, 1993).

1.2.3.2 Growth Management

The topic of growth management is related to planning instruments, because many of those instruments are used in the attempt to manage and control urban growth. The control of urban growth is important for several reasons, the most notable of which is the case for preventing urban problems such as sprawl, pollution, congestion, and strain on local services. It is also important from a conservationist standpoint - mainly the conservation of open space or agricultural lands. At the very least, methods should be able to slow the onset of urbanization to allow the municipalities to adjust and provide servicing in due time. The term growth management carries a positive connotation; growth is not curtailed or prohibited, but is allowed to occur within a guiding framework under the constraint of certain limitations.

Pacione (1990) lists many ways of placing a limit on suburban growth, which are useful if there is a need to stimulate housing demand in the inner city. For example, urban areas can limit the extension of services such as water and sewerage, for without them the development process cannot take place. The local government can place a limit on the total number of development permits it issues, with quotas for different sectors of the city to balance growth across a wider area. Policies of zoning for very low densities in the suburbs will result in fewer homes per land unit. Environmental regulations can be used to protect ecologically sensitive areas. The creation of green belts around cities provide breaks in development. Cities can purchase rural development rights, and then keep the land rural by prohibiting development. He also lists several which are already in use in Canada. These include shifting the financing for new infrastructure from general property tax to building and development fees, requiring local governments to prepare large scale land use plans, and requiring developers to prepare and file detailed plans and impact assessments prior to development.

Deakin (1991) lists techniques which are similar to those mentioned above, but also include the bounding of urban areas by setting limit lines which dictate where development should stop. Another idea is the use of timing ordinances to control the pace of growth, coupled with the manipulation of capital budgets to provide funding for services in an orderly manner.

Feldman (1987) points out that traditional planning instruments won't work on the periphery because there is often a lack of jurisdiction over peripheral lands. There are courses of action which can be followed to remedy this problem. Local governments can make an effort to gain jurisdiction by creating regional or metropolitan governments. They can also pressure the federal and provincial governments to acquire the land, since ownership would provide the power to plan. Methods of acquisition include the purchase or expropriation of blocks of land for use by specific public utilities and services, or the purchase to create a land bank for future use. Feldman also states that annexation is an alternative, but not possible in areas with adjacent incorporated municipalities. He also proposes the setting of urban boundaries for development, and the use of taxes to generate incentives and disincentives for particular land uses. He argues that green belts or rights-of-way are not really effective because they just tend to get passed over, resulting in development on both sides of an open strip of land.

Bossons (1993) states that development plan approval or zoning are often delayed in some areas. This is a form of growth control because it allows local governments to direct urban growth to areas for which there are services or an intention to provide infrastructure.

There are several other arguments supporting and opposing the need to control growth. Growth control can protect the environment, preserve community attributes which would be changed by new development, and help ensure orderly and financially responsible urban expansion (Deakin, 1991). Restriction of outward growth also increases the density of the inner urban area, thereby improving economic efficiency (Feldman, 1987). Opponents believe that management contributes to inflation by increasing land prices during times of high demand, since added development costs will be passed on to consumers. It can contribute to the exclusion of lower income segments of the population from housing; it may force developers to shift to more expensive housing developments because of the limitations placed on the amount of housing they can provide (Deakin, 1991). By restricting new growth to previously urbanized areas, policies cause development expenses to increase, since urban land at the core is more valuable and thus makes the construction of new facilities more costly. The intensified use of inner city infrastructure results in higher repair and maintenance costs, as well as the need to upgrade existing services if their capacities are not large enough (Feldman, 1987).

1.2.4 Subdivision

The act of subdividing the land occurs when the land owner decides to develop a large parcel into a set of smaller serviced lots capable of supporting development. It is a process which for the most part involves the conversion of raw and previously undeveloped land to land that is suitable for urban use. Part of the reason why the subdivision process is so important is because it is often the only opportunity planners have to determine the layout of neighbourhoods, since areas are rarely re-subdivided. Regulation exists to ensure that it is done properly (Ducker, 1988).

The history of subdivision regulation goes all the way back to the early 20th century. A 1912 Ontario law stipulated that a plan of any proposed survey was to be submitted to the Ontario Railway and Municipal Board for approval. The reason for this was to prevent what was termed "urban blight" - the waste of land parcels which are unusable and remain vacant due to their shape, size, or isolation from transportation routes (Cullingworth, 1987). Lot sizes were also a concern to government for health reasons; the use of septic tanks placed a limit on the allowable density of development. During the depression, subdivision approval was required for financial reasons; foreclosures on developers and the decrease in taxes entering city coffers made it important to prevent a premature development (Cullingworth, 1987). Pressures on municipal services that were created by rapid growth after World War II caused the subdivision approvals process to fully emerge as a planning tool (Bossons, 1993). There were relatively few controls post-war, but a recognition of the problems which could result from uncontrolled land subdivision (Miron, 1988). Today, subdivision approval is the main form of land use regulation in new and developing urban areas (Bossons, 1993).

Clayton & Scanada (1989b) identify three stages in the life of subdivision control after the Second World War. From 1946 to the early '50s, most development was in the control of the municipalities, who owned large amounts of land in peripheral areas (much of it acquired through tax defaults during the 1930s). This land was used to expand communities during the post war boom. Sewers, streets, and water mains were built by the city, and city planners laid out the subdivisions themselves. The serviced lots were then sold to private builders who constructed the houses. From the early 1950s to the early '60s, municipalities began to withdraw from land development as their land banks were depleted. They were also unwilling to continue providing services due to the high expense, and unable to keep up with the demand for serviced land. The diminished land surplus meant that development was more costly in rapidly growing areas, and when coupled with an increase in the costs of administration, the result meant an increase in taxes to pay for the process. Land development became a less appealing venture for municipalities. A gap in the supply of and demand for municipally serviced land was formed, forcing builders to begin to buy and service their own land. This gave birth to the land development business. In some areas, where there were many small builders, companies would band together to pool their resources and assure a sufficient supply of land. From the 1960s onward, the involvement of the municipality and the province has increased through greater control of the process. The governments provide for a long review and approval process which requires the consultation of many agencies (40 on average; for various Ontario examples see Table 1.1).

TABLE 1.1
Agencies Involved in Draft Plan Review

- area municipality	- Ministry of Agriculture and Food
- neighbourhood section	- Ministry of Industry and Tourism
- Board of Education	- Ministry of Culture and Communications
- Separate School Board	- Ministry of Natural Resources
- traffic department	- Ministry of the Environment
- building department	- Ministry of Transportation
- regional planning office	- Ministry of Municipal Affairs
- regional health unit	- Canadian National Railway
- department of engineering	- Canadian Pacific Railway
- urban design section	- Trans Canada Pipeline
- regional economic development department	- Canada Mortgage & Housing Corporation
- municipal non-profit housing corporation	- Niagara Escarpment Commission
- abutting region or municipality	- Union Gas
- regional conservation authority	- Bell Canada
- hydro commission	- Canada Post Corporation

The provision of services is seen as the major component in the cost of land (Clayton & Scanada, 1989b). There are differences in the costs of providing services from place to place due to the variety of standards and practices. There are also differences in the cost effectiveness of services (Cullingworth, 1987). In the 1940s, the main services were water, gravel roads, drainage ditches and swales for storm runoff, and septic tanks for sewage. The 1950s saw the development of underground storm and sanitary sewers, and paved roads with curbs, sidewalks and gutters. But the quantity and quality of services is not uniform across the nation due to a lack of a national code, making servicing standards a local concern (Clayton & Scanada, 1989b). The timing of service delivery has also changed - from flexible timing after the war, to a more cost effective and efficient system as developers took over the servicing (eg. provision of the underground services and a gravel road first, then paving and sidewalks as construction finishes). It is now common to have all of the services in place before housing construction begins (Clayton & Scanada, 1989b). Furthermore, since the servicing is no longer a cost to the municipality, the local officials do not often adopt the most value- and cost-effective servicing standards. They may have obsolete or excessive servicing standards, the latter of which is termed "goldplating" (Cullingworth, 1987). The life of services is also a consideration: high quality services are longer lasting and more amenable to future improvement (Cullingworth, 1987).

The concept of having the developer pay for servicing may also bring up the idea that it raises house prices, since developers now have to recoup the amount they spend providing those services, but this is false. If municipalities pay, it can be conceived as a subsidy to the home buyers to alleviate their costs, but the developer will just incorporate the value of those services into the final price anyway, giving him a higher profit (Cullingworth, 1987). The costs of acquiring and servicing land does affect the industry however. Many house builders lack the financial resources to do so, and many see no need to be involved in those processes. The result is a specialized land development industry that operates first, followed by a sector which builds the homes (Clayton & Scanada, 1989b).

The resulting configuration of subdivision has also changed throughout the years. Clayton & Scanada (1989b) outline the history, beginning in the 1940s when the rectangular street pattern and the single detached dwelling were predominant. By the late '50s, subdivisions began to contain cul-de-sacs, interior blocks, curved streets, and loops and crescents. These innovations added to the aesthetic beauty of the neighbourhood, and also allowed an increase in density by allowing for variations in lot shape. By the late 1960s, the trend was toward larger lots with larger homes, due to buyer preference. After 1970 we see a shift to combined forms of housing, such as semi-detached and multiple unit homes, because they decreased servicing and energy costs in comparison to single family dwellings, and are also more suitable for smaller lots. This had somewhat of an influence on the rules of planning. For example, the introduction of the "zero lot line" allows homes to be built right on the property line (providing proper clearance is maintained between adjacent houses), allowing higher densities with narrower lots.

The changes outlined here reflect the desire to decrease the per-unit cost of housing by making better use of the land. Additionally, a good subdivision design can ensure good circulation of traffic, adequate locations for public facilities, and sufficient open space (Lynch & Hack, 1985). The road patterns should not be planned in isolation from surrounding developments - they must provide for future connections and conform to the general traffic circulation of the local area. Each lot must also have at least one good building location within it (Lynch & Hack, 1985).

The control of subdivision involves a complex set of rules. The Ontario Planning Act prohibits the act of subdividing unless land is "described in accordance with and is within a registered plan of subdivision". There is the provision for the creation of a small number of lots on consent in cases where a full plan is not necessary. The applicant must submit a plan showing the locations of roads, the lots and their intended uses, services, natural features, and existing uses of adjoining lands. The plan must also conform to local zoning by-laws, but there is no obligation for the government to approve the plan.

In reviewing a subdivision plan, the local government must give consideration to the health, safety, convenience and welfare of the future inhabitants. It must also consider whether the draft plan of subdivision fits in with the official plan, how it compares and works with respect to adjacent plans of subdivision, and whether the it is premature or even necessary in the public interest. Consideration must be given to the suitability of the land, the local road system, the division and shape of the lots, and the existing and proposed restrictions on the lands and structures within and adjacent to the proposed subdivision. There are also considerations with respect to the conservation of natural resources and flood control, the adequacy of local services and school sites, and the area to be dedicated for public use.

There is provision in Ontario for the imposition of conditions on plans, and the drafting of agreements which legally force developers to fulfil them. The minister may impose stipulations respecting the dedication of public lands for road widening and other purposes, as well as the provision of servicing. The owner must agree in writing to satisfy all of the requirements of the local municipality (Makuch, 1983). Subdivision control is thus, in essence, a form of discretionary development control (Cullingworth, 1987).

All of these requirements are meant to ensure development that works, but there are other advantages to them as well. The regulations aid in the creation and preservation of adequate land records, and make it easier to determine title. The insistence on "as built" drawings for services and utilities saves money later on when maintenance and upgrading are required. A properly conceived subdivision can save costs in the future (which may be caused by erosion, inadequate drainage, etc.) for which local governments will be expected to pay. The regulations also protect the dwelling purchasers, who are generally ignorant of servicing standards (Ducker, 1988).

There are other consequences of subdivision control. Miron (1988) sees one such impact in the sequencing of costs to homeowners. Before controls there was a tendency for service installation to occur after construction was complete. With regulation servicing is put in before or during construction. Thus costs are now passed to consumers in total when they purchase, rather than incrementally after a home has been bought.

Subdivision controls have also resulted in an increase in the time it takes to get a development proposal approved, as well as an increase in uncertainty regarding the length of that time (Bossons, 1993). In the early 1970s, the city of Mississauga averaged 2 years from the time of submission to the approval of a plan. This increased to over 3 years by the early 1980s (Miron, 1988). Increases in the number of agencies given the opportunity to review proposals is one reason; the fact that those agencies have input on a greater quantity of details regarding each proposal is another (Bossons, 1993).

1.3 The Development Industry

Planners may guide the growth of urban development, but it is primarily the developers who make the determination of what gets built. The planner may be able to place limits on what can and cannot be done, and perhaps offer suggestions concerning what is proposed, but it is the developer who makes the ultimate decision regarding what will or will not be produced. The reactive nature of the planning process ensures that the initiative remain with those who would construct the built environment (Peiser, 1990). For this reason, it is important to examine the development industry in detail.

There are five stages in the land development process. Initially, there is some pressure for land to be converted to urban use. At the second stage, this land is then taken into active consideration for development, determination is made whether it is feasible to develop it, and negotiations for its sale take place. Planning begins in stage three, as do the processes of acquiring financing and government approvals. The fourth stage involves physically preparing the site, and construction. Finally, the finished product is marketed to the consumer (Bourne, 1981). The entire process is very time consuming.

Decisions regarding the end product are made long before the actual demand for the finished housing is revealed (Schaeffer & Hopkins, 1987). The two most critical include the decision to purchase the land, and the decision to develop that land. They both involve considerable financial obligations, but the latter also includes negotiation and approval which make it a more substantial commitment. The development decision is also dependent on other conditions related to the economy, profitability, and the community (Bourne, 1981). Thus the space of time in between the two is variable.

At each stage in the process there is a certain amount of uncertainty. The first such uncertainty involves the capability of a parcel of land to support development. Since land is heterogeneous, the quality of it depends upon many factors such as location, zoning constraints, topography, soils, tax rates, and infrastructure. Once land is acquired, uncertainty regarding its physical characteristics is removed, but more is introduced during the approvals process. By the time final approval has been given, the only uncertainty remaining concerns the final demand for the finished dwellings (Schaeffer & Hopkins, 1987). All of this uncertainty translates into risk, and it is the fundamental role of the developer to accept this risk in order for the city to grow (Peiser, 1990).

1.3.1 Actors Involved in Land Development

According to Bourne (1981), the industry (at least up to the 1980s) tends to be fragmented without much vertical integration, composed of actors who specialize in particular aspects of development. This fragmentation is also geographical, as companies tend to operate in specific regions. The industry is largely financed on credit due to the large investments involved, thus there is financial interdependence among the companies involved. The erratic nature of the housing market causes a likewise variability in participants over time. Bourne states that these characteristics make it difficult for participants to realize economies of scale. They also make control of the system more difficult.

At the local level, housing production is controlled by only a few key agents: "Perhaps less than two dozen landowners, developers, and financial agencies determine what land gets developed, what housing is built, and where" (Bourne, 1981, p.113). While the overall system may be controlled by relatively few companies, the decisions they make affect thousands of others made by smaller firms, sub-contractors, and public agencies involved in construction.

The developer is the firm which secures the rights to the land and begins the process of developing it for urban use. There are actually two processes at work: land development, which involves evaluating the site, assembling land parcels, and preparing them for construction; and property development, which involves the actual construction of dwellings. Each process can be undertaken by separate companies, or by a single firm that operates as both land developer and builder (Bourne, 1981).

Information is a necessity for developers. Greater information concerning development interests is associated with less risk. This is important because incorrect decisions can be very costly given the nature of the industry output (Schaeffer & Hopkins, 1987). A lack of information, particularly concerning the approvals process, is more worrisome to a developer than any fees they may incur. They will tend to avoid situations where there is a greater possibility of delay in receiving approvals (Peiser, 1990). This must, as a consequence, make land that is less regulated more attractive for potential development.

Costs the developer must consider include those associated with production, such as labour, material, land, and capital. Developers must also pay for services. Additional expense is added by planning and management of the projects. The largest of them all are materials, labour, and land, the latter of which can range from 15 to 30% of the final cost of a single family home. Land is also the only one which can vary within an urban area, affecting both the type and price of housing produced in specific locales (Bourne, 1981).

The size of the subdivision a developer chooses to build is a function of many factors, such as land availability, financial backing, market demand, planning constraints, and the capabilities of the firm itself, but there are advantages noted by Peiser (1984) to keeping projects relatively small in scale. Larger developments cost more in terms of financing and management. They may be subject to greater government regulation and higher environmental standards. They also take longer to complete, which increases the likelihood that circumstances and regulations may change before the development is finished, resulting in a potential loss of investment.

Beyond the land developer and builder are several other agents who act to bring land through the development process. A speculator is a purchaser of land that is expected to be in demand in the future, and therefore also expected to rise in value. The speculator will then sell the land at a profit, once its value potential is realized. Economists consider them useful in the commodities market because their profit-seeking activity leads to a more even allocation of resources over space and time (Cullingworth, 1987). However, land is a special case because it is durable and immobile, new lots form only a small fraction of total supply, and land markets are slow to adjust to economic cycles (Cullingworth, 1987).

Speculators can be individuals or corporations. They have their largest impact on the periphery, leading to "leap-frog" development as builder/developers try to avoid land which is tied up in the hands of speculators (Pacione, 1990). Pacione also lists some of their impacts. On the positive side, the rental of land back to farmers maintains agriculture and is attractive to the farmer if the rent is not too high. Negative impacts include an increase in land value due to sales, which increases taxes levied on assessed values. The land can become subject to urban shadow effects such as pollution, vandalism, and trespassing. The farmers themselves may become speculators, causing disinvestment in their farm operations, the use of farming methods which quickly use up soil fertility, or idle farmland. Cullingworth (1987) points out that speculators rarely influence prices, and only do so when they have control of the market.

Bankers are an important part of the process because developers are dependent on them to finance their projects. It is believed that previously successful development concepts are easier to finance than new or innovative ones (Peiser, 1990). One has to wonder whether this is the reason most new housing developments, regardless of where in the country they have been built, appear essentially the same.

Real estate agents facilitate the sale of property, but are involved in several activities, including aiding in the assembly of land parcels, or even acting as speculators. The profession can be profitable during periods of high inflation. There have been cases where land transactions have occurred between holding companies with the same owner as a means of increasing the land value (Pacione, 1990).

Another actor in the development business is actually a marriage between a private developer and a public agency (such as a municipality). The resulting hybrid is called a *development corporation*, the creation of which has benefits for both of its constituents. The municipality can control the development process more closely because it is a part of the actual development. The municipality also benefits by gaining the developer's financing capabilities. The developer gains land which the municipality may hold, and greater assistance in the planning and development process (Leung, 1989). The result is a "highly integrated financial and production industry with the power to undertake massive and complex projects" (Perks & Jamieson, 1991). Mandates for development are usually very clear, and the integration of planning and development functions means that the process is more efficient. However, there are commercial risks involved, and there may be conflicts between public and private goals. The corporation could become so powerful that the municipality loses control, or it could try to exploit its success and perpetuate itself after its mandate has been fulfilled (Leung, 1989). Perks & Jamieson (1991) note that the arrangement forces planners to negotiate more, and learn skills in management, business, financing, and public administration in order to hold up their end of the agreement.

1.3.2 The Canadian Experience

According to Clayton and Scanada (1989a), the single family home building industry in Canada during the 1980s was dominated in number by small firms. According to 1984 data, 96% of firms had yearly revenues of less than $2 million, with two-thirds having revenues not exceeding $250 thousand. There were some 9000 firms in Canada; 48 having revenues above $10 million (representing 25% of the total industry revenue), while 293 had revenues of between $2 and 10 million. Although only 4% had revenues exceeding $2 million, they accounted for 51% of total industry revenue. Also, according to 1984 data, 81% of builders in the metropolitan areas constructed fewer than 10 homes per year. There also didn't seem to be any relationship between market size and industry structure, thus the percentages were more-or-less the same across Canada. This dominance of small firms (in number, not revenue) was viewed as desirable, because in the hands of only a few builders, the industry would be given to collusive pricing practices (Clayton & Scanada, 1989a).

The land development industry is limited by a complex set of factors, including topography, land ownership, municipal planning, servicing standards, taxation and financial requirements, and general public attitudes toward growth. There is also the market to consider, as well as the entrepreneurial talents of the individual developers. However, since the Second World War, most serviced land has been brought into the market by the private sector. After the war, many municipalities had available serviced land, and extra capacity in their servicing systems. These disappeared as residential development occurred. Rising costs and the need to expand services to meet demand forced municipalities to begin to deal with the pressure of growth. Some began to install services only at the developers' expense. Towns could discourage the building of small houses (meaning that fewer homes would be built), or discourage development in general. Others required that the developer make a contribution to the local school board (Bourne, 1981).

During the 1950s, there was a general shift to prepaid servicing, with payment coming out of the developers' pockets. Other municipal actions included the "front-ending" of costs of extending trunk services, and the imposition of lot levies. Since the burden of financing was now off of the shoulders of the municipalities, they began to demand increased levels of services. As a result, there was an increase in capital funds required by land developers to pay for the services. This factor, in addition to long approval processes and restrictions on the quantity and phasing of development, gives large developers an advantage over small ones in that they can more readily absorb the financial and institutional constraints. They can also withstand the cyclic variations in the market by shifting their resources to sectors which remain profitable (Bourne, 1981).

In some areas of the country small firms are still the norm. For example, in British Columbia, the expense and difficulty of assembling large tracts of land in Vancouver makes it less economical for large firms to operate (the small tracts stem from the small average farm sizes in the region). Edmonton, during the early '70s, provides an example of the opposite. Six large firms controlled 72% of the lots, and their prominence was a result of the shift to developer-pays servicing. In Toronto, a 1977 study indicated that six large firms controlled 40% of vacant land accessible to trunk services and within a commuting distance of 30-45 minutes. This was not viewed as being sufficient enough for monopolistic behaviour (Clayton & Scanada, 1989a). A 1976 study - the Spurr Report - also looked at land in the Toronto area and pointed out that the results of such studies depend on the amount of land included in the study. Spurr states that developers must hold more land than they can develop to minimize risk (Cullingworth, 1987). It is also pointed out that land ownership does not necessarily imply that development will occur (Clayton & Scanada, 1989a). Smaller companies have the advantage of being able to make decisions more quickly because fewer people are involved in the decision process. However, rising costs and more stringent planning controls could increase risk in the future, favouring large firms, and creating monopolistic situations (Cullingworth, 1987).

1.3.3 Development in the Hamilton Area

Doucet & Weaver (1991) discuss the history of the development process for the specific case of the Hamilton area. The process of subdivision approval was formalized there following the Second World War. Developers have since then been required to sign agreements detailing both the costs and nature of servicing. By the 1980s, 36 copies of the draft plan of subdivision were required to be submitted by the developer.

The majority of the local industry is controlled by corporate interests. Three quarters of all plans registered between 1976 and 1987 belonged to private firms, which included holding companies, development and construction companies, as well as numbered companies. Of the remainder, a fifth were submitted by public bodies, including the Ontario Housing Corporation and the Ontario Land Corporation.

The average size of post-war subdivisions has been rather small, at 55 lots. This is because the subdividers tend to be builders as well. They purchase parcels of land, which are then developed in stages dependent on the company's capacity to construct homes within the building season. As a result, the city has grown in a slow and steady "piecemeal" fashion through the addition of modest developments.

There has been a tendency for the city to be developed by Hamilton area companies. It is estimated that external private sector companies only account for 10 to 15% of local construction. The likely reason behind this is that while the area has grown in population, the rate of that growth has been too slow to attract large out-of-town builders. Doucet and Weaver feel that this could change if the Toronto market becomes too expensive. This may force buyers to search for homes in cheaper surrounding areas such as Hamilton.

Advertisements for homes that are currently for sale in new Hamilton area subdivisions can give some insight into the local industry at present. There are at least two-dozen builders that were active in recently completed developments. Several firms have houses for sale in more than one location, and three have built homes in three or four areas. In addition, there are listings for about 10 companies involved in smaller projects or custom homes. However, these numbers do not by any means imply that there is a lot of variety in terms of local housing market participants. Some of these builders could be branches of the same parent company; it would make sense to segment a firm that way to build homes that cater to varying price levels. It also says nothing about the land developers, who remain anonymous in the listings because the homes are what are being advertised, not the serviced lots.

While the subdivision data utilized in the following sections of this document cannot provide many details regarding the builders or developers, they show a continued emphasis through the 1980s and early '90s on subdivisions which contain relatively few units. The average size quoted by Doucet and Weaver is actually larger than the average for the time series of the data, which is 45 units. Average sizes tend to vary on a yearly basis though, and range from below 30 to almost 80 during the current and preceding decades.

1.4 Land Use Modelling

Given that the development process is very complex, with a multitude of actors and a score of regulations, it would seem that there is too much detail to be able to empirically model residential growth at a local level. How can it be possible to determine what factors are involved in what gets built and where, when each development is unique and subject to its own special set of circumstances?

Chinitz (1991) notes that public regulation of land may constrain the choices of those who wish to locate a new development, but it is not the sole determinant of land use patterns. The developer chooses where and what to build. Surely that developer must have more than one option available regarding location.

There has existed a tradition of modelling urban areas for at least the past several decades. The problem has been explored from many perspectives and to varying levels of detail. However, there is no single accepted method of analyzing urban growth. This is partly due to the complex nature cities - models of land use are out of necessity forced to examine a simplification of the mechanism in order for any kind of useful insight to be gained. An analysis that attempted to include every aspect of the development process would require vast quantities of data, force the analyst to peruse stacks of relevant and sometimes conflicting documents, and take literally years to perform. The logistics of it would be enormous.

While analyses of urban areas are relatively abundant, the specific problem of analyzing housing supply at the local level has been addressed rather poorly. Bramley (1993a) notes that there has been a general lack of attention to the supply side in housing research. The majority of location and transportation models are cross-sectional (Putman, 1986), and therefore fail to capture lagged effects which are important for development. Many analyses are incomplete because they have no consideration for physical property or the market process (D'Arcy & Keogh, 1997). There is also little attempt to build planning factors into models of the urban economy (Bramley, 1993b). These problems are not merely due to ignorance on the part of analysts however. Urban change is constrained by the existing built environment, and moderated through a land market system that can be very specific to each urban area (D'Arcy & Keogh, 1997). It is thus more difficult to make a general statement about urban growth when the factors affecting it can be unique to the individual city.

