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AN EMPIRICAL ASSESSMENT OF A MODIFIED CENSAL RATIO ESTIMATION TECHNIQUE

by

(C) Wayne W. McVey, Jr.

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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ABSTRACT

The objectives of this research concerned: i) the development of a modified postcensal population estimation technique, ii) the application of the technique in the preparation of small area estimates and, iii) the assessment of estimate accuracy. The requisites considered in the technique development were simplicity, efficiency, cost, reliability, and availability of a continuous series of symptomatic data.

The estimation technique developed for this research was a refinement of the housing unit method for estimating populations at postcensal dates. It is a sequential process involving two basic stages. The first stage involved the determination of a revised housing inventory for the estimate date by type of housing. In the second stage, the appropriate population ratios were used to determine population estimates by type of housing on the estimate date. This modification permitted greater sensitivity toward shifts in housing construction over the estimate period.

Indicators were assembled from building permit files for use in estimation of sixty-one Edmonton sub-area populations. Population estimates were prepared or 119

Canadian municipalities which utilized housing data made available by the Central Mortgage and Housing Corporation.

Two postcensal population estimates (modified and unmodified) were prepared for each estimate area. These estimates were then compared to the 1971 census figures for the estimate area. The differences between these estimates and actual parameters were assessed in terms of percentage error, average per cent error, and Theil's U statistic of inequality. These summary measures of error were also used to assess the accuracy of the occupied household estimates derived in the first stage of the sequential process.

It was found that the modified estimation procedure produced more accurate population estimates for all estimate areas except the study cities between 10,000 and 50,000 in population size. The modified technique yielded superior occupied household estimates for Edmonton sub-areas and central cities only. The modified procedure derived estimates with lower average per cent error for Edmonton sub-areas, central cities, and census metropolitan areas.

Estimate accuracy was examined with respect to several characteristics of the study estimate areas. Estimate error tends to increase in estimate areas having higher proportion of multiple dwelling units, smaller population size, population growth or decline, annexation experience or change in household size over the estimation period.

The research directed attention toward several methodological problems which will involve further investigation, such as completion and occupancy lag-times by housing type, influence of vacancy fluctuations and demolitions, and the validity of census data for testing purposes.

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Acknowledgment must be made to Central Mortgage and Housing Corporation and to the City of Edmonton for providing access to the data instrumental for the completion of this research. Special thanks is extended to Mr. H. D. Collins, Director of the Building Inspection Branch for his able assistance and cooperation in the collection of local building permit data.

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CHAPTER I

INTRODUCTION AND OVERVIEW

The purpose of this research is to empirically assess the accuracy of a modified censal ratio technique in the estimation of city and small area populations for postcensal dates. This will involve the development of the modified censal ratio estimation technique, the application of the modified technique to Canadian cities and sub-areas, and the assessment of the technique's accuracy.

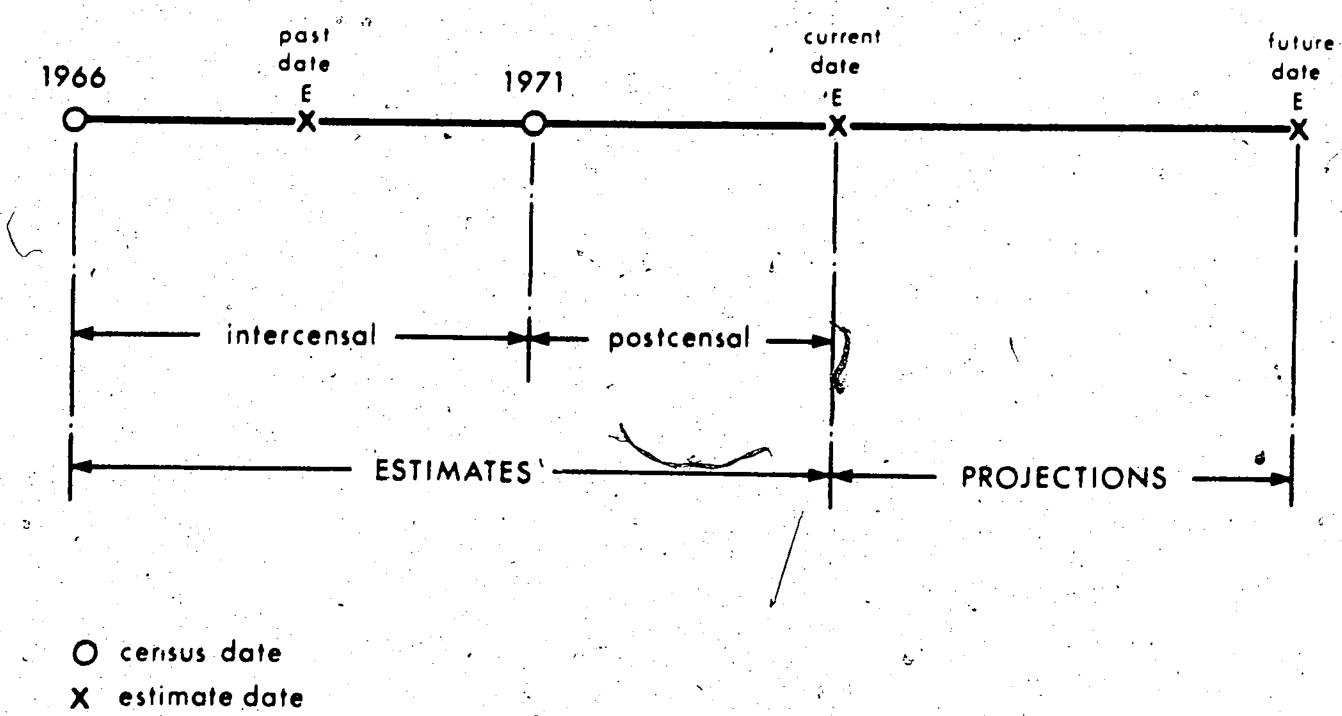
Population Estimates

The field of population estimation can be classified into three major categories: Intercensal estimation, postcensal estimation, and population projection. An intercensal estimate is a figure relating to a date intermediate to two censuses and the results of these two censuses are utilized in the derivation of the estimate. The postcensal estimate, which is the focus of the present research, is an estimate related to a past or current date following a census. The derivation of a postcensal estimate will utilize the most recent census results and possibly earlier censuses. The population projection refers to future dates for which no data are available and usually take into account past census results. (Shryock and Siegal, 1971, p. 725). For example, a population estimate prepared for June 1, 1972 would be considered a postcensal estimate, however, upon completion of the 1976 Census of Canada, an estimate for June 1, 1972 would be regarded as an intercensal estimate. A population figure derived for 1981 would be called a population projection or forecast. Intercensal estimates, can be viewed as interpolations, while postcensal estimates and projections can be regarded as extrapolations. John V. Grauman treats population estimates and projections separately, however, acknowledging their close relationship within the field of demography (Grauman, 1959, p. 544). Figure 1.1 graphically portrays the relationship of these three major categories.

Both intercensal and postcensal estimation techniques play an important role in Canada and the United States. Public health officials, market research analysts, public and private planners, and other researchers are faced with the dilemma of having excellent census data at the beginning of each census period but finding these data of limited usefulness as time progresses from the census date. This problem is further compounded when one considers

Figure 1.1

TYPES OF ESTIMATES



the existing time lag between the conduct of the census and the release of census results to the user. The population is constantly changing and even statistics for every tenth or fifth year are not adequate for most current purposes (Shryock and Siegal, 1971, p. 725).

Urban research and planning requirements are not scheduled according to census dates but must respond t current needs and future demands. Investigators in the areas of planning, health, social and consumer services, and market analysis need current data to facilitate their requirements and program evaluations. Sample surveys and complete enumerations can fulfill these current needs, however, they are often expensive, laborious, and time-consuming. Postcensal estimation techniques are designed to meet these current needs.

Knowledge of current population size of small areas or at the city level would supply a basic benchmark for the determination of space needs within the city (Chapin, 1965, p. 181). A postcensal estimation technique which can provide accurate population estimates would enable the planner and urban researcher to assess the population distribution, growth potentials in sub-areas within the city (or for the entire city), and the direction of population shifts within the city. Similarly, officials in the various municipal agencies would be able to utilize current population estimates for small areas to compute various measures, such as various vital event rates, morbidity rates, criminal and delinquency offense rates, and welfare recipient rates. Often an out-of-date census figure or a "quesstimate" is utilized in computation of rates and ratios for postcensal years.

State and provincial money is often distributed to cities on the basis of population size. Either a census or a postcensal technique is utilized to determine current populations at the city level for these allocations. The city of Edmonton's annual civic census serves in this regard. Population size, in many instances, is the whole case for state or provincial assistance -- and, it is the current size.

Research Focus

To meet the requirements outlined above, a postcensal estimation technique that can provide reasonably accurate population estimates for small areas is the focus of this research. In addition, the estimation technique should meet several criteria to heighten its utility at the small area level. First, the postcensal estimation technique should be relatively simple in concept and execution. Secondly, the basic data input should be readily accessible for the calculation of the estimates, and thirdly, the time required for the calculation of the estimate should be short.

The censal ratio technique selected for this research is a modified version of the housing unit method for estimating postcensal populations. This involves the determination of relationships between a symptomatic indicator and the population of a given area for the most recent census date. This relationship or ratio is then applied to the selected symptomatic indicator assembled over the estimate period. In this technique, housing changes over the estimate period are considered to be symptomatic or indicative of population change.

In addition, two improvements in the postcensal estimation technique are evaluated in this research. Housing completions rather than housing starts are utilized as the symptomatic data series for the preparation of city and sub-area postcensal estimates. This improvement is included in order to eliminate the time lag between a housing start and its completion. The second modification is a refinement in the technique itself, in that postcensal estimates are prepared by housing type. Since the ratio, or population per household, varies by structural type, this innovation will allow the method to adjust according to the prevailing shifts in housing activity. Heretofore, total building permit starts have been used as input data and the ratio applied has been for total dwellings in the estimate area.

First the modified version of the housing unit method is then applied to selected Canadian cities of varying size categories ranging from 10,000 to the metropolitan area level. These cities differ in terms of population size, type of postcensal building construction, growth patterns, annexation experience, and age. Furthermore, the modified housing unit method is used to derive postcensal estimates for sub-areas of the city of Edmonton. Correspondingly, population estimates derived through the unmodified housing unit method were prepared for these same urban centres and sub-areas. Four basic series of estimates are derived utilizing both methods of estimation:

<u>Series A-1:</u> Population estimates of selected metropolitan sub-areas utilizing unmodified housing unit method.

<u>Series A-2:</u> Population estimates of selected metropolitan sub-areas utilizing modified housing unit method.

Series B-1: Population estimates of selected municipalities utilizing unmodified housing unit method.

Series B-2: Population estimates of selected municipalities utilizing modified housing unit method.

The second stage of this research will assess the level of accuracy utilizing the modified housing unit method for cities experiencing differing rates of population growth; for cities in various size groupings; for cities with different annexation experience; for cities with differing proportions of housing by type; and for cities of different age. These variables may have significance in influencing the level of accuracy of the housing unit method. Postcensal estimate error tends to be lower for larger cities as opposed to smaller cities; lower for metropolitan areas as opposed to non-metropolitan areas; and tends to vary with the rate of population growth (Morrison, 1971). Assessment of the significance of these variables has not been done on a large scale in any single research effort utilizing one method with comparable input data for all test areas. The variability of these urban characteristics may be contributing to the inconsistency of results reported in earlier research.

Assuming that more systematic evidence can be revealed regarding estimate error and urban characteristics, then efforts can go forward with respect to further improvements in the estimation technique. The main reasons for the selection of the six stratification variables proposed in this research effort are as follows:

(1) Each stratification variable (independent) selected can be measured using a readily available indicator.

	Variable	Indicator source
a.	Construction Type	Building Permits
b.	City Size	1966 Census of Canada
c.	Population Growth Rate	Census of Canada
d.	Annexation Experience	Census of Canada
e.	Household Size (Change)	Census of Canada (1966 & 1971)
f.	Age of City	Census of Canada

(2) The variables selected have been either suggested or utilized in previous research in postcensal estimation (California, 1957; Shryock, 1938; Siegal, Shryock and Greenberg, 1954; Starsinic and Zitter, 1968; Zitter and Shryock, 1964; Zitter, Starsinic and Word, 1968; Rosenberg, 1968; and Morrison, 1971).

(3) All variables selected are indicators of the population dynamics in the urban area. Determination

of levels of estimate error according to the magnitude of the independent variables will point toward areas of improvement in the technique, as well as, assist in its application.

The third stage of this research assesses the accuracy of the same method at the sub-area level. Since the input data for such an analysis are not provided in any secondary sources, the actual building permit records will be utilized. The small area selected for this phase of analysis will be the census tract. The reason for utilizing the census tract is simply the availability of 1971 census data for checking the accuracy of the estimates.

To summarize, this research presents:

1. the development of a modified censal ratio technique;
2. the application of this estimation technique to Canadian cities;
3. the assessment of the accuracy of estimates derived utilizing the modified censal ratio technique; and
4. the assessment of the accuracy of estimates derived for sub-areas within the city utilizing the same method.

CHAPTER II

POPULATION ESTIMATION

> Perhaps one should recognize that the demand for forecasts is generated in part by motives only weakly related to their accuracy; in other words that even very inaccurate forecasts fulfil a need. The point has been put in its sharpest form by Professor Devons when he compares the use of statistical forecasting as a guide for policy to the function of the magician in some primitive societies. For example, if you want to go out hunting and do not know whether the best hunting is to the north or to the south, you consult a magician; and that after all is a sensible thing to do because the important thing is to get on with the hunting. It would be disastrous to get bogged down in arguing. Much the same need lies behind the demand sometimes faced by demographers "Give me some figures, any figures are better than none." What such people want, perhaps, is someone to make up their mind (Grauman, 1959, pp. 553-554).

Introduction

The origin of scientific population estimation can be traced to the works of John Graunt, considered by many as the father of demography. John Graunt opened the field of empirical research with his statistical calculations based upon birth and death records maintained by the local parishes of London. His research resulted in the publication of population estimates for the city of London (Lorimer, 1959, pp. 124-126). The development of these population estimates was primarily in response to demonstrated concern of the King of England over the cumulative effect of a series of plagues upon the population. In 1695, following John Graunt's significant contribution to the field of estimation, Gregory King estimated the population of England and Wales utilizing hearth-tax records as an indicator of population change. Ratios of population per dwelling unit derived from enumerations of selected administrative areas were then applied to these records of hearths to develop an estimate of population. This early censal ratio technique preceded England's first population census which occurred in 1801 (Lorimer, 1959, p. 128). These early developments in population estimation prompted by concerns about the population size of local areas in an industralizing nation demonstrated the shift from magician to demographer. The need for population estimates has increased as countries have experienced the industrial revolution. Improvement in estimation techniques yielding greater accuracy is a pre-requisite as society has become more complex. It is evident that today's urban-industrial country can no longer depend upon the magician for knowledge concerning population size.

Current Need in Estimation

There are a great many social changes implied in the increases of metropolitan populations, as well as the growth in numbers of cities and city populations in general. This has brought about a need for adequate indicators of population growth at both the city and the sub-area levels. No longer will the traditional benchmarks, such as national censuses, adequately serve the needs of the urban specialist and policy maker.

The rapid population changes experienced during intercensal years cast doubt upon the adequacy of the national censuses to serve as change indicators (Bauer, 1966; Grauman, 1959; Lithwick, 1970; Taeuber, 1968). The census in the United States is conducted every ten years, while the major Canadian census is also conducted on a decennial basis with a more restricted census completed every five years. Rapid population changes in growth areas soon invalidate the results of a decennial or quinquennial census.

The rate of population change for cities and sub-areas within cities is such that the census data are soon outdated. The continual population movement and growth creates ongoing changes in space requirements, traffic flows, parkland or open area needs, and may suggest different priorities with regard to land use and future planning for the urban complex. Of considerable importance is the availability of a relatively accurate postcensal technique for estimating the population in local areas following a census date.

Provincial and state assistance in the form of grants is often predicated on the size of municipalities, or on the population changes therein. These municipality populations are determined either by estimation or by the actual conduct of a census. For example, the city of Edmonton conducts an annual civic census in the latter part of the year in order to provide the Department of Municipal Affairs with a census figure as of the first of January. The recent census controversy which concerned the validity of Edmonton's population figures emphasized the importance of reliable postcensal population figures. In this case, three civic census figures were in question and, as a result of a costly and extensive evaluation, the 1970 and 1971 reported populations for the city were found to be in error (McVey, 1973). The availability of simple estimation procedures would have provided the planning department with a means for checking the validity of their census results. The salient point is that planning personnel had been utilizing incorrect census results in their long range planning program and making decisions based on these figures. The importance is placed, not on the population size one, two, or five years ago, but on the current population size.

Postcensal estimates of the internal distribution of the city's population among the various sub-areas would provide clues as to how the different land uses and facilities should be located within the urban area (Chapin, 1965). The availability of population estimates among the several neighbourhoods would be of importance for the study of residential areas and of their community services or facilities. A variety of statistical areas are utilized by different municipal agencies for the purposes of special data tabulations and analyses. There is usually little congruence between these statistical areas and census statistical areas for which population data are provided by Statistics Canada. Considerable manipulation is often required to make different statistical areas compatible with census areas and, data users often have to be satisfied with crude approximations. These other statistical areas include local service areas, transportation zones, recreation areas, social service areas, planning districts, polling districts, police patrol areas, health service areas, school districts, and local target areas for various research interests.

These statistical areas serve a variety of data needs by local researchers and agencies. Researchers utilizing these various data areas would have a need for estimates of population size in order to develop measures relevant to the social phenomenon of interest, such as offender or arrest rates, health service ratios, density measures, and welfare recipient rates. An estimation technique would equip the researcher with a valuable tool that could be used to determine population estimates for any bounded area within the city. Postcensal estimation would resolve the problem of working with outdated census data, as well as the problem of statistical area comparability with census areas.

The Edmonton Planning Department has relied on either special surveys or the civic censuses for population totals within the city. The Civic Centre Urban Renewal Scheme presented in 1968 utilized a survey to determine the population size of the target area. The *North East Edmonton Outline Plan Study* (Edmonton, 1969a) and the *West Jasper Place Review Area: Outline Plan* (Edmonton, 1967) used estimates based on a ratio of population per gross acre. Recommendations in these planning proposals were based on estimates of population within the planning areas. Presently, the Edmonton Planning Department is collecting 1961 and 1966 census data for several target areas designated as redevelopment areas throughout the city. Because of the urgency of their investigation, they are relying on available census data which are considerably outdated. In addition, the redevelopment areas are not compatible with existing census statistical areas and, therefore, the areal refinement cannot be accommodated with census data.

Edmonton and other Canadian cities conduct annual civic censuses in order to arrive at current population figures. In addition to the financial cost of such an undertaking, the lengthy time period involved in the actual canvass is conducive to duplication and omission of populations. Again, a postcensal estimation technique may be an efficient and inexpensive substitute for the more costly and time-consuming procedures currently in use. In addition, the accuracy of these surveys and censuses at the city level is unknown. The additional costs involved in post enumeration accuracy checks, field checking, and various coverage controls have proven prohibitive (McVey, 1973).

The city planner, city officials, and social investigators need population data primarily as a basis for action or future recommendations in the planning process. The city official has before him a matter requiring a decision, and in many cases, current population figures prove useful in determining the extent and direction of action. It is at this juncture that the professional demographer should contribute at the local level. Currently, demographic expertise on any continuing basis is limited to the national level.

Lacking this type of expertise, the city's requirements for effective decision making and planning involving population data at the local level are:

1. A reliable technique with known accuracy levels for the measurement of population change in small areas,
2. A technique that is simple in concept and procedure requiring non-demographic expertise,
3. A technique that is not time-consuming in its computational form,
4. A technique that is inexpensive to use, and
5. A technique that utilizes a readily available and continuous series of symptomatic data at the local level.

Postcensal Population Estimation

This section will explore the available literature pertinent to the focus of this dissertation -- estimation of postcensal populations for small geographical areas. Postcensal population estimation encompasses a variety of techniques ranging from simple extrapolation to the more complex component methods. The selection of an estimation technique is contingent upon data availability in the area for which a population estimate is desired. For purposes of organization, the small geographical area is defined simply as a city or subdivision thereof. The largest area used in the present research is the metropolitan area while the smallest is the census tract.

Population Registration Systems

According to the United Nations, several countries have utilized registration systems to derive local population estimates (Shryock and Siegel, 1971, p. 46). A registration system is a continuous record keeping of the population resident in the area. Whenever a death, birth or movement occurs, the resident is required to notify the local registrars in order that the effect of these vital processes is noted. A successful registration system must be compulsory, in that each resident is required to participate. This ideal source of information would allow estimates of population size to be prepared on a regular basis or for occasional dates for any area covered by the system.

Quasi-Registration Systems

The United States and Canada do not have registration systems as outlined above however, both countries have quasi-registration systems. A quasi-registration system is one that is restricted in coverage and may not be compulsory. The Henderson's city directory in Canada and the

Polk's city directory in the United States are examples of quasi-registration systems. City directories are compilations of information regarding the city's residents by address and usually include the occupation of each occupant, relationship to head of household, and whether or not there is a telephone in the household. While this type of information is useful to the business world, this form of quasi-registration system is less than adequate for purposes of deriving population estimates. The weaknesses in this source are due to it not being compulsory, variability in coverage, false reporting by respondents, and the lack of a designated registration moment.