1.4.1 General Factors Affecting Development Location

The pace of urban growth follows the cyclic pattern of the macro-economy (Wegener *et al*, 1986). Change at a local level is however also a function of factors which are more location specific. Bourne (1981) states that the spatial pattern of housing is "a physical expression, overlain with local topographic and transport variations, of the age and economy of the city and the socio-political system in which that housing is produced and consumed" (p. 59). Housing is affected by policy regarding transportation, investment, industry and employment, the environment, and education (Bourne, 1981).

One of the most important attributes of the urban landscape is its permanence: established land use patterns tend to remain the same for very long periods. This is what justifies the huge investments in transportation and infrastructure to service the urban area. The layout of the city is also lasting because of property rights, which are likely to be fairly rigid over time in terms of the separation of public and private land. Buildings tend to have a very long life span, therefore the decision to locate them is irreversible once construction is under way. These factors underline the importance of making that decision a good one from the outset (Wegener *et al*, 1986).

The location decision of the developer has been described as a hierarchical evaluation. The initial step is an assessment of the entire urban area to determine general accessibility to jobs, amenities, and utilities, in addition to the nature of planning restrictions. Next is an evaluation of sub-areas of the city to determine their relative development potential, their available amenities and services, and the quality of developments that have already been built within them. The final step involves the selection of the actual site, and this is based on land availability, zoning, taxes, and ownership, as well as the land's physical characteristics. In the end, developers tend to favour sites that are accessible to employment and transportation, close to public services, reasonably priced, and that have appropriate zoning or restrictions that can be amended. They also prefer locations that are close to environmental amenities. The dominant factors change over time, and also depend on the area, the market, and the nature of the planning process which governs the region (Bourne, 1981).

Accessibility has traditionally been emphasized by urban models. The problem is that not all areas similar in relative accessibility can be developed during the same frame of time. This makes other local factors important once accessibility constraints of potential sites are met. In addition, as land use controls have become tighter over time, the influence of servicing and zoning has increased (Bourne, 1981).

Developers look to find locations that maximize their goals with a minimum of financial expenditure. This means site selection is constrained not only by public regulation, but by the budget of the firm as well. Another issue is whether the criteria used by the developer in deciding where to build are very different than those which govern the location decisions of the people who buy their product. Choice of residential location on the part of the consumer seems to be most influenced by household size, composition, the relation of its members to the labour market, and the age of the head of household (Chinitz, 1991).

One other thing to consider is the inertia inherent in the system. Subdivision applications take time to revise and complete; there is a lag between the initial decision to invest in a development and its construction. Urban models should take into account the forces which are responsible for this delay (Wegener *et al*, 1986).

1.4.2 Models of Urban Growth

Brief summaries of several studies are provided here. They have been divided into two main classifications: empirical models which use real-world data to explain variation in land use; and simulation models which may or may not utilize actual data to predict urban growth under certain conditions. A third section listing some other methods of modelling urban change is also provided.

1.4.2.1 Empirical Models

Weiss, Donnelly, and Kaiser (1966) used multiple regression to test the effects of up to 14 different variables on the amount of land in urban use in North Carolina. Their study region was divided into 3980 grid cells, each having an area of 23 acres. Independent variables such as accessibility to work areas, availability of city water and public sewerage, and dwelling density were found to have a positive relation to quantity of urban land. Distance to a major street, land not suitable for building, distance to an elementary school, and distance to shopping areas were found to have negative parameters. They comment that it would have been desirable to have variables relating to ownership characteristics and intentions for development.

Chapin and Weiss (1968) used a similar data set for the city of Greensboro, with the same dependent variables. They see development as a consequence of what are termed "priming actions" which are concerned with the placement and construction of major infrastructure, and "secondary" or "conditioning actions" which include location decisions of firms, institutions, and housing developers. Priming actions determine the location and intensity of the pattern of urban growth exhibited by the secondary actions. Variables labelled as priming included distance to the nearest major street and distance to the nearest elementary school (both with negative parameters), and availability of sewerage, zoning protection, and accessibility to work areas (positive). Positive conditioning factors included proximity to mixed uses, assessed value, and what was termed "residential amenity" (but not explained), while marginal land not in urban use, and distance to nearest shopping area were negative.

Pierce (1981) studied factors which account for variation in rates of land conversion among Canadian cities. He found that as cities get larger, their developed area tends to increase at a decreasing rate. Urban growth is apt to favour regions with higher quality agricultural land, and occurs over greater areas for cities that have economies based on extraction and transportation. He states that lags in the development process may be the reason for unexplained variation in his model.

McMillen (1989) used a logit model to predict whether land was in a given use at the time it was sold for a fringe area of Chicago. Three types of land use were considered: agricultural, residential, and vacant. Explanatory variables included the size of the property, distances from Chicago and other smaller towns, and characteristics of the area, which were defined as proportions of surrounding land in various uses such as residential, transportation, open space, and agricultural. Land was found to be more likely to be residential than agricultural at the time of sale for smaller lot sizes and smaller distances to a large town. It was more likely to be residential than vacant for areas with a low proportion of railroads, and greater proportions of surrounding residential area and transportation, communications, and utilities. He found that residential lots tended to be smaller in size than agricultural or vacant lots, and that railroads appeared to be a disamenity for residential use.

Bramley (1993b) attempted to evaluate the effect of urban policy changes on the number of housing completions for a sample of 90 British housing districts. The data set included a variable for the quantity of land with planning permission, which was found to have a positive effect on the average number of dwelling completions. Bramley noted that variables relating to land use quantities were difficult to measure, and that new construction tends to reflect conditions of one to two years previous. It was also commented that house builders will reduce their output to maintain an even workload if there is an expectation that little land will be released for development in the future.

1.4.2.2 Simulation Models

Although they tend to consider the supply side of housing development rather simplistically, simulation models have been included here because they have been a major focus of analysts. A proper simulation of urban change should account for factors important in determining where housing is built.

The Lowry model (outlined by Webber, 1984) was one of the first, and is perhaps the most famous. The city is represented by a set of zones. Growth of the city is determined by three sectors: "basic" employment (employment in export industries); a service sector (employment in residence oriented businesses); and households (consumers of services, employed in the basic and service sectors). Basic employment is taken as exogenous, and distributed among the zones at a given level; the model calculates the number of households required to fill those positions and the relative accessibility of each zone to the basic industries. Households are then allocated to zones based on accessibility and subject to constraints on household density in each zone. The number of service jobs required for those households is then computed, and retail employment distributed across zones in proportion to their accessibility to households, and subject to a minimum level of service employment per zone. However, more households are required to fill the positions in the service industry, so a new accessibility to jobs is calculated, and households are re-allocated to the zones. These new households also require retail services, thus retail employment is redistributed among the zones in relation to the accessibility to the new household distribution. Through an iterative process households and service jobs are adjusted until the pattern stabilizes. The result is a distribution of employment and population among a set of zones, based on the initial allocation of basic employment.

The main problem with this model is that it ignores some important features in the urban system. It includes no supply side for development (Berechman & Small, 1988). Behavioural principles of supply and demand are absent because the model contains no price variables (Anas, 1986). The model is also limited because it ignores both the physical infrastructure and social structure of the city (Webber, 1984). What it does illustrate, in an elementary manner, is the interdependence between employment and housing demand. It assumes, for simplicity, that housing will be automatically provided for all households assigned to a particular zone. Planning restrictions are accounted for in a rudimentary manner by the zonal density limits.

Harris (1968) attempted to model the probability that land would move between an undeveloped and developed state, using a semi-Markov process for data from Sacramento California. The study region was divided into subareas that represented units of land that could be developed in a single operation. The probabilities that the land would be developed were based on an index of population and employment, which was used as a relative measure of accessibility for each sub-area of the urban region. Using the model, predictions were made regarding when subareas would be developed between 1970 and the year 2000.

Anas (1984) developed a long-run general equilibrium model of the urban economy which contains sectors for housing, land development, and land. It is based on behavioural demand and supply functions expressed as multinomial logit models. There are a fixed number of firms in basic and service industries, as well as a fixed number of employed residents who make a choice of where to live relative to where they work. Urban space is divided into a number of zones, each of which is connected to a road network. Each zone has a quantity of land available for development, and there are functions detailing the profit gained by developing different types of buildings on that land. Each developer-landowner maximizes their profit per unit of land from development, which dictates what kind of buildings they construct. An increase in the rent for any type of building increases the supply of land devoted to that type, as developers seek to capitalize on the increased income from their rent.

A modern example of a simulation model is provided by Landis (1994), regarding the California Urban Futures Model. This model allocates development to individual sites based on their potential profitability if developed. The model is based upon two units of analysis: incorporated municipalities, and developable land units (DLUs). DLUs are undeveloped or underdeveloped parcels of land. They are constructed, using GIS, as the geometric intersections and unions of land areas that are defined by environmental, market, and policy attributes (including planned urban boundaries, service limitations, highway buffers, slope data, wetlands, agricultural land, and earthquake faults). The DLUs therefore represent the supply of land available for development. Profitability potential for the land units takes into account the development capacity of the land and the price of housing, from which are subtracted expenses associated with land purchase, construction, site improvement, servicing, fees, delay and holding and other costs. Demand is provided at five-year intervals by population projections for the cities and counties in the analysis. This demand is then allocated to DLUs in order of their profitability potential. Once the area of highest potential has been "filled" based on allowable densities, the next most profitable land unit is chosen and development is allocated to it. The process stops when either all of the projected population growth has been allocated, or when there is no more land available to accommodate it. Landis admits that the model could better incorporate accessibility measures. The model assumes that if a demand exists, it will automatically be filled, thus demand is driving supply. Yet, in attempting to account for all of the development costs and locational data, this model is more realistic than others in many ways.

1.4.2.3 Other Models

There are other ways of trying to describe land use and urban growth beyond the two mentioned above. Diamond and Wright (1989) propose that land use be allocated among a set of zones based upon maximization of a utility function for a developer. They are actually discussing the allocation of public facilities, but the same ideas could be applied to housing subdivisions. They state that it may not be possible to identify one single "best" location - it may be more appropriate to find the "noninferior" locations. Objectives to be met involve the minimization of costs to acquire and develop the land, while maximizing the suitability of the land for the intended purpose.

Batty, Longley, and Fotheringham (1989), and Batty (1991) advocate the use of fractals to model urban growth. The idea is that because cities grow in a contagious fashion, they can be modelled by a process called *diffusion-limited aggregation.* The way it works is as follows: picture a circular lattice with a single "seed" at its centre; "walkers" are released into the lattice, and move about randomly until they come into contact with the seed. They attach themselves, and a new walker is released into the lattice. Eventually, the addition of many walkers results in a dendritic pattern reminiscent of the transportation network of a city. This is an interesting idea, but at the moment a gross oversimplification of the process. It does not fully account for location-specific attributes of land. Development potential is solely a function of proximity to previous development.

Finally, many analysts such as Ganderton (1994) create models of land conversion that are descriptive in nature. Such models outline the development process in the form of a flow chart detailing the participants and decisions made at each stage. Gore and Nicholson (1991) believe that these types of models provide nothing more than a starting point for future research. They can also become very region specific; it would be difficult to develop a flow-type model containing great detail that could generalize for all urban areas. However, as an illustration of the process in a particular urban area they are probably a worthwhile exercise, especially prior to beginning any analysis of land-use change.

1.5 Conclusion

Wegener *et al* (1986) state that there are few models that incorporate many of the features of the urban growth process. The models that do typically combine sub-models to account for them. This brings up the issue of complexity: is it better to even try and model the entire development process all at once, or investigate each aspect on its own in greater detail. In 1973 Lee published a paper outlining what he termed the "7 sins of large scale models", berating the practice of urban modelling as trying to accomplish too much, with too little, too slowly, and at too great a cost in terms of theory and resources. A lot has changed since then, but the essence of his statements are still valid. As Muth (1985) points out, "Pure mathematics is far more interesting mathematically than economic or spatial phenomena. Therefore if we are to be more than second-rate mathematicians, it is the real world that should receive our primary attention." Current models of housing development are clearly lacking in that regard, though one could also argue that once basic theory and methodology are established and understood, other additions can be made to increase realism.

Bourne (1981) calls for further research into housing supply, including both the nature of the building industry and the factors which affect the location and time of land purchase and development. The catch is to be able to account for planning regulation and developer behaviour in a realistic manner.

The literature regarding residential development is definitely lacking in terms of empirical analysis of the activity at the sub-municipal level. Simulation models may provide this in the way they allocate housing to small regions of the city, but they are generally not comprehensive enough to account for both planning regulations and demographic data. Most models also do not examine housing the way the bulk of it is constructed - as subdivisions. They consider growth in an aggregate manner, when it does not occur that way in the real world. The issue is not often approached from the perspective of the individual developers and builders, who are ultimately responsible for initiating residential growth and constructing the dwellings of which it is comprised.

The following sections examine development in the Hamilton-Wentworth region, using a data set which contains information for each subdivision approved between 1980 and mid-1994. This data affords the opportunity to study residential growth at a level of detail not possible with aggregate dwelling counts. By using the subdivision as the basic unit of development, it is possible to gain insight into the factors affecting the decisions made by the land developers in a manner that more closely matches reality.

Chapter Two:
Data Summary

2.1 Introduction

The primary data set used for the analyses in this chapter and those that follow contains data detailing residential subdivisions registered between January of 1980 and June of 1994, for the Regional Municipality of Hamilton-Wentworth. It was provided by the regional planning department in the form of a spreadsheet which contained summary information for each subdivision plan. A hard copy map which plotted the location of each subdivision was obtained at the same time.

When a developer submits a draft plan of subdivision, a file with a unique identifier is created to hold the plan and any information collected regarding the specific details that amass as it goes through the review process. The plan is also assigned another unique value, the registration number, which serves as the reference for the subdivision plan. These numbers are assigned in sequence as development plans are submitted over time. During the time period for which data were obtained, the registration numbers range from 283 to 761 (the plans did actually begin with a registration numbered 1, but for reasons detailed later the early plan data were not obtained).

The information contained in the spreadsheet included, for each subdivision plan, the file number, the registration number, the municipality in which it is located, the name given to it by the developer, the type (residential or industrial; there were data for several industrial subdivisions which were irrelevant to this research and deleted), the date it was registered, and physical characteristics of it such as the number of dwellings by type (single detached homes, semi-detached dwellings, townhouse units, and apartments) and the area of the subdivision in hectares. That which were useful consisted of the registration number, the dwelling counts and areas, and the date of registration. Names for each subdivision did contain some information regarding the identities of the firms that registered the plans, but it was too deficient to be of any use.

The hard copy map was a 1:50,000 scale plot of Hamilton-Wentworth, upon which were drawn the polygons that represented each subdivision. Each polygon was identified with the registration number, allowing for reference to the summary data. The map was digitized, and the GIS package Arc/INFO used to create a coverage, or digital map, containing the subdivision polygons. Each one was assigned the registration number in the GIS database to allow the summary data to be attached. The end result was a database containing both spatially referenced data and a set of characteristics for each registered subdivision, which would allow for more complex multivariate and spatial analyses.

Out of the 457 subdivisions that were listed in the summary spreadsheet, only 18 were unmarked or not identifiable on the map, leaving a total of 439 in the spatial database. There were actually many more subdivision polygons in the original Arc/INFO coverage, because the map accounted for subdivisions that were registered as far back as the mid-1970s. However, due to the incomplete nature of some of the earlier subdivision file data, only the post-1980 figures were made available. There were a total of 267 pre-1980 polygons that were therefore not usable for any analysis.

There were other errors in the original data sets. In a couple of cases, two subdivisions in the summary sheet were assigned the same registration number, but because they were phases of the same development it was possible to combine them into single observations. There were also a few polygons which were given duplicate numbers, and some no number at all; where possible these were corrected through a process of elimination and careful examination of the data. There were also a number of records in the spreadsheet for which no polygon could be identified - these records were used for the descriptive analysis in this chapter because they did contain usable information, but they were left out of the spatial analysis. Errors that could not be resolved were deleted.

The only other problems noticeable in the data concerned the areas assigned to each subdivision in the summary data. There were many that were given area values that did not seem correct, or were missing entirely. It was decided to use the polygon areas generated by Arc/INFO in place of the regional data. This invariably introduces an element of digitization error into the data set, but since the polygons on the hard copy map were hand-drawn originally, there would have been slight errors to begin with. A comparison of the GIS-calculated areas with those from the initial data revealed that the vast majority were close anyway, and it was felt that it was more important to have relative polygon areas that were more reliable.

This chapter will provide a descriptive overview of the subdivision data. It begins with a detail of the spatial pattern of growth. The data are then broken down into several categories, and examined yearly in aggregate and by municipality. A brief comparison of development activity to local and macro-economic variables is also provided.

2.2 Spatial Description of Subdivision Growth

The use of GIS with this data allowed a rather unique opportunity to examine growth in a spatial fashion, at a level of detail not usually possible. Later chapters contain more sophisticated analyses of the spatial pattern of growth, but this section will provide a more general visual description of the city growth portrayed by the subdivision coverage. As will be further discussed later, it was possible to identify 3 main periods of activity, grouped by year, which represent intervals of slow growth (1980 to 1984; 112 subdivisions), rapid expansion (1985 to 1989; 228 subdivisions), and another with relatively low counts of subdivision plan approvals (1990 to mid-1994; 117 in total). Figure 2.1 depicts the entire set of polygons, which are shaded based on the interval of registration. Figure 2.2 has the same theme, but focuses on the urban area of the region to illuminate more of the detail at a larger scale. To accompany these maps, a written summary of year-to-year trends will be provided here.

1980: few subdivisions; two in the rural area of Flamborough; the rest are scattered widely around the urban area; Hamilton subdivisions are located north of what was then the proposed freeway.

1981: 3 rural subdivisions near Highway 6 in Flamborough; more development in Ancaster and Dundas; several along the freeway corridor in Hamilton; several in lower Stoney Creek, 2 on the mountain.

1982: 2 rural subdivisions in north Flamborough; a couple in Ancaster and Dundas; development in Stoney Creek along the lakefront; Hamilton subdivisions are near the expressway and Highway 20 below the escarpment.

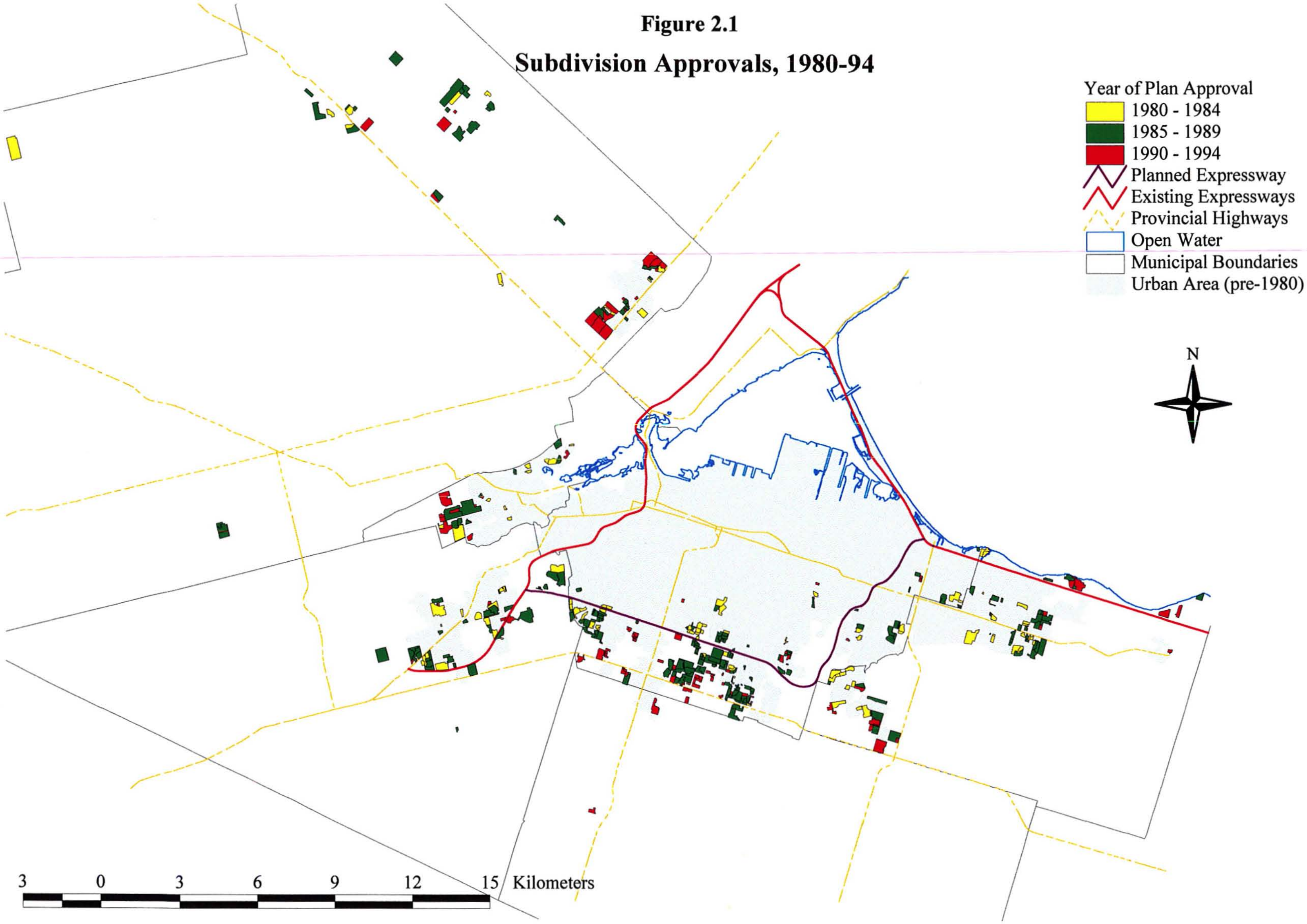
1983: no rural development; only 1 in Waterdown; 1 large subdivision in Dundas; 3 in Ancaster; several in Hamilton near the expressway; more development in lower Stoney Creek.

1984: several developments in Waterdown; 2 in Dundas; several along the expressway in the central part of upper Hamilton; 6 in upper Stoney Creek and 4 in the lower city; a few in Ancaster.

1985: more development in lower Stoney Creek; a few in Waterdown; a couple of developments in rural Flamborough; Ancaster and upper Hamilton have growth along highway corridors.

Figure 2.1

Subdivision Approvals, 1980-94



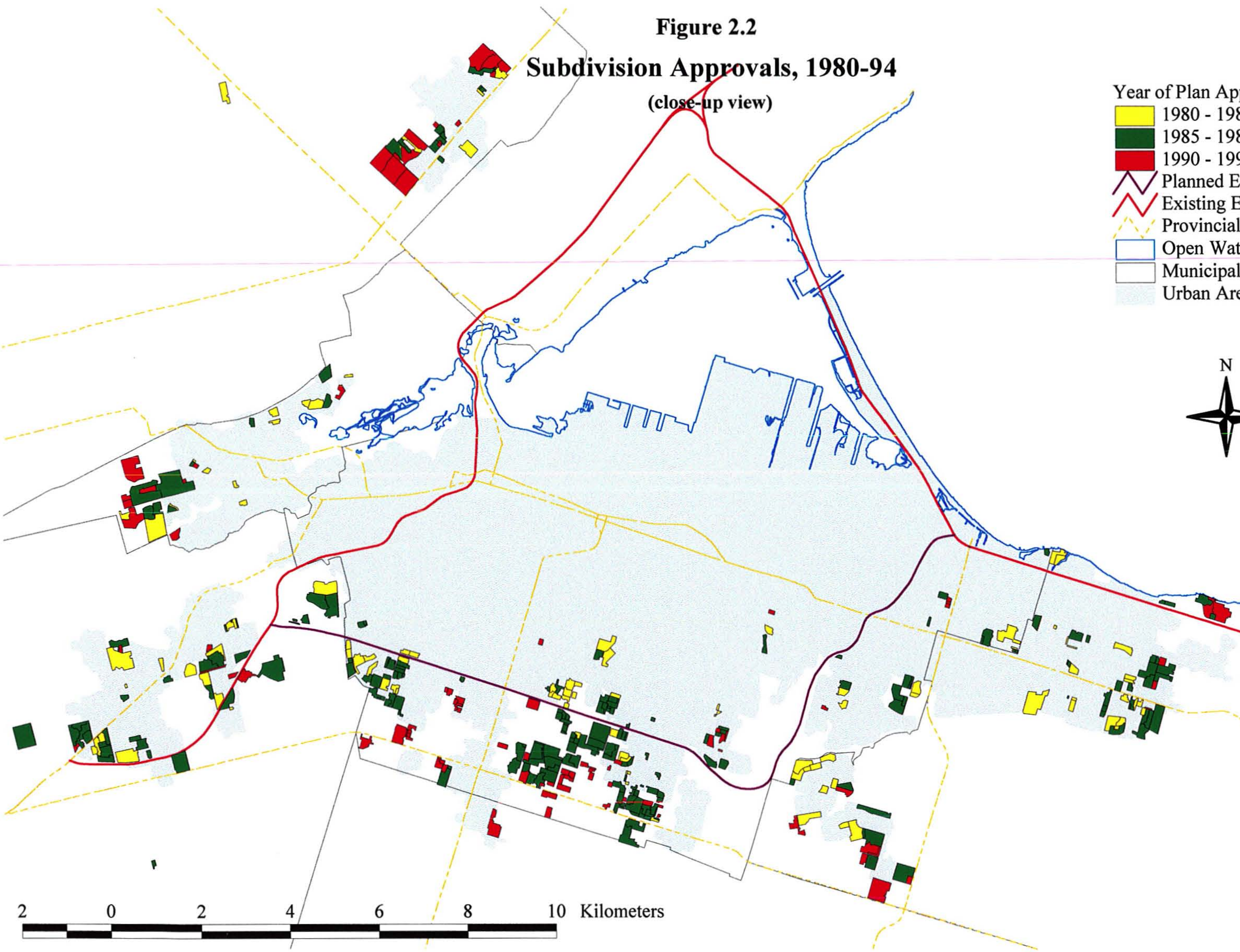


Figure 2.2
Subdivision Approvals, 1980-94
(close-up view)

1986: 2 waterfront developments in Stoney Creek; 3 in Carlisle, in north Flamborough; several in Ancaster near the 403, including one large one; Hamilton development is on the central and west mountain, and now located south of the freeway corridor.

1987: several developments in lower Stoney Creek, and 2 in upper; 7 in Carlisle and north Highway 6; there is a scattering across the mountain in Hamilton and Ancaster, with many south of the freeway; 2 in Dundas including one large one.

1988: 2 more developments along north Highway 6; 2 in Waterdown; many spread across the mountain, mainly south of the proposed freeway and near the 403 in Ancaster; 3 subdivisions in upper Stoney Creek, and several below the escarpment, with 2 on the lake.

1989: 1 in Carlisle; 2 in Waterdown; 3 in Dundas including one very large development; others scattered across the south-central mountain with a couple in upper Stoney Creek; several below the escarpment with 2 more on the lake.

1990: 2 large developments on Lake Ontario; 1 in Winona, in eastern Stoney Creek; 2 in Waterdown and another in Carlisle; a couple in Dundas (1 large); a few in Hamilton on the south mountain.

1991: a big drop in the number registered, with only a few in south Hamilton; 2 in Dundas, 1 in Ancaster, and 2 above the escarpment in Stoney Creek.

1992: 2 developments along Highway 6 north; 7 approvals in Waterdown, 1 in Dundas, and nothing in Ancaster; 2 small clusters on the south Hamilton mountain, with one further south in Mount Hope; 2 in upper Stoney Creek, and 3 in lower.

1993: 1 development near 50 Point on the lake; a very small group on the west mountain; 3 in Dundas, including 1 large one; 1 in Ancaster; 4 in Waterdown, 3 of them fairly big.

1994: 4 in south Hamilton, with 1 along Highway 6 north and another in lower Stoney Creek.

It is difficult to see any regional trends that hold for more than a short span of time. Hamilton has the most development overall, and most of it occurs in the southern portion of the city, but that is also where there was the most room to grow and the most land available to develop. Each succeeding subdivision approval is not necessarily located farther out from the city centre; there appears to be evidence that much land is left undeveloped closer to the existing urban area, and then filled in later. However the general progression in that part of the region is toward the south. Development in Ancaster, Dundas, and Flamborough (especially in the Waterdown area) occurs erratically, and there seems to be a tendency for subdivisions with larger areas to locate in those towns. Stoney Creek gets new subdivisions with more regularity than any other suburb, but the growth tends to happen either above the escarpment or below, and rarely both during a given year. Housing growth in the rural areas occurs in small numbers (aside from during 1987) without any noticeable regularity.

In total, these subdivisions added over 18 square kilometres of residential area to the region during the 1980s and early years of the 1990s. Those which were approved near the main urban areas totalled over 15 square kilometres alone. Given that the pre-1980 urban area created for later analysis covered around 135 km^2, this represents a growth of approximately 11% that can be attributed to residential subdivision development over the 14 year span of the data set.

2.3 General Trends in the Data

2.3.1 Number of Subdivision Registrations

Table 2.1 shows total registrations for each year by municipality. For the region, there is generally an increase in activity toward the late '80s, then a decline. The highest levels of approvals occur during the years 1985 to '89. A graphical representation of approvals is shown later in Figure 2.5.

Most of the municipalities tend to follow this trend. Hamilton dominates, capturing almost 50% of all subdivision activity during the time series. This holds true for most years. Ancaster has most of its development in the late 1980s. Dundas has a fairly steady rate of normally 2 or 3 registrations per year. Flamborough has a very distinct peak of 11 subdivisions in 1987, with another jump of 8 in 1992. Stoney Creek seems to exhibit stronger trends that start earlier in the decade, with a peak in 1984, and high levels to 1989. There were only two registrations for Glanbrook (1991 and 1992); it was left out of the table.

The effect of the escarpment divides both Hamilton and Stoney Creek. In the case of Hamilton, the urban area in the lower city is older, and any subdivisions registered there are usually infill in established neighbourhoods. It has relatively fewer subdivisions than most other municipalities, with most approved between 1985 and 1990. The upper city, or "mountain" as it is locally called, contains most of the registry activity, mainly because it had the most land available for development over the time period. Stoney Creek is somewhat different in that it has much developable land both above and below the escarpment. The upper city has been constrained by limitations in the transportation network; the regional government chose to limit development there until the completion of the Red Hill Expressway. The town therefore has twice as much growth below the mountain, which occurred at a fairly constant rate throughout the 1980s. Upper Stoney Creek has had its steadiest activity after 1986.

TABLE 2.1
Subdivision Registrations, by Municipality

year	Ancaster	Dundas	Flamborough	Stoney Creek total (low/up)	Hamilton total (low/up)	Region total
1980	1	2	3	1 (1/0)	6 (1/5)	**13**
1981	4	3	3	6 (4/2)	9 (1/8)	**25**
1982	2	2	3	3 (3/0)	4 (1/3)	**14**
1983	4	2	1	9 (6/3)	9 (2/7)	**25**
1984	5	3	3	11 (5/6)	13 (2/11)	**35**
1985	7	1	5	7 (7/0)	22 (3/19)	**42**
1986	5	1	4	5 (5/0)	24 (3/21)	**39**
1987	6	3	11	7 (5/2)	27 (4/23)	**54**
1988	7	1	5	8 (5/3)	23 (2/21)	**44**
1989	5	3	4	8 (6/2)	29 (4/25)	**49**
1990	4	2	5	5 (4/1)	18 (2/16)	**34**
1991	1	2	0	2 (0/2)	8 (1/7)	**14**
1992	0	1	8	5 (2/3)	14 (1/13)	**29**
1993	1	4	4	4 (1/3)	17 (1/16)	**30**
Totals	**52**	**30**	**59**	**81 (54/27)**	**223 (28/195)**	**447**

Note: there were 2 subdivision approvals in Glanbrook (1991, 1992).

2.3.2 Total Units in Approved Subdivisions

To only look at registrations ignores any trends related to the size of the subdivisions that were being approved. Unit totals are useful in this regard. Table 2.2 shows yearly totals for the region. The temporal pattern is similar for total units to the one that was shown by subdivision registrations. Most dwellings tend to be of the single family detached type, but there has been a general increase in multiple unit homes starting in 1989. There seems to be a long term trend toward larger subdivisions, as the average units per development increases. The maximum size of subdivision approved also seems to get bigger over time. However, these trends could be the result of a few large developments skewing the averages, for example the several that contain apartment complexes that were approved in 1989 and the 1990s.

TABLE 2.2
Unit Summary by Year, Hamilton-Wentworth

year	single family	multiple units	apart-ments	total	max units	avg units per subdivision
1980	618	172	132	922	217	70.92
1981	669	164	0	833	143	33.32
1982	323	50	0	373	54	26.64
1983	704	193	0	897	139	35.88
1984	1107	112	0	1219	114	34.83
1985	1658	113	0	1771	194	42.17
1986	1010	36	127	1173	179	30.08
1987	2429	108	0	2537	234	46.98
1988	1714	0	0	1714	163	38.95
1989	2201	628	216	3045	343	62.14
1990	732	460	420	1612	300	47.41
1991	475	241	0	716	139	51.14
1992	1105	674	160	1939	402	66.86
1993	1466	621	259	2346	335	78.20

Table 2.3 looks at frequency counts for various sizes of subdivision and how they change over the time series in the region, to help illustrate whether there is actually a trend toward larger subdivisions. There appears to be a higher frequency of large subdivisions later in the time series, but it is difficult to state whether this is really a trend because the number of units approved is not steady over time. The jump in frequency of the over-200 unit subdivisions may be an aberration. A data set that covered a longer period would be required to detect any long term increase. Other than this, most developments are in the 11 to 20 unit range, a trend which holds for all years. There are relatively few developments with more than 20 units overall, but the years 1985 to 1989 seem to have more. The frequency count does not drop off as dramatically for that period in comparison to the others. The category of 10 units and under also has high counts, so it is clear that small subdivisions are approved with greater regularity than large.

TABLE 2.3
Frequency of Units per Subdivision, Hamilton-Wentworth

range (units)	1980-84	1985-89	1990-93	*1980-93*
< 10	19	38	14	*71*
11 - 20	24	53	31	*108*
21 - 30	20	30	15	*65*
31 - 40	16	20	7	*43*
41 - 50	10	20	6	*36*
51 - 75	11	27	6	*44*
76 - 100	4	16	7	*27*
101 - 150	5	15	10	*30*
151 - 200	2	5	3	*10*
201 - 500	1	4	8	*13*

The municipal counts shown in Table 2.4 show that most units were approved in Hamilton, specifically in the upper city. There tend to be more multiple unit dwellings in Hamilton and Stoney Creek - the latter of which has the most of any municipality in the region. Those in Hamilton are almost exclusively above the escarpment, while Stoney Creek's are divided more evenly. The only developments containing apartments are also in those two cities. The average units are highest in upper Stoney Creek, and lowest in Hamilton (the lower city in particular), with the other area suburbs lying somewhere between. Hamilton, Stoney Creek, and Dundas were the only municipalities with subdivisions over 300 units in size.

Table 2.5 has frequency counts for the municipalities. Ancaster, Dundas, and Flamborough have most of their subdivisions in the under-20 unit range. There is more dispersion for Stoney Creek than the other suburbs. Hamilton has higher frequencies of larger (51 to 100 unit) subdivisions, but most are still under 20 units in size. Upper Hamilton has the most dispersion across frequency ranges of all. The lower city tends to have developments of under 30 units. Lower and upper Stoney Creek share the same pattern as the Hamilton areas, with a jump for the lower city in the 51 to 75 range, and have the most very large housing developments.

TABLE 2.4
Unit Summary, by Municipality

municipality	single family	multiple units	apart-ments	total	max units	avg units per subdivision
Ancaster	2292	84	0	2376	270	45.69
Dundas	1251	319	0	1570	343	52.33
Flamborough	2139	561	0	2700	286	45.76
Glanbrook	119	8	0	127	105	63.50
Stoney Creek	3066	1429	580	5075	402	62.65
- lower	1677	746	250	2673	250	49.50
- upper	1389	683	330	2402	402	88.96
Hamilton	7344	1171	734	9249	330	41.48
- lower	818	64	0	882	104	31.50
- upper	6526	1107	734	8367	330	42.91

TABLE 2.5
Frequency of Units per Subdivision, by Municipality

range				Stoney Creek			Hamilton			Region
(units)	Anc	Dund	Flam	*total*	*lower*	*upper*	*total*	*lower*	*upper*	Total
< 10	9	8	15	8	7	1	31	7	24	*71*
11 - 20	12	7	12	16	11	5	61	6	55	*108*
21 - 30	6	2	9	8	7	1	39	6	33	*65*
31 - 40	6	1	7	10	5	5	19	1	18	*43*
41 - 50	4	4	2	7	4	3	19	2	17	*36*
51 - 75	5	2	4	12	10	2	21	4	17	*44*
76 - 100	3	3	2	6	2	4	13	1	12	*27*
101 - 150	5	0	4	7	6	1	13	1	12	*30*
151 - 200	1	1	2	2	0	2	4	0	4	*10*
201 - 500	1	2	2	5	2	3	3	0	3	*13*

Note: Glanbrook's 2 subdivisions contained 105 and 22 units.

2.3.3 Area of Approved Subdivisions

Table 2.6 shows area statistics for the region. Matching the higher approval rates for subdivisions in the late 1980s is an increase in the total area contained within them. In terms of average area per development, there doesn't seem to a very clear trend over time. The 1980 average is considerably higher than the other years, owing to the effect of a couple of large subdivisions in Ancaster and Flamborough on the relatively small number approved. Maximum area does not seem to have any temporal pattern.

TABLE 2.6
Subdivision Area, Hamilton-Wentworth

year	area (ha)	avg area	max area
1980	93.14	7.16	33.48
1981	75.51	3.02	13.04
1982	50.12	3.58	9.53
1983	103.30	4.13	20.78
1984	108.32	3.09	14.32
1985	164.17	3.91	17.77
1986	107.38	2.75	21.33
1987	294.65	5.46	34.25
1988	174.55	3.97	16.06
1989	227.85	4.65	23.00
1990	84.35	2.48	13.13
1991	49.14	3.51	10.35
1992	130.20	4.49	18.35
1993	144.16	4.81	19.76

In terms of frequency, shown on Table 2.7, most subdivisions are under 5 hectares in size, with a peak in the 1.01 to 2.5 hectare range. This pattern tends to be fairly stable over time, but there is more dispersion in terms of areas for the under 10 hectare ranges during the middle period. It is also interesting to note that no observations fall in the 25.01 to 30 hectare range.

TABLE 2.7
Frequency of Subdivision Area, Hamilton-Wentworth

range (hectares)	1980-84	1985-89	1990-93	*1980-93*
< 1	18	43	30	*91*
1.01 - 2.5	40	67	37	*144*
2.51 - 5	29	54	16	*99*
5.01 - 10	17	45	12	*74*
10.01 - 15	4	12	6	*22*
15.01 - 20	1	2	6	*9*
20.01 - 25	2	3	0	*5*
25.01 - 30	0	0	0	*0*
30.01 - 35	1	2	0	*3*

Table 2.8 summarizes frequency and area data by municipality. Hamilton had the greatest total area in approved subdivisions, with Flamborough and Stoney Creek second and third. Upper Hamilton also has more on its own than any of the suburbs. Flamborough has the greatest average area of subdivision, and also the largest maximum area. Upper Hamilton may have the most subdivision activity, but its developments tend to be the smallest in the region in terms of area. Ancaster, Dundas, and upper Stoney Creek are very similar in terms of the average area of subdivisions that were approved there.

In terms of the frequency data, Hamilton tends to have relatively more subdivisions of less than 1 hectare in area than its suburbs, which would explain the low average area it exhibits. Most developments tend to fall in the 1.01 to 2.5 hectare range for most municipalities, and there is a big drop in frequency beyond 10 hectares. Flamborough has relatively more that fall in the higher area ranges than the other municipalities, and most of its developments fall in the 5.01 to 10 hectare category. It has more dispersion across frequency ranges as well.

TABLE 2.8
Subdivision Area, by Municipality

range				Stoney Creek			Hamilton			Region
(hectares)	Anc	Dund	Flam	*total*	*lower*	*upper*	*total*	*lower*	*upper*	Total
< 1	7	4	4	10	8	2	66	9	57	*91*
1.01 - 2.5	14	10	15	25	18	7	80	7	73	*144*
2.51 - 5	12	8	11	18	11	7	49	8	41	*99*
5.01 - 10	11	3	16	20	14	6	24	3	21	*74*
10.01 - 15	5	1	5	6	2	4	4	1	3	*22*
15.01 - 20	0	1	6	2	1	1	0	0	0	*9*
20.01 - 25	3	2	0	0	0	0	0	0	0	*5*
25.01 - 30	0	0	0	0	0	0	0	0	0	*0*
30.01 - 35	0	1	2	0	0	0	0	0	0	*3*
total area	277.0	176.6	422.3	361.8	208.9	152.9	555.0	75.5	479.5	*1806.8*
max area	21.50	31.80	34.25	18.78	18.78	18.35	14.79	11.31	14.79	*34.25*
avg area	5.33	5.89	7.16	4.47	3.87	5.66	2.49	2.70	2.46	*4.04*

Note: Glanbrook's 2 subdivisions were 10.35 and 3.72 ha in area.

2.3.4 Subdivision Density

Figure 2.3 illustrates density of development by year for the region. It seems to indicate a long-term increase in densities over time. Since this could be partly a function of the numbers of apartment units included in some of the subdivisions, and particularly those late in the time series, Figure 2.4 was included to graph density when calculated with apartments left out. It too shows a general trend toward higher densities. This tendency is also affected by the greater numbers of multiple-unit dwellings (which include duplexes and townhouses) that many subdivisions include during the latter part of the time series. Whether this is going to remain typical of future growth will ultimately determine whether the density trend is long-term.

Figure 2.3

Average Subdivision Density

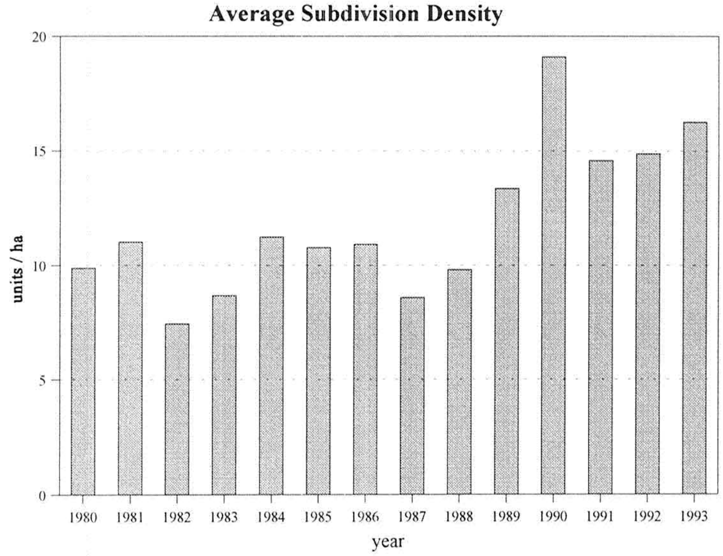


Figure 2.4

Average Subdivision Density Excluding Apartments

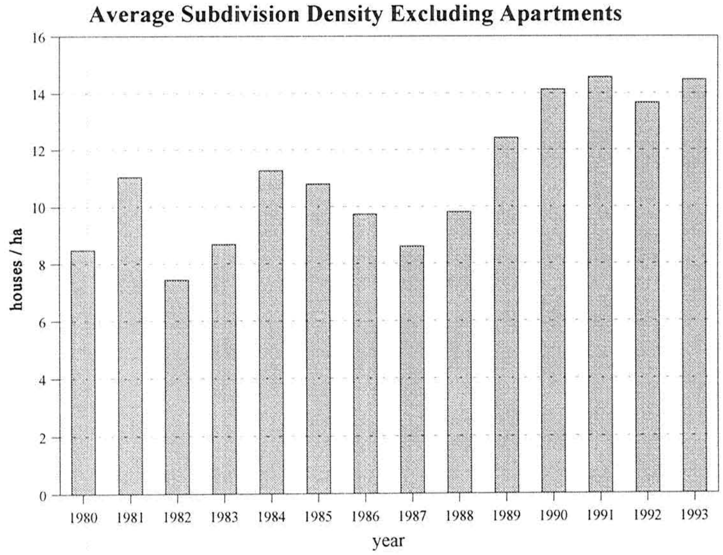


Table 2.9 shows frequency counts for the region. Most subdivisions tend to fall in the 10.01 to 15 unit per hectare range, but later in the time series there is a tendency for greater counts of higher density subdivisions, with fewer in the lowest ranges, matching the trend illustrated by the previous graphs.

TABLE 2.9

Frequency of Subdivision Density, Hamilton-Wentworth

range (units/ha)	**1980-84**	**1985-89**	**1990-93**	***1980-93***
< 5	11	28	5	*44*
5.01 - 10	28	50	11	*89*
10.01 - 15	36	76	34	*146*
15.01 - 20	24	57	25	*106*
20.01 - 25	5	9	13	*27*
25.01 - 30	4	1	10	*15*
30.01 - 40	2	4	5	*11*
40.01 - 50	2	2	1	*5*
50.01 - 100	0	1	3	*4*

Table 2.10 illustrates municipal variation in density. Hamilton and Stoney Creek tend to have the highest average densities. Upper Hamilton is particularly high, and much higher than the lower city. Stoney Creek also has higher average subdivision density above the escarpment. Ancaster and Dundas are fairly similar, and Flamborough exhibits the lowest average density of all.

In terms of municipal frequencies, Flamborough has its peak at less than 5 units per hectare, and Ancaster in the 5.01 to 10 category. Most Dundas subdivisions have densities between 5.01 and 15 units per hectare. Stoney Creek has relatively more between 10.01 and 15, and Hamilton's distribution is greatest between 10.01 and 20. Lower Hamilton seems to have relatively fewer high density subdivisions than the area above the escarpment.

TABLE 2.10
Subdivision Density, by Municipality

range				Stoney Creek			Hamilton			Region
(units/ha)	Anc	Dund	Flam	*total*	*lower*	*upper*	*total*	*lower*	*upper*	Total
< 5	5	4	29	3	2	1	3	2	1	*44*
5.01 - 10	31	12	10	17	12	5	18	7	11	*89*
10.01 - 15	12	11	11	36	23	13	75	9	66	*146*
15.01 - 20	4	2	5	15	12	3	80	5	75	*106*
20.01 - 25	0	0	2	2	0	2	23	2	21	*27*
25.01 - 30	0	1	1	2	1	1	11	3	8	*15*
30.01 - 40	0	0	1	5	4	1	5	0	5	*11*
40.01 - 50	0	0	0	0	0	0	5	0	5	*5*
50.01 - 100	0	0	0	1	0	1	3	0	3	*4*
avg density	8.58	8.89	6.39	14.03	12.80	15.71	16.67	11.68	17.45	*11.68*

Note: the densities of the 2 Glanbrook subdivisions were 10.14 and 5.92 units/ha.

2.4 Comparison to Economic Trends

Now that the general patterns of subdivision activity have been established, they can be related to other economic factors. Figures 2.5 and 2.6 show an obvious trend in regional subdivision registrations and the units within them, increasing to a peak during the period of 1987 to 1989, followed by a substantial drop and then another rise in 1992. Figures 2.7 and 2.8 show very similar trends at the provincial level for housing starts and investment in new housing. Figure 2.9 depicts gross domestic product for Ontario, and shows a steady increase between 1982 and 1989, followed by a dip that seems to level off. This fall in GDP coincides with the large drops in housing starts and provincial investment, and represents the recession that the nation went through which lasted into the mid-1990s. Figure 2.10 shows local employment levels, which also drop during the recession, and unemployment which increases following 1989 after years of decline. House prices in Figure 2.11 follow much the same pattern as provincial GDP.

Mortgage rates are another important factor which generally govern housing production. The trend shown in Figure 2.12 is more difficult to relate to the graphs of housing output or subdivision registration, because mortgage rates tend to decline overall. There is a slight jump in the late 1980s as the recession began, but they then decline again. They are lowest during the period of high local activity, but then even lower during the early '90s. It is more difficult to relate this to what happened during this decade because the time series ends too soon.

While it is difficult to state that there is a causal relationship between the economic factors and housing production based on these graphs, the trends within all of the indicators are very similar, which implies a general association between them. The growth in the provincial economy is reflected in housing investment and output. Local housing development matches the pattern of that at the provincial level, indicating that it may be a function of the same economic fluctuations, which are also evidenced at the local level through employment trends. It is more difficult to generalize about house prices, but they tend to be higher during periods of greater activity in the housing market, which would also be influenced by the economy.

2.5 Conclusion

This section provided an overview of the development scene in Hamilton-Wentworth during the 1980s and early '90s. The final section regarding the influence of economic trends is interesting, but of little value in terms of drawing any statistical conclusions from the relationships presented. With only 13 full years of data, there are not enough observations to perform a more involved analysis, such as a multiple regression, and be able to draw statistically significant conclusions. It would make sense to alleviate this problem by aggregating the data in monthly or quarterly periods, but information regarding the relevant economic indicators is often not available at that level (especially for local factors). Even if it were possible to build a complete set of independent variables, the subdivision data tend to be fragmented if examined using too small a time interval, making statistical inference more difficult. This time series included a period of rapid growth sandwiched between two recessions, and based on the graphs it is fairly evident that there must have been economic forces at work to some degree which influenced development in the Hamilton area.