Other types of quasi-registration systems include family allowance plans, various kinds of licensing, war time ration schemes, military and college registration, medical and pension schemes (Eldridge, 1945). Ration card registration schemes were utilized during World War II to prepare population estimates for states, provinces, and counties in Canada and the United States (Shryock and Siegel, 1971, p. 747). Several adjustments were required to include institutional populations and to exclude military personnel resident in private households. In addition, late registration and deceased registrants were difficult to account for in the correction of estimates derived from these quasi-registration systems.

Vital Events Technique

The vital events technique for preparing estimates in postcensal years is commonly used at the city level (Grauman, 1959; Lee and Hamilton, 1966; Newling, 1968; U.S. Bureau of the Census, 1957 and 1969b). The essential feature of the vital events technique is that current population estimates are based on the assumption that changes in births and deaths reflect changes in the size of the population exposed to the risk of these events occurring. Several disadvantages of this technique have resulted in it being considered the least accurate of all postcensal estimation techniques (California, 1957). Morrison summarizes the chief weaknesses of the vital events technique.

> Vital rates estimation is vulnerable to several weaknesses to which the analyst should be alert. First, in relying on crude birth and death rates, it fails to account for changes in age and sex structure. Strictly speaking, the method amalgamates authentic change in numbers and structural shifts altering a population's output of vital events. From a practical standpoint, the analyst should exercise special caution when age structure is changing rapidly..... Another difficulty is that births and deaths are relatively infrequent in a population. Neither event has a high incidence except at specific ages, and small errors necessarily are subject to inflation. (Morrison, 1971, p. 16).

Further disadvantages include the time lag before the symptomatic data series (births and deaths) become available to the estimator and the omission of the migration component. For local areas within a city, vital events data are normally difficult to obtain, thus making the vital events technique a poor choice of estimation procedures. In cities for which vita events data have been utilized in population estimation, it has been found that this technique is the least accurate of all the postcensal estimation methods (California, 1957).

Component Method

The component technique utilizes migration estimates in conjunction with estimates of natural increase. This technique attempts to satisfy the basic components in the standard population 'bookkeeping' equation:

$$Pe = Pc + (B-D) + (Mi-Mo)$$

Where, Pc = population enumerated at previous census date,

Pe = estimated total population on the estimate date,

B = births in the postcensal period

D = deaths in the postcensal period

Mi = in-migration in the postcensal period

Mo = out-migration in the postcensal period

The migration component can be derived from direct data on igration. For example, continuing national surveys, surveys on internal migration, population registration systems, special administrative records, such as family allowance and tax returns can be utilized to derive estimates of the migration component (Shryock and Siegel, 1971, p. 747). The national Labor Force Survey provided sample data on migration which has been incorporated into the provincial estimation procedures in Canada (D.B.S., 1968f). It is often the case that a symptomatic series of data has to be used to derive an estimate of the migration component. This technique is somewhat limited in that migration component estimates are often difficult to prepare, particularly for small geographical areas. School enrollment data series are normally utilized in the preparation of the migration estimate for the total population. The requirement of birth enrollment data and vital event data is a limiting factor in the applicability of this technique.

Composite Method

The composite technique of estimating city size incorporates school enrollment data for arriving at estimates of the school age population, while vital events (births and deaths) are used to estimate the remaining age groups in the population. This technique compared favorably with the component technique and the vital rates technique, however, its applicability was restricted to larger areas. No test estimates were prepared for smaller areas due to the difficulty encountered in obtaining the necessary symptomatic data series (U.S. Bureau of the Census, 1957 and 1969b; Grauman, 1959; Bogue and Duncan, 1957; Zitter and Shryock, 1964; Hillery, 1962).

The variant of this technique that is in most use today is called the Bogue-Duncan Composite Method. This procedure utilizes three sources of data -- school enrollment, births, and deaths -- to estimate the respective population segments most exposed to the risk of these events occurring (Bogue and Duncan, 1957; Morrison, 1971, pp. 16-18; Shryock and Siegel, 1971, pp. 750-751). These population segment estimates are then combined to arrive at an estimate of the total population.

Censal Ratio Methods

Rather than deriving estimates for the basic components of population change, the censal ratio method attempts to estimate the total population change directly. These methods involve the determination of relationship between a symptomatic indicator and the population in a defined area for the most recent census date. The second step is to extrapolate the ratio to the estimate date. This extrapolated ratio, or relationship, is then applied to the symptomatic data tabulated for the postcensal estimation period for the same defined area (Grauman, 1959; Chapin, 1965; Morrison, 1971).

Censal ratio estimates have been prepared for cities and smaller subdivisions within cities utilizing a variety of symptomatic indicators. A report to the Mayor of New York by the Committee on Statistical Programs assessed both the need for population data and the various indicators used in arriving at postcensal estimates (Brunsman, 1955). The minor subdivisions reported were health care units, census tracts, school study areas, and multi-purpose local areas. Various indicators of population change were explored, such as vital statistics, enrollment data, census data, selective service registrations, real property inventories, postal deliveries, electric and water meter connections, telephone subscribers, pension plan accounts, and building permit data. Limitations were found with every symptomatic data series utilized. The shortcoming of this report was that there was no effort to evaluate the methods or indicators.

If the symptomatic data are to be useful, accurate and comparable data must be available at regular intervals throughout the postcensal estimation period. It is also important that the ratio be fairly stable or change in a relatively constant fashion over the estimation period. The usefulness of a symptomatic series for preparation of population estimates may also be influenced by variation in the quality of data over time or by region within a country.

A variety of data available in series form have been used as symptomatic indicators of population change. In industrialized countries, the list includes school enrollment or school census data, utility connections, volume of bank receipts, volume of retail trade, postal stops, voter's registration, welfare recipients, automobile registration, tax returns, birth and death statistics, and building permit records (Shryock and Siegel, 1971, p. 753).

Ratio-Correlation Method

This method utilizes symptomatic data in the derivation of an estimate of the total population for an area. The distinction from censal ratio methods is that this technique involves mathematically relating changes in a combination of symptomatic indicators to known changes in population over a period of time. Multiple regression equations are used to determine this relationship (Shryock and Siegel, 1971, p. 756; Schmitt, 1954). The basic assumption is that this determined relationship will remain the same over the estimate period and, hence, can be applied to observed symptomatic indicators for the estimate date.

(Morrison, 1971, pp. 18-20). The accuracy of this estimation procedure is contingent upon the validity of this assumption (Schmitt and Crosetti, 1954).

Estimation in Canada

The only significant effort on estimation in Canada is the series of reports produced by Statistics Canada. These annual estimation reports were initiated in 1968 and report population estimates for counties and census divisions in each province. To date, the series covers four estimation periods from 1967 through and including 1970. Unfortunately, there is an approximate two year time lag between the estimate date and the release of the publication containing the estimates. Extensive comment is provided regarding estimation methodology in the initial volume (Statistics Canada, 1969b) and there has been no refinement or modification in technique over the four year period.

The estimation methodology incorporates the basic family of techniques discussed in the previous section, such as vital events, component, or censal ratio methods. The focus is upon preparation of estimates for small areas at the county or census division level. Municipality or census tract estimates were not attempted in any of the estimate years.

> The county (census division in Newfoundland and the western provinces) was chosen over the municipality as the areal frame of reference partly for technical reasons: suitable methodology using available data for smaller areas has not yet been developed. In addition, many data users are content with an areal frame of reference no smaller than the county. (D.B.S., 1969b, p. 3).

Estimation references reviewed are contrary to this statement by the Dominion Bureau of Statistics, in that, there is considerable interest and need for postcensal estimates by smaller areas than the county level and that there has been progress in the United States in the development of a "suitable" methodology for preparing postcensal estimates at the small area level (Morrison, 1971; Shryock and Siegel, 1971).

In the preparation of the estimates by province, different techniques are utilized. Data availability determined the technique chosen in the preparation of estimates for each province and its subdivisions. No single technique was utilized for preparing the estimates in all provinces (D.B.S., 1969b, p. 8).

The vital events technique proved to yield inaccurate estimates and, therefore, was abandoned. A "direct method" was used in Ontario and Saskatchewan based on excellent vital registration administrative records. Due to boundary changes over the estimation period, only the component method was used for the Manitoba estimates. Data availability enabled two methods -- component and censal ratio -- to be employed in the preparation of the Newfoundland estimates. Both the component and censal ratio techniques were used for the remaining six provinces, however, the censal ratio technique yielded greater accuracy for the Quebec estimates and an average of estimates derived from the two techniques was used for Alberta and British Columbia.

The symptomatic indicators used in the censal ratio techniques included motor vehicle registrations, electricity and gas meter registrations and the value of county assessments. Building permit data were not utilized, however, this type of symptomatic indicator is more consistent and available at the municipality level and would have likely been used if city estimates were being prepared. It was the conclusion of the report that the indicators used were not sufficiently accurate at the county level and were not uniformly available in every province (D.B.S., 1969b, p. 10).

An attempt was made at producing metropolitan area estimates by using combinations of county estimates where the county boundaries were compatible with existing metropolitan boundaries. Usually metropolitan areas consist of only one county and parts of several other counties. In 1966, only one census metropolitan area in

Canada was coterminous with a census division (Winnipeg) (D.B.S., 1969b, p. 13). Succeeding annual population estimates prepared for counties and census divisions utilized the same procedures set forth in 1967 (D.B.S., 1970, 1971).

A census technical paper, released in June of 1965, discusses the terms of reference for the Population Estimates and Analysis Section of the Census Division (D.B.S., 1965). This section of the Census Division prepares postcensal estimates of the total population of Canada, as well as, a set of provincial population estimates by marital status classified according to age groups and sex. These estimates are based on available birth, death, and immigration data since the previous national census. A secondary function is to prepare provincial and national estimates of families derived from the annual Labour Force Survey.

Summary

There are several shortcomings to the available postcensal estimation techniques which can be summarized.

1. Data availability varied from locality to locality.
2. Data quality varied over time.
3. Generally, no city estimates are provided.

4. Several estimation techniques are not simple in concept and the component and composite techniques require demographic expertise.

5. The vital events, component, and composite techniques are restricted in application to the metropolitan area or county level.

6. The time lag between the estimate dates and the release of published estimates is too lengthy for the estimates to be of any real value in the decision making required in the planning process at the local level. (In Canada, the time lag is 23 months which is a considerable length of time even if city estimates were provided.)

The above techniques have been used quite frequently with inconsistent results (Morrison, 1971). Research findings have indicated a tendency toward increased accuracy for larger, non-metropolitan areas, such as counties, when these techniques are used in postcensal estimation. In addition, these techniques require more refined data series, a certain amount of expertise in preparation, are more costly to prepare, and have revealed unacceptable results for small areas.

In summary, the past efforts in small area estimation support the conclusions generated in the overview:

1. There is a need for a reliable technique with known accuracy levels for the measurement of population change in small areas.

2. There is a need for a technique that is simple in concept and procedure requiring non-demographic expertise.

3. There is a need for a technique that is not time-consuming in its computational form.

4. There is need for a technique that is inexpensive to use, and,

5. There is need for a technique that utilizes readily available and continuous series of symptomatic data at the local level.

The requirements of simplicity, efficiency, economics in cost, available symptomatic data, and accuracy may best be fulfilled by yet another technique -- the housing unit method.

CHAPTER III

DEMOGRAPHIC, ECONOMIC, AND SOCIAL TRENDS

Introduction

This chapter will deal with several of the recent demographic, economic, and social trends which have influence of varying magnitudes upon the population size of cities and sub-areas within the city of Edmonton. The wide range of problems in today's urban society requiring decisions at all levels of government is further compounded by these trends and their interrelationship -- all of which are associated with the continuing concentration of population in urban areas. The difficulties and assumptions encountered in the estimation of population parameters for urban estimate areas are more clearly understood when viewed in terms of these trends.

Urbanization and Metropolitanization

One of the major social transformations experienced by the world is that of urbanization. Eldridge defines this process as involving three interrelated trends -- the multiplication of points of population concentration, the growth of these concentrations, and the increasing proportion of the total population living in these concentration points (Eldridge, 1942). The factors influencing the urbanization process are many, ranging from the increasing spatial mobility of the population to the shift from an agrarian economy to that of an industrial economy.

Problems of definition notwithstanding, Canada has emerged as one of the leading examples of the urbanization process with 76.1 per cent of its national population residing in urban areas. In 1901, only 34.9 per cent of Canada's population was classified as urban. The balance shifted in favour of urban populations for the first time at the beginning of the Depression decade. Over half of the country's population -- 52.5 per cent -- were classified as urban in the 1931 Census of Canada, and by 1971, the urban component accounted for over three-quarters of the population (Kalbach and McVey, 1971, p. 95).

One of the leading indices of urbanization is the proportion of a country's population residing in cities of selected size categories. The urban population can be measured in terms of the proportion of the total population in cities over 20,000 in population size, or cities with over 100,000 population, or any other size category. The selection of an urbanization index depends upon the investigator's perspective and can be quite arbitrary. For Canada, metropolitan area growth illustrates the increasing importance of the larger urban complex, both in terms of increasing proportion of the population residing in such areas, as well as the increase in the number of these points of concentration.

The Census Metropolitan Area (CMA) in Canada is an area containing approximately 100,000 or more persons and a central city which has at least 50,000 inhabitants. The built-up part of the CMA outside the central city must have a population density of at least 1,000 persons per square mile, and at least seventy per cent of the labour forc[illegible] this part of the CMA must be engaged in non-agricultura[illegible] activities. Hence, the Canadian metropolitan area consists of two basic components: a central city and a built-up fringe area surrounding the central city.

The population in Canadian metropolitan areas has increased from 30.3 per cent [illegible] 1931 to 55.0 per cent in 1971. In 1971, over half of the Canadian population resided in the twenty-two major urban areas classified as metropol[illegible]an. In a span of forty years, the number of metropolitan areas increased over two-fold from ten in 1931 to 22 in 1971.

While the concentration of Canadians in metropolitan areas has been impressive, the population increase has been lessening. Table 3.1 portrays the population change that has occurred in the last two census decades for fourteen selected metropolitan areas. It is noteworthy that only two metropolitan areas -- Windsor and London, Ontario -- experienced an increase in population change in the most recent decennial period. The remaining metropolitan areas reflected a lessening in percentage change in the last decennial period.

Table 3.1.--Population Trends
Selected Metropolitan Areas[a]
Canada: 1951 - 1971

Metropolitan Area	Percentage Change		
	1951-1961	1961-1971	1966-1971
Montreal	43.9%	23.8%	6.7%
Toronto	52.1	36.9	14.8
Vancouver	40.9	30.7	16.0
Winnipeg	33.4	13.4	6.2
Ottawa/Hull	46.7	31.8	13.9
Hamilton	41.8	24.3	9.0
Quebec	31.0	26.8	10.0
Windsor	18.9	19.1	8.5
Halifax	39.7	15.1	6.1
Saint John	21.6	8.8	2.4
London	35.1	46.5	18.0
Victoria	34.4	23.1	11.7
Edmonton	85.9	37.8	16.5
Calgary	96.1	44.5	22.0

[a]Areas adjusted to 1971 metropolitan area boundaries

Source: 1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas, and Census Agglomerations. Vol. 1, Pt. 1, Bulletin 1.1-8, January, 1973, Table 8.

1966 Census of Canada, Population, Incorporated Cities, Towns and Villages, Vol. 1 (1-7), October, 1967, Table 8.

Central city growth has been less dramatic in recen census years. Table 3.2 reveals that generally the central cities did not experience the high population growth reflected in the earlier quinquennial period -- 1961 - 1966. Four central cities showed an actual population decline from 1966 to 1971. Considering the annexations which have occurred in the recent intercensal period, it is likely that more central city declines would have been recorded had it not been for successful annexation activity.

Decentralization within Metropolitan Areas

Parallel with the trend toward metropolitanization of the Canadian population, the residents are also becoming more decentralized within the metropolitan area. As in the United States, "suburbia" has been absorbing increasingly larger proportions of the total metropolitan increase. It is somewhat unlikely that decentralization is a new phenomenon on the Canadian scene as it is doubtful that the boundaries of incorporated places were any more successful in containing the actual limits of the expanding populations during the early 1900's than they generally are today (Kalbach and McVey, 1971, p. 98). Where urban concentrations began to emerge, the unincorporated areas adjacent to the central cities, as well as satellite incorporated communities have

Table 3.2.-- Population Trends for Selected Central Cities
Canada: 1961-1966 and 1966-1971

Central City	Population Change				Population Change			
	1971	1966[b]	#	%	1966[b]	1961	#	%
Calgary	403,319*	330,575	72,744	22.0	330,575*	249,641	80,934	32.4
Edmonton	438,152*	381,846	56,306	14.7	376,925*	281,027	95,898	34.1
Halifax	122,035*	120,808	1,227	1.0	86,792	92,511	- 5,719	- 6.2
Hamilton	309,173	298,121	11,052	3.7	298,121*	273,991	24,130	8.8
Kitchener	111,804*	94,446	17,358	18.4	93,255*	74,485	18,770	25.2
London	223,222*	194,419	28,803	14.8	194,416	169,569	28,847	14.6
Montreal	1,214,352*	1,293,992	-79,640	- 6.2	1,222,255	1,191,062	31,193	2.6
Ottawa-Hull	365,921*	351,746	14,175	4.0	350,917*	325,135	25,782	7.9
Quebec	186,088*	188,333	- 2,245	- 1.2	166,984	171,979	- 4,995	- 2.9
Regina	139,469*	131,136	8,333	6.4	131,127*	112,141	18,986	16.9
St. John's	88,102*	80,016	8,086	10.1	79,884*	63,633	16,251	25.5
Saint John	89,039*	89,921	- 882	- 1.0	51,567	55,153	- 3,586	- 6.5
Saskatoon	126,449*	115,900	10,549	9.1	115,892*	95,526	20,366	21.3
Sudbury	90,535	84,888	5,647	6.6	84,888*	80,120	4,768	6.0
Toronto	712,786*	697,422	15,364	2.2	664,584	672,407	- 7,823	- 1.2
Vancouver	426,256	410,375	15,881	3.9	410,375	384,522	25,853	6.7
Victoria	61,761	57,453	4,308	7.5	57,453	54,941	2,512	4.6
Windsor	203,300*	192,544	10,756	5.6	192,544*	114,367	78,177	68.4
Winnipeg	246,246	257,005	-10,759	- 4.2	257,005*	265,429	- 8,424	- 3.2

[a]Figures noted for 1966 are adjusted to the new 1971 city boundaries.

[b]Figures noted are for the central cities as defined in 1966. (DBS. 1966 Census of Canada, Population, Incorporated Cities, Towns and Villages, Vol. I (1-7), October, 1967, Table 8.)

*Cities experiencing successful annexation during the intercensal period.

1971 Source: Statistics Canada. 1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas, and Census Agglomerations. Vol. 1, Pt. 1, Bulletin 1.1-8, January, 1973, Table 8.

shown a tendency to grow more rapidly than the core city. The central city soon becomes over-bounded because of the rapid increase in population. Suburbanization has often been referred to as the "flight to the suburbs" suggesting that the central city is soon left depleted of population. This is only partially true, in that, while populations are continually moving outward with the expansion of the city, there is a counter-movement of new arrivals into the central part of the city. Over the years, the core of the central city has been the primary receiving area for recent immigrants to the metropolitan area, however, with immigration restrictions and shifts in the internal migration patterns, it is likely that the proportional movement into the central areas of the larger metropolitan complex will lessen in the future.

In an analysis of regional migration patterns, it was found that both the central city and the fringe had substantial rates of in-migration from outside the metropolitan area (Stone, 1969, p. 13). Stone found that the central city had higher relative out-migration losses than did the fringe resulting in a net loss to the central city and a net gain to the fringe. The consequence of this shift in internal movement patterns is the increase in the proportion of married persons in the fringe and, conversely, a decline in the proportion of married persons in the centra city. The implications of such shifts would be revealed in declines in family or household size and the concomitant increase in non-family households for the central city.

Coincident with this change and influencing further declines in in-migration to the core area of the central city is that the inner zores of metropolitan areas are rapidly becoming saturated with people. The means to counte this trend is to increase population density by the construction of multiple-family structures, i.e., high rise apartments. This has been done to some extent in the inner areas of Edmonton resulting in recent population increases immediately north of the river.

Two basic factors accounting for this shift of population to outlying areas of the city and beyond are, first, the increased sophistication of transportation networks in the urban area. This advancement allows the population to settle further away from the central city at minimum cost and inconvenience. Secondly, as already indicated, is the fact that many of the central cities are already fully populated or rapidly becoming so. This has been a major influence partially accounting for the continued radial expansion of the population settlement patterns transcending the city's political limits.

Since new population settlement tends to take place in the peripheral areas of the city, the suburban parts tend to grow more rapidly than the central cities. Utilizing the Statistics Canada definition of suburban parts for 1971, data in Table 3.3 for Edmonton support this differential growth pattern. As these forces continue to operate, the central city may soon reach the point where it will actually lose population while the entire metropolitan area continues to grow (Tables 3.1 and 3.2). In these cases, the decline of central city populations is more than offset by the population increases experienced in the suburban parts, i.e., remainder of the metropolitan area. Table 3.3 portrays the population change in the component parts of the Edmonton metropolitan area for the past two quinquennial periods.