Figure 2.5

Subdivision Registrations, Hamilton-Wentworth

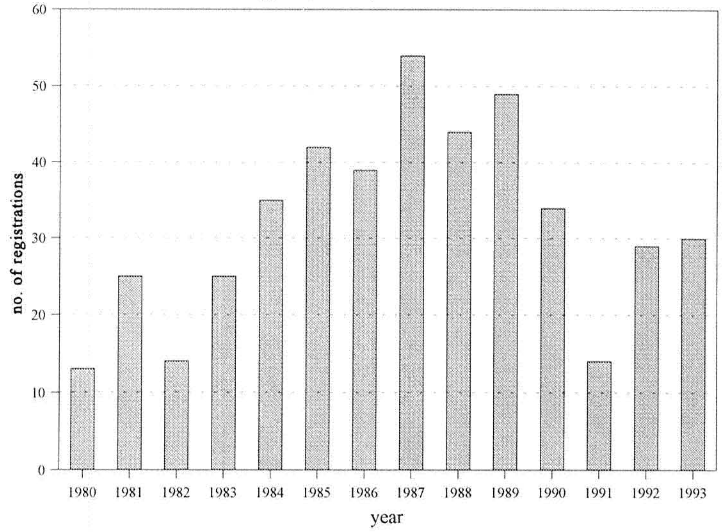
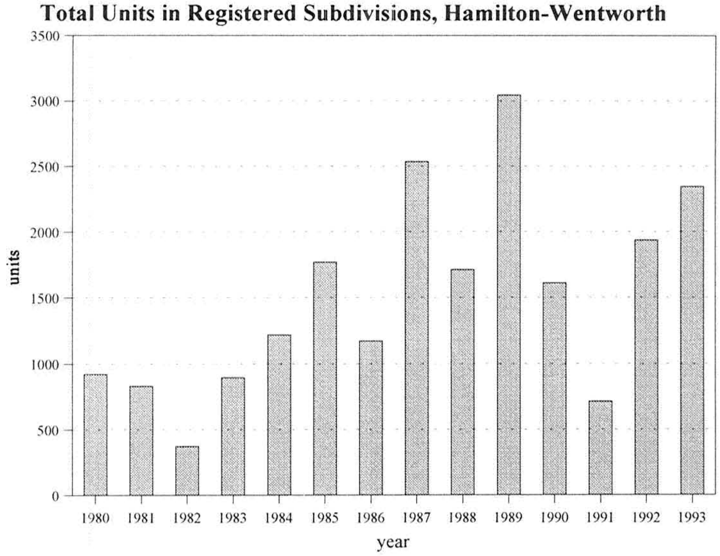


Figure 2.6

Total Units in Registered Subdivisions, Hamilton-Wentworth



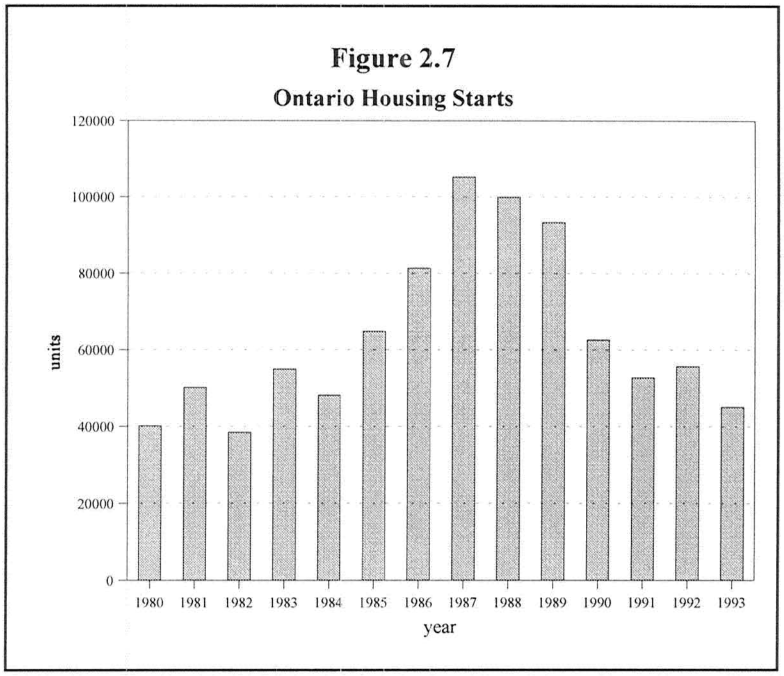


Figure 2.7
Ontario Housing Starts
units
120000
100000
80000
60000
40000
20000
0
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
year

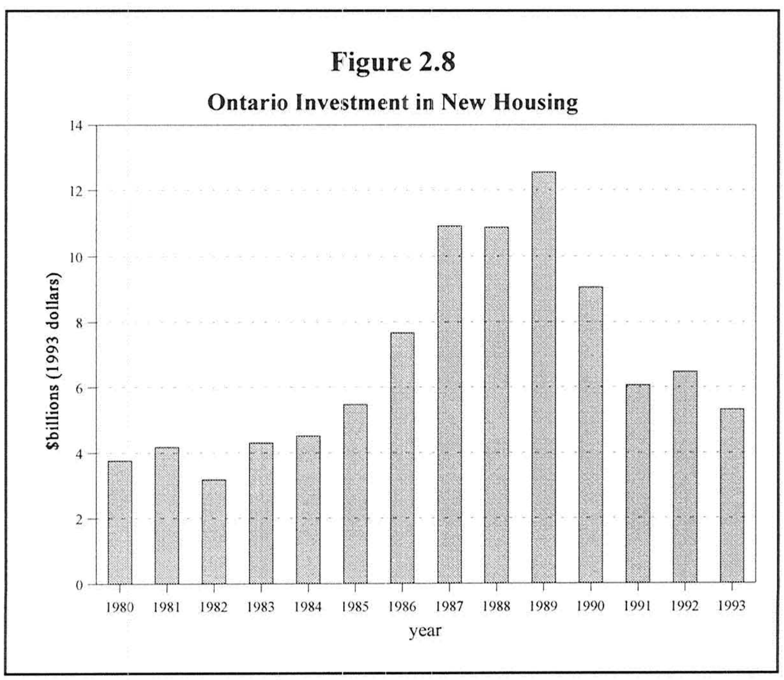


Figure 2.8
Ontario Investment in New Housing
$billions (1993 dollars)
14
12
10
8
6
4
2
0
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
year

Figure 2.9
Ontario GDP

Figure 2.10
Employment, Hamilton CMA

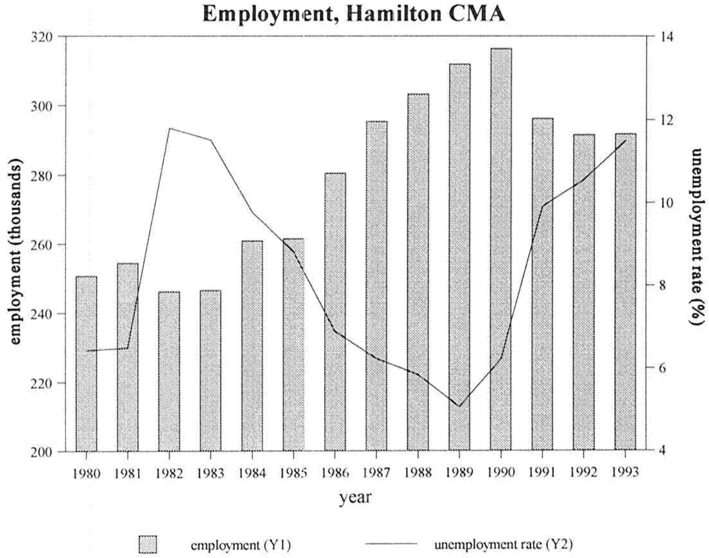


Figure 2.11

Average MLS House Prices, Hamilton CMA

Figure 2.12

Average 5-Year Mortgage Rate

Chapter Three:
Subdivision Density

3.1 Introduction

The physical planning of land involves the application of criteria which stipulate the specific characteristics of a development. These criteria are broken down into the measurable and non-measurable (Shirvani, 1985). Non-measurable criteria include concepts such as livability and aesthetics, convenience, variety, and compatibility. These things cannot be physically quantified; they exist in plans as vague notions which are desirable, but the subjective nature of their evaluation limits their inclusion in policy. Measurable criteria most often involve the environment and the buildings to be constructed. One of the most common measurements required of and used by planners is density.

This section will provide an overview of density as it relates to housing development. To illustrate whether it is possible to model the concept at a very small urban scale, an empirical analysis of subdivision densities will be presented. The aim is to determine which factors of the urban area can be used to explain variation in density.

3.2 Concepts of Density

3.2.1 The Measurement of Density

The most basic definition of density is a quantity per unit of area. With respect to housing, density can be measured in terms of dwellings per hectare. However, depending upon how one takes account of that land area, there are several ways in which density can be calculated. *Net density* is the most precise, and is calculated by dividing the total number of units within a structure by the area of all of the land assigned to it. For detached housing, this is a simple calculation. It excludes private areas, parking, and open spaces. *Project density* uses a land base that includes all of the land to be developed as a single project, and may include areas of common use with adjacent projects. *Neighbourhood density* includes the area occupied by housing as well as local support facilities such as streets and parks. It takes into account both public and private land. *Overall density* is used in larger planning studies, and lumps together land for commercial and employment oriented use as well as residential and undeveloped land. Other measures of density can involve using, for example, population, the number of habitable rooms per dwelling, or children per hectare. Another gauge, the *floor-area-ratio* (FAR), is the ratio of the total usable floor space of all buildings to the total site area. It is also known as a plot ratio or floor-space index (Lynch & Hack, 1985).

Density is not a rigid element - it can be changed by designers or constricted to specific levels depending on the particular site in question. It is mainly dependent on three things: how residents plan to store their automobiles, and how many they have; the amount of private and common space to be provided in a development; and the privacy distances to be maintained between dwellings. Table 3.1 presents typical densities, based on U.S. housing development, which are common to each residential type.

TABLE 3.1
Densities by Residential Type

		density of families per hectare	
housing type	**FAR**	**net**	**neighbourhood**
single family	< 0.2	up to 20	up to 12
zero lot line detached	0.3	20-25	15
2 family detached	0.3	25-30	18
row houses	0.5	40-60	30
stacked townhouses	0.8	60-100	45
3 story walk-up apartments	1.0	100-115	50
6 story walk-up apartments	1.4	160-190	75
13 story elevator apartments	1.8	215-240	100

source: Lynch, K. & Hack, G. (1985). *Site Planning*. Cambridge, MA: MIT Press, p253.

3.2.2 The Determination of Development Densities

Given that dwelling counts and lot sizes are predetermined in the subdivision design, what factors are used as the basis for deciding on a particular density? Are the developers free to choose whatever density they wish, or are there guidelines which they follow?

In classical urban equilibrium theory, density is essentially a function of demand for land. The basic argument (following the work of Alonso, Muth, and others), is that competition for land within the city results in a continuum of rents ranging from high at the core to low at the periphery. Assuming that every individual living in the city has the same level of income, those at the core are thus able to buy less land than those near the edge. Periphery residents trade off low land prices for higher costs to travel to the city centre. At equilibrium, this distribution of land rents and consumption is such that urban utility, the benefit derived from living in the city, is the same at all distances from the centre for each resident. Since high rents mean that more people occupy a unit of land in the central city than on the fringes, densities are higher there. The decline in density over distance occurs at a continuous and decreasing rate - this is termed the *density gradient*.

In reality, this theoretical pattern is only generally observable. Most cities have high density urban development in their downtown areas, usually in the form of an office complex surrounded by high-rise dwellings. The pattern is however variable throughout urban regions. Suburbs usually contain large tracts of single detached homes, but there can be pockets of higher density structures interspersed throughout. The pattern is also influenced by the location of other types of land use, the age of each neighbourhood, and the transportation network that threads together the fabric of the city. The resulting configuration is best described as sectoral; densities may not vary that much within a given parcel of land, but neighbouring tracts may differ greatly from one another.

Probably the greatest direct influence on density in the modern city is planning policy. Zoning bylaws generally restrict densities at the neighbourhood level, either by explicitly placing limits on the number of structures per unit of land, or by stipulating the widths or sizes of lots that can be subdivided in a particular area. In rural regions not serviced by sewers, density is also a function of the properties of local soils, specifically their ability to support septic systems without contamination of ground water.

Beyond that there can be cultural and historical influences at work. European cities tend to be more compact for their size than North American, with more dwellings in multiple unit buildings. Canadian cities are also generally less dense than American. Cities of the east and north of the U.S.A. tend to have higher densities than those of the south and west; the latter contain larger less dense central cores, and their suburbs are more sparse and sprawling by comparison (Fowler, 1992). Within urban areas, older sections of North American cities usually have closely spaced dwellings or multi-unit walk-ups, while newer suburbs tend to have detached homes on larger lots.

Part of the reason behind these contrasts is connected to automobile use. North American cities have on average four times as much roadway as cities in Europe (Fowler, 1992). Cities of the U.S. also tend to have more roadway and smaller transit revenue per capita than their Canadian counterparts. This is indicative of a greater reliance on auto usage in the United States, and cities there are inclined to be less compact in form (Mercer, 1991). Differences between Canada and the U.S. can also be attributed to housing type: the proportion of dwellings that are made up of single detached homes is higher on average in American cities (Mercer, 1991).

Post war suburbanization has been characterized by low density segregated land uses, with a tendency toward large tracts of purely residential development (Chinitz, 1991). Recent trends (as shown for Hamilton in Chapter 2) are toward higher density construction. What is unclear is whether this is based on the realization of some of the benefits of increased densities, or whether it reflects the behaviour of developers trying to maximize the return on their investments by building more homes per unit of land.

3.2.3 Density and Sprawl

Much recent empirical work regarding density has revolved around the issue of urban form. Density is one of the main distinguishing characteristics of the form of urban land. As such, it has ramifications for the city, its inhabitants, and the physical environment.

One of the density related concepts most commonly mentioned in literature and the media is that of sprawl. Often associated with suburban development, urban sprawl is characterized by tracts of low density housing which spread across huge expanses of the urban fringe. Basically, this is correct as far as the meaning of the word itself is concerned, but the definition of sprawl in economic terms is somewhat different. Sprawl is viewed as an outcome of discontinuous development. Peiser (1989) loosely defines it as a condition where undeveloped tracts of land within the urban boundary cause urbanized areas to be larger than they otherwise would be if all development within them were continuous.

Sprawling urban areas are believed to result from the influence of our transportation systems. Chinitz (1991) notes that the automobile has had both a cause and effect relationship with the land use patterns of our cities. Dependency on the automobile has resulted in the construction of road networks that promote development at greater distances from city centres, but such development reinforces the need to continue to use the automobile to move about in the North American city. Given the fact that Canadian and American citizens generally rely on their cars to a greater extent than people elsewhere, this argument seems satisfactory in helping explain the lower density developments of their respective countries.

Mills (1990) states that scale economies and indivisibilities in construction may also result in "lumpy" development that does not proceed in a continuous manner. Ottensman (1977) offers another line of economic reasoning - if owners of land perceive greater future returns on their investment, they may wait until such time that they can maximize their return, which means that development may instead occur on land farther away from the city centre. This may be affected by the overall growth rate of the city. In a slowly growing city, landowners may be less likely to expect future returns on land investment to have a larger payoff, and therefore develop their land right away. In rapidly growing cities, the expected future returns may be higher, causing more landowners to wait, and creating more discontinuous development on the periphery in the present.

One possible reason not mentioned in the literature concerns available space; North American cities often have space to expand with less discretion because land is an abundant resource. A country such as Japan has more finite limits due to terrain, as well as the need to reserve fertile lands on its coast for farming, which force developments to make the most of available acreage (Kivell, 1993).

The consequences of this development pattern are many. Discontinuous development is viewed as inefficient because it is more costly to service non-contiguous tracts of land, and it fails to use parcels which may be more accessible to the city's core, forcing residents to travel farther (Ohls and Pines, 1975; Ottensman, 1977). By influencing automobile use, such land promotes congestion, pollution, and energy consumption, while creating a need for greater expenditure on roads (Chinitz, 1991). It consumes excessive quantities of land which may formerly have been unspoiled wilderness or used for agriculture (Ottensman, 1977; Peiser, 1989).

However, in the context of discontinuous development, sprawl is also believed to have benefits. It is argued that in a competitive land market, such development can promote higher density infill over the long run. It is a natural product of urban expansion due to market imperfections, such as the timing of land availability, differing tax levels, uneven information, alternative investment opportunities, and imperfect land pricing. If expectations of future returns are high, land which is initially skipped over or left vacant may become more valuable over time, because the withholding creates a restriction in the present supply of developable land. Such higher prices will drive up densities once the land is eventually converted to urban use because the high prices force developers to use relatively less land in the production of each unit of housing. Furthermore, the risk associated with development is lower on such parcels of land because there is less uncertainty regarding the direction of urban growth than there may be in fringe areas (Ottensman, 1977; Peiser, 1989).

Among other benefits, such undeveloped parcels can allow for future development of commercial or institutional land uses, once there is a demand for them (Ohls and Pines, 1975). This flexibility is desirable if there is uncertainty or imperfect knowledge regarding future urban conditions. The scattering of development may also result in a greater future variety of land uses or more heterogeneity in housing stock (Ottensman, 1977).

The possible effects of government regulation of density become less clear when all of these points are taken into account. A case can be made for reduced controls on development. Local governments may use zoning, planned urban boundaries, and the financing or construction of infrastructure extensions to force land development to occur in a certain manner. Such public policies which force contiguous or sequential development at specified densities may result in growth that is less efficient than that which would occur in a free market. On the other side of the coin, a restriction on developable land will place a limit on supply, which may drive up land prices and result in higher density growth. It may also create a temporary monopolistic situation by allowing relatively few landowners on the periphery the opportunity to develop their land at a given time. If such limitations are also combined with low-density zoning, then the result may be more problematic because it does not allow for high density development to offset the expensive land prices (Peiser, 1989).

3.3 Empirical Analysis of Density

Despite the preceding discussion regarding sprawl, and some of the early theoretical work regarding urban density gradients, there have been few statistical analyses of density, and therefore little to go on in the way of how to explain the complex pattern of urban housing densities. It is a given that zoning regulations are mainly responsible for determining density at the local level, but are there other factors which may be at work as well? The following regression analysis was performed to test whether neighbourhood characteristics could be used to explain the variation in the density of housing subdivisions.

3.3.1 Primary Data

The primary data set used for the regression analysis is the Arc/INFO coverage containing subdivisions approved for development by the Region of Hamilton-Wentworth between January of 1980 and mid-1994. A total of 439 residential subdivisions displayed on the hard-copy map from which the coverage was digitized were approved during the time period. It was decided to leave out those observations which contained apartment complexes because of the skewing effect their large quantity of units would have on their densities, thus leaving 431 observations in the data set. Rural subdivisions were left in the data in the interest of testing whether their generally lower densities could be predicted.

Density was calculated by dividing the number of units in each subdivision by its area. Based on the definitions provided earlier, this calculation could be termed *project density*, since each subdivision is developed as a single project and the area within also includes that devoted to roads and open spaces. Noticeable errors in the data obtained from the Region regarding the areas of each subdivision necessitated using the polygon areas provided by Arc/INFO, converted into hectares. While this inherently introduces some digitizer error into the analysis, it was felt that this would still provide a more reliable area measurement, and comparison with the original area data showed a fairly close correspondence for most observations anyway.

As noted in Chapter 2, densities throughout the region vary from below 1 unit per hectare to over 90. Most of the subdivisions fall in the range of 5 to 20 units per hectare. However this distribution is not even across Hamilton-Wentworth. Figure 3.1 and the larger scale close-up of the urbanized area in Figure 3.2 are

Figure 3.1
Subdivision Density

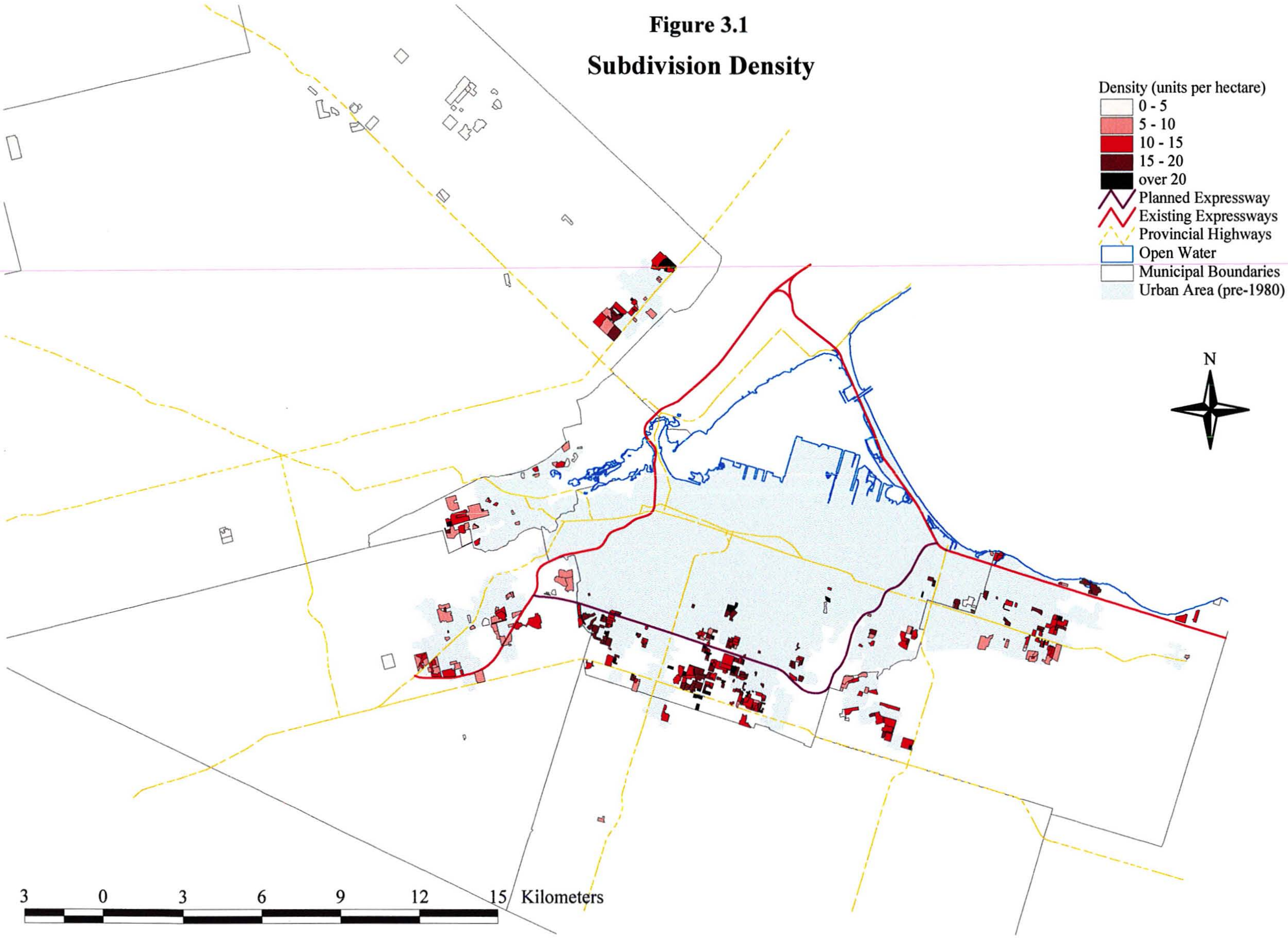
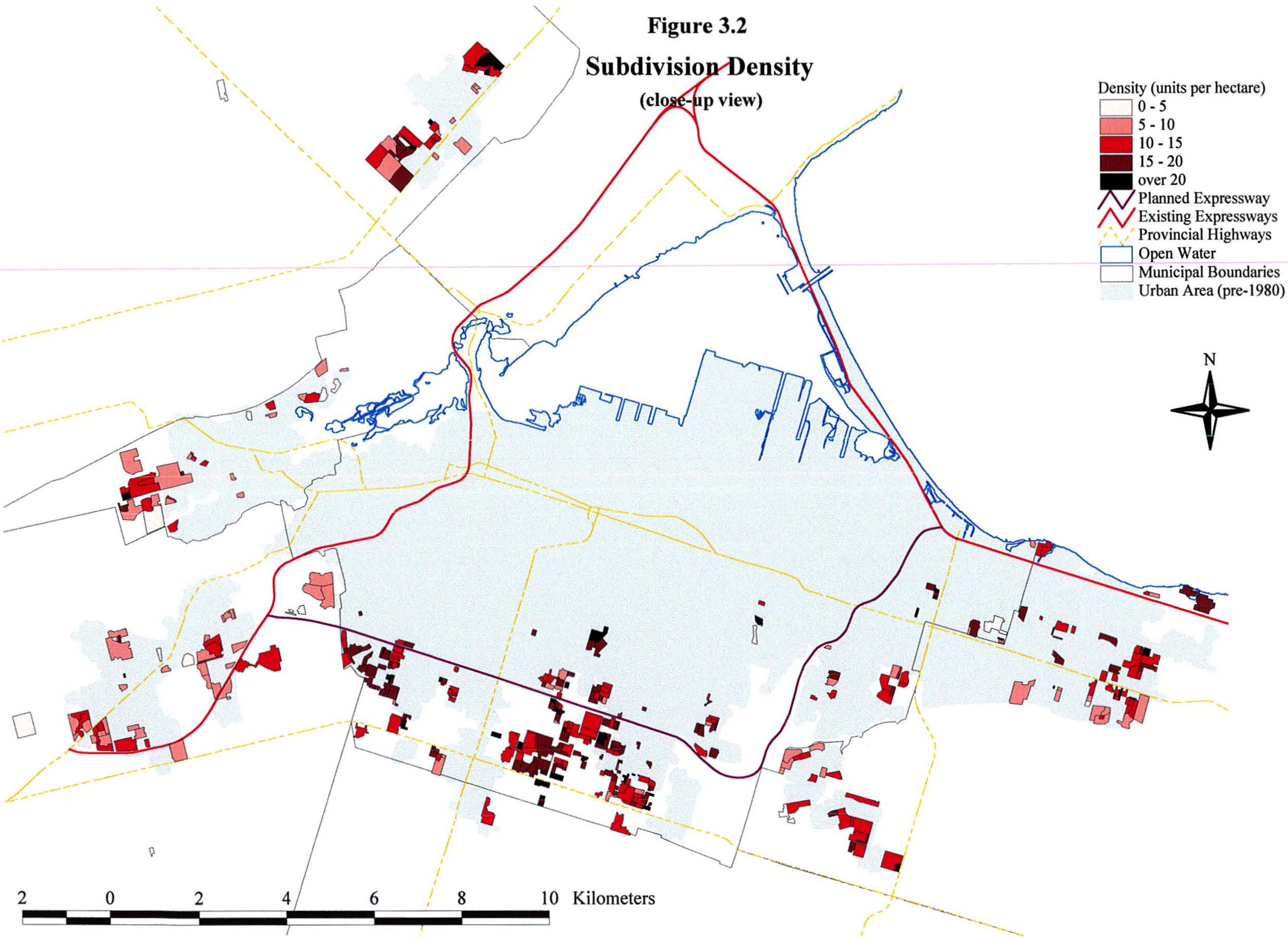


Figure 3.2

Subdivision Density

(close-up view)



thematic maps of subdivision density. The few rural developments are all below 5 units per hectare, but the majority that ring the main urban area are 5 units per hectare and above. There is a distinct difference between Hamilton and the suburban municipalities; Hamilton tends to have more variation, and more patches of higher density. Stoney Creek is much like Hamilton, but tends to have fewer subdivisions of very high density. Dundas and Ancaster developments for the most part fall in the under 15 unit per ha range, and Flamborough's are a mixture of high and lower density in the Waterdown area. There are definite clusters of subdivisions which are in the same density categories.