For many of Canada's central cities, annexation is becoming the viable means for counteracting slower growth or potential population declines. As noted in Table 3.2, fifteen of the twenty central cities experienced population increases through annexation between 1966 and 1971. During the 1956-1966 census decade, most of the central cities experiencing high rates of increase also reflected successfu annexation efforts. Annexation has become an increasingly

Table 3.3.-- Population Change
Metropolitan Area Components
Edmonton: 1961-1966 and 1966-1971

Component Parts	Population		Change		Population		Change	
	1961[a]	1966	#	%	1966[a]	1971	#	%
Total Metropolitan Area	337,568	401,299	63,731	18.9	425,370	495,702	70,332	16.5
Edmonton City	322,238	376,925	54,687	17.0	381,846	438,152	56,306	14.7
Fringe	15,330	24,374	9,044	59.0	43,524	57,550	14,026	32.2
St. Albert	4,059	9,736	5,677	139.9	9,736	11,800	2,064	21.2
Sherwood Park	2,923	6,339	3,416	113.4	6,339	14,282	7,943	125.3
Remainder of Fringe	8,348	8,299	-49	-0.6	27,449	31,468	4,019	14.6

[a] Figure for 1961 and 1966 are for areas comparable to those defined in 1966 and 1971, respectively.
The metropolitan area for Edmonton in 1971 was re-defined and is now larger in area.

Sources: 1966 Census of Canada, Population, Unincorporated Places, Bulletin S-3, August, 1963, DBS.
1966 Census of Canada, Population, Incorporated Cities, Towns and Villages, Vol. 1-7, October, 1967, DBS, Table 11.
1971 Census of Canada, Population, Unincorporated Places, Bulletin S-1, March, 1973, Statistics Canada.
1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Bulletin 1.1-8, January, 1973, Statistics Canada, Table 8.

important element to consider in any realistic appraisal of city growth. For Edmonton, annexation contributed a sizable population component in the amalgamation of the towns of Jasper Place and Beverly during the 1961-1966 censal period. Between 1970 and 1971, the BACM annexation to Edmonton accounted for 4,642 additional people to the city total. Population additions through annexation are not derived from either natural increase or net migration. However, this factor is often overlooked in the assessment of determinants of growth.

Internal Changes in the City

Aside from the brief summary of metropolitanization and decentralization within the metropolitan complex, there have been profound changes taking place within the central city itself. Recent census tract data made available by Statistics Canada allow an assessment to be made of several of the more important variables which serve as indicators of these changes. Figure 3.1 is an orientation map of the City of Edmonton portraying the estimate area boundaries and designations. Actual population changes between 1966 and 1971 are revealed in Figure 3.2 by estimate area.

It is significant to note, that of the sixty-one estimate areas, twenty-seven reflected population declines

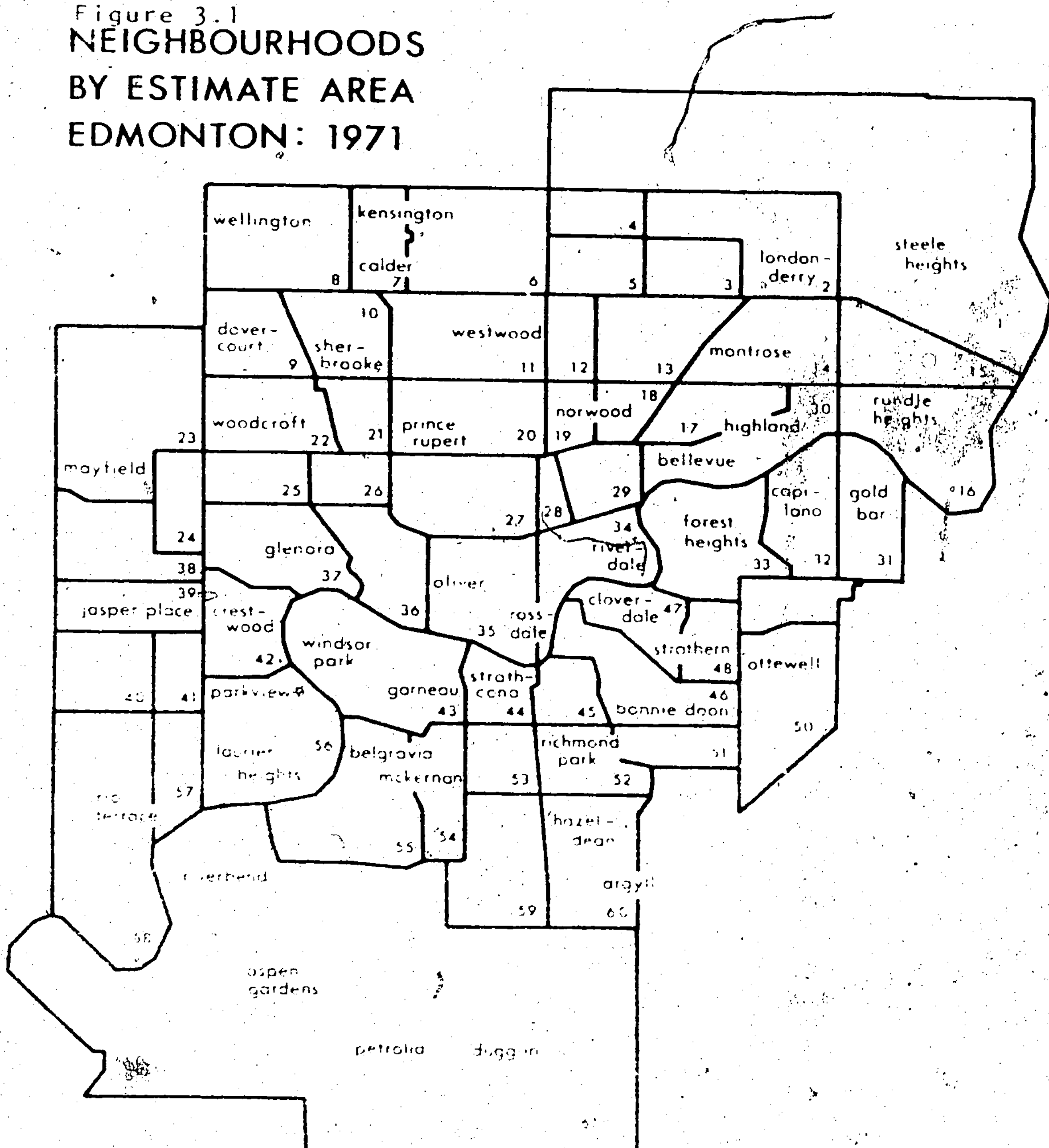
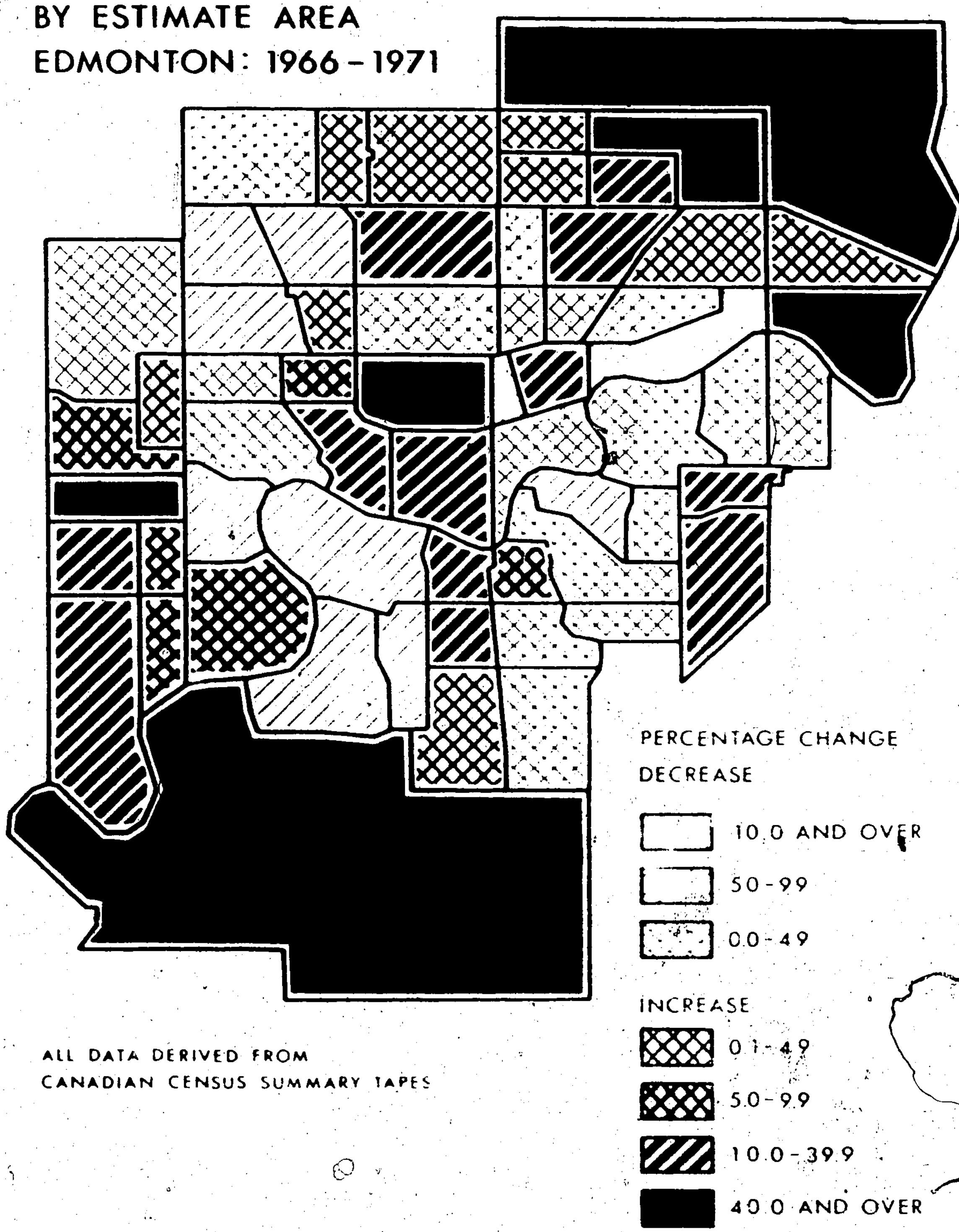


Figure 3.1
NEIGHBOURHOODS
BY ESTIMATE AREA
EDMONTON: 1971

Figure 3.2

POPULATION CHANGE BY ESTIMATE AREA EDMONTON: 1966 – 1971



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ranging from 0.4 to 18.4 per cent (Table 3.4). These losses during the quinquennial period occurred in the northwest (Wellington, Dovercourt, Sherbrooke, Woodcroft, and Mayfield districts); northcentral (Norwood, Bellevue, Highland, Riverdale, and Rossdale districts); southcentral (Capilano, Forest Heights, Cloverdale, Strathern, Bonnie Doon, Avonmore, Argyll, Richmond Park, and Hazeldean districts); and the westcentral areas (Crestwood, Glenora, Windsor Park, Garneau, Belgravia districts). These areas of decline are located partly in the older, central areas of the city, older immigrant areas, and in several of the older, established middle-class areas of the city. These declines are likely in response to the normal aging of the populations, where children mature, marry, and leave home. Correspondingly, these areas are experiencing greater declines in average household size and fertility.

The largest numerical and percentage increases were recorded in three major areas of development -- the northeast, west Jasper Place, and the southwest. Population increases of 1,000 or more were reported in fourteen estimate areas over the five-year period. Of these fourteen estimate areas, three were located in the central portion of the city north of the river. The growth in the central areas is in response to an increase in high density

Table 3.4.--Population Change by Estimate Area
Edmonton: 1966-1971

Estimate Areas	Census Population 1966	Census Population 1971	Population Changes #	Population Changes %
Total City[a]	381,846	438,152	56,306	14.7
1	1,855	16,577	14,722	793.6
2	7,735	11,269	3,534	45.7
3	4,885	5,786	901	18.4
4	4,816	5,026	210	4.4
5	5,997	6,284	287	4.8
6	13,133	13,322	189	1.4
7	6,122	6,131	9	0.1
8	8,966	8,687	- 279	- 3.1
9	3,843	3,585	- 263	- 6.8
10	6,928	6,556	- 372	- 5.4
11	3,220	4,349	1,129	35.1
12	5,058	4,896	- 162	- 3.2
13	6,985	8,090	1,105	15.8
14	8,072	8,105	33	0.4
15	5,786	5,824	38	0.7
16	5,073	7,658	2,585	51.0
17	4,441	4,255	- 186	- 4.2
18	5,367	5,188	- 179	- 3.3
19	5,866	[illegible]	- 114	- 1.9
20	[illegible],437	[illegible]	- [illegible]	- 1.2
21	5,249	5,35[illegible]	105	2.0
22	5,642	5,170	- 47[illegible]	- 8.4
23	4,277	4,156	- 121	- 2.8
24	5,217	5,359	142	2.7
25	5,371	5,369	2	- 0.0
26	4,424	4,743	319	7.2
27	8,519	11,580	3,061	359.3
28	3,712	3,029	- 683	- 18.4
29	6,016	6,905	889	14.8
30	4,608	4,046	- 562	- 12.2
31	6,302	6,275	- 27	- 0.4
32	[illegible],250	7,115	- 135	- 1.9
33	[illegible],977	7,893	- 84	- 1.1
34	[illegible],393	7,180	- 213	- 2.9
35	[illegible]	[illegible]	[illegible]	[illegible]

Table 3.4.--Continued

Estimate Areas	Census Population		Population Changes	
	1966	1971	#	%
36	6,599	8,599	2,000	30.3
37	7,486	7,419	- 67	- 0.9
38	6,307	6,893	586	9.3
39	5,394	7,807	2,413	44.7
40	7,202	8,366	1,164	16.2
41	4,367	4,667	300	6.9
42	5,335	4,917	- 418	- 7.8
43	5,139	4,664	- 475	- 9.2
44	3,217	4,387	1,170	36.4
45	5,883	6,402	519	8.8
46	7,948	7,859	- 89	- 1.1
47	4,742	4,345	- 397	- 8.4
48	5,366	5,302	- 64	- 1.2
49	4,757	5,243	486	10.2
50	10,521	11,961	1,440	13.7
51	5,128	4,936	- 192	- 3.7
52	5,579	5,347	- 232	- 4.2
53	3,978	4,747	769	19.3
54	7,270	6,848	- 422	- 5.8
55	5,350	5,067	- 283	- 5.3
56	7,111	7,704	593	8.3
57	3,871	4,137	266	6.9
58	5,624	7,350	1,726	30.7
59	9,453	9,812	259	3.8
60	5,736	5,541	- 195	- 3.4
61	10,247	27,272	17,025	1,661.5

[a] City of Edmonton totals include annexations between 1966 and 1971.

Source: Statistics Canada, 1971 Census of Canada, Census Tracts, Bulletin 1.1-10, February, 1973.

structures. The growth in the peripheral areas to the northeast, southwest, and west is primarily reflecting the outward expansion of residential development -- the single-detached dwelling unit. These growth areas correspond to the areas of residential development outlined in the Edmonton General Plan. (City of Edmonton, 1972, p. 14.2).

The population percentage change declined from 17.0 to 14.7 for the City of Edmonton over the two quinquinnial periods. The average annual rate of change for the first half of the decade was 3.4 per cent and this declined to 2.9 per cent for the 1966 to 1971 census period. Although the average annual rate of change declined, the increment of population added to the city of Edmonton during these two census periods increased from 54,687 to 56,306. As the total population of the city increases, it will require larger additions to the population in order to maintain a given annual rate of growth.

The urban centres across the nation have experienced a shift in housing activity from construction of the typical single-family housing structure to the apartment or multiple-family structure. For example, apartments, which are primary an urban housing form, only accounted for two per cent of the 1921 total housing stock in Canada. By

1971, apartment units accounted for almost one-third (28.2 per cent) of the housing in Canada, whereas single-detached dwelling units had declined to 59.5 per cent from the 85 per cent so classified in 1921 (Kalbach and McVey, 1971, p. 311). It is evident that the single-detached dwelling is still the most common type of housing available in the urban centre, however, the trends indicate a decline in its importance on the housing scene. Table 3.5 derived from data made available by the City of Edmonton, indicate recent housing activity for Edmonton over the estimate period. These data support the general trends in housing noted for Canada with the apartment unit increasing in the proportion of total housing starts.

The counter trends of recentralization and decentralization have influenced the location of these two major types of housing construction in Edmonton. Slightly over 60 per cent of the total occupied housing units were classified as single-detached accommodations, while over thirty per cent (30.7) were counted as apartments. In examination of the distribution of housing by estimate area, it was found that areas with high proportions of single-detached housing are located generally in the outlying portions of the city, in the expanding recent residential

Table 3.5.-- Building Permit Starts[a] by Type of Housing
City of Edmonton, Alberta: June 1, 1966-May 30, 1971

Year	Total Housing Units		Single-Detached		Double/Duplex		Row		Apartment	
	#	%	#	%	#	%	#	%	#	%
Total Estimate Period	33,733	100.0	8,789	26.1	894	2.7	1,732	5.1	22,318	66.1
1966[b]	2,708	100.0	1,376	50.8	113	4.2	---	0.0	1,219	45.0
1967	5,947	100.0	1,861	31.3	168	2.8	162	2.7	3,756	63.2
1968	8,570	100.0	2,551	29.8	206	2.4	338	3.9	5,475	63.9
1969	7,317	100.0	1,424	19.5	173	2.4	156	2.1	5,564	76.0
1970	5,087	100.0	845	16.6	166	3.3	837	16.5	3,239	63.6
1971[c]	4,104	100.0	732	17.8	68	1.7	239	5.8	3,065	74.7

[a]Excludes cancelled and expired permits.
[b]June 1 through December 31
[c]January 1 through May 30

Data Source: City of Edmonton building permit records.

developments, as well as, a few of the older, well-established neighbourhoods (i.e. Laurier Heights, Park-view, Crestwood, Montrose, Highland, McKernan, and Bellevue). The high density structure is likely to be found in the older, central areas of the city. Estimate areas with 50 per cent or more of their housing classified as apartments are found along the north bank of the Saskatchewan River extending northward to the CNR railroad (McVey, 1973, pp. 47-50). High proportions are also found south of the river in the Strathcona district and north of the Industrial Airport.

Changes in housing by type of structure are indicated by census tract in Table 3.6. For the entire City of Edmonton, occupied apartment units increased from 32,531 to 43,745 between 1966 and 1971 -- a 34.5 per cent change. Single-detached dwelling units increased by 18.4 per cent from 66,523 in 1966 to 78,770 in 1971 (McVey, 1973, p. 45). The more significant increases occurred in the areas of residential expansion in the northeastern and southwestern sections of the city. Generally, areas of decline in single-detached units are found to be areas of increase in apartment units. The highest increases are located in the peripheral areas of the city (Figures 3.3 and 3.4). In considering the change in numbers of apartment

Table 3.6--Housing Change Dwelling Units by Type
Edmonton Estimate Areas: 1966-1971

Estimate Areas	Single-Detached				Apartment/Flat			
	1966	1971	Difference		1966	1971	Difference	
			#	%			#	%
Edmonton City	66,523	78,770	12,247	18.4	32,531	43,745	11,214	34.5
1	408	1,720	1,312	643.9	7	200	193	2,757.1
2	1,531	2,130	599	39.1	130	280	150	115.4
3	943	965	22	2.3	120	310	190	158.3
4	700	695	- 5	- 0.7	12	175	163	1,358.3
5	579	600	21	3.6	454	685	231	50.9
6	2,252	2,320	68	3.0	359	575	216	60.2
7	1,104	1,155	51	4.6	331	425	94	28.4
8	1,484	1,450	- 34	- 2.3	44	140	96	218.2
9	740	775	35	4.7	60	25	- 35	- 58.3
10	1,260	1,405	145	11.5	335	270	- 65	- 19.4
11	567	565	- 2	- 0.4	375	1,095	720	192.0
12	1,042	1,295	253	24.3	492	290	- 202	- 41.1
13	1,332	1,460	128	9.6	634	1,005	371	58.5
14	1,573	1,845	272	17.3	571	465	- 106	- 18.6
15	1,160	1,235	75	6.5	160	210	50	31.3
16	1,040	1,565	525	50.5	111	255	144	129.7
17	1,045	1,130	85	8.1	316	210	- 106	- 33.5
18	1,112	1,305	193	17.4	403	305	- 98	- 24.3
19	1,048	1,230	182	17.4	723	665	- 58	- 8.0
20	854	1,035	181	21.2	768	420	- 348	- 45.3

Table 3.6--Continued

Estimate Areas	Single-Detached 1966	Single-Detached 1971	Single-Detached Difference #	Single-Detached Difference %	Apartment/Flat 1966	Apartment/Flat 1971	Apartment/Flat Difference #	Apartment/Flat Difference %
21	793	830	37	4.7	950	1,225	312	28.9
22	628	700	72	11.5	814	745	- 69	- 8.5
23	800	810	10	1.3	19	75	56	294.7
24	1,085	1,170	85	7.8	153	230	77	50.3
25	1,064	1,130	66	6.2	308	275	- 33	- 10.7
26	889	895	6	0.7	484	675	191	39.5
27	892	910	18	2.0	2,204	3,810	1,606	72.9
28	238	345	107	45.0	1,228	1,205	- 23	- 1.9
29	534	810	276	51.7	1,324	1,615	291	22.0
30	1,094	1,120	26	2.4	276	195	- 81	- 29.3
31	1,157	1,170	13	1.1	4	15	11	275.0
32	1,574	1,600	26	1.7	24	55	31	129.2
33	1,166	1,515	349	29.9	965	725	- 240	- 24.9
34	811	915	104	12.8	1,943	2,050	107	5.5
35	484	435	- 49	- 10.1	4,467	5,955	1,488	33.3
36	733	700	- 33	- 4.5	1,952	3,245	1,293	66.2
37	1,965	1,955	- 10	- 0.5	116	365	249	214.7
38	1,151	1,125	- 26	- 2.3	361	835	474	131.3
39	1,219	1,420	201	16.5	62	680	618	996.8
40	1,398	1,435	37	2.6	76	215	139	182.9
41	806	845	39	4.8	201	415	214	106.5
42	1,275	1,295	20	1.6	20	25	5	25.0
43	931	835	- 96	- 10.3	461	645	184	39.9
44	403	345	- 58	- 14.4	805	1,615	810	100.6
45	831	1,070	239	28.8	1,339	1,500	161	12.0

Table 3.6.--Continued

Estimate Areas	Single-Detached 1966	Single-Detached 1971	Single-Detached Difference #	Single-Detached Difference %	Apartment/Flat 1966	Apartment/Flat 1971	Apartment/Flat Difference #	Apartment/Flat Difference %
46	1,554	1,740	186	12.0	605	700	95	15.7
47	808	855	47	5.8	667	600	- 67	- 10.0
48	977	1,030	53	5.4	134	160	26	19.4
49	882	890	8	0.9	280	505	225	80.4
50	2,090	2,195	105	5.0	222	540	318	143.2
51	1,074	1,210	136	12.7	344	285	- 59	- 17.2
52	1,068	1,260	192	18.0	561	465	- 96	- 17.1
53	693	785	92	13.3	718	1,120	402	56.0
54	1,578	1,665	87	5.5	559	670	111	19.9
55	1,120	1,170	50	4.5	295	295	0	0.0
56	1,597	1,810	213	13.3	1	5	4	400.0
57	859	935	76	8.8	3	30	27	900.0
58	1,004	1,365	361	36.0	205	115	- 90	- 43.9
59	1,679	1,745	66	3.9	362	645	283	78.2
60	816	940	124	15.2	343	260	- 83	- 24.2
61	1,896	4,870	2,974	156.9	135	895	760	563.0

The 1971 figures noted in this table have been subjected to the confidentiality procedure introduced in the 1971 Census of Canada. This procedure involves the rounding of all last or unit digits. Since totals are independently rounded, they do not necessarily equal the sum of the rounded sub-parts.

Source: Statistics Canada, 1971 Census of Canada, Census Tract Bulletin, Edmonton, Series A, Catalogue 95-727 (CT-27A), March, 1973.

Figure 3.3

HOUSING CHANGE APARTMENT UNITS BY ESTIMATE AREA EDMONTON: 1966 - 1971

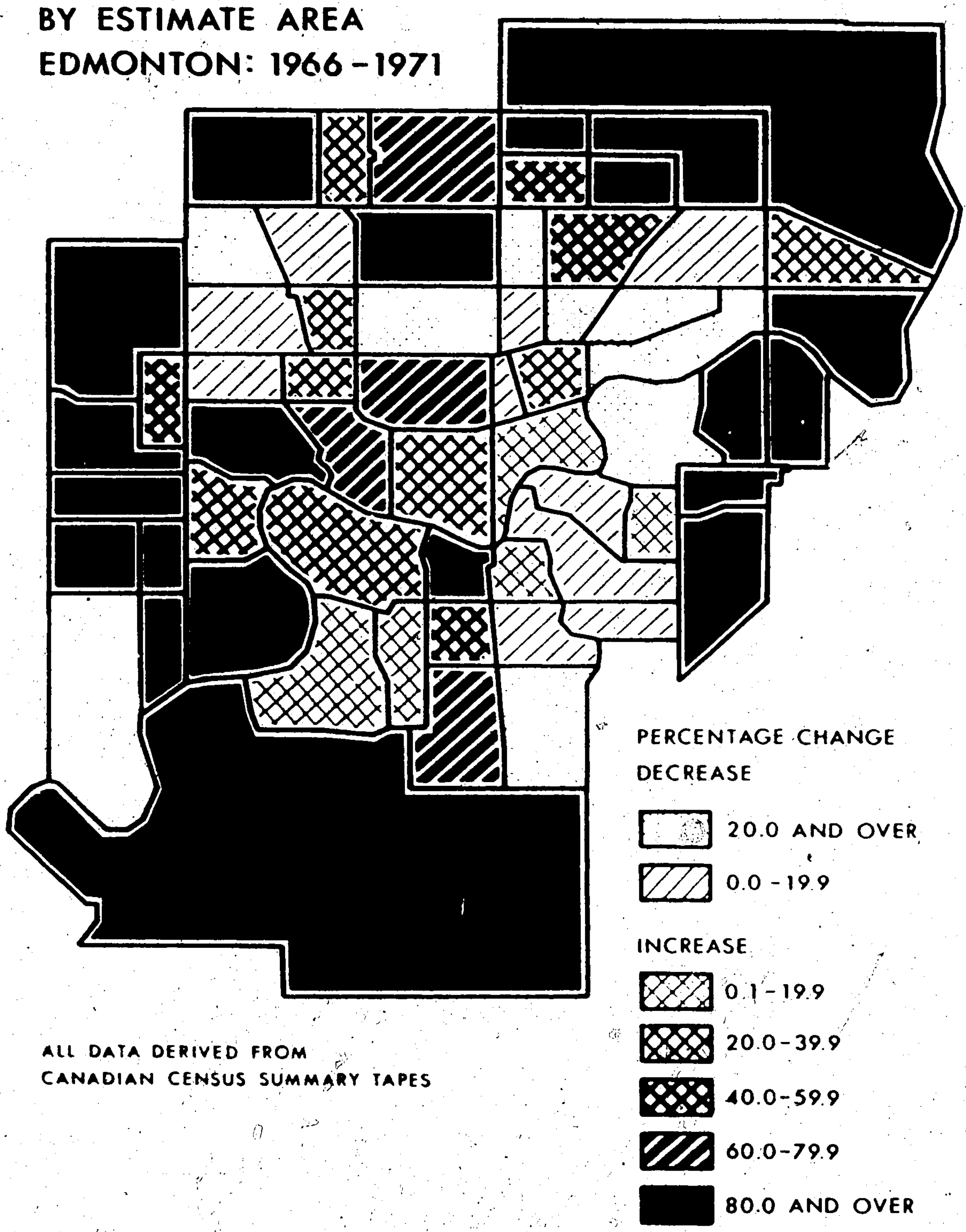

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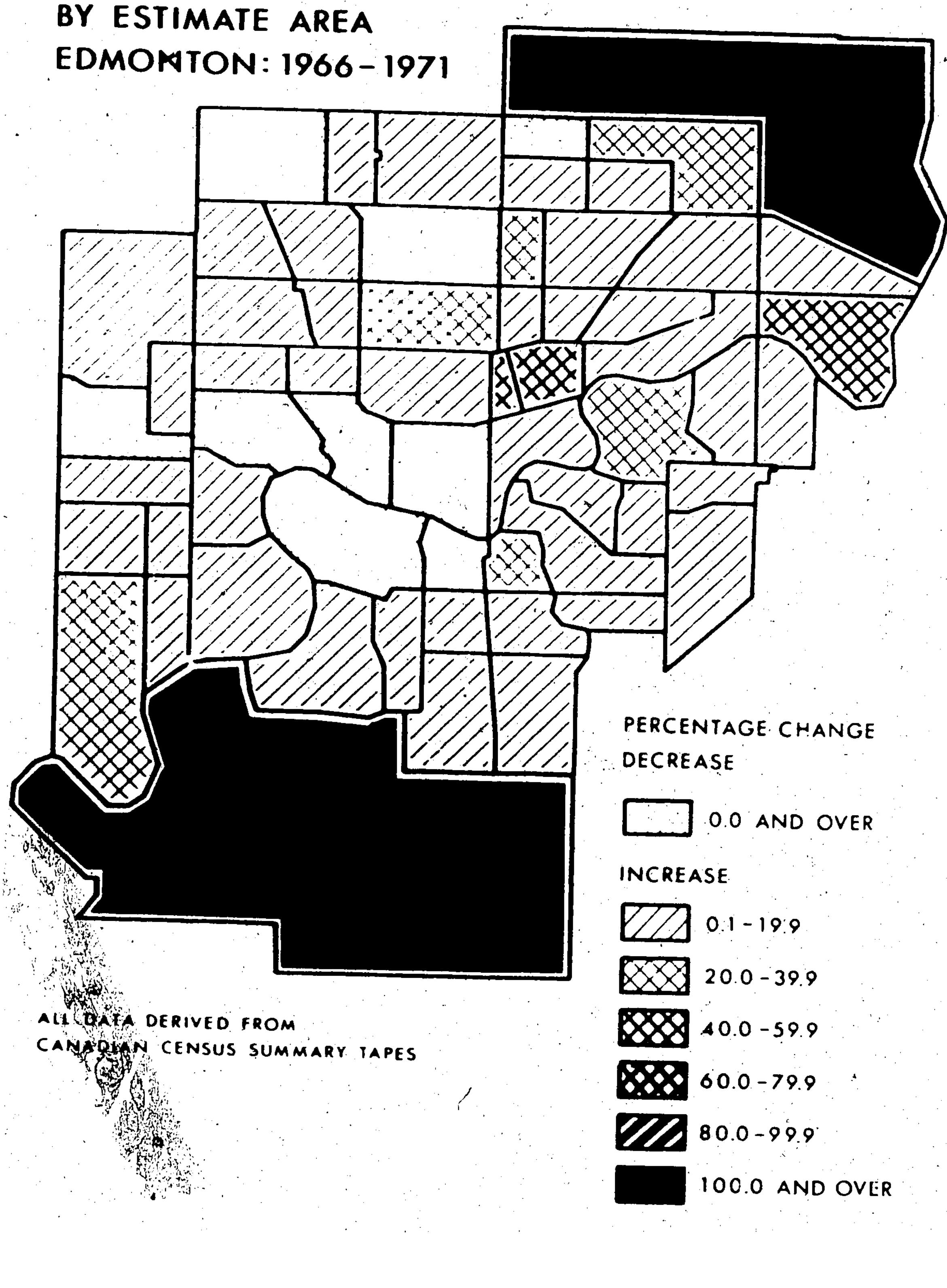
Figure 3.4

HOUSING CHANGE SINGLE - DETACHED UNITS BY ESTIMATE AREA EDMONTON: 1966 - 1971



units, the more significant changes occurred in the Westwood, Prince Rupert, Oliver, Strathcona, the older parts of Jasper Place, and in the southwestern portion of Edmonton. This shift to high density structures in these areas serves to partially explain the population increases experienced in the recent quinquennial period for these central and older areas. The increased apartment construction activity in the peripheral areas of the city may be the forerunner of mixed housing types in areas formerly dominated by the single-detached unit.

As mentioned earlier, it is obvious that the priorities in housing have shifted in emphasis toward the apartment accommodation. Several demographic trends have accounted for this direction in housing activity. It is acknowledged that the apartment with its bachelor and one-bedroom suites is not conducive to childrearing, hence it is not the desired accommodation for the family in its formative years. Family desires continue to be satisfied by the single-detached dwelling. The apartment structure, however, does meet certain types of demand for housing. It is suitable for the single individual, the young married couple without children; the divorced, the widowed or separated person, and the older, retired couple. The size of these population groups has been influenced by other trends occurring in our society. The decreasing age at marriage has increased the number of young couples, and the postponement of childbearing serves to increase the length of time that an apartment will serve their needs. In addition, increasing numbers of females are entering the labour market, a factor which further influences the delay in childbearing and for some the postponement of marriage. Improvement in mortality has added years to the longevity of the Canadian population, which means that married couples will continue to enjoy many years together after their children have matured and left home to form their own families. Consequently, the proportion of aged population increases and the demand for smaller accommodations with lighter maintenance appears. More and more college-age populations are requiring apartment-type accommodations creating a need for this type of housing on or near the university campus. These essential demographic trends have influenced a change in life style and, necessarily, living arrangements.

Economic factors, such as the cost of single-detached dwellings and spiralling land costs within the urban centre, have become prohibitive forces faced by the population groups discussed above. While rental accommodations may fulfill their needs, for many, it is the only viable housing alternative available to them. In the earlier stages of the family life cycle, young married couples are not likely to achieve the income level necessary to allow them access to the home ownership market even if they have need for larger accommodations.

Family Formation and Fertility

A distinction between the concept of family and household is basic to the understanding of the following discussion and tabular presentation. The census family consists of a married couple with or without children who have never married, regardless of age; or a parent with one or more unmarried children living in the same dwelling. A census household pertains directly to the economic aspects of living arrangements. A household is defined as consisting of a person or group of persons occupying one dwelling unit (Statistics Canada, 1972c, p. 9). The size of the household generally reflects the size of the family, however, such persons as lodgers, employees, relatives, and other families contribute to the size of households. Using the household concept as defined, two families occupying one dwelling unit would be indicated as only one household in census tabulations -- a "two-family household."

Basically, unrelated individuals sharing common living arrangements and individuals living by themselves are not considered as constituting family households. Instead, they are classified as non-family households.

The two-family household is an example of the process of "doubling" which was common during the depression and war years when housing was either too expensive or difficult to locate. Economic prosperity may trigger an "undoubling" process which, in turn, would increase the number of households without substantial increase in population. Similar to the undoubling process in which households increase without increase in population, is the creation of new households through marriage. For example, when the bride and groom come from existing city households and form a new household within the same city, the initial population from the two original households are re-distributed into three households resulting in no increase in population. Increases in divorces and separations will serve to create new households, but not additional population. As a consequence of the increasing tendency for young people to leave the residence of the parent family at earlier ages, the single, young adult can create a new non-family household.

There has been substantial evidence to indicate that non-family households have been increasing in Canada. Between 1951 and 1966, non-family households increased from 385,010 to 804,064, or 109 per cent as compared to a 44.7 per cent increase in family households. Contributing to this increase in non-family households has been the trend toward more people electing to live by themselves in addition to the increase in the number of divorced, widowed, and separated members of society (Kalbach and McVey, 1971, p. 304). It would be safe to assume that the major share of these non-family households select the apartment as their housing accommodation.

Increases in the proportion of total households that are classified as non-family will have consequences for the household size (average number of persons per household), in that, the average household size would likely decline. Canada, as well as the City of Edmonton, have experienced declines in household size over the last decennial period. The average household size in 1961 for Canada and Edmonton was 3.9 and 3.5, respectively. By 1971, the average household size declined to 3.3 for both Canada and Edmonton.

Estimate areas within the city of Edmonton experienced no increase in average household size between

1966 and 1971. In the examination of household size by census tract, it was noted that the greatest declines in household size occurred in estimate areas experiencing increases in apartment dwelling units over the intercensal period. Counter influences, such as in-migration into an estimate area, would have to occur to offset household size declines. These counter influences would have to be greater in magnitude in areas of household size declines.

Another trend which influences household size and, of course, overall population size in an area is the trend in fertility. Urban populations have experienced lower fertility levels than rural populations ever since large cities have made their appearance on the national scene. These differences can be attributed to several factors not all of which involve purposeful family limitation. The attraction of young unmarried persons, particularly single females, in search of employment opportunities in the city tends to make the city populations less married than rural populations. The major reason often stated for family limitation in urban areas is the higher cost of childraising, as well as the hindrance that children may present to occupational and geographic mobility. Within urban areas the people who have most severely limited their family size have more often been those who have a moderate economic position or status in the community rather than those who are poor. The increased participation of females in the labour force has had a depressing influence upon family formation and the birth rate. Employed single females may postpone marriage and employed married females may postpone or limit childbearing to later years. As already mentioned, the typical city apartment accommodation is not necessarily conducive to the rearing of large families and may, in itself, be a limiting factor. The building industry with its apartment and three bedroom detached dwelling seems to be compatible with the prevailing trend in the formation and composition of family and non-family households. The above are just a few of the several factors which combine to influence the patterns of fertility.

Marriage rates for Edmonton have been relatively stable over the ten year period, as well as, crude death rates. Since mortality has not changed very much, natural increase for Edmonton has declined over the ten years from 24.2 to 10.1 b~~ecause of~~ the downward trend in birth rates as indicated in Table 3.7. These declines in fertility will partially account for the reported decline in household size. In other words, migration would have to play a

Table 3.7.--Vital Statistics Trends
Edmonton: 1961-1971

Year	Birth Rate	Death Rate	Natural Increase	Marriage Rate
1971	18.9	5.6	13.3	11.3
1970	20.8	5.3	15.5	11.3
1969	20.9	5.4	15.5	12.2
1968	21.0	5.5	15.5	10.8
1967	21.7	5.4	16.3	10.5
1966	22.0	5.4	16.6	10.1
1965	23.4	5.8	17.6	9.1
1964	25.9	5.7	20.2	8.7
1963	28.4	6.4	22.0	10.3
1962	30.0	6.1	23.9	10.9
1961	30.4	6.2	24.2	11.2

Source: Local Board of Health, Edmonton.

greater role in any future population growth if present fertility trends continue. The contributing factors to the more recent declines in fertility have been the liberalization of abortion laws, availability of effective contraceptive methods, and the postponement of family formation after marriage by many young couples.

The effective fertility ratio, or child-woman ratio, is designed for use as an indicator of fertility when more detailed and refined birth statistics are lacking. One of the advantages of this particular fertility measure is that it can be easily calculated from available census data. Hence, the fertility performance of different sub-sections of the same population can be assessed. It should be noted, however, that the children aged 0 - 4 reflect survivors only. The procedure for deriving the effective fertility ratio is to divide the number of children, 0 - 4 years of age, by the number of women in the primary childbearing years, 15 - 44 years of age. Fertility ratios were calculated for each estimate area in Edmonton, as well as the change in fertility ratios between 1966 and 1971 (Table 3.8). The changes in fertility levels by estimate area are illustrated in Figure 3.5 for the entire city.

Low fertility ratios of 149.2 and 155.0 were recorded for estimate areas 35 and 43, respectively. These

Table 3.8.--Change in Fertility
Edmonton Estimate Areas: 1966-1971

Estimate Areas	Fertility Ratios 1966	Fertility Ratios 1971	1966-1971 Per Cent Change
Edmonton City	526.2	383.4	- 27.1
1	722.7	685.2	- 5.2
2	800.1	540.7	- 32.4
3	728.7	470.4	- 35.4
4	683.9	341.8	- 50.0
5	720.5	452.5	- 37.2
6	702.4	425.6	- 39.4
7	658.0	389.1	- 40.9
8	789.5	424.9	- 46.2
9	464.2	316.1	- 31.9
10	499.0	393.0	- 21.2
11	351.8	285.7	- 18.8
12	526.0	507.6	- 3.5
13	490.6	482.7	- 1.6
14	565.3	429.0	- 24.1
15	723.9	438.2	- 39.5
16	656.7	508.3	- 22.6
17	523.9	396.3	- 24.4
18	598.0	446.0	- 25.4
19	479.6	460.5	- 4.0
20	426.9	316.4	- 25.9
21	353.8	302.2	- 14.6
22	476.7	337.2	- 29.3
23	677.2	429.3	- 36.6
24	688.7	473.7	- 31.2
25	397.9	318.8	- 19.9
26	419.3	375.0	- 10.6
27	240.1	270.5	12.7
28	422.3	300.0	- 29.0
29	492.6	413.3	- 16.1
30	425.8	353.3	- 17.0
31	726.0	387.5	- 46.6
32	473.0	234.5	- 50.4
33	521.9	390.7	- 25.1
34	489.0	351.9	- 28.0
35	152.3	149.2	- 2.0

Table 3.8.--Continued

Estimate Areas	Fertility Ratios 1966	Fertility Ratios 1971	1966-1971 Per Cent Change
36	277.2	232.4	- 16.2
37	370.6	295.0	- 20.4
38	640.1	443.1	- 30.8
39	549.7	464.2	- 15.6
40	680.9	334.9	- 50.8
41	655.4	404.4	- 38.3
42	354.3	261.3	- 26.2
43	195.0	155.0	- 20.5
44	258.9	163.8	- 36.7
45	388.5	300.9	- 22.5
46	464.3	359.2	- 22.6
47	488.3	335.0	- 31.4
48	448.9	328.9	- 26.7
49	626.5	344.8	- 45.0
50	704.6	402.1	- 42.9
51	493.0	354.8	- 28.1
52	501.7	392.0	- 21.9
53	367.8	250.0	- 32.0
54	359.6	308.4	- 14.2
55	374.8	237.9	- 36.5
56	435.6	275.2	- 36.8
57	731.2	406.6	- 44.2
58	824.6	426.9	- 48.2
59	609.3	411.4	- 32.5
60	602.4	457.5	- 24.0
61	804.2	495.8	- 38.3