3.3.2 Secondary Data

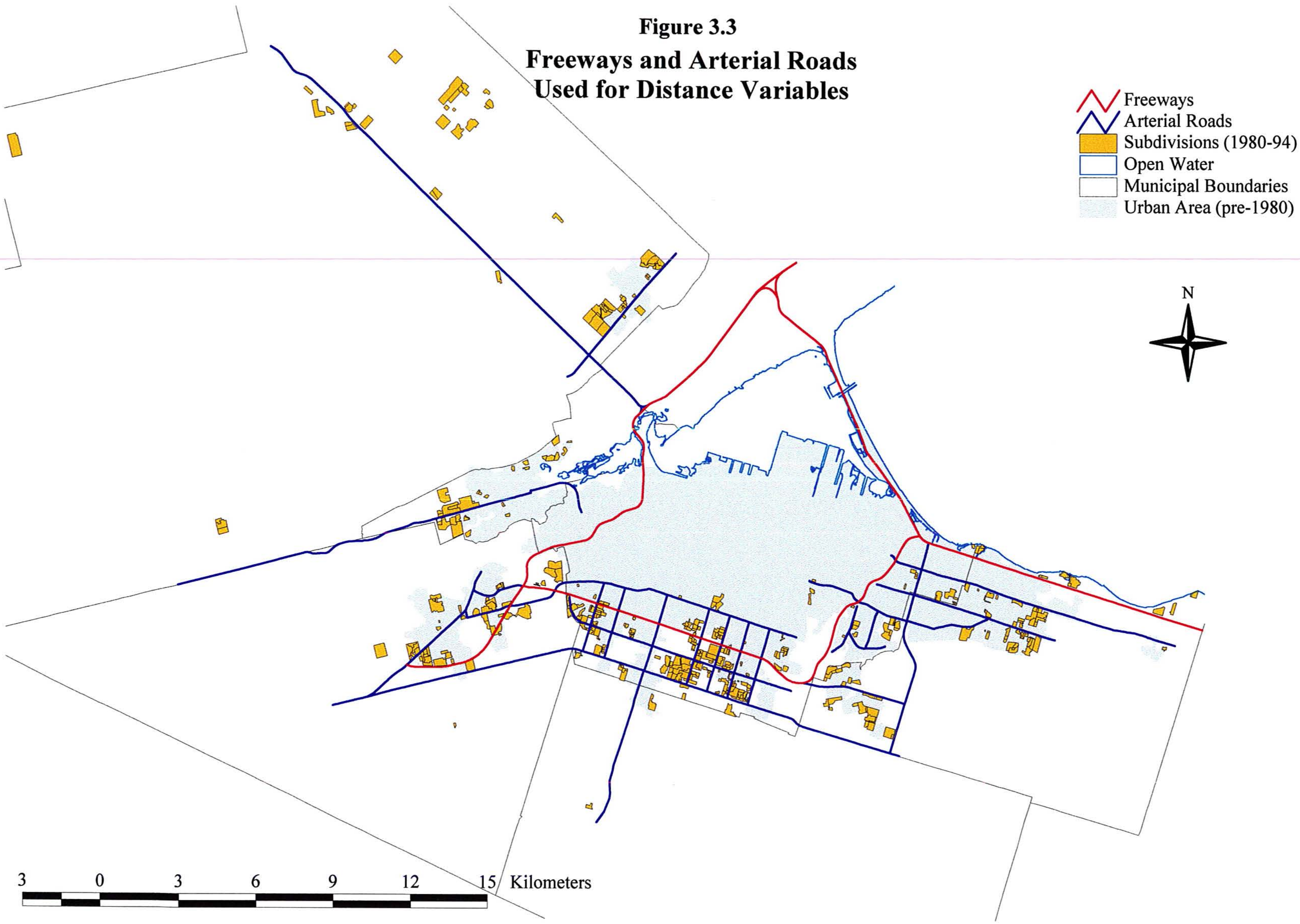
Independent variables used in the analysis were created using data collected from various sources. They included subdivision-specific measures as well as census variables for the census tract within which a subdivision was located. The following is the set of variables that were tested:

YEAR	- year in which subdivision was approved
DIST_ART	- distance from a major road (km)
DIST_FWY	- distance from a limited-access highway (km)
URBAN	- 1 if subdivision is in the urban area
RURAL	- 1 if subdivision is far removed (ie. greater than 2 km) from the urban area
LOWER	- 1 if subdivision is below the Niagara Escarpment
WEST	- 1 if subdivision is west of Highway 6 (both north and south of the central area)
ANC	- 1 if subdivision is in Ancaster
DUND	- 1 if subdivision is in Dundas
FLAM	- 1 if subdivision is in Flamborough
HAM	- 1 if subdivision is in Hamilton
STCR	- 1 if subdivision is in Stoney Creek
ROAD	- 1 if subdivision is adjacent to a major road
HWY	- 1 if subdivision is adjacent to a limited-access highway
HHLDSIZE	- average household size
FAMSIZE	- average family size
HOMEVAL	- average value of dwelling
HOMEPAY	- average monthly payments of dwelling owners
AVGFAM	- average family income
MEDFAM	- median family income
AVGHHLD	- average household income
MEDHHLD	- median household income

Given that there has been a trend toward higher average densities during the time series, the variable YEAR was included to try and capture this effect. If subdivisions are becoming more dense over time, then there should be a positive parameter on YEAR.

Figure 3.3

Freeways and Arterial Roads Used for Distance Variables



The road network used to define "major roads" and "limited-access highways" is shown on Figure 3.3. The expected signs for the parameters of DIST_ART and DIST_FWY were negative; you would expect density to be greater closer to such thoroughfares because the value of neighbouring lands would be high, due to their accessibility. This follows the same argument that was presented in the earlier discussion of density - builders are forced to use less land in the production of housing to offset high land prices. The other reason for the expected negative parameters involves subdivision design. In many cases, projects adjacent to busy roadways contain multiple-unit dwellings that are oriented in such a way that they provide a kind of noise barrier between the traffic and the quieter interior of the neighbourhood. These multiple units would be reflected in higher densities for subdivisions immediately adjacent to the roadways.

Quite a few dummy variables were tested. URBAN and RURAL were one grouping, to reflect the possible differences in urban and rural densities. LOWER and WEST were included to account for possible intra-region variation in density. The municipal dummy variables were to test for differences that might show up among the components of the region, in particular between the City of Hamilton and its suburbs. It is possible (and probable) that densities in some municipalities are planned to be higher or lower than in others. ROAD and HWY were alternates for the distance variables, and based on the same network. Of the entire bunch, it was expected that URBAN, HAM, ROAD, and HWY would have positive parameters, with most of the others negative. There was no expectation for LOWER or WEST.

The census variables were meant to test whether certain demographic characteristics of a neighbourhood had any relationship to density. The direction of this association is perhaps not as clear as the other variables, since density is determined before subdivisions begin to receive their occupants, who are ultimately the subjects of the census surveys. It would be reasonable to assume that families with certain characteristics are drawn to certain types of subdivisions. However, given that census tracts tend to be much larger than the typical subdivision, these variables could instead be understood to represent the general characteristics of the neighbourhood or city block in which a particular form of subdivision is built. It is difficult to predict the signs for HHLDSIZE and FAMSIZE; these would probably relate better to the sizes of dwellings built rather than their density. High values for the payment variables would probably be associated with homes on larger lots; one might expect, all else being equal, that a higher house price would buy a homeowner more land. This would mean that lower density subdivisions may be found in areas of higher prices, and the sign would be a negative. The income variables might show a similar relationship, since they represent the ability of the residents to pay for a dwelling rather than the cost of the dwelling itself.

While distance from the central business district is a factor in the density of housing as far as urban theory is concerned, such a variable was not included in this analysis. Figures 3.1 and 3.2 show that most subdivision development occurred in a ring-shaped pattern around the City of Hamilton. The distances from each polygon to the downtown core would likely be very similar for many subdivisions. Looking at the two maps, it is difficult to see a noticeable density gradient as distance from the centre city (or even from the local town centres) increases. The most obvious pattern are the low densities far from the urban area, which would probably be explained by the dummy variable for rural subdivisions.

3.3.3 Regression Results

Many runs of the model were performed using the statistical software package SPSS. At first, the dependent variable used was simply density. The relationship can be shown by the following equation:

$$density = \beta_0 + \beta_i^{\prime} X_i, \qquad [3.1]$$

where X_i is a vector of i attributes associated with each subdivision, β_0 is a constant, and β_i is a vector of parameters for the independent variables. Ordinary least squares was used to determine the values for the parameters. Since the distribution of the dependent variable is positively skewed, with a higher frequency of observations in the lower density ranges, the natural logarithm of density was used instead to normalize the data. This would make density an exponential function given by the equation

$$density = e^{\beta_0 + \beta_i^{\prime} X_i}. \qquad [3.2]$$

The adjustment to an exponential relationship greatly improved the fit of the model; the variables were able to explain much more of the variation in density. Table 3.2 illustrates the results for one of the better models. As predicted, DIST_ART has a negative parameter, meaning that the greater the distance from an arterial road, the lower the density. YEAR is positive, reflecting the tendency for densities to increase over time. The dummy variables showed proper signs as well: RURAL was negative, reflecting the lower densities in the non-urban areas of the region; ANC, DUND, FLAM, and STCR were all negative as well, explaining the lower densities in the suburban areas. These dummy variable parameters should be compared relative to Hamilton; ie. the negative signs denote the propensity for subdivisions outside of the City of Hamilton to be lower. The other thing they exemplify is how density tends to vary between municipalities; there is a fair bit of difference in the parameter values for each municipal dummy.

TABLE 3.2
Regression Results - Model 1

Dependent Variable: LN_DEN
No. of Observations = 431
R-square = 0.558
Adjusted R-square = 0.551
F statistic = 76.298 (prob = 0.000)

Variable	Coefficient	t-ratio	Prob(t)
Constant	-26.46724	-2.122	0.0345
DIST_ART	-0.19342	-5.654	0.0000
YEAR	0.01471	2.344	0.0195
RURAL	-1.05436	-9.608	0.0000
ANC	-0.59579	-8.525	0.0000
DUND	-0.52586	-6.024	0.0000
FLAM	-0.26772	-3.194	0.0015
STCR	-0.15989	-2.671	0.0078

For the most part, the dummy variables were interchangeable. Table 3.3 shows how substituting HAM for FLAM and STCR affects the model. The fit is almost the same, but the HAM dummy has a positive parameter because densities within Hamilton are generally higher than elsewhere (in this case, Flamborough and Stoney Creek are the basis for comparison). ANC and DUND are still negative.

TABLE 3.3
Regression Results - Model 2

Dependent Variable: LN_DEN
No. of Observations = 431
R-square = 0.557
Adjusted R-square = 0.550
F statistic = 88.712 (prob = 0.000)

Variable	**Coefficient**	**t-ratio**	**Prob(t)**
Constant	-25.62703	-2.069	0.0392
DIST_ART	-0.19944	-5.881	0.0000
YEAR	0.01420	2.277	0.0233
RURAL	-1.09906	-10.849	0.0000
HAM	0.19214	3.572	0.0004
ANC	-0.40395	-5.298	0.0000
DUND	-0.33289	-3.609	0.0003

Some of the census variables were also tested, and the fit they provided was nearly as good as the two previously discussed specifications. Table 3.4 shows a model containing HHLDSIZE and AVGHHLD. The positive sign on the household size variable means that densities are higher where household sizes are larger. This could be a reflection of builders putting larger homes on smaller lots into those areas. It is difficult to say whether or not this is really the case because the density calculation is an aggregate one - the data set contains no information about the actual size of dwelling. It may just be coincidental: perhaps areas that have higher density housing happen to be home to larger average households. The census data do show that tracts in Hamilton and Stoney Creek have larger households in general, and the primary data has shown them to contain higher density subdivisions, whereas the opposite are true for the other area municipalities. AVGHHLD is negative, meaning that densities are lower where average household income is greater. This makes sense because Ancaster, Dundas, and Flamborough tend to have higher average incomes than Hamilton and Stoney Creek, and densities are lower in those three towns. One other point regarding the census variables is their incompatibility with the dummy variables for the suburban municipalities, probably the result of multicollinearity. It seems obvious that some of the regional variations in income or household size can be accounted for instead by dummy variables, so it would make little sense to have too many dummies in a specification that also utilized census data.

TABLE 3.4
Regression Results - Model 3

Dependent Variable: LN_DEN
No. of Observations = 431
R-square = 0.545
Adjusted R-square = 0.538
F statistic = 84.534 (prob = 0.000)

Variable	Coefficient	t-ratio	Prob(t)
Constant	-66.13510	-4.464	0.0000
DIST_ART	-0.20747	-6.054	0.0000
YEAR	0.03445	4.618	0.0000
RURAL	-0.96557	-9.783	0.0000
HAM	0.18697	3.149	0.0018
HHLDSIZE	0.26397	3.235	0.0013
AVGHHLD	-1.216E-05	-4.262	0.0000

Table 3.5 depicts a model that does not contain any dummy variables at all. While the significance of the variables that are included is greater, the fit drops by a considerable amount. Thus it is more sensible to keep at least a couple of dummy variables in the model to explain more of the variation in density.

TABLE 3.5
Regression Results - Model 4

Dependent Variable: LN_DEN
No. of Observations = 431
R-square = 0.418
Adjusted R-square = 0.413
F statistic = 76.535 (prob = 0.000)

Variable	Coefficient	t-ratio	Prob(t)
Constant	-83.26184	-5.434	0.0000
DIST_ART	-0.43172	-14.006	0.0000
YEAR	0.04319	5.604	0.0000
HHLDSIZE	0.35496	4.128	0.0000
AVGHHLD	-1.984E-05	-7.871	0.0000

Table 3.6 illustrates the linear form of the model shown in Table 3.3, with density as the dependent variable. The major difference lies in the fit - R^2 drops to just below 0.3, meaning this model explains little better than half of the variation in density that the exponential model does. DIST_ART becomes insignificant at the 5% level (though in other linear models it can have a higher t-score). RURAL is less significant as well.

TABLE 3.6
Regression Results - Density as Dependent Variable

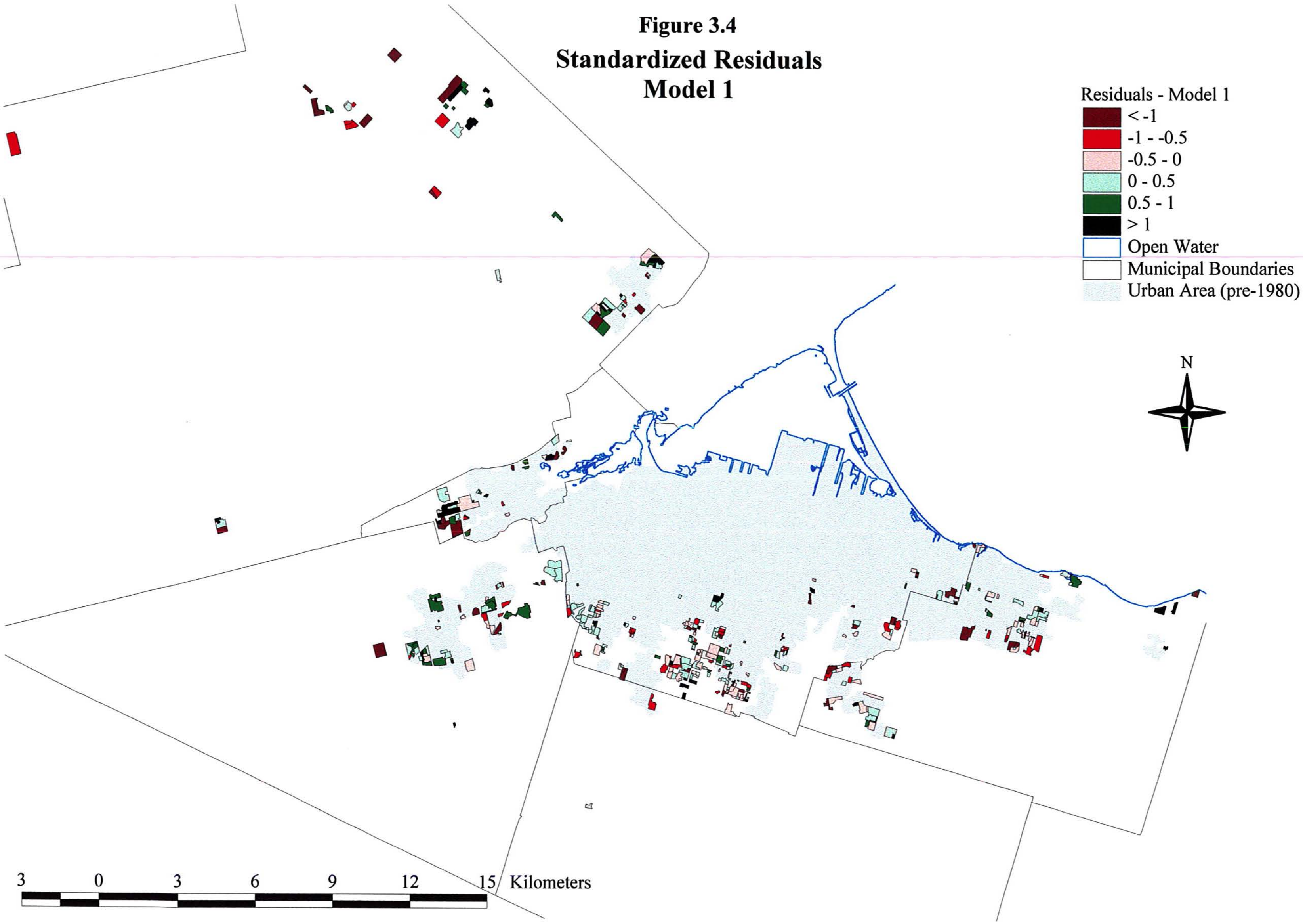
Dependent Variable: DENSITY
No. of Observations = 431
R-square = 0.299
Adjusted R-square = 0.289
F statistic = 30.157 (prob = 0.000)

Variable	Coefficient	t-ratio	Prob(t)
Constant	-934.26537	-4.373	0.0000
DIST_ART	-0.86741	-1.755	0.0799
YEAR	0.47441	4.411	0.0000
RURAL	-7.06234	-4.963	0.0000
HAM	2.81261	3.285	0.0011
HHLDSIZE	3.75276	3.190	0.0015
AVGHHLD	-1.362E-04	-3.310	0.0010

3.3.4 Spatial Autocorrelation of the Residuals

Figure 3.4 is a map of the subdivisions, which have been categorized based on the standardized values of their residuals from Model 1. Standardized values were obtained by dividing the raw residual for each observation by the standard error of the estimate for the model; thus a standardized residual of less than 1 means that the actual residual was less than the standard error. This allows the residuals from one specification to be comparable to those of another, and also makes it easier to create a classification scheme for the map. Each residual is calculated by subtracting the predicted value of density (ie. the value that can be calculated directly from the parameters and variable data) from the observed. Negative residuals are indicative of observations that were over-predicted by the model, and are shown in shades of red. Positive residuals indicate under-prediction and are shown in shades of green.

Figure 3.4
Standardized Residuals
Model 1



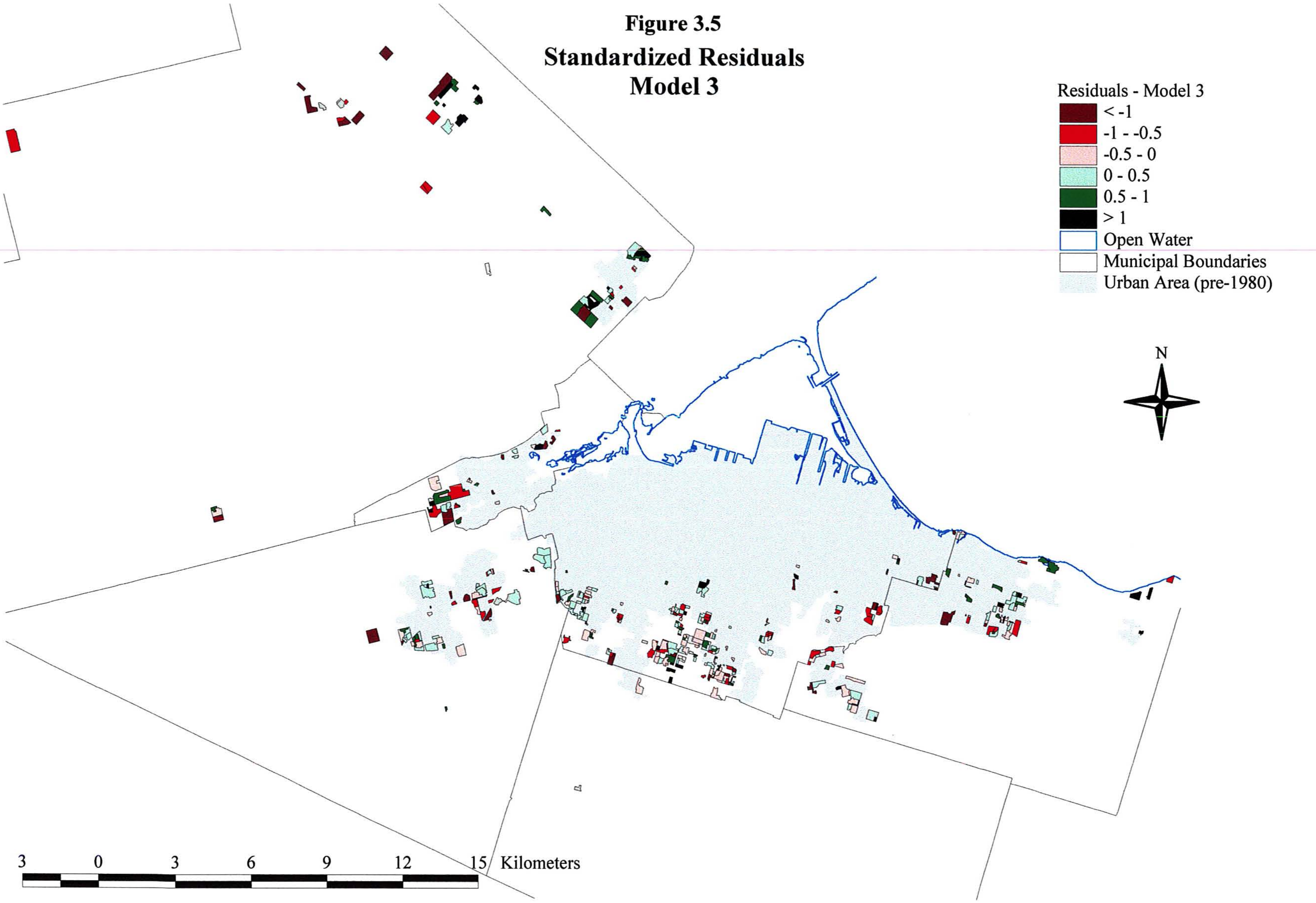


Figure 3.5
Standardized Residuals
Model 3
Residuals - Model 3
< -1
-1 - -0.5
-0.5 - 0
0 - 0.5
0.5 - 1
> 1
Open Water
Municipal Boundaries
Urban Area (pre-1980)
N
3 0 3 6 9 12 15 Kilometers

In the case of this particular specification, which contained mainly dummy variables, most over- and under-prediction lies within 1 standard error of the observed densities, and it is difficult to see any major bias in the map. There is a definite clustering of similar residuals, but this is to be expected to a certain extent. This clustering could be a result of similarity in the data for contiguous subdivisions. Subdivisions that border on each other are likely to be in the same municipality, and will probably lie a similar distance from a major road. They are also both likely to have been approved within a short span of time. It is also valid to assume that they will have similar densities due to zoning regulations. Based on this run of the model, it is valid to say that some spatial autocorrelation of the residuals exists, but that it may be expected given the nature of the data.

Figure 3.5 offers another map of residuals, this time for Model 3, in which two census variables replaced some of the municipal dummy variables. While the variables in this model performed just as well over all as in the other, the inclusion of census data introduces greater spatial variation in the data set. Where the dummy variables represent large sub-sections of the region, the census tracts are much smaller in area, so there is a better chance that the census data would capture sub-municipal variation in density. With respect to Figure 3.5, the spatial patterns in the rural areas and the suburban fringes are much the same as in Figure 3.4, which might be expected as census tracts tend to be very large there and may not provide much more information than the dummy variables they replace. As for the main urban subdivisions, there is not a large difference between the two either, aside from a few scattered polygons that changed classifications slightly. It is difficult to judge which model is better based on these maps.

3.4 Conclusion

This section has demonstrated that it is possible to relate the density of a subdivision to other characteristics of the urban area. While strong relationships were found between density and variables such as distance to arterial roads, household size, household income, and regional dummy variables for the location of each development, overall fit of the regression models were relatively mediocre.

The lack of any significant change in the residuals when the specification was altered suggests that something else is missing from the variable set. The patterns of residuals are seemingly more varied than the patterns of density. While this could be due to the classification ranges chosen for the maps, is it possible that somehow the model is trying to account for *more* variation than it needs to? If this is the case, then maybe what is missing are some factors such as zoning controls or prices which could provide localized information about the land itself, in addition to the existing data which was derived mainly from the entities that live or are built on it. Maybe it would be possible to create a regressor that accounts for the density of older neighbouring subdivisions to account for neighbourhood homogeneity in densities. One other possibility is that the density data is too precise to be able to make stronger generalizations about its relationship to other characteristics of the city. Perhaps a better model could be realized by aggregating small groups of subdivisions with like densities, and use them to calculate the dependent variable.

The logical next step would be to attempt a statistical solution to the problem of spatially correlated density residuals. Methods of testing for and dealing with spatial autocorrelation can be found in texts by Cliff & Ord (1981), Anselin (1988), and Odland (1988), in addition to papers by Anselin & Griffith (1988), Anselin (1990), Getis (1990), Anselin *et al* (1996), and Hepple (1998).

Chapter Four:
Discrete Choice Analysis

4.1 Introduction

This section deals with the question of where new development takes place. It details an attempt to determine whether the developer's choice of location for new housing can be related to various characteristics of land at the intra-urban level. While there have been many studies of housing growth, most have examined it at an aggregate level, where data for housing starts in metropolitan areas is readily available. Studies which have looked at local housing development in an empirical manner were outlined in Chapter 1.