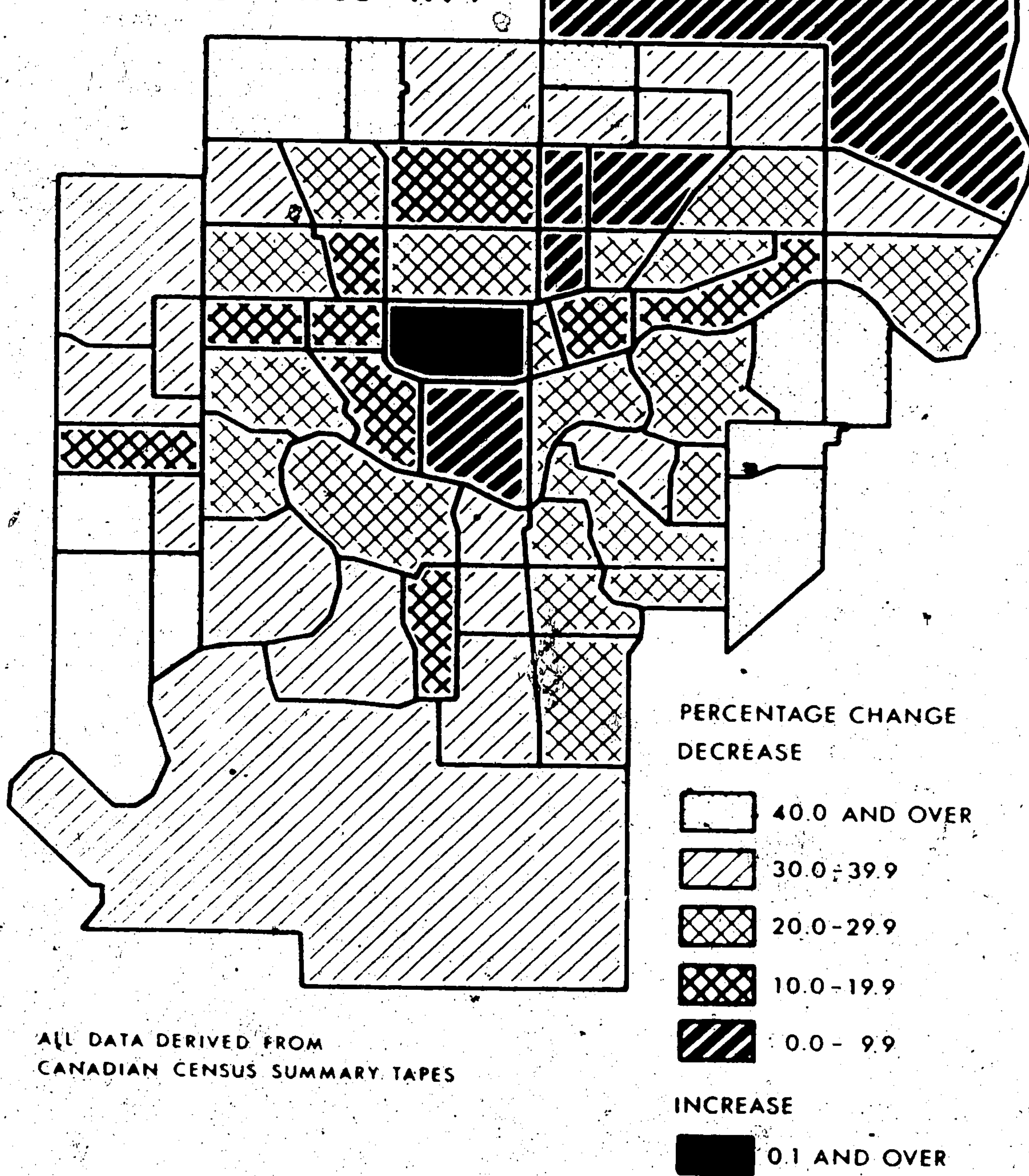
Source: 1966 and 1971 Census of Canada special tabulations.

areas comprise portions of the city centre, Oliver, Windsor Park, Strathcona, and the Garneau districts. These areas are characterized by concentrations of aged, single populations, females in the labour force, and apartment structures. Areas with populations having higher education and relatively established middle and upper class families reflected moderate to low levels in fertility. These areas are located in the western part of the city (Belgravia and Laurier Heights), and the eastern edge of the city (Capilano, Avonmore, and Argyll districts). The peripheral districts of the city, most notably in the northeast, western edge, and southwest, indicated higher levels ranging from 400 to over 600. The highest fertility ratio of 685.2 was reported for the northeast sector of the city. The housing in these areas are primarily the single-detached dwelling unit. It may be noted that the fertility level generally increases in magnitude with increasing distance from the centre of the city.

In the examination of fertility change, it was determined that the city fertility ratio declined from 526.2 in 1966 to 383.4 in 1971, a decline of almost one-third (-27.1 per cent). In Figure 3.5, it will be noted that only one estimate area in the entire city registered an increase

Figure 3.5

FERTILITY CHANGE BY ESTIMATE AREA EDMONTON: 1966 - 1971



ALL DATA DERIVED FROM CANADIAN CENSUS SUMMARY TAPES in fertility between 1966 and 1971. Peripheral areas normally exhibiting high fertility ratios experienced the greatest declines. Most notably, these greater declines occurred in the Capilano, Ottewell, Goldbar, Avonmore, and Argyll districts located on the eastern part of the city, in the western districts of Meadowlark and Rio Terrace, and in the northwestern districts of Calder, Kensington, and Wellington. Such changes are compatible with the recent declines in the Canadian birth rate. These declines suggest either a preference for smaller families or, particularly in older areas, that families are maturing beyond the family formation stage of the life cycle.

In summary, several major trends having influence with respect to the size and distribution of urban populations may be noted:

1. Central cities are experiencing declines in growth rates.
2. Central cities are experiencing continual decentralization of populations which may extend beyond the corporate limits.
3. The suburban parts of the Canadian metropolitan areas are reflecting greater proportional increases in population than the central cities.
4. The central cities record greater absolute increases than the suburban parts.
5. Annexation and utilization of high-density structures in the inner, older areas of the central city serves to offset potential population declines.

6. The newer residential development areas on the periphery of the central city and the older, inner areas experiencing shifts toward high-density housing are the areas of greatest population growth.

7. Non-family households have been increasing in central cities and are providing a market for apartment construction.

8. Fertility and household size have continued to decline over the past decennial period.

9. The apartment dwelling unit has increased in the proportion of the total housing units constructed in Canada, and particularly, in Edmonton.

CHAPTER IV

RESEARCH DESIGN AND THE HOUSING UNIT METHOD

Introduction

The three basic components of the research design involve:

1. the development of a modified housing unit postcensal estimation technique;
2. the preparation of several series of postcensal population estimates employing the modified and unmodified estimation technique;
3. the assessment of accuracy in the population estimates derived.

The strategy exercised is to prepare a series of postcensal population estimates for Canadian cities and urban sub-areas exhibiting varying characteristics. The postcensal estimation period is the five years between 1966 and 1971. This estimation period was selected because the 1966 Census of Canada provided the benchmark housing and population parameters needed for the postcensal estimation procedures and the 1971 Census of Canada provided the parameters necessary to assess the accuracy of results.

Discrepancies between the estimated and enumerated populations are measured and compared for the cities in total, and for the cities categorized according to several control variables, i.e., large versus small cities, growing versus declining cities, and the like. This strategy allows the determination of what type of estimate area yields the most acceptable estimates using the modified housing unit technique.

As stated earlier, the intent of this research is to improve an existing postcensal estimation technique. These refinements or modifications were included in the estimation procedures of the housing unit method discussed in the next section of this chapter.

Measurement techniques are employed in order to assess the improvement in accuracy gained when the modified housing unit technique is used for preparing postcensal population estimates. This assessment of improvement necessitated a series of population estimates to be prepared for the same areas using the unmodified housing unit method.

These two estimation procedures were used to prepare postcensal population estimates for 19 metropolitan areas, 10 central cities, 90 urban centres of over 10,000 population size, and for 61 sub-areas within the city of Edmonton. In every case, 1971 Census of Canada population results were utilized to assess estimate error.

The Modified Housing Unit Method

The housing unit method for estimating postcensal populations is the subject of the research investigation. This method is a censal ratio technique and has been suggested as a promising procedure for determining post-censal population estimates for cities (Taeuber, 1968, p. 70; Morrison, 1971, pp. 22-23; Starsinic and Zitter, 1968, pp. 483-484; Zitter and Shryock, 1964, pp. 240-241). The current popularity of this technique is demonstrated in a recent report of the U. S. Bureau of the Census in which 178 metropolitan areas have listed this method as the primary estimation procedure used (U.S. Bureau of the Census, 1970). The primary reason for this popularity is the availability of the symptomatic indicators -- building permits or utility connections -- at the municipal level.

This postcensal estimation procedure involves the determination of relationships between a symptomatic indicator and the population in a defined area for the most recent census date. This relationship, or ratio, is then applied to the postcensal symptomatic data tabulated for the same defined area at the required postcensal date (Grauman, 1959; Chapin, 1965; Morrison, 1971). The housing unit method rests on the assumption that changes in the number of occupied dwellings for a given area essentially reflects changes in the population for that area (Shryock and Siegel, 1971). Building permit or utility connections comprise the symptomatic data series used to determine the change in the housing stock between the previous census period and the postcensal estimation data.

Utility connections have been used on the assumption that there would be a direct relationship with occupancy, i.e., for every utility connection there is an occupied household. This is not necessarily the case, in that utility connections are often maintained even when the housing unit is vacant and apartment structures are sometimes utilizing single utility connections. These instances cast doubt upon the soundness of the assumption. In addition, research has indicated that postcensal estimate derived from public utility data revealed greater error than estimates based on building records (McVey, 1965, pp. 82-83). The present investigation selected building permit records as the continuous symptomatic data series.

The housing unit postcensal estimation technique involves two primary stages in its operation:

1. A determination of the net change in the number of existing housing units since the last census, and
2. the net housing units are then multiplied by the estimated average size of household to derive an estimate of the population.

The advantages of the housing unit method overcome several of the deficiencies associated with the other postcensal estimation techniques discussed. First, housing unit starts and completions are maintained for cities of 10,000 population or more, as well as for Census Metropolitan Areas. Hence, the symptomatic series is continuous and readily available for cities across Canada. The availability of housing completion data allows for refinement in the housing unit method. Heretofore, the method utilized building permit starts as the symptomatic data series (Shryock and Siegel 1971, p. 755). The building permit start only represents the intent to build by the applicant. Hence, housing completions represent a more accurate indicator of actual housing construction. In addition, there is a time period between the issuance of a permit to build and the actual completion. The availability of this continuous series of completion data allows for the uniform application of the postcensal estimation technique in a wide variety of cities and will reduce error due to "uncompleted" housing starts and the time lag between issuance and completion.

Secondly, a further refinement is made in the housing unit estimation technique. This additional refinement takes advantage of the availability of greater detail provided in the continuous series of symptomatic data.

Building permit start and completion data are recorded by type of housing unit, i.e., single-detached, single-attached, and apartments. This allows application of appropriate household size estimates in the second stage of the technique. For example, rather than be restricted to utilizing an estimate of household size for the entire city applied to the total number of housing starts for the postcensal estimation date, the availability of this further detail in data will enable the technique to utilize an estimated average household size for apartments, an estimated average household size for single-detached dwellings, and an estimated average household size for single-attached dwellings. This modification will provide the appropriate weighting according to the shifts in type of dwelling contruction experienced by the different cities.

Finally, the housing unit method is not complex in its computational form and is not costly to execute. The method is simple in concept and requires little expertise to use. Availability of a continuous series of symptomatic data (building permits) at the local level is instrumental in the selection of this particular technique. Another reason is the relatively recent improvement in the record keeping at the city level, most notably with regard to the use of standard definitions of building type, starts, completions, and units under construction. These improvements alone would have bearing upon the relative accuracy of this technique at the local level.

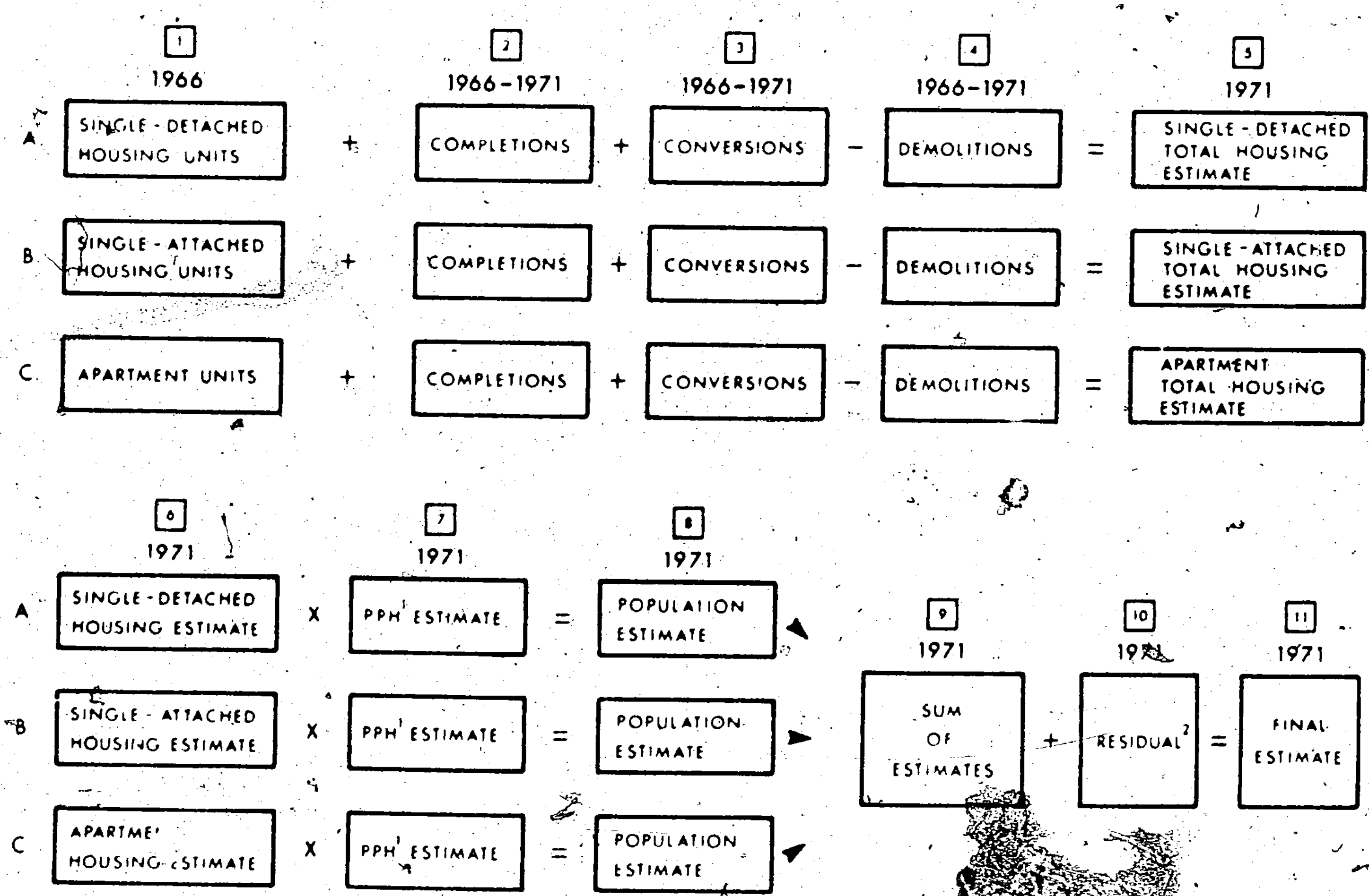
Figure 4.1 portrays the sequence of steps involved in the modified postcensal estimation method as followed in this research. These procedures were applied in the preparation of total city estimates, as well as for estimate areas within the city of Edmonton. Availability of additional information at the census tract level permitted further refinements to be introduced into the procedural estimation sequence. These will be discussed in the next chapter.

The modified method involves eleven basic steps through which postcensal estimates can be obtained for small geographic areas. As indicated in the figure, these eleven steps are repeated for each type of housing resulting in three sub-estimates which are then summed to arrive at a total estimate of population in occupied housing.

Step 1 involves the determination of the number of occupied housing units existing in the selected estimation area at the time of the most recent census. The net housing change in the estimate area between the most recent census date and the postcensal estimate date is then assessed using the symptomatic indicators. Housing unit completions

Figure 4.1

MODIFIED HOUSING UNIT METHOD



[1] population per occupied unit

[2] collective and institutional population

(Step 2) are added to the housing unit conversions (Step 3) arriving at a total housing stock to be included over the estimate period. From this housing total, the demolitions (Step 4) are deleted resulting in a net housing unit figure. This net housing figure when added to the census housing total determines an estimate of the housing inventory for the postcensal estimate date (Step 5).

The second stage of the procedures involves converting the estimated housing figures into an estimate of the population. This is done by applying an estimate of the population per occupied housing unit (Step 7) to the estimated housing inventory (Step 6). This operation results in a population estimate for occupied units (Step 8) for the estimation area. Since the operational procedures to this stage are repeated for each major type of housing, Step 9 involves the summation of these individual population estimates. The remaining component to be considered -- the institutional and collective population (Step 10) -- is then added to the sum of estimates (Step 9) resulting in a final population estimate (Step 11) for the designated estimate area.

Estimation Assumptions

As with any estimation or forecasting technique, there are assumptions associated with the prepared estimates which must be recognized. These assumptions are important not only from the standpoint of the estimate user, who must be aware of the methodological limitations, but also as a safeguard to the estimator.

Population estimation can be conceived as essentially a series of judgments. For example, judgment is required in selection of the kind of estimate one wishes to present, in determination of the most appropriate procedures for preparing the estimate, and in appraising the effects of the factors that have induced such population changes.

The problem of population estimation is a simpler task for areas which are characterized by stability in the size of their populations over a period of several decades or census periods; and for which no dramatic change or fluctuation in the economic and social conditions of the estimate area likely occurred over the estimate period. For larger, more complex areas which have experienced major social and economic swings, the task of population estimation is more difficult.

The factors that are specified in preparing and reporting estimates are customarily expressed in the form of basic assumptions. This, of course, is consistent with the practice of the scientist in preparing "scientific" estimates in any discipline. If there is not an explicit formulation of assumptions, estimation becomes tantamount to mere speculation. As an illustration, a population projection assumes that the factors influencing births, deaths, and migration will interact in a manner that will result in the projected figure (Stanbery, 1952, pp. 2-3).

The basic assumptions which the modified postcensal estimation technique required in the determination of the population estimates may be stated as follows:

1. That changes in the number of occupied dwelling units essentially reflect changes in the population.
2. That the average size of the household in any estimate area will be closely related to the type of housing available in that area.
3. That the proportion of vacant units in the estimate area remains unchanged over the estimate period.
4. That the proportion of collective and institutional populations in the estimate area remains unchanged over the estimate period.

Alteration of any or all of these basic assumptions may have completely unpredictable consequences on the reliability of the postcensal estimates.

The unmodified housing unit method for determining postcensal population estimates is well documented (McVey, 1965; Shryock, 1938; Shryock, 1951; Shryock, 1957; Shryock and Lawrence, 1949; Shryock and Siegel, 1971; Zitter and Shryock, 1964; Siegel, Shryock and Greenberg, 1954; Starsinic and Zitter, 1968; Zitter, Starsinic and Word, 1968). A more recent study by Starsinic and Zitter (1968) reports on the accuracy of the housing unit method in its application to 47 metropolitan areas of the United States. Their general conclusion was that while the method shows promise, there is need for further refinement in the indicators (i.e., building permit data). This refinement concerned estimation of the lag between issuance of a building permit and the actual completion. The modified version of the housing unit method suggested above will utilize completion data and, therefore, will be a step toward resolving this difficulty. A shortcoming of their study is that the cities selected for testing were all growth centers where special censuses had been conducted in postcensal years. These special censuses are utilized for the check on the accuracy of the estimates prepared by the housing unit method. Low growth cities or cities reflecting decline or stability are not likely to finance special censuses and, therefore, these types of cities have not been included in any test of the housing unit method.

Several explorations into the applicability of the housing unit method have indicated a lack of extensive testing. In several cases, the method has not been consistently applied to various cities, i.e., the computational procedures have been modified to "fit" the available data. The uneven quality of data has influenced the precision of the estimates. Morrison states that it is rare where one method has been applied to every population in a computationally consistent manner. (Morrison, 1971, p. 25).

Stratification Variables

Several explorations into the applicability of the unmodified housing unit method have revealed conclusions that may be suspect because of the character of the cities used in the testing. Rosenberg (1968) suggests that stratifying the test cities according to different urban characteristics may aid the investigator in determining with more precision the level of accuracy of the method utilized. Earlier testing had not systematically controlled for these variations in urban characteristics which may have contributed to the inconsistency of the test results. This research purports to determine what urban characteristics are associated with greater precision of estimates. The cities for which estimates are prepared are stratified according to the following characteristics and comparison in estimate error made:

a) Type of construction in the postcensal period.

b) Size categories of cities.

c) Growth patterns.

d) Annexation experience.

e) Household size.

f) Age of city.

Incorporation of these control variables in order to assess their significance for estimating error using housing data has not been done on a large scale in any single research effort (Morrison, 1971, p. 25). This feature of the research will determine the conditions or urban characteristics associated with estimate accuracy. For example, cities with a greater proportion of apartment units added over the postcensal period may be associated with higher estimate error as it may be more difficult to estimate the average household size for apartments. Estimate error may be lower for larger cities as opposed to smaller cities; higher for cities experiencing annexation as opposed to cities with little or no annexation during the postcensal period. Larger cities and cities experiencing annexation would be expected to be rapidly growing and possibly reflecting an "abnormal" population or highly mobile population. The household size control variable will allow an assessment of the magnitude of error associated with estimates for areas experiencing an actual change in average household size over the postcensal period. The limited testing that has been reported so far has been restricted to cities experiencing population growth (California, 1957; Shryock, 1936; Siegel, Shryock and Greenberg, 1954; Starsinic and Zitter, 1968; Zitter and Shryock, 1964; Zitter, Starsinic and Word, 1968).

A brief discussion of the way each variable reflects the population dynamics within an urban area and the expected relationship between the magnitude of the variable and estimate error will further justify the selection of these indicators.

Construction Type

Generally, activity in housing construction has been used as an indicator of the economic well-being of an urban area. In addition, the type of housing constructed is associated with types of living arrangements, family life cycle stages, population structure, and mobility. It is assumed that the single-detached dwelling unit (family type housing) would be more indicative of population stability, i.e., home ownership reflecting commitment to the area or municipality. Whereas, the apartment structure would be more indicative of population change, in that, residents of apartment units tend to be young singles or married without children and are likely to be more mobile. Furthermore, the tendency toward mobility by apartment residents is likely to be associated with higher vacancy rates in predominantly apartment areas. It would therefore be expected that as the proportion of apartment units increase, the level of estimate error will increase.

City Size

There are several assumptions with regard to estimation accuracy associated with city size. If the municipality is large in population size, consequences of population mobility (in and out-migration) are likely to be concealed. It is also likely that data sources for the symptomatic indicator (building permits) are more sophisticated, routinized, and accurate, i.e., the quality of data is likely to improve as the city increases in population size. Concomitant with city population increase and the complexity of decision making, emphasis is placed upon more detail and accuracy in data routinely collected by the various municipal departments. It is expected, therefore, that estimate error will vary inversely with the size of the urban unit.

Growth Rate

The city's or sub-unit's growth rate would be indicative of the area's economic activity. Again, associated with high economic activity and population growth would be the increased mobility or migration input into the city or area. High in-migration would influence the city's population structure by providing younger adults, basically in the economically-active and reproductive age groups. Consequently, the population structure would not only be influenced by the young migrants themselves but also by their tendency toward higher fertility behavior. The reverse situation would likely prevail if an area experienced excessive out-migration. In either case, an "abnormal" population structure would be the consequence. With either excessive out- or in-migration for an urban area, the average household size may be substantially influenced and, consequently, affect any estimation technique that utilizes the average household size in the computational formula.

It is expected that accuracy will improve as the population growth in an area approaches stability (no growth) and, conversely, that estimate error will increase as the areal unit reflects either significant growth or decline.

Annexation Experience

Annexation of land or territorial expansion of the city may influence estimate error in two ways. First, by annexation of land parcels already containing residential units, the municipality record-keeping unit may not have these annexed units recorded in the detail required or the definitions used in the area prior to annexation may be incompatible with the prevailing municipality definitions. Secondly, cities experiencing annexation are likely to reflect high growth rates and the "abnormal" population structure and movement discussed under the item cited above.

Annexations may be adjusted for by utilizing municipal verbal descriptions of proposed land acquisitions. These descriptions fully document the new land area and usually provide actual counts or estimates of dwelling units located in the area at the time of annexation. Hence, the major influence on estimate error will be that of growth by annexation. It is expected that estimate error will vary directly with the annexation experience of the urban area.

Household Size

The most vulnerable element in the estimation sequence is the assumption of no change in household size over the estimation period. The strategy for this variable is to calculate the actual change in the average household size between 1966 and 1971 for each estimate area. This would enable the researcher to assess the magnitude of estimate error associated with change in household size for each area.

It is expected that estimate error will vary directly with change in the average household size over the estimation period. The modified censal ratio procedure proposed will include the appropriate household size ratio for each type of housing thereby allowing the estimate to be weighted according to the emphasis in housing activity over the estimation period. This would ameliorate the distorting influence of using the total average household size which would be weighted in the direction of the larger number of single-detached dwelling units already existing in the area. Census data for 1966 reveals that there is a significant difference between the household size factor for the apartment versus the single-detached unit.

Table 4.1.--Average Number of Persons per Household by Type of Dwelling, Metropolitan Area of Edmonton: 1966.

Dwelling Type	Number of Units	Persons per Household
Total Dwelling Units	110,224	3.5
Single-Detached	70,784	4.1
Single-Attached	6,362	4.0
Appartment/Flat	32,667	2.3

Dominion Bureau of Statistics. 1966 Census of Canada, Households and Families, Household Characteristics by Structural Type and Tenure of Dwelling, Vol. 2-7, Ottawa: DBS, 1969, Tables 44 and 45.

Accordingly, if an urban area reflects a greater percentage of apartment construction during the estimation period than single-detached unit construction, it would be expected that there would be greater error in population estimates if the average household size for total housing was used in the computational formula.

This investigator does not suggest that estimate error will be completely eliminated by using household size ratios appropriate to the housing activity, however, two expectations can be set forth: it is expected that population estimates using the modified censal ratio technique will reflect greater accuracy than estimates prepared using the unmodified censal ratio technique, and estimate error will vary directly with change in household size over the estimation period, regardless of method utilized.

Age of City

Older cities are likely to reflect a stabilization or decline in economic activity and population size. The decentralization of both industry and population are likely to affect the older, larger city rather than the younger, still growing city. The younger cities are still likely to be subject to economic influences and concomitant population influx. In addition, record keeping in the older cities is likely to be more standardized and accurate and, therefore, higher quality in symptomatic indicators would be expected. It is expected that accuracy in estimation will vary directly with age of city.

The indicator of age of city selected is the census year when each city reached a population size to be first reported in the national census (Schnore and Evenson, 1966). This indicator was used for the central city of both the census metropolitan areas and major urban areas.

A different age of area indicator was used for the Edmonton sub-areas. Date of annexation or amalgamation and sub-division registration dates were originally selected, however, neither of these adequately differentiated the sub-areas. Age of construction proved superior to the above indicators and these data were available in census tract publications. Each sub-area was classified according to the proportion of dwelling units constructed prior to 1921.

Assessment and Measurement

In order to assess the improvement gained by incorporating the modified postcensal estimation technique, two series of population estimates are prepared for the municipalities and metropolitan sub-areas. As indicated in Table 4.2, Estimate Series A represents the postcensal population estimates prepared for metropolitan sub-areas, using the modified and unmodified housirg unit method. Similarly, Estimate Series B represents postcensal estimates determined by the two methods for the municipalities. The results derived using these two techniques can be compared to determine which method provides the greater accuracy in population estimation.

Table 4.2.-- Postcensal Population Estimate Series Summary Information: 1966-1971

Estimate Series	Housing Method Used	Estimate Area	Building Permit Data Required	Data Source
A-1	unmodified	city sub-area	starts	Edmonton
A-2	modified	city sub-area	completions	Edmonton
B-1	unmodified	municipality	starts	C.M.H.C.[1]
B-2	modified	municipality	completions	C.M.H.C.[1]

[1]Central Mortgage and Housing Corporation.

Two basic approaches are presented in the assessment of the modified postcensal estimation technique. The first approach involves the evaluation of the symptomatic indicator and procedures used in the preparation of estimates. The second approach incorporates two measurement techniques whereby the population estimates can be assessed in terms of accuracy.

In the evaluation of the symptomatic indicators, specific attention will be directed toward the quality of building permit information, the reliability of the sources, the detail in data provided, the availability of the indicators as a continuous series, consistency in record keeping, and whether the indicator sources are the best sources.

Quality of data retrieved from both the building permit records and from publications released by Central Mortgage and Housing Corporation are checked for accuracy in reporting by matching with census data released from the 1971 Census of Canada. Local housing totals derived from building permits can be matched by type of construction with 1971 Census of Canada figures at both the city level and census tract level. These quality checks are incorporated wherever possible and reported in the next chapter.

In addition, the estimation procedures are systematically examined. These methodological aspects include the comparability of the estimate areas, occupancy ratios, completion factors, and the secondary estimates of changes in household size and non-residential populations (institutional/collective populations).

With the second approach, there are several standards possible for evaluating the accuracy of a population estimate. One can measure the agreement of the estimate with another type of independent estimate, a figure obtained from a population register, or an actual census count (Shryock and Siegel, 1971, p. 764). The estimation period from June 1, 1966 to June 1, 1971 was selected in order to take advantage of 1971 Census of Canada population results for purposes of assessing the accuracy of population estimates. The four series of estimates are then compared to the actual population counts in order to determine which method -- unmodified or modified -- yields the more accurate postcensal estimates. These discrepancies or errors are then presented as numerical and percentage deviations from the actual figures.

A summary measure of error was selected which allows the accuracy of the two methods to be assessed for all estimate areas and various groups of areas. This measure is deri ed by adding all the individual absolute differences, disregarding the signs, and dividing by the number of estimates prepared by a given method. This measure indicates relative error independent of an area's absolute population size, hence, weighting large and small estimate areas equally. This easure is formulated in the following manner:

$$\bar{D} = \frac{\sum_{i=1}^{n} \left| \frac{P - E}{P} \times 100 \right|}{N}$$

Where: P = observed population

E = estimated population

N = number of estimates

The cities, for which estimates are prepared, are grouped according to the various control variables. Rapidly growing cities are compared with stable or declining cities with respect to accuracy of the estimates. Cities with considerable annexation experience are compared with cities with little or no annexation experience. Cities which have recorded changes in the average household size are compared with cities where household size had not changed between 1966 and 1971. Older cities are compared with younger cities and cities experiencing a large proportion of apartment construction during the postcensal period are compared with cities that have experienced less construction of this type.

The last phase in the testing sequence will be the determination of estimate error of this method at the small area level. Population estimates have been prepared for 61 estimate areas within the City of Edmonton. These estimates will be measured for error against the population figures for comparable areas provided by the 1971 Census of Canada. These estimate areas are formed by grouping census tracts to attain comparability over the estimation period. The estimate areas are then grouped according to rates of population growth and major type of housing and the levels of accuracy between the groups estimate areas compared.

A second summary measure incorporated in the analysis of estimate accuracy is Theil's U statistics. This measure is based on the comparison of the estimated population with the observed population parameter for the estimate area (Chisholm and Whitaker, 1971, pp. 161-167). Its computational formula is as follows:

$$U = \frac{\sqrt{\frac{1}{n}\sum_{i}^{n}(P_i - A_i)^2}}{\sqrt{\frac{1}{n}\sum_{i}^{n}P_i^2} + \sqrt{\frac{1}{n}\sum_{i}^{n}A_i^2}}$$

Where the P_i = population estimates

A_i = observed populations

N = number of estimates

The denominator of this statistic normalizes it so that its range in value is the closed interval of zero to one. Therefore, when U is equal to zero it represents a perfect estimate, since the estimate would equal actual and $P_i - A_i = 0$ for all e lates. Conversely, when U is equal to one, one would have all extremely incorrect estimates. (See Appendix A)

Research Propositions

In the following analysis, several research propositions are explored with respect to the resulting accuracy of the modified housing unit method. The major research proposition concerns the improvement in accuracy of postcensal population estimates using the modified housing unit method.

Proposition 1. It is expected that the modified housing unit method will yield more accurate postcensal population estimates than will the unmodified housing unit method.

The following research propositions refer to the modified housing unit method and stratification variables only. Using the modified housing unit method, it is expected that:

Proposition 2. Estimate error will vary directly with the proportion of apartment units in the estimate area.

Proposition 3. Estimate error will vary inversely with the population size of the estimate area.

Proposition 4. Estimate error will vary directly with the population growth rates of the estimate area.

Proposition 5. Estimate error will vary directly with the population decline rates of the estimate area.

Proposition 6. Estimate error will vary directly with the territorial expansion experienced by the estimate area over the estimation period.

Proposition 7. Estimate error will vary directly with change in the average household size experienced by the estimate area over the estimation period.

Proposition 8. Estimate error will vary inversely with the age of the estimate area.

CHAPTER V

EVALUATION OF SYMPTOMATIC INDICATORS

Introduction

In the current investigation, population estimate series were derived using symptomatic indicators gathered from two different sources. The population estimates (Series A) prepared for Canadian cities resulted from data obtained through Central Mortgage and Housing Corporation's central office in Ottawa. Population estimates (Series B) produced for sub-areas within the City of Edmonton utilized data sources provided through the local building inspection office. The possibility for indicator refinement and the difficulties encountered in data assembly varied according to the sources used.

The utilization of two sources for the collection of data and the preparation of the population estimate series necessitates that this chapter be organized by substantive topic, each of which will be subdivided in terms of city and sub-area estimation procedures. For example, discussion of housing category definitions would be followed by separate sections pertinent to city sub-areas and Canadian cities.

Sources and Collection of Data

Although the symptomatic indicators utilized in the derivation of the two postcensal population estimate series were identical, two basic sources of the indicator were employed in this research. The justification for the employment of two sources was that the sub-area postcensal estimates required knowledge of exact addresses for housing activity in order to properly code them by local sub-areas. This refinement is only available at the local municipality level and required access to the actual building permit records.

City Sub-Areas

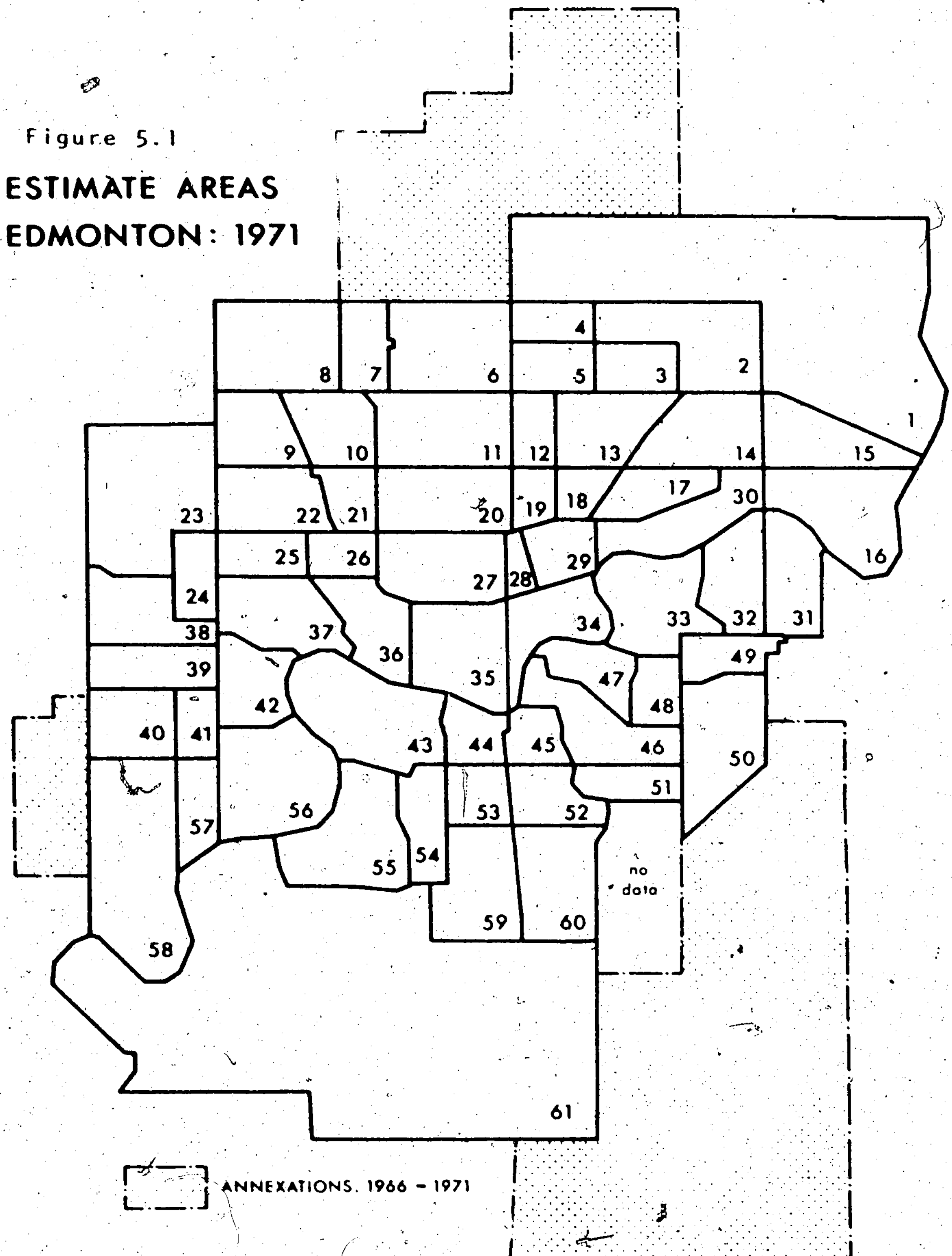
The City of Edmonton was subdivided into comparable areas over the estimation period. Since several 1966 census tracts had been officially subdivided by Dominion Bureau of Statistics prior to the conduct of the 1971 Census of Canada, the estimate area was delineated for purposes of this research. The estimate area is a statistical area that is comparable over the estimation period between June 1, 1966 and June 1, 1971.* In the majority of cases, the estimate area is coterminous with the 1966 census tract configuration. A comparability table is included in Appendix B indicating the similar 1966 and 1971 census tracts. Figure 5.1 portrays 61 estimate areas delineated for the City of Edmonton. The large estimate areas in the northeastern and southwestern sections of Edmonton could not be subdivided further because the 1966 enumeration areas were not compatible with the 1971 census tracts designed for these two growth areas.

All construction activity ongoing within the city requires the completion of a building permit form which is kept on file in the city's building inspection office. Building permits are required for a wide variety of building activity such as commercial signs, pigeon lofts, fences, garages, rumpus rooms, basement suites, new residential buildings, demolitions, conversions, commercial renovations and new establishments, and all multiple-unit construction. Permits for commercial establishments and signs are filed separately from the other types of building activity. Nevertheless, the task of data assembly required filtering through a large number of irrelevant construction permits in order to retrieve the new housing, conversion, and demolition records only. There were approximately six to eight thousand permits per year contingent upon the fluctuating construction activity within the municipality.

The Building Inspection Branch of the Edmonton Planning Department is responsible for the completion of

Figure 5.1

ESTIMATE AREAS EDMONTON: 1971



the building permit and for ensuing building inspections. The building permit is standardized and had not been modified or revised during the estimation period. Arrangements were made with the Planning Department to gain direct access to these building permits for the period from June, 1966 to May, of 1971. The data collection required approximately seven weeks of labour and involved the actual recording of information from 13,187 individual housing construction records. See Appendix C for the tabulation form utilized in the retrieval of building permit data.

Cities and Census Metropolitan Areas

Central Mortgage and Housing Corporation (C.M.H.C) provided access to building information aggregated to the city level only. These data aggregations were derived from information provided to C.M.H.C. by individual cities throughout Canada. This building permit information is housed in C.M.H.C.'s central office in Ottawa. These data are filed by year for each city in housing ledgers. Data transcription forms were completed and checked for 102 cities by a research assistant in Ottawa employed by this investigator. (Appendix C)

Data aggregations by type of housing for the census metropolitan areas were retrieved from the <u>New Residential Construction</u> monthly publications of

Statistics Canada (Statistics Canada, 1972b). These published data are in actuality obtained from C.M.H.C., however, the monthly tabulations are presented in the necessary detail for the nineteen census metropolitan areas used in this study. This monthly series contains housing start and completion statistics for all metropolitan areas and urban centres of 10,000 population and over. This building permit information, however, is not presented by housing type for the urban centres. This deficiency necessitated data retrieval from the housing ledgers at C.M.H.C. for the urban centres not classified as census metropolitan areas.

Table 5.1 indicates the distribution of cities and census metroplitan areas by province for which postcensal estimates have been prepared. A total of 238 postcensal estimates have been derived for the 119 cities and census metropolitan areas under investigation. The majority of cities for which postcensal estimates have been prepared are found in the two most urban provinces -- Ontario and Quebec.

Symptomatic Indicators: Housing Data

The indicators symptomatic of population change incorporated in the postcensal estimation model are the gains and losses in dwelling units experienced by the

Table 5.1.-- Distribution of Estimate Cities, Central Cities, and Census Metropolitan Areas by Province, Canada: 1971

Province	Total	Cities 10,000 and over[a]	Central Cities	Census Metropolitan Areas
Canada	119	90	10	19
Newfoundland	3	1	1	1
P.E.I.	1	1	--	--
Nova Scotia	5	3	1	1
New Brunswick	8	6	1	1
Quebec	36	31	2	3
Ontario	37	27	4	6
Manitoba	4	3	--	1
Saskatchewan	6	4	--	2
Alberta	7	4	1	2
British Columbia	12	10	--	2

[a]This category includes fifteen Major Urban Areas. The Major Urban Area is a statistical area having an urban centre of over 1,000 population with an adjacent built-up area of at least 1,000 population and a minimum density of 1,000 persons per square mile. Major Urban Areas (MUA) are called Census Agglomerations (CA) in the 1971 census.

estimate area over the estimation period. These gains and losses in the housing inventory are determined by the actual records of new housing activity, conversions, and demolitions as maintained by the individual municipality.