The problem with performing spatial analysis at an urban scale is data. The census provides dwelling counts, but they are aggregated up to zones that can be quite large on the fringe of the urban area where new development generally takes place, and such data are only available at five year intervals. Another method might involve looking at aerial photographs and performing manual housing counts, but such photos are not always available for an area, and if they are it is unlikely they have been taken at regular intervals. A researcher who wished to collect their own data this way would have to plan the study years, if not decades, in advance of the analysis, then spend exorbitant amounts of money on air transportation and photography. Satellite images might be easier to obtain, but not provide the necessary detail. One other way to go would be to gather data for building permits issued by the local government, but the explicit spatial component would be missing and require plotting on maps by hand.

Homes are for the most part not developed as single units; the growth of the urban area does not occur one building at a time. It makes more sense to analyze change as it really happens, in parcels called subdivisions. Each subdivision is a unit of development in itself; it contains dwellings that are built within a frame of time, and that are then purchased and occupied soon after completion. The urban area thus grows in a non-continuous piecemeal fashion, in blocks of development along its border.

There are limits as to where these subdivisions can be built. The developer must obtain approval from the local planning department, who ensure that development takes place in a logical and feasible manner without infringing on other urban or natural features. While there are restrictions on where new residential land can be created, there is enough leeway in the planning for some choice of location. The developer must also account for the local demand or market for housing to ensure that once built, the new homes become occupied. Essentially, the developer is making a spatial choice, under constraints, regarding where to locate new housing.

Assuming then that development is a spatial choice, what is the best way to model the choice process? Since the data set contains no information regarding the actual firms responsible for each subdivision plan, it must be assumed that the location decision for each subdivision represents the choice of a single independent developer. All subdivisions must also choose from among the same set of areas containing developable land, since nothing is known about the spatial variation of land availability specific to each. The logit model is a useful tool to model such choice. The software used to perform this analysis is the econometrics package LIMDEP, which is capable of estimating parameters for non-linear models.

4.2 The Modelling Framework

4.2.1 Theory of the Logit Model

In the most basic sense, choice modelling is an attempt to explain why a particular individual or group makes a particular selection from a set of alternatives, or choices. In our case, we have the land developer, who must make a choice of location within the urban area for the housing development they wish to build. The following section detailing a specific choice model, the logit, has been adapted from Ben-Akiva and Lerman (1985).

Preferences for choice are based on the concept of utility. Utility can basically be explained as the perceived benefit an individual or choice maker believes they will receive by choosing a particular alternative.

It can be defined as a function:

$$U_{in} = V_{in} + \varepsilon_{in}, \qquad [4.1]$$

where V_{in} is the systematic part of utility, or that part of utility which is influenced by factors that can be observed or known, and ε_{in} is the random component, or the disturbance term representing that part of utility which cannot be known to the analyst. Typically, the systematic component of utility is some function of a set of variables that factor in to the choice decision. Thus

$$V_{in} = V(z_{in}, S_n), \qquad [4.2]$$

where z_{in} represents data concerning the choices available to decision maker *n*, and S_n represents attributes of individual *n*. Each characteristic in the function is weighted by a parameter which denotes the relative effect the attribute has on utility.

Individuals generally choose the alternative which gives them the greatest utility; choice makers are assumed to follow utility maximizing behaviour. Therefore, what is really being modelled is the probability that the utility associated with one alternative is greater than that of the other alternatives:

$$P_n(i) = Prob(U_{in} > U_{jn}, \forall j \in C_n), \qquad [4.3]$$

which states that the probability individual *n* will choose alternative *i* is equal to the probability that the utility of *i* is greater than that of the alternatives not chosen, for all *j* which are elements of *n*'s choice set C_n. When systematic and random components of utility are brought into consideration, the probability becomes

$$P_n(i) = Prob(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}). \qquad [4.4]$$

Since the disturbance terms are unknown, we cannot know for certain that the utility of alternative *i* is actually greater than that of alternative *j*. However, if we assume that the disturbances are independent and identically Gumbel distributed, we can model the probability using the logistic function. Where there are more than two choices (termed *multinomial choice*), this function takes the following form:

$$P_n(i) = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}}}. \qquad [4.5]$$

The systematic utilities may then be represented as linear functions:

$$V_{in} = \beta' x_{in} \quad and \quad V_{jn} = \beta' x_{jn}, \qquad [4.6]$$

where x_{in} and x_{jn} are vectors of attributes for choices i and j and the decision maker n, and β represents a vector of parameters associated with them. The parameters may then be estimated using maximum likelihood.

In terms of how this represents the choice problem of the developer, what we are modelling is the probability that subdivision n gets approved in location i of the urban area. Each subdivision is considered to be a choice maker, and the urban area is divided into a set of j zones (in this case, the 12 zones illustrated by Figure 4.1) from which subdivision n makes a choice. The utility of choosing a particular zone for development is assumed to be a linear function dependent on a set of alternative specific subdivision characteristics (S_n), and a set of location specific attributes (z_{in}) for each zone.

On a final note regarding logit theory, consideration must be given to the property of *independence from irrelevant alternatives* (IIA). IIA is an often discussed weakness of the logit model. It essentially means that the ratio of the choice probabilities for any two alternatives is unaffected by the utilities of any other alternatives in the choice set (Ben-Akiva & Lerman, 1985). This is expressed mathematically as:

$$\frac{P_n(i)}{P_n(l)} = \frac{\dfrac{e^{V_{in}}}{\sum_j e^{V_{jn}}}}{\dfrac{e^{V_{ln}}}{\sum_j e^{V_{jn}}}} = \frac{e^{V_{in}}}{e^{V_{ln}}}. \qquad [4.7]$$

The ratio of the probabilities that decision-maker n chooses alternatives i and l is equal to the ratio of the exponentials of their systematic utilities. The utilities of all other alternatives cancel out of the equation.

Applied to the problem of zone choice in the model of subdivision location presented here, this equation states that the ratio of the probabilities that subdivision n locates in Zones 6 and 7, for example, is unaffected by the systematic utilities of Zones 1 through 5 and 8 through 12. IIA also holds if any new zones were to be added to the choice set, such as a Zone 13 in the area immediately south of Zones 6 and 7. Adding a new zone may decrease the actual choice probabilities for the other zones, but their relative probabilities would remain unchanged.

In this particular case, IIA is not a realistic assumption. One would expect that adding a Zone 13 would be more likely to draw development away from its closest neighbours (Zones 6 and 7) than from zones that are farther away (such as Zones 1 and 12), which would affect relative choice probabilities for the entire set of zones.

The question is whether this violation of IIA means the logit model is inappropriate for this analysis. The answer is no - the *form* of a logit model can still be applied in the absence of an IIA choice process (Train, 1986). The addition of alternative specific constants to the model will account for the variation in choice that is not captured by the other variables in the utility functions. When alternative-specific constants are included, V_{in} and V_{ln} become dependent on the utilities of all choice alternatives, because the magnitude of the constants is responsive to the proportions of decision-makers choosing each of the elements in the choice set. These constants can be replaced by attributes of alternatives, but this may introduce bias because they are not specified in an alternative specific manner. Such attributes may represent the utilities of some alternatives better than they do others, and may also lead to problems of multicollinearity (Ferguson, 1995).

Violation of IIA may also be circumvented by using a different choice model. The multinomial probit model is one such example that does not contain the IIA property. The probit assumes that the disturbance terms are normally distributed, instead of using the Gumbel distribution on which the logit is based. However, it is much more computationally demanding than the logit (Ben-Akiva & Lerman, 1985; Wrigley, 1985). It becomes intractable for large choice sets, and comparisons of identical probit and logit estimations have demonstrated similarity (Anas, 1982).

4.2.2 Logit Elasticities

Once the logit probabilities have been derived, we can calculate a *direct elasticity* as a measure of the incremental effect a change in one of the variables has on the probability of an individual choosing a particular alternative, (Ben-Akiva & Lerman, 1985):

$$E_{x_{ink}} = [1 - P_n(i)]\, x_{ink}\, \beta_k, \qquad [4.8]$$

where $P_n(i)$ is the probability of individual n choosing alternative i, x_{ink} is variable k associated with individual n and choice i for which the elasticity is being calculated, and β_k is the parameter assigned to the variable. It is important to note that these elasticities are alternative specific; there will be one for each element in the choice set for each observation.

As a summary statistic it is not very efficient to report elasticities for every individual, especially for data sets with large numbers of observations. Therefore, an *aggregate elasticity* can be calculated from the direct elasticity to measure the incremental effect a change in a variable has on the probability that all individuals choose a particular alternative:

$$E_{x_{jk}} = \frac{\sum_n P_n(i)\, E_{x_{jnk}}}{\sum_n P_n(i)}. \qquad [4.9]$$

This gives the average of individual elasticities weighted by choice probabilities. The result, if this is performed for each variable, is a k by j matrix of elasticities.

4.2.3 Measures of Fit

To determine how well a model is performing, it is useful to include a measure of fit. The results provided by LIMDEP contain final and initial log-likelihood values, as well as a chi-squared statistic. The chi-square is essentially comparable to an F-statistic in regression analysis. When the chi-squared is significant, we can reject the null hypothesis that all of the coefficients are equal to zero.

The final and initial log-likelihoods can be used to calculate the *likelihood ratio index*, otherwise referred to as the *rho-squared* (ρ^2) statistic. This is useful in comparing the fit of models which are based on the same data set, but contain different variables. The formula, from Ben-Akiva and Lerman (1985), is:

$$\rho^2 = 1 - \frac{\mathcal{L}(\beta)}{\mathcal{L}(0)}, \qquad [4.10]$$

where $\mathcal{L}(\beta)$ represents the value of log-likelihood given the final parameter estimates, and $\mathcal{L}(0)$ represents the initial value of log-likelihood calculated with parameter values of zero. However, the final value of log-likelihood will always increase due to the addition of extra variables to the utility functions. Rho-squared can therefore be modified to allow for better comparison of models estimated from the same data set, but with different quantities of variables:

$$\bar{\rho}^2 = 1 - \frac{\mathcal{L}(\beta) - K}{\mathcal{L}(0)}. \qquad [4.11]$$

Thus, *rho-squared bar* is calculated by first subtracting the number of variables (K) from the final value of log-likelihood to control the measure of fit for the size of the specification.

Rho-squared ranges in value from zero to one; ie. from a case where the variables predict none of the decision-maker's choice, to one where that choice is perfectly predicted. The value of rho-squared is only important as a relative measure. Ben-Akiva and Lerman (1985) state that "there are no general guidelines for when a ρ^2 value is sufficiently high" (p. 167). Train (1986) explains that "the likelihood ratio has no intuitively interpretable meaning for values between the extremes of zero and one" (p. 50). It is however noted in Wrigley (1985) that values ranging between 0.2 and 0.4 can be considered to represent a good fit. Regardless, the measure was used in this analysis to help determine which specifications were superior relative to others.

A final way to measure model performance is to compare the probabilities generated by the logit model to those observed in the data. For each alternative, for every observation in the data, a predicted probability can be calculated. In the case of the particular choice problem examined here, these represent the probability that subdivision n will choose to locate in zone i. Since we have 12 zones in the model, each subdivision will be assigned 12 fitted probabilities. The fitted probabilities for each zone can be averaged, and compared to the proportions of observed choices for each zone over all observations in the data (ie. if a zone is chosen 20 times over of a total of 100 observations, it will have been chosen 20% of the time - a proportion of 0.2).

4.3 The Data Set

4.3.1 Primary Data

The primary data set used for the logit analysis is the Arc/INFO coverage containing subdivisions approved for development by the Region of Hamilton-Wentworth between January of 1980 and mid-1994. Out of a total of 439 residential subdivisions displayed on the hard-copy map from which the coverage was digitized, 402 were located within the area of the zones used for analysis, and mainly represent urban housing developments. Those developments lying outside of the study zones included rural housing tracts and subdivisions in rural satellite communities. It was decided to leave those observations out of this analysis because constraints on rural development tend to differ from those in the urban area.

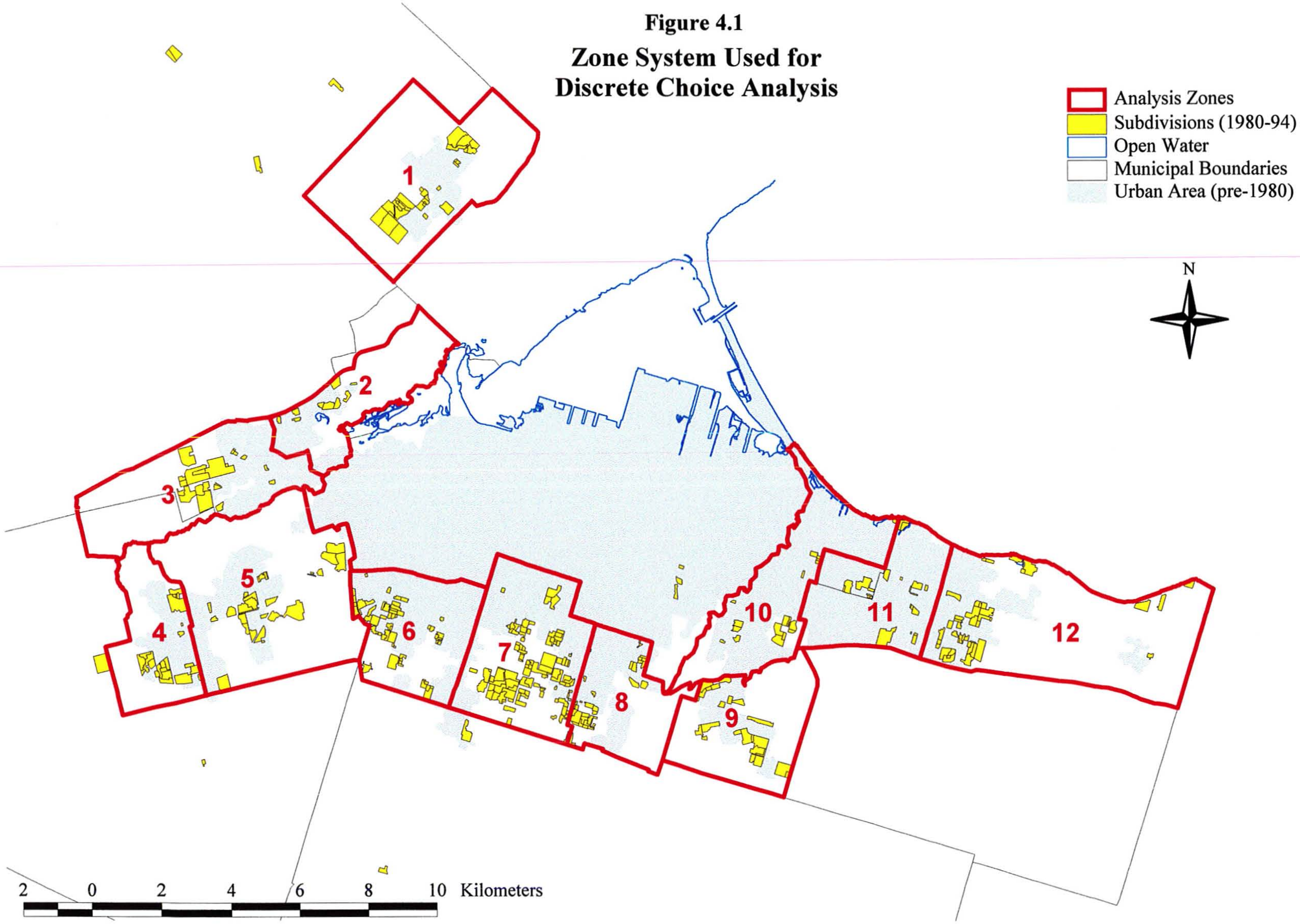
4.3.2 Secondary Data

Independent variables used in the analysis were created using data collected from various sources. A zonal system was set up to serve as the choice set for each development. A set of 12 zones was created which cover the urban area of Hamilton and its immediate suburbs (see Figure 4.1). The central core of the city was left out of the analysis because it contains older development - the interest was in areas on the urban fringe where developable land exists.

The decisions on where to place zone boundaries was largely intuitive. It was possible to divide the study area in a sensible manner by municipality. Within municipal boundaries consideration was given to division by natural barriers (eg. the Niagara Escarpment), major transportation corridors (eg. Upper James Street and Centennial Parkway), or separation of areas containing large quantities of older development from those with more room for urban expansion. The inclusion of Census data meant the added requirement of following the boundaries used to delineate census tracts, to ease calculation of demographic variables for each zone. A choice set covering the same area, but divided into 8 zones, was also tested to see if zone definition had a great effect on results. While none are included here, the models based on the smaller choice set performed similarly to the 12 zone specifications, but it was felt that the latter zone system was more representative of the staging of development in the area, and provided more variation between zones in terms

Figure 4.1

Zone System Used for Discrete Choice Analysis



of the values of the independent variables used.

Since it is assumed that each observation in the primary data represents the location choice of a single developer from among the set of 12 zones described above, a set of independent variables was required for each zone to test factors that could possibly have an impact on zone choice. The following set of zone attributes was used in the discrete choice model. They are divided into groups according to type of variable.

4.3.2.1 Previous Development

These are quantities of development calculated from the subdivision database. The expectation is that zones with high levels of previous development will be more attractive for future development, indicative of a sort of "contagious" affect where there is an inertia to maintain high rates of construction. Areas are calculated using Arc/INFO coverage units (which are in square metres before conversion to hectares), as some of the data provided by the Region contained suspicious or missing values for subdivision area. These variables, if used in the analysis, require reducing the time series to 1981 onward to account for the one-year lag (a loss of only 10 observations).

PREVUNIT - number of units approved in each zone for the previous year
PREVAREA - total area (in hectares) of subdivisions in each zone for the previous year

4.3.2.2 Developable Land

In order for an area to be considered a viable choice for subdivision location, it must contain land on which new development is possible. The combination of planning restrictions, available servicing (ie. roads, water, and sewage), and previously existing development can be used to define this. Thus, it was necessary to know what development was in existence prior to 1980 (the urbanized area, shown on Figures 4.1 and 4.2), where the regional government had decided to allow development and how this changed during the study period (the planned urban boundary, illustrated on Figure 4.2), the catchment areas for services, natural areas unavailable for development due to planning restrictions (see Figures 4.3 and 4.4), and other areas off-limits to residential construction such as parks, industrial and commercial zones, and lands used for institutional purposes (Figure 4.5).

Creation of these variables was done in Arc/INFO, and required a large amount of digitizing and combining of coverages. Digital versions of the Ontario Base Maps (OBMs) were used as a basis for much of the information. Each OBM is a 1:10,000 scale map of an area of the province displaying cartographic natural and man-made features. They were reproduced by the Ministry of Natural Resources in digital format as part of what is termed the *Digital Topographic Data Base*. Each "tile", the equivalent of a single hard-copy map, is available as a set Arc/INFO interchange files with which coverages displaying the different types of feature data can be created. OBMs were used to define woodlots and stream buffer zones used to calculate natural areas. They also contained information about the built environment (point locations of homes and polygons for larger buildings) which was used to generate an urbanized area for the start of the study period.

Maps provided by the planning department in various documents and official plans were used for several purposes. They provided delineation for the environmentally sensitive areas, which were used in conjunction with OBM data to designate non-developable land. They were used to digitize special policy areas such as lands under the jurisdiction of the Niagara Escarpment Commission (Figure 4.6). Such lands are subject to amendment, and it is thus difficult to totally eliminate them from development consideration, but it would be wrong to completely dismiss them (though there is a significant overlap with the natural lands coverage). The Region's maps were also used along with documents to denote the planned urban boundary. Retail road maps of the Region were used to define parks and other areas unavailable for residential use.

All of this information was used to calculate a quantity of developable land which varied year to year. While natural or special policy lands do not generally change yearly, amendments expanded the planned urban boundary several times during the study period. The lack of available documents showing change in serviced areas was a problem; for this analysis it was therefore necessary to assume that all developable land is serviced. However, maps from the 1970s clearly show that servicing is available or possible in most of the study area, and extensions of trunk utility lines have been built regularly, so the assumption is not unrealistic. The subdivision data itself was used to add to the previously developed area on a yearly basis. In short, developable land was determined for each zone and each year by taking the total area within the planned urban boundary, and subtracting restricted areas and previous development. Arc/INFO's overlay capabilities were used to perform the "spatial mathematics" to arrive at zonal quantities.