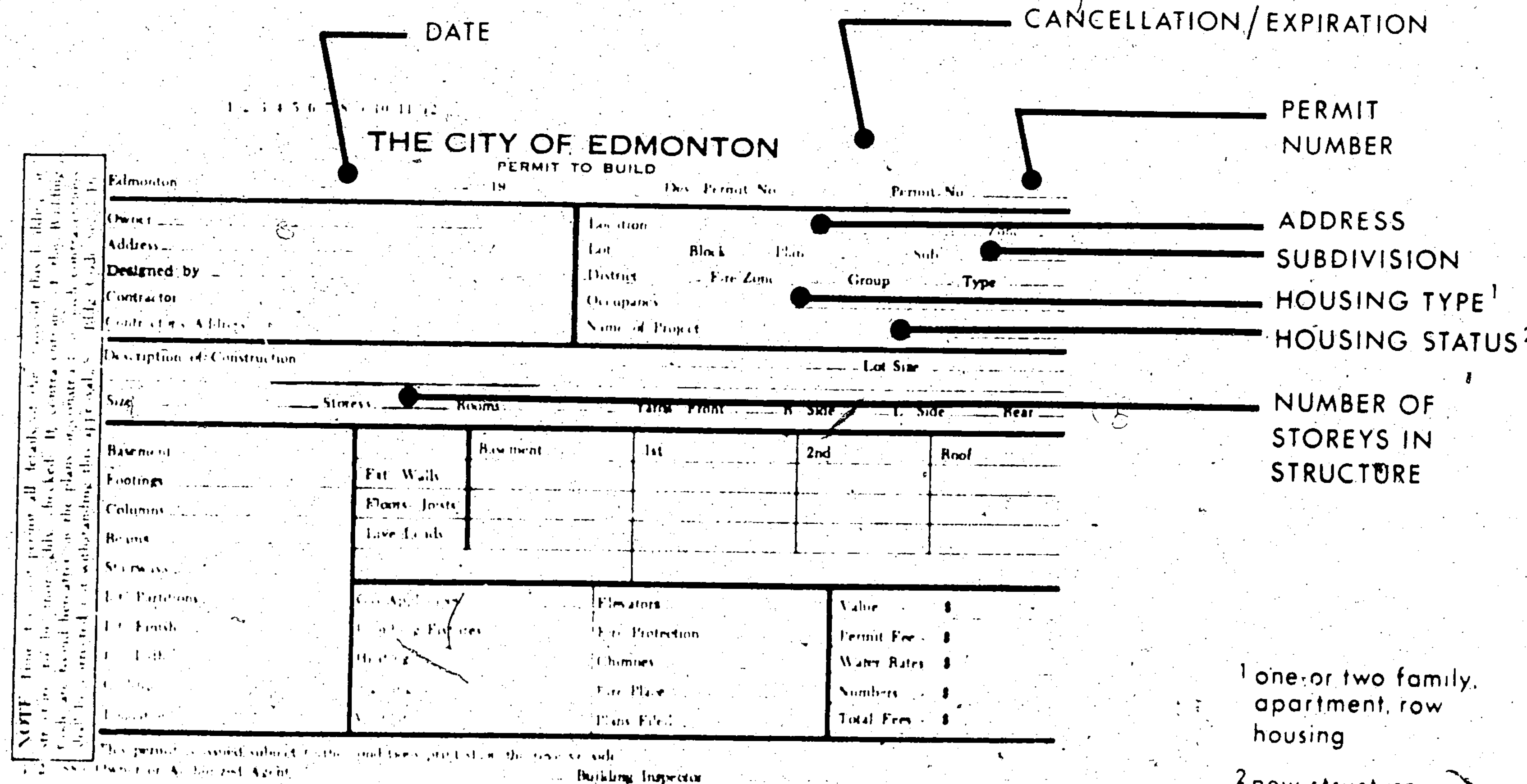
City Sub-Areas

Figure 5.2 illustrates the Edmonton building permit form and the information retrieved relevant to this research. The data assembly required gathering information regarding date of issue, status of the permit, address of the construction activity, type of housing, and whether permit was cancelled or had expired. Additional information regarding number of storeys in structure was collected for every multiple-unit structure constructed during the estimate period. Table 5.2 indicates the data collected from the building permit form and their appropriate application in the research.

The cancellation or expiration entry is handwritten in the upper righthand corner of the permit itself. Included is the date this status becomes effective. All cancellations and expirations by housing type were utilized in the calculation of total number of housing starts by estimate area. A total of 346 cancellations and expirations were recorded for the estimate period which represent .01 per cent of the total number of housing

Figure 5.2

BUILDING PERMIT FORM, EDMONTON: 1966 - 1971



[1] one or two family, apartment, row housing

[2] new structure, demolition, conversion

Table 5.2.-- Data Retrieved and Application in Preparation of Postcensal Estimates, City of Edmonton: 1966-1971

Building Permit Data	Application of Building Permit Data
Date of Issue	Determination of data of housing start
Cancellation/Expiration	Determination of status of permit, i.e., not completed
Permit Number	Reference number for cross-checking purposes
Address	Determination of area assignment
Subdivision Name	Determination of area assignment
Housing Type	Determination of type of housing structure
Housing Status	Type of activity, i.e., new structure, conversion, or demolition
Number of Storeys	Provides detailed information on multi-unit structures i.e., "walk-ups" versus "high rise"

starts tabulated. Subtraction of cancellations and expirations from the total housing starts does not automatically result in the total completions since the housing units started just prior to the estimate date are also not completed. Adjustments for this completion lag are discussed in a later section. Cancellations and expiration dates noted on the permit range from three months to two years after the date of issue. In utilizing the estimation model these cancellations and expirations have to be considered as housing starts.

The Building Inspection Branch policy over the estimate period stated that every permit would automatically expire if active work had not commenced within three months from date of issue and that work started must continue at a reasonable rate until the project is completed. Whether the status of a building permit changes from start to cancellation or expiration is determined by a continuing series of "on site" construction inspection until the project is completed.

The permit number was recorded for purposes of identification and referencing. In several instances, it was necessary to refer to a particular permit a second time to check on possible duplication or to locate more pertinent information for coding the location of the project. The permit number was most useful for referencing in the case of multiple-unit structures. For example, a single multiple-unit structure often has several permits, contingent upon what stage of construction the structure is in. There are three major permit statuses for multi-unit structures, particularly for those structures over six storeys. These structural stages are represented by footing and foundation, structural elements, and final permits. The footing and foundation permit was utilized as the "start" permit for these structures. This was in keeping with the data sources from C.M.H.C. It is obvious that the lag time between the issuance of a footing and foundation permit and the final permit varies according to the structural size of the project undertaken. Instances where a structural elements only or a final permit was recorded for the estimation period, it was necessary to locate the previous construction stage permit. This was done to determine the lag time, i.e., whether the previous permit was dated within the estimation period or was inadvertantly omitted in the original data transcription. The permits for each stage of the construction include notations concerning the permit numbers of previous stages, thus façilitating referencing.

Each construction activity within the city over the estimation period had to be located geographically and coded by estimate area. The address noted on the permit is sufficient to perform this task, however, it was found that the subdivision name proved to be more efficient. In the majority of cases, the subdivisions used by the Building Inspection Branch were coterminous with the estimate areas used in this study. This advantage negated the necessity to locate individual addresses either through a census tract street index or a detailed city map. For example, every building permit indicating a Steele Heights subdivision could automatically be coded as estimate area one; Beverly Heights as estimate area 16; Duggan as estimate area 61, and so forth. In a few cases it was necessary to be aware of boundary streets dividing a subdivision into two estimate areas. About midway in the data transcription, the majority of codification was done simultaneously with transcription.

The most important item on the building permit was that of housing type. The Building Inspection Branch was consistently explicit in recording the type of unit being constructed. Even in the distinguishing characteristic of duplex and double, they were careful to record "over and under" and "side by side" and one-family or two-family in addition to the housing type. The definitions of these housing types are compatible with those used by Statistics

Canada and C.M.H.C. and had not changed over the estimate period.

Housing status includes information as to whether the unit under construction is new, or simply a renovation activity, such as constructing a basement recreation room or partition in an existing structure. It is at this point that demolition or conversion activity is noted. If a family elects to build a basement suite, thus changing an existing single-detached one-family dwelling into a two-family dwelling, it is noted on the permit as a conversion of an existing one-family unit to an "over and under" duplex. In a few cases there were conversions from two-family to single-family units or from a fifteen suite apartment to a fourteen suite apartment. This type of conversion necessitated appropriate recording as a demolition as it would be a housing loss. There were less than fifty conversions recorded over the estimate period and of these, only three resulted in housing loss.

Demolition activity was carefully noted in terms of housing type. In five cases, transient hotel structures were removed from the city's housing stock, however, the permit did not record the number of units within the hotels.

The <u>Henderson's City Directory</u> was utilized to determine the number of occupied units existing in the year prior to the date of the demolition permit. It was found that there were very few occupied households in these structures prior to demolition, however, this additional information was recorded in the data transcriptions.

Removal of housing units from one part of the city to another also requires a construction permit as it involves the preparation of a foundation at the unit's destination. On these construction permits, the expression "move on" is recorded indicating the type of activity involved. In addition, it is noted where the "move on" originated. It was then possible to record a "move on" both on a new unit in the area of destination, as well as a demolition in the area of origin. This type of activity was relatively common in Edmonton, particularly in areas subjected to re-zoning from single-detached to multiple-unit structures.

The "number of storeys" item was recorded for each multiple-unit structure constructed in the city over the estimate period. This allowed differentiation between the typical "walk-up" structure and the "high-rise" multiple-unit structure, as well as ascertaining any shift or trend in type of multiple-unit construction over the estimation period.

Cities and Census Metropolitan Areas

Secondary sources available through C.M.H.C and Statistics Canada provided the data on starts and completions by housing type needed for the estimation models. Building permit data by housing type and status are reported for census metropolitan areas and major urban areas in C.M.H.C.'s annual Canadian Housing Statistics report and its monthly supplements (C.M.H.C., 1971a, 1971b). Contrary to what was initially expected, published data for the remaining Canadian cities were not reported by individual city but only in aggregate form for all cities in excess of 10,000 population. Statistics Canada also publishes building permit data which originate from C.M.H.C. building records, however, while reporting building starts and completions by individual city, there are no published tabulations by housing type (Statistics Canada, 1972a, 1972b) This necessitated retrieving the needed detailed data directly from C.M.H.C. housing ledgers which are housed in Ottawa.

Building permit ledgers are maintained on a quarterly basis for each municipality over 10,000 in population size. The data are provided by each municipality in this size category to C.M.H.C. In addition, these tabulations are kept current for the census metropolitan areas and major urban areas in Canada. A common occurrence is, of course, alteration in municipality and metropolitan area boundaries over the estimate period either through annexation, amalgamation, or definitional change. The records are adjusted according to these boundary changes, and data, in recent years, have been reported in terms of 1966 and 1971 census area boundaries for census metropolitan areas and major urban areas. Data for individual cities experiencing annexation or amalgamation are reported by current boundaries at the time of quarterly data submission.

For these cities it was necessary, where possible, to determine the number of households or population involved in the annexation or amalgamation. Census publications for 1966 and 1971 were utilized to determine the population resident in areas added to the city over the estimate period. Since the building permit information pertained to the original 1966 city, as well as the newly added areas, it was necessary to ascertain the population in the added areas as of June 1, 1966. This population factor was then added to the population estimate for cities experiencing boundary changes.

In several cities, this population factor could not be determined due to the annexation of segments or parts of areas for which data in 1966 were only available for the entire area. It was decided to retain these cities in the analysis as the land area involved in the annexation was not significant. In these cases it would be expected that the unmodified technique would provide estimates closer to the actual population than the modified technique because the housing unit total would be somewhat inflated.

Housing Definitions

The definitions of the basic housing concepts used by the City of Edmonton, C.M.H.C., and Statistics Canada were identical and had not been changed over the estimate period. The "dwelling unit" for purposes of this research was consistently defined as a structurally separate set of self-contained living quarters with a private entrance from either outside the building or a common hall (Statistics Canada, 1972c, p. 36, and C.M.H.C., 1971a, p. 102). A "start" is defined as the beginning of construction work on a building (C.M.H.C., 1971a, p. 102) For a multiple-unit structure, the beginning of construction is when the footing and foundation permit is issued. A "completion" is considered to be the stage at which all proposed work on the construction has been performed (C.M.H.C., 1971a, p. 102)

The housing type definitions used by all data sources were compatible with those employed in the Canadian census. The only change occurring between the 1966 and 1971 censuses involved changing the single-detached label used in 1966 to read single house in 1971. The structural type definitions pertinent to this research are as follows:

> Single House: a structure with one dwelling only, separated by open space from all other structures except its own garage or shed.
>
> Single House Attached: a single dwelling unit attached to a non-residential structure at ground level but separated from it by a wall extending from ground to roof.
>
> Semi-Detached or Double House: a dwelling joined to only one other dwelling, separated from it by a wall extending from ground to roof and not attached to any other building. (This is the "side by side" dwelling noted by the Building Inspection Branch of Edmonton).
>
> Row House: a dwelling unit in a row of three or more dwellings, separated from each other by walls extending from ground to roof. Town Houses, Garden Houses, and Maisonnettes are considered in this category.
>
> Duplex: two dwelling units, one above the other (each having a separate entrance), but not attached to any other building. This includes dwellings which were built as single houses, but in which the basement or upper storey has been converted to form a structurally separate set of living quarters with its own entrance. (This is the "over and under" dwelling noted by the Building Inspection Branch of Edmonton).
>
> Apartment: a dwelling unit in an apartment building (multi-dwelling structure other than a double house or row house), or a house that has been converted into apartments. This includes dwelling types such as triplexes, quadruplexes, or apartment(s) in a non-residential building such as a school, or over a store.

<u>Mobile</u>: a movable dwelling used as a permanent home, but constructed to be transported (e.g., domestic mobile home, trailer, or houseboat). If placed on a permanent foundation, it is considered (for census purposes) to be a "single house".

(Statistics Canada, 1972c, pp. 41-42)

City Sub-Areas

The building permit forms provided the necessary detail in housing type for attainment of compatibility with the above cited housing definitions. Although it was possible to assemble permit data for each estimate area by the detailed housing types, it was necessary to collapse the data into three major housing groups to be compatible with 1971 census housing categories. The housing groups used in the postcensal estimation procedures were: the single detached dwelling unit, the single-attached dwelling unit, and the apartment unit.

Cities and Census Metropolitan Areas

Both the Central Mortgage and Housing Corporation and Statistics Canada utilize these standard housing type definitions, however, they group them differently in their various annual and monthly housing publications. For example, Statistics Canada classifies a duplex (over and under) dwelling unit as a "two-family" dwelling in their <u>New Residential Construction</u> monthly series, while in the census program the duplex is included in the "apartment" tabulations. Therefore, in order to utilize the published residential data of Statistics Canada in the estimation procedures, it is necessary to shift the duplex housing data from the apartment category to the single-attached category. Notwithstanding this ineptness in standardizing published data tabulations, Statistics Canada discontinued the practice of providing detailed housing type tabulations in the 1971 census program; hence, in order to complete appropriate accuracy measurement of the symptomatic indicators, it is necessary to combine the single-attached units and apartment units into a multiple-unit category as it is impossible to determine the number of duplexes enumerated in the census. C.M.H.C. demonstrates a similar pattern in their classification system.

Tables 5.3 and 5.4 portray the manipulation of housing data required in order to attain comparability with both the 1966 and 1971 census periods. The 1966 census summary tapes provided access to the housing detail necessary for the estimation procedures, and the classification system utilized by the sources of the symptomatic indicators determined the three primary housing types needed for the preparation of the postcensal estimates.

Table 5.3.-- Comparable Housing Categories for Edmonton Estimate Area: 1966-1971

1966 Census of Canada	1966-1971 Edmonton Building Permits	1971 Census of Canada
1. Single-Detached Units	One-Family Units	Single Houses
2. Single-Attached Units	Two-Family Units	Single-Attached Units
Double House	Double House	Double House
Row House	Row House	Row House
3. Apartment Units	Apartment Units	Apartment Units
Duplex House	Duplex House	Duplex House

Table 5.4.-- Comparable Housing Categories for Cities, Major Urban Areas, and Census Metropolitan Areas, Canada: 1966-1971

	1966 Census of Canada	1966-1971 C.M.H.C. Housing Records	1971 Census of Canada
1.	Single-Detached Units	Single-Detached Units	Single Houses
2.	Single-Attached Units	Semi-Detached Units	Single-Attached Units
	Double House	Double House	Double House
	Row House	Row House	Row House
	Duplex House	Duplex House	
3.	Apartment Unit	Apartment Unit	Apartment Unit
			Duplex House

Lag-Time in Construction and Occupancy

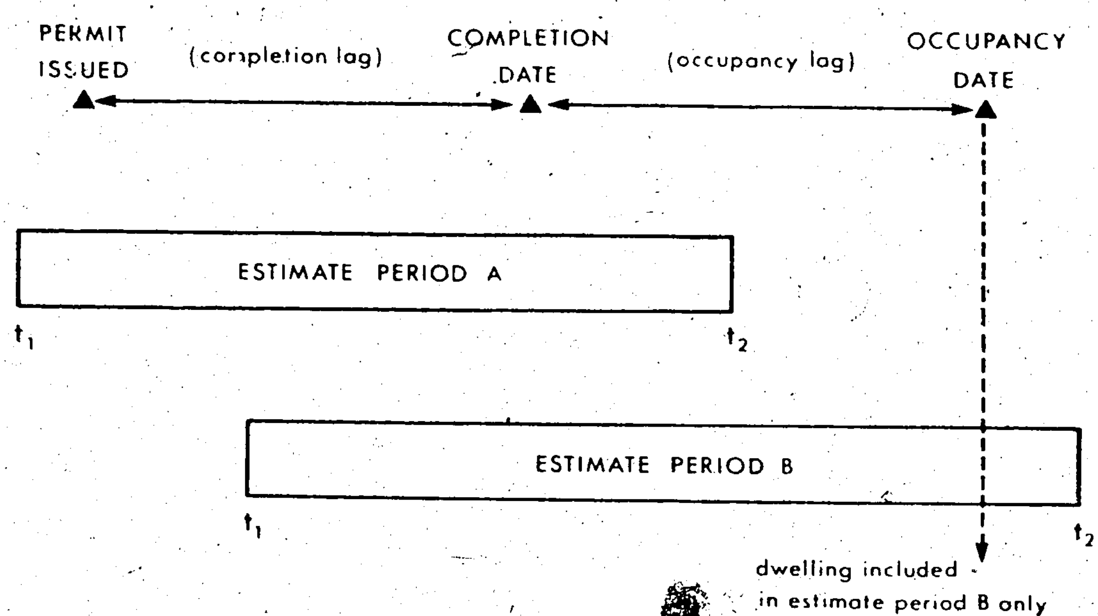
An important dimension in the estimation procedures is the determination of when the building was completed and when it was occupied. In utilizing the modified housing unit estimation method, it is necessary to derive the number of dwelling units by type that were completed within the estimate period. For example, a dwelling unit in the initial stages of construction in May of 1971 would not be completed during the estimate period (June 1, 1971) and, therefore, should not be included in the revised housing inventory. This completion lag is further compounded in that, even when a dwelling unit is completed in the latter part of the estimate period it may not be occupied and, therefore, would not be included in the housing inventory for June 1, 1971. Figure 5.3 portrays the two major lag-times that must be accounted for in the estimate procedures.

City Sub-Areas

Completion and occupancy lag-times vary by type of housing structure. For example, single-detached dwelling units can be completed in a relatively shorter period of time than row housing or large multiple-unit structures. Similarly, occupancy lag-time would vary according to structural type depending upon local housing market demands.

Figure 5.3

COMPLETION AND OCCUPANCY LAG-TIME EXAMPLE



The City of Edmonton's Building Inspection Branch does not indicate a completion date on the actual permit. Since this factor is important only at the beginning and end of the estimate period, it was necessary to derive an average completion lag-time that would be relevant to the basic structural types used in the estimation procedures. These completion lag-times were then applied to building permits issued in the year prior to June 1, 1966 and to those permits issued in the final year of the estimate period. The regional C.M.H.C. office provided information concerning the average completion lag-times by housing type for the local area. In addition, these figures were verified by various Edmonton construction firms responsible for building primarily single-detached, row, and apartment housing. Table 5.5 shows the completion lag-time in months for the major housing types. These completion lag-times do not consider such variable factors as building trade strikes, freight strikes, material shortages, and inclement weather.

Table 5.5.-- Completion Lag-Time Factors by Housing Type, Edmonton: 1966-1971

Type of Housing	Average Completion Time
Single-Detached	3 months
Double/Duplex	3 months
Multiple-Unit (less than 3 storeys)	5 months
Multiple-Unit (more than 3 storeys)	8 months
Row	8 months

The lag-time between the permit being issued and the initiation of actual construction is an unknown factor. It is assumed that construction begins following the issuance of the permit. A further complication occurs when a construction firm actually begins construction before the issuance of a building permit. The only penalty for such a contravention is the payment of double the permit fee if caught, otherwise, construction must begin within three months of the issue date.

The completion lag-time is greater for the larger housing projects, such as row and town house complexes and high rise apartment projects. It was noted that construction activity had shifted notably to the high-density, multiple-unit structures in Edmonton over the estimation period. The completion lag-time fo- these larger structures and projects could be considerably longer than the eight months used in this study, however, improvements in building technology could have the off-setting effect of reducing the completion lag-time.

Cities and Census Metropolitan Areas

Lag-time between the issue date of a building permit and the completion of the building has already been accounted for in the building statistics reported by Central Mortgage and Housing Corporation and Statistics Canada. For the multiple-unit structure, the completion refers to the entire structure rather than the individual apartment units within the structure. The completions are determined by actual physical inspection and, in conjunction with this inspection, a survey is completed with respect to the occupancy of newly constructed units. The dwellings are surveyed each month until it is found that they are occupied, at which time they are excluded from the survey. Unfortunately, C.M.H.C. occupancy information was not reported in sufficient detail or for all cities of 10,000 population size for it to be incorporated in the present study.

CHAPTER VI

VACANCIES, HOUSEHOLD SIZE, AND COLLECTI ~ POPULATIONS

Introduction

Incorporated in the estimation procedures are three estimates of dimensions for which readily available indicators are often lacking. The refinement of any local population estimation technique is contingent upon indicators relevant to the vacancy levels, the average population per household, and the collective population.

Vacancy and Occupied Housing Ratios

There is a paucity of data with respect to the number of vacant dwelling units in Canadian cities. While vacant dwelling units are enumerated during each census year, this information is utilized for administrative purposes only. For example, knowledge regarding the location and number of vacant units in a census year allows census commissioners to insure complete coverage of a census area. This valuable housing information is neither reported in published census documents nor is it available on the census summary tapes. Provincial and census metropolitan area vacancy counts are made available in the Statistics Canada Weekly bulletins, thus permitting vacancy rates to be calculated. Since occupied housing is reported, data concerning vacancies would complete the statistical picture on housing in Canada.