Figure 4.2
Planned Urban Land

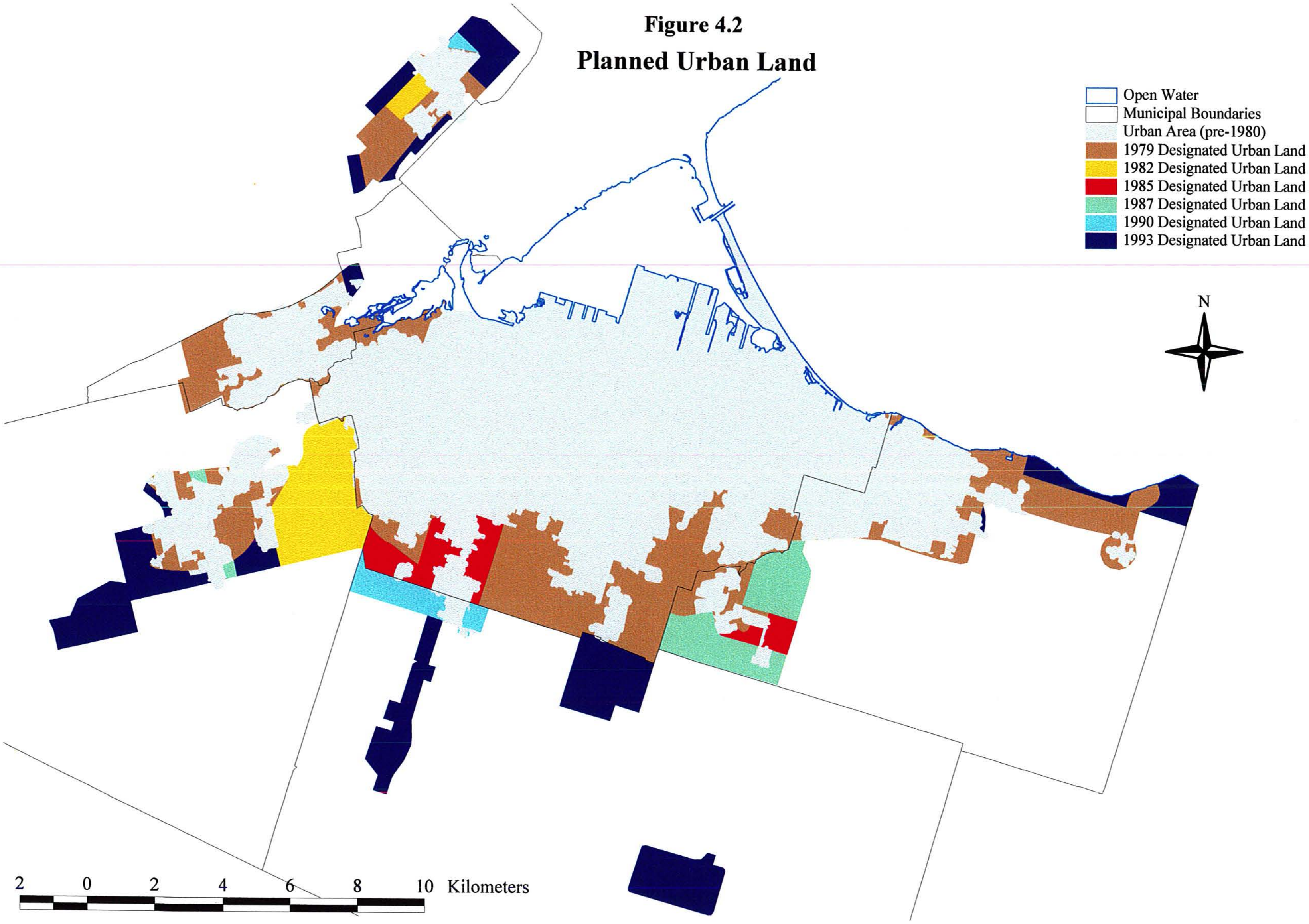


Figure 4.3
Natural and Environmentally Significant Lands

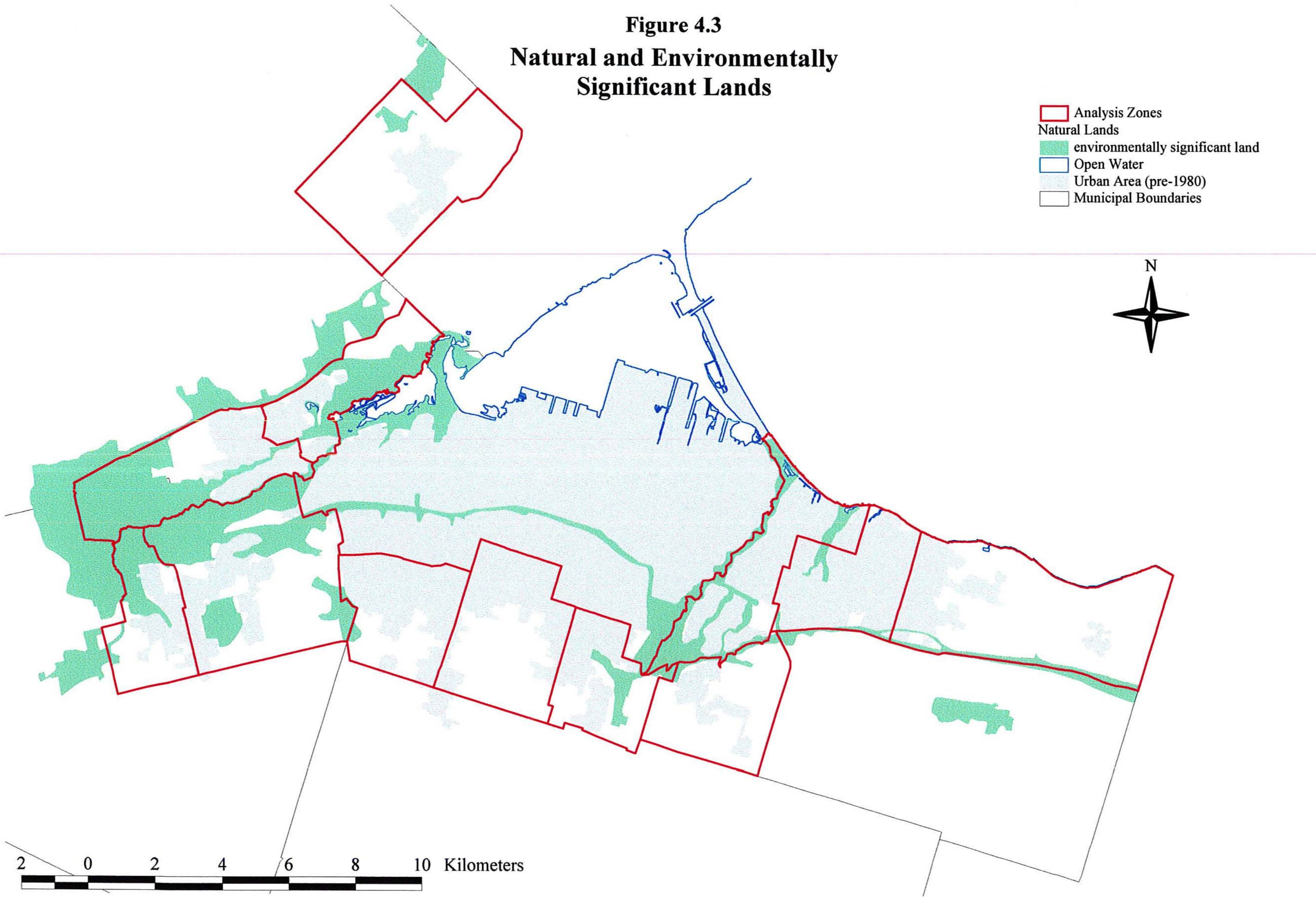


Figure 4.4

Stream Buffers and Wooded Areas

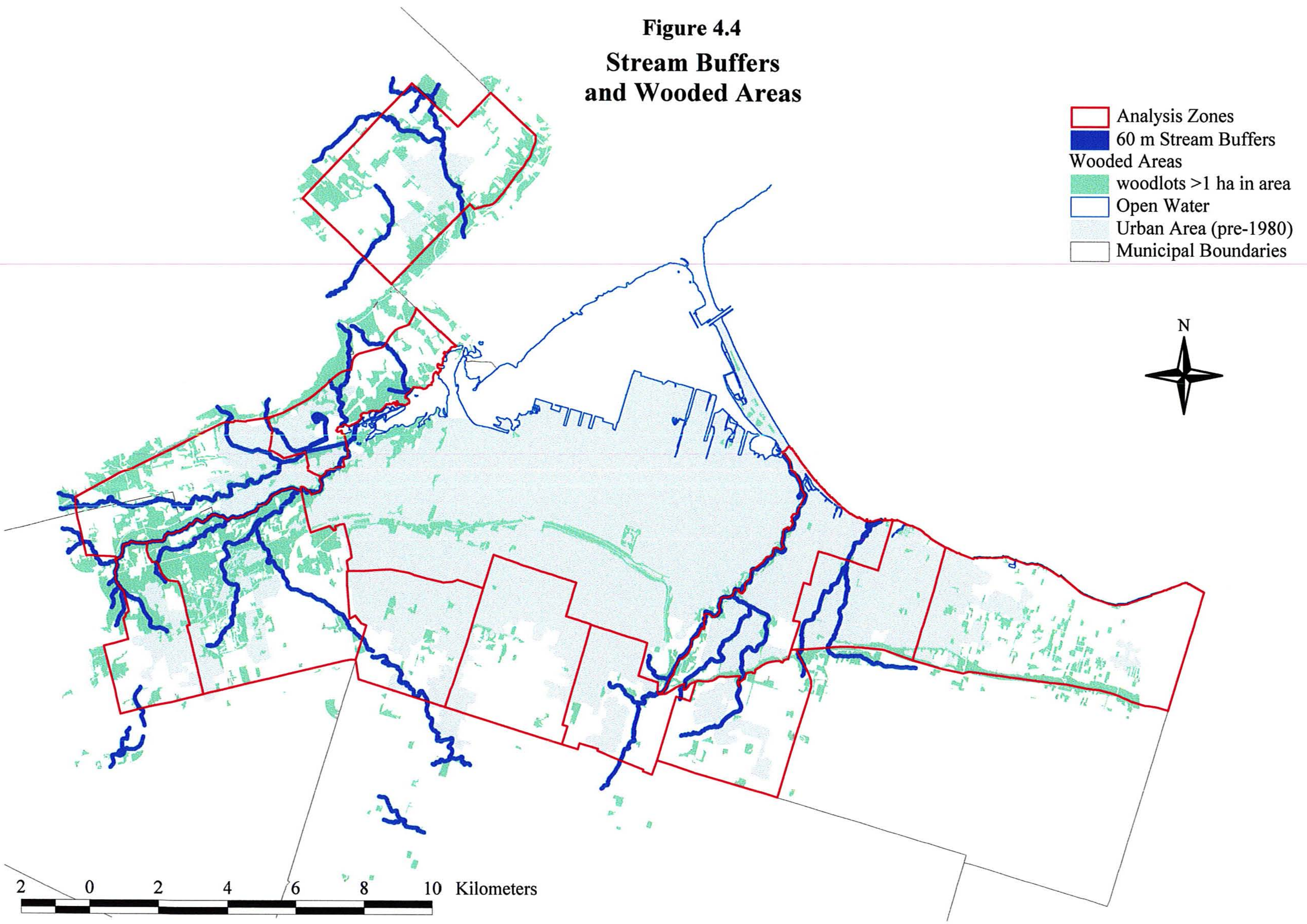


Figure 4.5

Other Non-Residential Lands

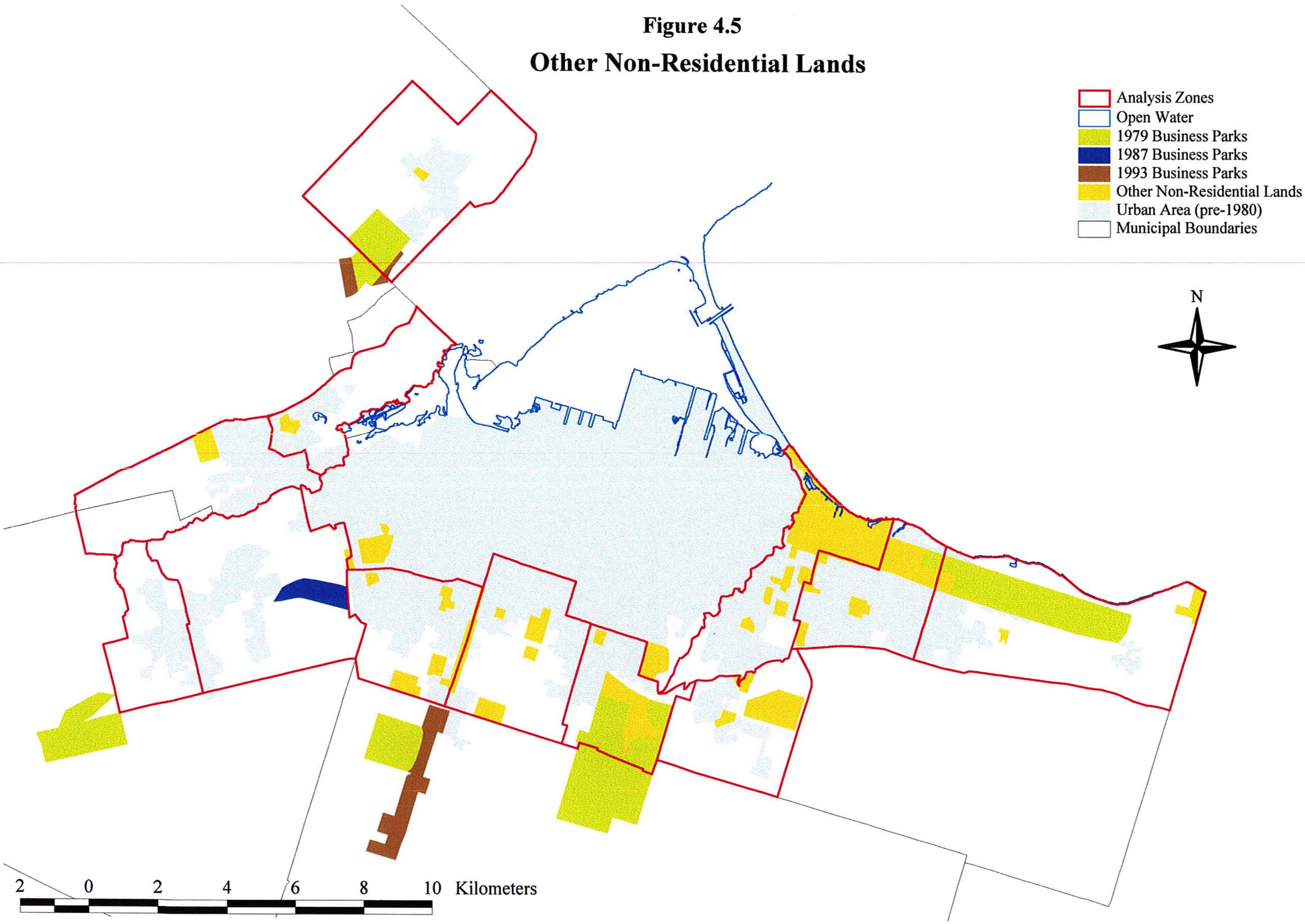
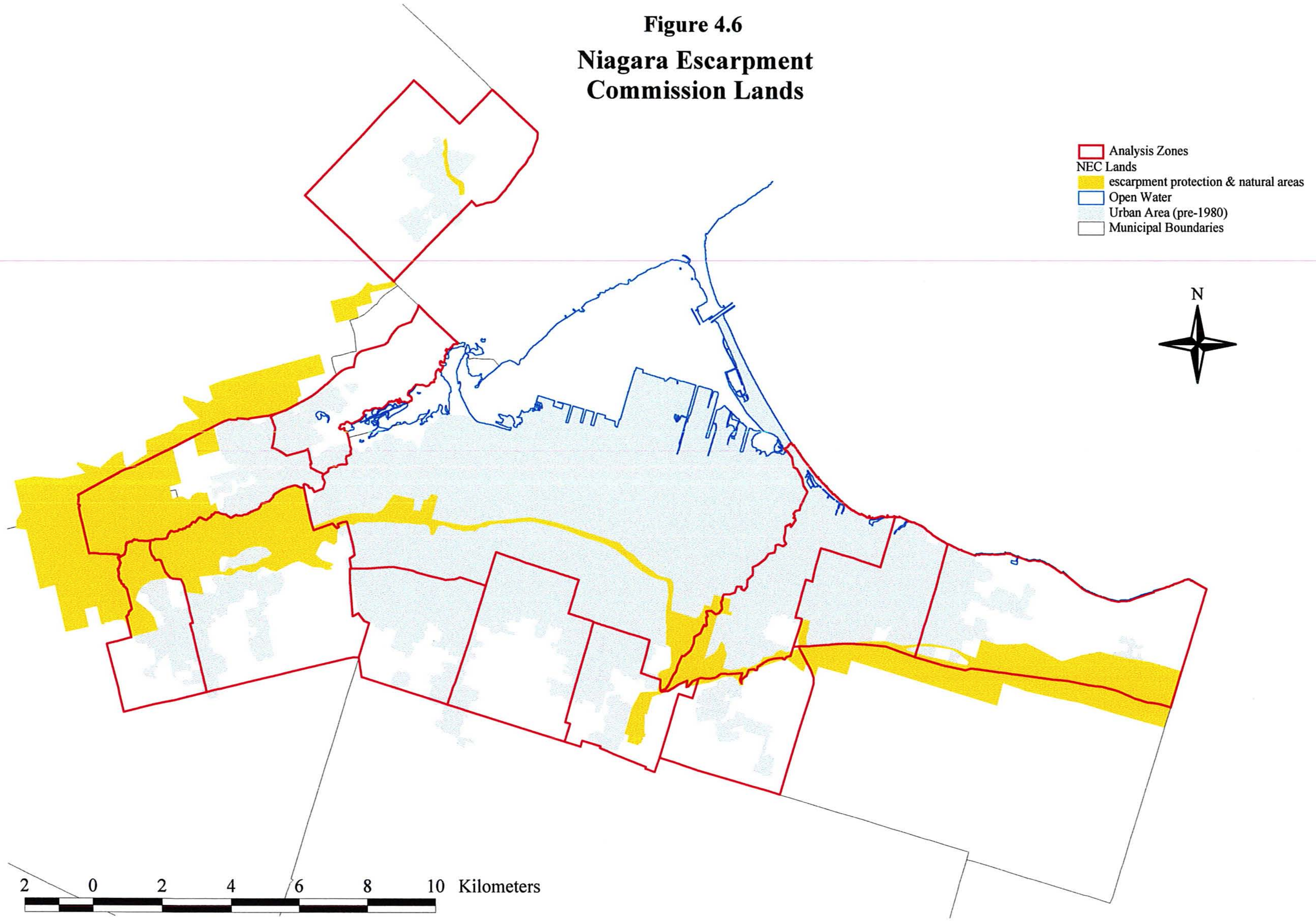


Figure 4.6
Niagara Escarpment Commission Lands



It is hypothesized that areas with more developable land are more attractive to future development, because there is less restriction on choice and more room for growth. Several variables were tested:

DEV_UN	- the developable area, without accounting for natural areas or NEC lands
DEV_PART	- developable area, accounting for natural lands but not woodlots or NEC lands
DEV_TOT	- developable area, accounting for all natural and NEC lands
NATURAL	- area within natural or environmentally sensitive lands (used with *DEV_UN*)
WOODLOTS	- area of woodlots greater than one hectare in size (used with *DEV_UN*)

4.3.2.3 High-Speed Road Variables

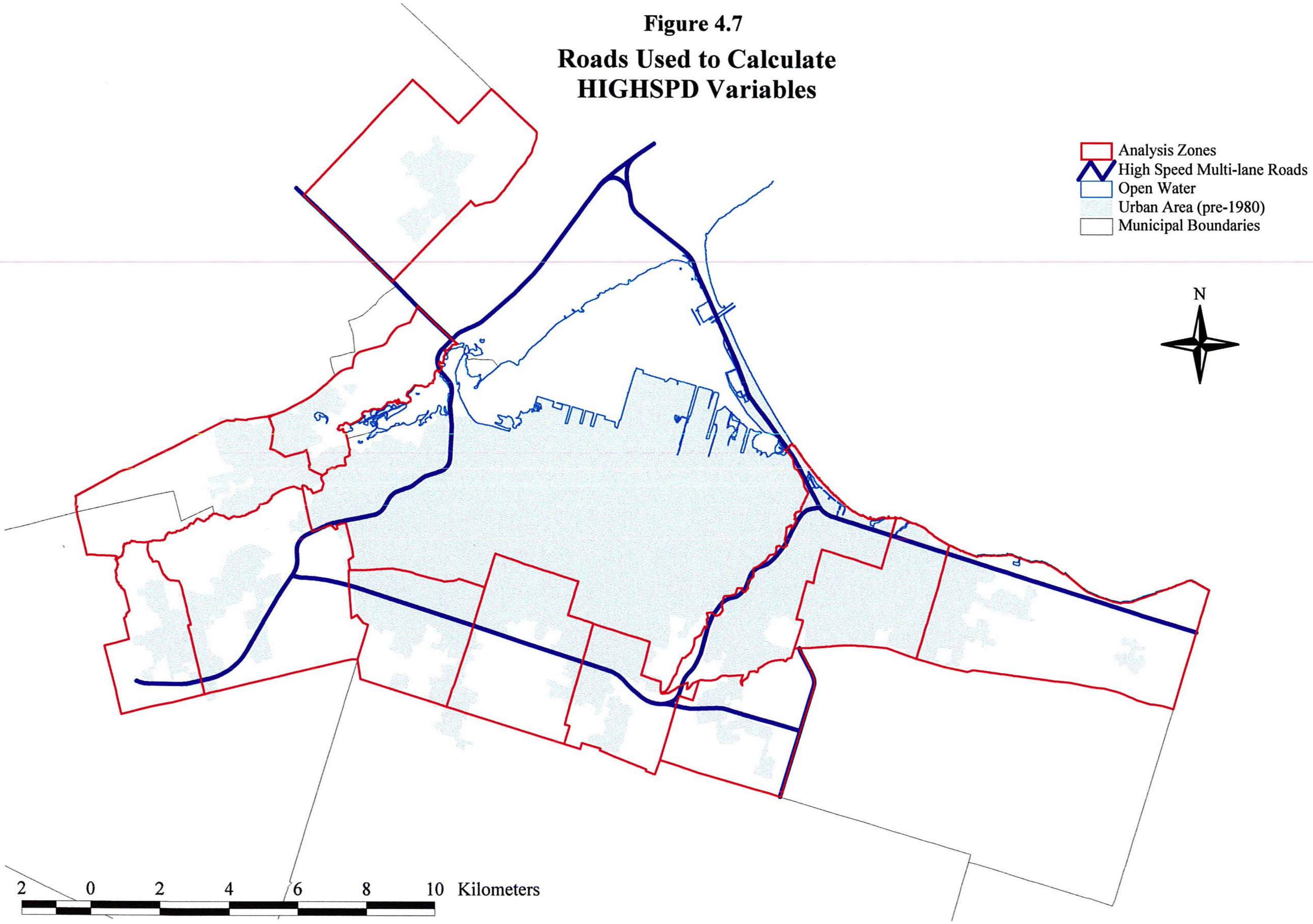
The impact of the road network on development is a very important consideration. Arterial roadways are the main accesses to sub-sections of the urban area. Arterial roads with high speed limits are generally used to access more distant locations in a region. It is reasonable to predict that those areas with more of such roads will have more development, simply because access to and within them should therefore be theoretically easier and faster, and people generally prefer to minimize the time it takes to get between two places, especially where it concerns a commute to work.

The local network was used to calculate the length of high speed multi-lane roads per zone (see Figure 4.7). OBM data for roads was used as the basis, with digitized additions where required. The Red Hill Creek Expressway was one such addition, and is a roadway that has been in debate for decades. Proponents have argued that it is necessary to improve access to the city's south-eastern portion and promote urban growth; opponents cite environmental concerns and the destruction of a major natural corridor in their condemnation of the road. The Expressway, while not built during the time series of this analysis (and in fact only the corridor above the escarpment was complete by late 1997) has been a major planning consideration of the Region for quite some time - land for the east-west portion was set aside long ago and urban growth allowed on either side of the right of way. Thus it was deemed necessary to include it in calculations.

HIGHSPD	- kilometres of multi-lane roads with speed limits greater than 80 kph
HIGHSPD2	- kilometres of 80+ kph multi-lane roads, not including the Expressway
HIGHSPD3	- kilometres of 80+ kph multi-lane roads, including the Expressway but not the Mud Street access into Stoney Creek

Figure 4.7

Roads Used to Calculate HIGHSPD Variables



4.3.2.4 Accessibility Variables

These variables measure the accessibility of each zone to employment zones and central areas. The Regional planning department has split the region up into areas which are termed planning units, which are basically sets of zones which denote local neighbourhoods in the city. These units are used to keep track of various statistics, among which is employment. The neighbourhoods are then aggregated up to larger zones called planning divisions, which represent larger areas of the city (see Figure 4.8). To accurately gauge accessibility to employment, the centroids of the divisions were used to calculate distances between each planning division and the centroid of each analysis zone. Furthermore, it was decided not to simply use the Cartesian centre for each division, but to calculate a spatial mean to more accurately reflect the "centre" of employment in each division. The planning department periodically performs surveys of employment across the Region, and the 1990 employment survey contained coordinates for each firm in the survey. These data were used to calculate the spatial means; coordinates were weighted by firm employment in the calculation. While this may provide a fairly accurate representation for the year of the survey, it should be recognized that employment changes over time and it is unlikely that the spatial means remain static over the long term. However, due to a lack of earlier employment survey data, it was necessary to assume a constant location for each calculated centroid. It was also necessary to include the city of Burlington, in recognition of the fact that many people from the region commute to that city for work and use of its amenities. A single point location was used to represent that city.

Central places were arbitrarily assigned based on what are "centres" of commercial activity. Precedent was set by the planning department, which has designated what it terms *regional centres* in its official plans. These were used to specify 9 point locations, which were further divided into "high" and "low" order - the former denoting main commercial centres providing a wide variety of services, the latter describing local cores providing basic services. Among the high-order were downtown Hamilton, Limeridge Mall, Eastgate Square, and Burlington Mall. The low-order included the suburban downtown cores of Ancaster, Dundas, Stoney Creek, and Waterdown, as well as Hamilton's Centre Mall.

Accessibility can be measured two ways: as a simple distance, or as a distance weighted by some measure of attraction. It can also be measured along a road network, or as a straight line distance. Network distances were measured using Arc/INFO along a digitized representation of the major arteries of the Hamilton area, to which zone centroids were attached (see Figure 4.9). Euclidean distances were also calculated using the GIS software.

The distance measures were simply calculated as a sum of the distances from each analysis zone centroid to the destination points (either employment centroids or central places). Thus, zones with larger distance measures can be considered less accessible. Weighted accessibilities were calculated using the following equation:

$$accessibility = \sum_{j} \frac{weight_j}{distance_{ij}} . \qquad [4.12]$$

For employment accessibility, the weighting is the total employment of planning division j. Employment data were available for several years during the time series, therefore for a particular year the weighting is employment from the closest yearly published data. The weighting for the central places was arbitrarily set at 2 for high-order and 1 for low-order, though it is uncertain whether high-order centres are actually twice as attractive as low-order central places. The resulting value for accessibility will be higher for more accessible zones, since the weighting has a positive effect on accessibility, while the distance has a negative one. It was predicted that zones with greater accessibility (or smaller total distance values) will be more likely to be developed - thus accessibility variables should return positive parameters, while distance variables should return negatives.

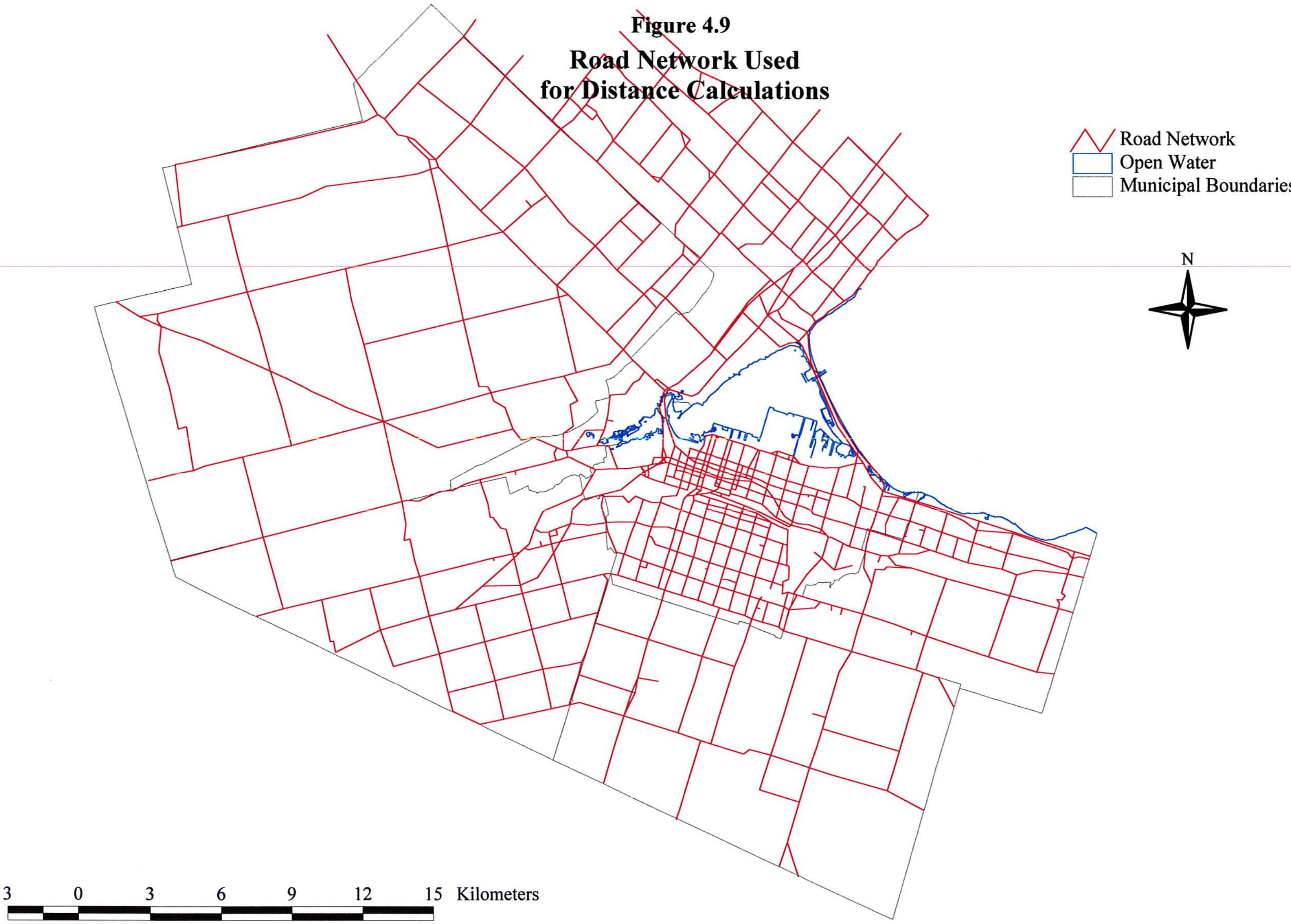
EMP_NET	- network distance to employment centroids
EMP_EUC	- Euclidean distance to employment centroids
CENT_NET	- network distance to central places
CENT_EUC	- Euclidean distance to central places
HIGH_NET	- network distance to high-order central places
HIGH_EUC	- Euclidean distance to high-order central places
ACCEMP_N	- network accessibility to employment centroids
ACCEMP_E	- Euclidean accessibility to employment centroids
ACCENT_N	- network accessibility to central places
ACCENT_E	- Euclidean accessibility to central places

Figure 4.8

Planning Divisions

Figure 4.9

Road Network Used for Distance Calculations



4.3.2.5 Census Variables

To account for the demographic variations which may influence development, census data from Statistics Canada were used. As previously mentioned, zone boundaries were delineated to account for census tracts, eliminating the need for splitting and estimating data for partial tracts. Observations during inter-censal years were given data from the closest census year. All averages were weighted by family or household population, and currency amounts adjusted for inflation and reported in 1993 dollars.

It was expected that the growth rate would have a positive effect on the likelihood of development (as in the contagious affect described previously). It was also expected that developers would be more likely to choose areas with a high percentage of home ownership, and a high percentage of families. Such areas would be associated with less risk, because the likelihood of being able to sell a home there once it is built is greater. The signs of family and household size variables cannot be predicted; the choice of zones with high or low average size would largely depend on the market the builder intends to serve. All of the value and income variables are hypothesized to have positive parameters - areas with high income or high value of housing would probably be associated with greater financial returns, though this would depend to a great degree on builder costs, for which we have no information.

GROWTH	- population growth rate (as a percentage)
PCTOWN	- percentage of dwellings that are owned
PCTFAM	- percentage of households that are families
HHLDSIZE	- average household size
FAMSIZE	- average family size
VALUE	- average value of dwelling
PAYMENT	- average monthly payments of dwelling owners
AVGFAM	- average family income
MEDFAM	- median family income
AVGHHLD	- average household income
MEDHHLD	- median household income

4.3.2.6 Alternative Specific Variables

The choice of location within the urban area, or where to build a subdivision, has an impact on the form of the end product. This is so for several reasons: zoning constraints will place restrictions on densities or lot sizes; the amount of available land or the size of the parcels available for development will limit the total area of the subdivision, and depending on allowable densities, the number of units built; and the type of housing within the new subdivision may depend on what kinds of dwellings pre-exist in an area if the local government desires to maintain a continuity of housing styles. However, the reverse could also hold true and it may be valid to state that the type of development proposed has some affect on the choice of location. For example, builders of large or expensive single family dwellings would be more likely to choose areas into which their homes would be a better fit, just as developers who concentrate on high-density multiple unit housing would be more likely to select sites more appropriate to that type of construction. Therefore, to test whether choice of zone is dependent to any degree upon characteristics of the subdivision itself, a set of alternative specific variables was included.

Alternative specific variables are set up in much the same way that a set of zonal dummy variables for the choice set would be. Instead of a having a value of one or zero for each zone, each categorical variable takes on a value representing some attribute of the subdivision, and zero otherwise. The result is a categorical variable for each alternative in the choice set. In the case of this model, there will be 12 possible alternative specific variables for each subdivision attribute tested, though the maximum number allowable in any single specification for this data would be 11 (the variable for the remaining zone would represent the "base case" to which parameters for the others are compared).

The question these variables are meant to answer is whether specific zones are more or less likely to be chosen by subdivisions with certain qualities. One would expect that subdivisions of a given character will locate within zones that contain similar previous development. The variables for year of approval were included to see if there is any temporal bias in zone choice over the time series.

YR1 to YR12	- year subdivision was approved
UN1 to UN12	- total units in the subdivision
AR1 to AR12	- area of subdivision in hectares
DEN1 to DEN12	- density of the subdivision
SF1 to SF12	- percentage of units that are single family dwellings

4.4 Logit Estimation Results

Several dozen runs of the model were performed using LIMDEP. Initial testing involved trying to determine which variable from each grouping was most significant to the outcome of the model. Combinations of the stronger or more important variables were then tested. Alternative specific variables were added later, when it was found that only subtle improvements in the model could be achieved using zone characteristics alone. Table 4.1 details the "best" model specification that emerged from the testing, which is to say that it has good fit and the variables are significant with parameters that are explainable. Dropping alternative specific variables from the model results in a much poorer specification (see Table 4.2 on the next page).

TABLE 4.1

Discrete Choice Model Results - Best model

No. of Observations = 392

$\mathcal{L}$**(0)** = -974.083

$\mathcal{L}(\beta)$ = -858.997

$\chi^2 = 230.173$

$\rho^2 = 0.11815$

$\bar{\rho}^2 = 0.10788$

Variable	Coefficient	t-ratio	Prob(t)	Elasticity
DEN_MT	0.10248	7.777	0.00000	0.677
DEN2	-0.17483	-3.427	0.00061	-0.028
DEN5	-0.11343	-3.581	0.00034	-0.075
HIGHSPD	0.06600	2.612	0.00900	0.255
PREVUNIT	0.00082	2.569	0.01021	0.128
DEV_PART	0.00097	3.718	0.00020	0.213
NATURAL	0.00061	2.099	0.03584	0.104
EMP_NET	0.00309	2.937	0.00332	1.192
FAMSIZE	-2.48540	-3.815	0.00014	-6.975
PAYMENT	0.00303	2.809	0.00496	2.007

Almost all of the signs of the coefficients came out of the estimation as expected, and are significant to the level of 5%. DEN_MT is a combination of DEN6, DEN7, and DEN8, which represent the zones on top of the escarpment in the City of Hamilton. The decision to combine them was made because when run separately the parameter values were very close for those three alternative specific variables. DEN2 and DEN5 represent alternative specifics for sections of the towns of Dundas and Ancaster. The zones encompassed by DEN_MT have a higher density on average; the positive sign reflects that higher density subdivisions tend to locate there. DEN2 and DEN5 represent zones with low density; the negative sign here reflects a lack of choice of those areas by higher density subdivisions. These variables may imply that density is determined prior to the final choice of location, but in reality it is more a function of area planning restrictions, so densities are set once the subdivision location is decided.

While the DEN alternative specific variables were not the only set that worked, they were generally the strongest and made the most improvements in the model. They are also the most explainable. The YR variables were also tried, but the yearly trends in development do not generally increase or decrease for every zone throughout the time series (there is an increase in subdivision approvals during the mid-years, then a decrease into the early '90s for several of the zones). Alternative specific constants were tried, but the DEN variables outperformed them as well. The other variables are less explainable. Their addition also tends to create collinearity problems which affect other variables important in the model, without adding very much to the fit.

TABLE 4.2

Discrete Choice Model Results - Alternative specific variables dropped

No. of Observations = 392
$\mathcal{L}$**(0)** = -974.083
$\mathcal{L}(\beta)$ = -917.234
χ^2 = 113.698
ρ^2 = 0.05836
$\bar{\rho}^2$ = 0.05118

Variable	**Coefficient**	**t-ratio**	**Prob(t)**	**Elasticity**
HIGHSPD	-0.03285	-1.398	0.16197	-0.130
PREVUNIT	0.00148	5.016	0.00000	0.261
DEV_PART	0.00084	3.722	0.00020	0.194
NATURAL	-0.00066	-2.852	0.00435	-0.114
EMP_NET	-0.00116	-1.301	0.19333	-0.457
FAMSIZE	0.76084	1.493	0.13540	2.192
PAYMENT	-0.00138	-1.520	0.12846	-0.932

Most of the remaining variables have positive signs on their parameters. Therefore, we can state that the likelihood of choosing a specific zone is greater if it has more kilometres of high-speed roads, if there was a high quantity of development the previous year, if there is more developable land in the zone, and if the zone exhibits high monthly housing payments.

NATURAL was included as an amenity. While natural lands are considered in the calculation of developable land, all things being equal people would prefer to live in areas that have greater amounts of parkland or green space; builders would probably have more success selling homes in such areas, thus the positive coefficient reflects increased likelihood of choosing to construct in zones with more natural land.

TABLE 4.3

Discrete Choice Model Results - Accessibility replaces distance

No. of Observations = 392
$\mathcal{L}(\mathbf{0}) = -974.083$
$\mathcal{L}(\boldsymbol{\beta}) = -860.5339$
$\chi^2 = 227.0989$
$\rho^2 = 0.11657$
$\overline{\rho}^2 = 0.10630$

Variable	**Coefficient**	**t-ratio**	**Prob(t)**	**Elasticity**
DEN_MT	0.09752	7.558	0.00000	0.642
DEN2	-0.19757	-3.807	0.00014	-0.030
DEN5	-0.11726	-3.704	0.00021	-0.077
HIGHSPD	0.09977	3.358	0.00079	0.386
PREVUNIT	0.00087	2.738	0.00618	0.135
DEV_PART	0.00074	2.815	0.00488	0.162
NATURAL	0.00042	1.430	0.15271	0.071
ACCEMP_N	-0.00005	-2.273	0.02302	-1.114
FAMSIZE	-2.84710	-4.313	0.00002	-7.998
PAYMENT	0.00219	1.805	0.07102	1.448

One would have expected EMP_NET to be negative; that builders would choose the most accessible zones (with smaller average distances to employment) first. However, the positive sign here can be explained. Development generally moves from the interior of the city outward. This makes peripheral areas with relatively poor accessibility more attractive over time simply because the more accessible locations have already been chosen. When DEN_MT is left out of the model, the sign on the distance variable becomes negative, but the fit of the model drops considerably. Complicating the issue is that almost 50% of all subdivisions were approved in three zones (6, 7, and 8) that tend to have relatively good accessibility, so an examination of the data does not provide a clear explanation for the sign on the distance variable. Inclusion of accessibility in place of distance results in a similar model (see Table 4.3 on previous page) with a negative sign for ACCEMP_N, but other variables such as PAYMENT and NATURAL become insignificant so there is likely some collinearity. The more basic distance variable is probably the better one to use for the sake of simplicity. Accessibility is more difficult to explain because it accounts for employment which changes over time.

FAMSIZE is an interesting variable. While there was no expectation as to the sign of its coefficient, the negative makes some sense. People tend to buy their first home before having children or while their children are very young. As the children get older, the mobility of the family declines, and they are less likely to move. The implication of this for the housing market is that young families or newlywed couples must constitute a large percentage of the buyers of single family dwellings. Also, all other things being equal, a family would probably prefer to locate in an area where they would have something in common with their neighbours, such as being of similar age or family status, or where there are amenities suited to families with small children (such as schools). Therefore, if builders are providing most of their houses for young families, there is an impetus to construct homes in areas that are already dominated by households with young parents and few children. It is difficult to provide a statistical argument here - family sizes are not reported by age of the head of the household. An attempt at correlating family sizes in the zones and census tracts with percentages of people aged 25 to 34 (the age at which most people likely marry and start a family) revealed no significant correlation.

What is known is that average family and household sizes have been declining over time; a reflection of the fact that couples are having fewer children, but there has also been a great increase in non-family households due to higher incidences of divorce and bachelorhood during the past several decades (Miron, 1988 and 1993). Chinitz (1991) reports that suburban areas have been attracting the smaller households faster than they have the large families. The implications of this are that average family and household sizes in the expanding urban fringe areas should be smaller, and this is likely being manifested through the negative parameter for FAMSIZE. It should be pointed out that HHLDSIZE also turns out negative if it is included instead, but it is a marginally weaker variable than FAMSIZE in terms of how it performs (see Table 4.4 below).

TABLE 4.4

Discrete Choice Model Results - Household size replaces family size

No. of Observations = 392

$\mathscr{L}(\mathbf{0}) = -974.083$

$\mathscr{L}(\beta) = -860.298$

$\chi^2 = 227.571$

$\rho^2 = 0.11681$

$\bar{\rho}^2 = 0.10655$

Variable	Coefficient	t-ratio	Prob(t)	Elasticity
DEN_MT	0.10573	7.650	0.00000	0.699
DEN2	-0.16712	-3.310	0.00093	-0.027
DEN5	-0.10062	-3.283	0.00103	-0.068
HIGHSPD	0.06149	2.443	0.01456	0.238
PREVUNIT	0.00085	2.666	0.00767	0.133
DEV_PART	0.00096	3.716	0.00020	0.212
NATURAL	0.00060	2.058	0.03963	0.102
EMP_NET	0.00375	3.503	0.00046	1.448
HHLDSIZE	-1.27560	-3.530	0.00042	-3.389
PAYMENT	0.00225	2.318	0.02045	1.487

To simplify things and report a single elasticity for each variable, the aggregate elasticities were calculated and then averaged over the 12 zones (weighted by the number of times each zone was chosen by a subdivision). Most elasticities range below a magnitude of 1, but the demographic variables have considerably larger values. PAYMENT shows that for a 1% increase in the amount homeowners pay for housing in a zone, there is a corresponding increase of just over 2% in the probability that the zone will be chosen by a developer. FAMSIZE has the greatest elasticity of all: a 1% increase in average family size in a zone decreases the probability of choice by 7.4%.

As a better measure of how the model predicts choice behaviour for specific elements of the choice set, it was useful to look at the predicted choice probabilities as they compare to the observed (see Table 4.5 below). Since the observed values are either a 1 or 0, the average fitted probabilities for each zone were compared to the proportion of times a zone was actually chosen, calculated from the frequencies of zone choice (for example, Zone 7 has an observed value of 0.240, meaning it was observed to be chosen by subdivisions 24% of the time, or 94 times out of the 392 records in the data). Most of the differences are relatively small. There appears at first glance to be a slight spatial bias, with more zones in the western section of the urban area being under-predicted and the majority of eastern zones over-predicted. However, the zones with the largest differences between predicted and observed probabilities are not bunched together. These residuals do not seem to be temporally biased either when the probabilities are examined on a year to year basis.

TABLE 4.5
Average Zone Choice Probabilities - Best model

Zone	1	2	3	4	5	6	7	8	9	10	11	12	all
N(I)	28	7	21	20	27	55	94	39	24	18	20	39	392
Obs	.071	.018	.054	.051	.069	.140	.240	.099	.061	.046	.051	.099	1
Pred	.079	.011	.069	.048	.053	.117	.249	.118	.064	.060	.038	.095	1
P-O	.008	-.007	.015	-.003	-.016	-.023	.009	.019	.003	.014	-.013	-.004	

It is difficult to explain why these differences exist. One possibility is administrative in nature: perhaps local planning departments have encouraged development in a certain area over another, though both were ready to accept new housing at the same time. The lack of detailed servicing data could also be a problem. While it has been assumed that most of the urban area is serviceable and can support development, extensions to water and sewage lines are not continuous over time, and are sometimes dependent on budgetary constraints or even opinion concerning local growth trends. There have been cases where developments have been put on hold pending increases in service capacities. Without more specific data these instances are unknown for the purposes of the model.

Also of note is how transportation routes constrain development. While the Red Hill Creek Expressway has been planned by the Region and its predecessor for years, development in the south-east corner of the city has been limited or allowed to occur slowly until the expected completion of the roadway. It is interesting to note that development choice in each of zones 7 through 10 is over-predicted. The bulk of the expressway runs through those zones. Since the road was not actually in existence during the years of this study, it is possible that such growth limits have held back development until the road is built. This could be what is reflected in the comparison of observed and predicted probabilities.

To test for possible effects due to the expressway, a model was run with it excluded from the data. Tables 4.6 and 4.7 on the next page display results for a model that leaves the expressway out of the calculation for high speed multi-lane roads (it uses HIGHSPD2 in place of HIGHSPD). Zones 7 and 8 are still over-predicted in this specification, but to a lesser degree. Curiously, the over-prediction of zone 10 increased. While the overall fit of the model is better without the expressway present in the data, there is a strong argument for its inclusion because it has been a dominant planning issue for so long. Zones 5 and 6 are under-predicted by the model. That area has become one of the fastest growing in the region, so there are likely effects which are not being captured by the variables in the data set. The major factor which has probably influenced this growth planning related - large quantities of land have been designated as available for development there during the latter half of the time series. Zone 5 contains the Meadowlands development, which is often mentioned in local media and has been widely promoted by the developers that are building there. Perhaps there has been some political coercion toward developers to choose that area. The zones are also aesthetically attractive, and have very good accessibility due to the presence of Highway 403. The impact of this highway on development is probably not adequately accounted for in the data. Perhaps there are multiplier effects associated with proximity to certain major transportation routes, and they do not show up in simple distance measures such as the HIGHSPD variable. As mentioned in the literature review, the Hamilton region could become a recipient of housing demand generated by Toronto. An out-of-town developer would be very attracted to an area such as this with excellent highway access to the larger city, but without knowing which firms have actually been building there this line of thinking is speculation at best. Zone 11 could be under-predicted for the same reason, only the QEW is the major access in that case.

TABLE 4.6

Discrete Choice Model Results - Expressway dropped from data set

No. of Observations = 392

$\mathcal{L}$**(0)** = -974.083

$\mathcal{L}$**(β)** = -855.415

$\chi^2 = 237.338$

$\rho^2 = 0.12183$

$\bar{\rho}^2 = 0.11156$

Variable	Coefficient	t-ratio	Prob(t)	Elasticity
DEN_MT	0.11143	8.091	0.00000	0.741
DEN2	-0.19502	-3.737	0.00019	-0.030
DEN5	-0.15015	-4.193	0.00003	-0.092
HIGHSPD2	0.15413	3.754	0.00017	0.296
PREVUNIT	0.00085	2.656	0.00790	0.133
DEV_PART	0.00084	3.157	0.00160	0.182
NATURAL	0.00078	2.580	0.00989	0.131
EMP_NET	-0.00015	-0.110	0.91248	-0.056
FAMSIZE	-2.41470	-3.928	0.00009	-6.757
PAYMENT	0.00307	2.928	0.00342	2.024

TABLE 4.7

Average Zone Choice Probabilities - Expressway dropped from data set

Zone	1	2	3	4	5	6	7	8	9	10	11	12	all
N(I)	28	7	21	20	27	55	94	39	24	18	20	39	392
Obs	.071	.018	.054	.051	.069	.140	.240	.099	.061	.046	.051	.099	1
Pred	.079	.011	.063	.045	.056	.122	.245	.112	.066	.066	.038	.099	1
P-O	.008	-.007	.009	-.007	-.013	-.019	.006	.012	.004	.020	-.013	-.001	

4.5 Conclusion

What is missing from the model? One point to be made concerns developable land - in some zones much of that land is available in large contiguous tracts, while in others it is available in dispersed patches mixed among previously developed or non-residential land. Perhaps zones with large "greenfield" sites are more attractive because they allow developers more leeway in terms of subdivision design. Zone 10 is an example of an area where land is available in small parcels among pre-existing housing, and its choice probabilities are over-predicted. Zones 5 and 6, which have had relatively large tracts of developable land, are under-predicted by the model. How this may be quantified is a good question.

Another missing element concerns staging of individual subdivision production. In many cases, developments are phased by a builder for reasons such as consumer demand, or limitations of financial or construction resources. If a developer has a subdivision approved as the first phase of several, then a future location choice of that same developer has essentially been pre-made, since the initial phase will inevitably be added to over time (assuming the same developer completes the succeeding stages). Even if a subdivision is approved, changes in the economic fortunes of the developer or market fluctuations could delay construction, though it is fairly rare that the housing would not eventually be built, probably due to the large investment made by firms in the planning and approval process.

A related issue is the effect of oligopolistic behaviour on development in the urban area. If there are relatively few large developers that dominate the local building industry, what affect would this have on choice? This analysis considered each subdivision choice to be an individual one - it is an implied assumption that zone choice is unrelated to the choices made by other developments. This was necessary because there was no information regarding the identities of the subdivision developers. If there are few developers who divide the lion's share of land amongst themselves, then it would likely be wise to consider some attributes of the firm in the model. If the firm has a lot of capital available to back their developments, then the choice of whether to develop at all is probably greater. If they've been extensively building in particular areas, then they could be more likely to continue developing there if the land is available, or less likely if the development capacity has been exhausted. There is also the question of whether there might be any spatial collusion with other developers. Agreements to restrict activity to specific sections of the city would make the choice sets different for each firm.

The main thing missing from the data is information about land ownership. Development cannot occur unless the land is in the hands of the developer. The choice set of a particular development company is in reality constrained to areas where they own land. It is unlikely that smaller developers would be able to choose from among all 12 zones because they probably do not own land in each. While large developers are likely to own more land in more areas of the city, it is by no means certain that their holdings are evenly distributed spatially, which would affect their choice set as well. However, there are complications involved in adding ownership information that make it an arduous task. It would require tracking parcels of land as they change hands over years and perhaps decades. Beyond the time it would take to collect such data, there are questions regarding how to judge whether land was being held in speculation, or just kept vacant until development was feasible. There is also the problem of land changing title between firms owned by a common parent company.

Although these may seem like large problems, would it not make sense to say that purchase of land with the intent to build on it is a location choice in itself? While buying the land by no means guarantees its eventual development (because it would occur before the draft plan of subdivision would even be created, let alone submitted for approval), a development firm is unlikely to be willing to pay for something it does not intend to use. It is also doubtful the firm would obtain land that cannot be developed, or that is in a poorly marketable location. The large expenses associated with land acquisition would also be a big incentive to build sooner rather than later, if only to ensure a quicker return on the firm's investment.

Conclusion

This research has covered three main areas of analysis. The first, regarding the temporal and municipal variation in local subdivision activity, was outlined in a descriptive manner but did reveal patterns in the data. Most developments were found to be small in terms of their area and the number of units they contain. There appears to be a long-term increase in average densities over the time series. The quantity of development in a given year shows a distinct cyclical pattern which seems to correlate very well with fluctuations in economic indices at the local and provincial levels.

The second line of inquiry looked at spatial variation in subdivision density. Regression analysis showed that density is negatively related to a development's distance from an arterial road. The increase in density over time was explainable by the year of subdivision plan approval. Local variation in density could also be related to census variables such as the average household size and income of an area, as well as a set of categorical (or 'dummy') variables for the location of each subdivision with respect to municipality, and whether it was approved for construction in a rural or urban area.

The final testing involved the use of a logit model to explain the choice of location by developers among a set of zones which contained most of the land available for development in the region. A set of spatial variables were constructed for the choice set, and it was found that there was a greater probability for subdivisions to locate in zones that had more high-speed roads, more developable and natural land, and greater quantities of previous development. Zone choice was negatively affected by distance to employment and the average size of the families living there, and positively related to the size of the average monthly dwelling payment made by homeowners. Density of the subdivision was also found to have an important influence on the probability of locating in a given zone through the use of alternative-specific density variables.

Given that there has been relatively little analysis of housing at such a small geographical scale, and a lack of supply-side residential modelling in general, it is hoped that these results are a step toward alleviating the deficiencies of the literature. This research shows that there is great value in examining land use at a disaggregate level over a longer time series, rather than taking the 'snapshot' approach common to many analyses. The regressions for density provide results that are more substantive than those of previous studies, which have tended to be theoretical in nature, and can be used as a starting point for further investigation.

This thesis has also established that planning data can be successfully introduced into a spatial analysis. There has been some skepticism on the part of planners over whether a process as heavily regulated and constrained as development can be characterized through empirical analysis. The logit results show that it is possible, at least to some degree, to explain patterns of local development. They also demonstrate that there is utility in using logit theory as a methodological basis for analyzing urban growth. By assuming that each subdivision is the outcome of a choice made by a developer, this work offers a novel approach to the way the development process can be modelled.

The research revealed a need to add more information to the data sets used in each analysis, to try and provide results that are more conclusive. A larger data set would probably have been of the greatest value. The length of the time series imposed a limitation regarding any empirical investigation into the effects of economic cycles on the quantity of yearly activity. This could also be alleviated if enough relevant data could be found at the monthly or quarterly level. Additional yearly data would also have been useful for the logit and density analyses. It would have provided a more complete picture of the development pattern of the region by allowing investigation of a longer period in the evolution of the urban area. Although sample size was not an issue with either of the latter two sets of tests, a lengthier series could also be more readily split into intervals to examine whether relationships to independent variables change over time.

Greater quantities of data would also have been preferable in a spatial sense. While the Hamilton area is a distinct housing market, it is also a part of a much larger urban system that includes cities located all around the western end of Lake Ontario, from Toronto to Niagara Falls. It would have been useful to look at whether the factors that were found to be significant in Hamilton are also important in other cities. Growth in the

Greater Toronto Area has been much more rapid, and has occurred on a more consistent basis than it has in Hamilton-Wentworth. This has probably resulted in a more competitive land market, with greater demands placed on planning regulations and servicing. It would have been interesting to examine how this has affected development trends in the GTA. Another appealing question that a larger spatial data set could answer would be whether there is any degree of dependency between development in the Hamilton market and the conditions of its larger neighbour to the east.

The density analysis requires some statistical testing for spatial autocorrelation. Several suggestions for additional variables were put forth, including better information regarding local zoning, land prices, and some type of measure to capture the tendency for neighbourhoods to have relatively homogeneous densities. It would have been useful to test for sprawl, to see whether infill developments really do exhibit the higher density that the literature predicts.

The logit model lacks data regarding land ownership, and the identities of the firms responsible for submitting development applications. This would allow for better definition of choice sets, since it would be possible to know where a development company owns land and where in the region it has tended to build in the past. Developer identities would also ease the assumption that each subdivision is a chooser, which was inherent (and necessary) in the way the model was set up. It would have been useful to have local land prices to see what impact cost has on choice. More comprehensive servicing data would have been useful in calculating values for developable land with a greater degree of accuracy.

One other possible line of analysis which could be pursued using this data would involve the concept of 'leapfrogging'; it would be interesting to see if there was a tendency for developers to skip over land close to the urbanized edge in favour of building on property that is deeper into the surrounding non-urban area. This would require looking at the distances of each subdivision from the urban boundary that existed at the time of their approval. The goal would be to determine whether there are any patterns to those peripheral gaps, and if there are could they be explained by factors related to economic cycles or characteristics of the area.

On a technical note, this entire line of research would not have been possible without the use of a geographic information system. It is possible that much of the criticism levelled at previous studies regarding their general lack of comprehensiveness is somewhat unfair, due to the fact that more sophisticated tools for spatial data analysis have only recently been available. Developments in software and computational ability are quickly expanding the range of research possibilities for analysts. While these tools may be accompanied by their own set of obstacles and intricacies, they are opening up new worlds that could not previously be explored by researchers. It is hoped that this work has been able to blaze a new trail in that regard.

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