The housing method, as utilized in the United States, incorporates the total housing inventory (including vacant units). This procedure necessitates the determination of a reasonable estimate of current vacancy ratios in order to arrive at an estimate of net occupied housing units for the estimate date. In using the modified and unmodified estimation procedure in this research, it is required that vacancy ratios be applied only to the net completed housing in the estimate period, since an assumption of no change in vacancies permits the use of the census counts of occupied housing units for June 1, 1966.

There are two basic sources of vacant units in any housing stock: (1) those dwelling units available for sale or rent in the housing market and (2) those dwelling units maintained as vacant for a variety of reasons. The vacant units available are either newly constructed or older housing units. Although outside the scope of this research, it is suspected that there would be a greater occupancy lag associated with the old or used housing than with the newly constructed housing. The maintained vacant units or unavailable vacancies would include the second home, or seasonal vacancies; the dilapidated or condemned housing unit; or the housing unit that is continually vacant because of a lack of buyers in a particular area; or the unit maintained simply as an investment (Marcin, 1972, pp. 15-17; Muth, 1969, pp. 116-121; Smith, 1966).

The condemned or dilapidated dwelling unit is likely to result in eventual demolition or removal from the existing housing stock. In actuality, the dilapidated or condemned unit has already been effectively removed from the housing stock prior to demolition (Illing, 1970, p. 12). The estimation procedures used herein assume that the demolition was occupied in the estimation period, whereas, in fact it could very well have been a maintained vacancy. It is also plausible that housing units destined for demolition could have been occupied; however, if occupied, it is likely that the household size would be smaller than average. An example serving to illustrate the latter point would be the Garneau neighbourhood area located near the University of Alberta in Edmonton. Land in this area has been expropriated and contained dwelling units with small household size, e.g., widows or widowers residing in one-family dwellings. Removals from the housing stock should be the subject of further investigation to determine what significance this variable has for housing projections or estimation.

Marcin suggests that the vacancy dimension is relatively unimportant, in that the vacancies will fluctuate between two and four per cent of the total housing stock (Marcin, 1972, p. 15). Wolfgang Illing, in a study concerning housing demand in Canada, alludes to the importance of vacancies in his discussion of short-run deviations as a consequence of temporary overbuilding or underbuilding that may take place in an area (Illing, 1964, p. 10). These short-run deviations could be significant in any local area estimation model that discounts the vacancy dimension.

City Sub-Areas

In both the modified and unmodified estimation procedures, appropriate vacancy ratios were utilized for June of 1966. The vacancy measure derived was the available vacant units expressed as a per cent of the total housing stock, .e., total occupied housing units plus total available vacant units (Winger, 1967, p. 86). These vacancy ratios were converted to occupancy ratios (reciprocal) in order to shorten the procedural steps required in computation. Since vacancy or occupancy ratios vary by housing type, i.e., single-detached dwellings would likely have higher occupancy ratios than multiple-unit structures, it was necessary to obtain a "best" estimate of these differential vacancy ratios. Central Mortgage and Housing Corporation conducts a semi-annual vacancy survey of apartment structures with six units or more, however, this information is only published for census metropolitan areas (C.M.H.C., 1971d, p. 18).

In the preparation of the postcensal population estimates for Edmonton sub-areas, differential vacancy ratios were utilized for June, 1971 as ratios for earlier years were unavailable. For structures with less than six units, including single, duplex and double houses, the "best" vacancy ratio estimate selected was the 1966 average for the City of Edmonton. These differential ratios were only utilized in the preparation of estimates for sub-areas in Edmonton. The collection of data concerning number of suites per apartment structure from the Edmonton building permits allowed this refinement to be included for the sub-area estimates (Table 6.1).

Cities and Census Metropolitan Areas

Detailed housing data regarding size of apartment structure (number of suites) was not available for the cities, major urban areas, and census metropolitan areas. The "best" estimate of the vacancy ratio to be used in the

Table 6.1.-- Vacancy and Occupancy Ratios by Size of Apartment Structure, Edmonton: June, 1971

Structure Size (in units)	Vacancy Ratio	Occupancy Ratio
Total	6.3	93.7
Under 6 units[a]	3.6	96.4
6 - 9	5.0	95.0
10 - 19	4.4	95.6
20 - 29	4.6	95.4
30 - 49	5.9	94.1
50 - 99	9.4	90.6
100 - 199	12.0	88.0
200 and over	11.2	88.8

[a] 1966 Census of Canada data, Statistics Canada Weekly, April 13, 1973, p. 2.

Source: C.M.H.C. semi-annual apartment vacancy survey, February 1, 1972, Table 11.

estimation procedures was determined from provincial and census metropolitan area data released by Statistics Canada. Table 6.2 portrays the provincial vacancy and occupancy ratios by province which were used in the preparation of city estimates. Although these vacancy rates conceal potential variation of rates within the province, e.g., between urban and rural, or between individual cities, they do allow the estimates to reflect regional or provincial variation in vacancies.

Statistics Canada vacancy ratios for 1966, as revealed in Table 6.3, were used for the metropolitan area and central city postcensal estimation procedures. These 1966 ratios were used, rather than extrapolating ratio estimates for the 1971 estimate date, because of short-term fluctuations experienced in vacancy levels. It was decided not to use the 1971 vacancy information from Statistics Canada because of the unusually lengthy delay in the public release of vacancy data, thus making it impractical to use in these procedures.

Household Size

The first stage in the sequential development of the postcensal population figures produces an estimate of the total occupied housing units for the estimate date. Once this revised occupied housing inventory is obtained, the

Table 6.2.-- Vacancy and Occupancy Ratios by Province, Canada: 1966 and 1971

Province	1966		1971	
	Vacancy Ratio	Occupancy Ratio	Vacancy Ratio	Occupancy Ratio
Canada	4.1	95.9	4.6	95.4
Newfoundland	6.8	93.2	5.2	94.8
P.E.I.	6.6	93.4	5.2	94.8
Nova Scotia	5.4	94.6	4.2	95.8
New Brunswick	5.0	95.0	3.9	96.1
Quebec	4.2	95.8	5.1	94.9
Ontario	3.3	96.7	3.7	96.3
Manitoba	4.5	95.5	5.1	94.9
Saskatchewan	6.1	93.9	7.2	92.8
Alberta	5.2	94.8	5.6	94.4
British Columbia	3.3	96.7	4.1	95.9

Source: Statistics Canada Weekly, April 13, 1973, p. 2.

Table 6.3.-- Vacancy and Occupancy Ratios by Metropolitan Areas, Canada: 1966 and 1971

C.M.A.	1966		1971	
	Vacancy Ratio	Occupancy Ratio	Vacancy Ratio	Occupancy Ratio
Calgary	4.2	95.8	6.1	93.9
Edmonton	3.6	96.4	4.3	95.7
Halifax	4.1	95.9	4.1	95.9
Hamilton	2.2	97.8	3.0	97.0
Kitchener	2.3	97.7	4.1	95.9
London	5.6	94.4	5.4	94.6
Montreal	4.0	96.0	5.9	94.1
Ottawa/Hull			3.4	96.6
Quebec	4.5	95.5	5.3	94.7
Regina	3.4	96.6	5.1	94.9
St. John's	2.2	97.8	3.0	97.0
Saint John	5.5	94.5	2.0	98.0
Saskatoon	5.0	95.0	7.6	92.4
Sudbury	2.0	98.0	1.3	98.7
Toronto	2.5	97.5	4.2	95.8
Vancouver	2.4	97.6	4.2	95.8
Victoria	4.1	95.9	3.7	96.3
Windsor	1.4	98.6	2.7	97.3
Winnipeg	3.5	96.5	4.2	95.8

Source: Statistics Canada Weekly, April 13, 1973, p. 2.

second stage of the procedures is contingent upon an adequate current estimate of the average number of persons per household.

This household size estimate can be determined either by utilizing the values provided in the most recent census year (1966) or by deriving extrapolations for the estimate date from the household size reported in the two most recent censuses (1961 and 1966). Previous research has indicated that estimates achieved through extrapolation yielded smaller deviations or error in estimation (Starsinic and Zitter, 1968, p. 480). In the modified technique, extrapolations of household size by housing type were derived from 1961 and 1966 census publications.

City Sub-Areas

The "best" estimate of household size used in the determination of sub-area estimates was an extrapolation of reported 1961 and 1966 household size for the City of Edmonton. Extrapolations of average household size for each of the three basic housing types were used in the derivation of the modified postcensal estimates. It would be desirable to have extrapolated household size estimates for each sub-area within the city in order to account for intra-city variations, however, Statistics Canada does not provide this detail for small areas. An extrapolation of the average population per household for all households was used in the unmodified method of estimation. Table 6.4 portrays these extrapolated values used for sub-area population estimation.

Table 6.4:-- Actual and Estimated[a] Household Size by Type of Structure for Edmonton, Canada: 1961, 1966 and 1971

Year	Total Households	Single-Detached[b]	Single-Attached	Apartment
1961	3.7	4.1	3.8	2.7
1966	3.5	4.1	4.0	2.3
1971	3.3[a]	4.1[a]	4.2[a]	1.9[a]

[a]Extrapolations.

[b]Includes mobile dwelling units.

Source: 1961 Census of Canada, Housing Characteristics by Type and Tenure, Bulletin 2.2-7, Table 77; 1966 Census of Canada, Households and Families, Household Characteristics by Structural Type and Tenure of Dwelling, Vol. II (2-7), Table 45.

Cities and Census Metropolitan Areas

Similarly, extrapolated estimates of 1971 average household size were calculated for each city and census metropolitan area. These extrapolations were utilized in the second stage of the unmodified postcensal estimation procedures.

Extrapolation of household size values by type of structure were used in the modified estimation technique.

The paucity of available detailed household data prevented the derivation of household size estimates for individual cities with the exception of census metropolitan areas. In the case of city postcensal population estimates, urban household size data by province were incorporated as the closest estimate, e.g., Albertan cities utilized the Alberta urban household size values by type of structure as presented in Table 6.5

Household size by type of structure was available for census metropolitan areas in 1961 and 1966, thus permitting extrapolations to be prepared for 1971 as indicated in Table 6.6. The census metropolitan area household size extrapolations were considered the best estimates attainable for use in the derivation of the ten selected central city postcensal population figures.

Collective Household Population

The final step in the preparation of the postcensal population estimates involved augmenting the occupied household population with the population resident in collective households. The collective household population includes residents of health and welfare institutions, correctional institutions, religious and educational institutions, hotels and lodging-houses, military and construction camps, Hutterite colonies, merchant vessels,

Table 6.5.-- Estimated[a] Urban Household Size by Type of Structure for Provinces and Canada: 1971

Province	All Structures	Single-Detached[b]	Single-Attached	Apartment
Canada	3.5	4.0	4.0	2.6
Newfoundland	4.8	5.0	4.9	3.6
Prince Edward Island	3.9	4.3	4.2	2.8
Nova Scotia	3.8	4.1	4.3	3.0
New Brunswick	3.8	4.2	4.2	3.0
Quebec	3.6	4.4	3.8	3.1
Ontario	3.6	3.9	4.5	2.4
Manitoba	3.2	3.7	3.8	2.2
Saskatchewan	3.3	3.8	3.4	2.0
Alberta	3.4	3.9	3.8	1.9
British Columbia	3.1	3.6	3.2	1.9

[a]Extrapolated from 1966 and 1961 Census of Canada data. 1966 Census of Canada, Households and Families, Bulletin 2.7, Vol. II, Table 44; 1961 Census of Canada, Housing, Dwelling Characteristics by Type and Tenure, Bulletin 2.2-7, Table 76.

[b]Includes mobile dwelling units.

Table 6.6.-- Estimated[a] Household Size by Type of Structure for Census Metropolitan Areas: 1971

C.M.A.	All Structures	Single-Detached[b]	Single-Attached	Apartment
Calgary	3.4	3.9	3.2	1.8
Edmonton	3.3	4.1	4.2	1.9
Halifax	3.8	4.2	4.8	3.0
Hamilton	3.5	3.9	4.2	2.3
Kitchener	3.6	3.9	3.7	2.6
London	3.4	3.8	3.7	2.1
Montreal	3.3	4.4	3.8	3.1
Ottawa/Hull	3.5	4.1	4.6	2.5
Quebec	3.8	4.5	3.9	3.1
Regina	3.2	3.8	3.9	1.9
St. John's	4.4	4.8	5.0	2.8
Saint John	3.6	4.1	3.7	3.1
Saskatoon	3.3	3.9	3.7	2.0
Sudbury	3.9	4.9	3.7	2.8
Toronto	3.5	4.1	4.8	2.3
Vancouver	3.1	3.8	3.1	1.7
Victoria	2.9	3.4	2.9	1.7
Windsor	3.6	4.0	3.6	2.2
Winnipeg	3.2	3.9	3.7	2.0

[a]Extrapolated from 1966 and 1961 Census of Canada data. 1966 Census of Canada, Household Characteristics by Structural Type and Tenure of Dwelling, Vol. II (2.7), Table 45.

[b]Includes mobile dwelling units.

and diplomatic residences. A detailed listing of collective and other special types of households included in this general category is included in Appendix D. The collective population is simply defined as the household population occupying a collective dwelling. The collective dwelling refers to a dwelling in which a large number of persons are likely to reside (Statistics Canada, 1972c, pp. 9-10, 36-37). Also included in this category of collective dwellings are small hotels, nursing homes, and the like, which display indications of a business establishment, e.g., Single Man's Hostel or the Good Samaritan Nursing Home.

Since the collective population is not included in the calculation of the occupied household population estimate, it must therefore be accounted for in this final stage of the procedures. In primarily residential sub-areas or cities, the collective population is not likely to be a significant dimension to consider, however, in estimate areas or cities experiencing large numbers of collective populations it is of considerable importance to the accuracy of the final population estimates.

The urban collective-type households that must be considered in the preparation of the final population estimate would include any military barracks or installations, general hospitals and staff residences, nurses' residences, homes for the infirm and aged, jails and detention centers, hotels and lodging centers, orphanages, convents, boarding schools, special residential schools for the handicapped, and student residences at universities. It is not uncommon for sub-areas in the central part of the city containing collective households to have a greater proportion of collec population than population in occupied households.

The "best" estimate of collective population is to utilize the most recent census data when other reliable sources are unavailable. For all postcensal estimates prepared in this study, the collective population estimate for the 1971 estimate date was the 1966 Census of Canada enumerated figures. These most recent census counts of collective population were incorporat both the modified and unmodified estimation proce . For each estimate area and city, the population in occupied dwelling units was determined and this figure was subtracted from the total population reported for the estimate area in the 1966 census. The residual obtained in this manner is equivalent to the collective population in the estimate area. This operation is expressed in the following equation: Collective population = total population - population in occupied households. This operation is facilitated by the fact that collective households are not included in any occupied household tabulations released by Statistics Canada.

Alternative Measurement of Vacancies, Household Size, and Collective Populations

In keeping wit he basic intent of developing a set of estimation p dures that would incorporate readily available indicators, secondary sources were used in the derivation of the estimates of vacancies, household size, and collective populations in this study. By conforming to this principle, it is known that the estimation method can be applied to any urban area for which these sources are available.

It is recognized that these variables can experience significant change over the estimation period and, thus, can cast serious doubt upon the validity of basic assumptions of no change in these parameters. Various municipalities may have access to alternative ways to measure changes in these dimensions, in which case, they may prove superior to the indicators used in this investigation. Several alternating means of indicator determination can be suggested for incorporation in the estimation procedures which are contingent upon local initiative and availability of sources.

Vacancies

Vacancy ratios in local areas can fluctuate according to shifting economic levels. In situations where lower or higher vacancy conditions are suspected, it would be advisable to determine a reasonable estimate of the vacancy ratio for the estimate date. When other information is lacking, the Central Mortgage and Housing Corporation semi-annual vacancy surveys can be used as the best estimate, however, these data are available only for the larger urban areas in Canada.

Another alternative is to utilize sample surveys in the estimate area or city to determine vacancy levels. This technique would be an efficient and inexpensive way of obtaining current measures of vacancies by housing type which could be introduced into the estimation procedures.

In the event that a municipality conducts bi-annual censuses, the information obtained on vacancies and household size could be utilized to update these parameters in the estimation methodology. In this instance, the estimation technique could be employed in alternating years in conjunction with an actual census undertaking.

The average household size is extrapolated for the estimate year in the estimation procedures. Actual censuses or sample surveys can also be utilized to obtain current measurement of changes in household size by type of structure which then can be incorporated into the estimation procedures. Exploration of the possible use of Henderson City Directories may prove fruitful in providing indicators of change in household size in estimate areas. If well planned, it is felt that a sample survey can provide the necessary information for both the vacancy level and household size in the area.

The collective population is likely to increase as the municipality increases in size. It is possible to get information on the collective population in institutions from a telephone survey based on known institution listings for the municipality and this procedure should be relatively inexpensive in time and cost. An actual census conducted every other year would also be a means of obtaining up-to-date information on the collective populations.

These suggestions are a few of the ways for achieving more accurate measurement of the changes that may take place with respect to the three parameters in question. It is important that these resources be utilized if there is firm suspicion of changes in any one or all of the parameters used in the second stage of the estimation model.

CHAPTER VII

ACCURACY OF THE SYMPTOMATIC INDICATOR

Introduction

This chapter presents a limited assessment of the accuracy of the symptomatic indicator employed in the initial stage of the estimation sequence. The occupied dwelling units derived by both the modified and unmodified estimation procedures will be compared in terms of agreement with actual 1971 census counts. This assessment is hampered by the fact that the final estimate of occupied households is the result of two estimates: the revised inventory of total households and the estimated occupancy ratio. If either or both of these dimensions are in error, then the final estimate of households would likely be in error.

The evaluation of indicator accuracy is important, in that while the occupied household estimate derived in the first stage of the estimation process could be quite accurate, the population estimates derived in the second sequential stage could be in error. This dilemma can be explained by inaccurate estimates of other parameters utilized in the second stage, such as the average household size estimate or the estimated collective and institutional population. Error in either one of these estimates can result in estimation error, although the symptomatic indicator could be reasonably accurate.

The best way to assess the accuracy of the occupied household estimate is to compare these estimates with the observed occupied households for each area or municipality provided by the 1971 Census of Canada. Two measures were utilized in this assessment: simple percentage error between the estimate and actual count and the U statistic for indicating improvement between the two estimation procedures employed in this investigation.

City Sub-Areas

Table 7.1 portrays the comparison of household estimates and per cent error for each of the sixty-one estimate areas by method used. It will be noted that for all estimate areas, the error was 1.1 per cent using the modified estimation procedure as compared to a 4.8 per cent error using the unmodified procedure. Forty-seven estimates produced by the modified technique were within ±5 per cent deviation from the actual counts, and only two indicator estimates deviated by more than ten per cent. Correspondingly, the unmodified procedure produced 41 indicator

Table 7.1.—Comparison of Occupied Household Estimates with Actual Occupied Households for Sixty-One Estimate Areas, Edmonton: 1971

Estimate Area	Actual Occupied Households[a]	Unmodified Estimates: Occupied Household Estimate	Diff.	% Error	Modified Estimates: Occupied Household Estimate	Diff.	% Error
Total	128,545	134,766	6,221	4.8	129,945	1,400	1.1
1	4,020	5,045	1,025	25.5	4,321	301	7.5
2	2,615	2,522	- 93	- 3.6	2,515	- 100	- 3.8
3	1,420	1,440	20	1.4	1,429	9	0.6
4	1,230	1,210	- 20	- 1.6	1,201	- 29	- 2.4
5	1,740	1,724	- 16	- 0.9	1,714	- 26	- 1.5
6	3,360	3,309	- 51	- 1.5	3,282	- 78	- 2.3
7	1,630	1,654	24	1.5	1,651	21	1.3
8	2,040	2,067	27	1.3	2,065	25	1.2
9	905	904	- 1	- 0.1	904	- 1	- 0.1
10	1,840	1,809	- 31	- 1.7	1,804	- 36	- 2.0
11	1,695	1,714	19	1.1	1,680	- 15	- 0.9
12	1,595	1,587	- 8	- 0.5	1,584	- 11	- 0.7
13	2,570	2,671	101	3.9	2,654	84	3.3
14	2,355	2,327	- 28	- 1.2	2,324	- 31	- 1.3
15	1,475	1,481	6	0.4	1,466	- 9	- 0.6
16	1,880	1,980	100	5.3	1,900	20	1.1
17	1,365	1,390	25	1.8	1,390	25	1.8
18	1,650	1,635	- 15	- 0.9	1,644	- 6	- 0.4
19	1,955	1,907	- 48	- 2.4	1,910	- 45	- 2.3
20	1,725	1,747	22	1.3	1,658	- 67	- 3.9
21	2,080	2,204	124	6.0	2,180	100	4.8
22	1,650	1,657	7	0.4	1,658	8	0.5
23	1,040	1,021	- 24	- 2.3	908	- 137	-13.1
24	1,430	1,524	94	6.6	1,471	41	2.9
25	1,520	1,528	8	0.5	1,528	8	0.5
26	1,615	1,663	48	3.0	1,646	31	1.9
27	4,770	5,078	308	6.4	4,960	190	4.0
28	1,580	1,501	- 79	- 5.0	1,501	- 79	- 5.0
29	2,440	2,806	366	15.0	2,607	167	6.8
30	1,360	1,433	73	5.4	1,429	69	5.1
31	1,385	1,385	0	0.0	1,385	0	0.0
32	1,660	1,607	- 53	- 3.2	1,607	- 53	- 3.2

Table 7.1.--Continued

Estimate Area	Actual Occupied Households[a]	Unmodified Estimates: Occupied Household Estimate	Diff.	% Error	Modified Estimates: Occupied Household Estimate	Diff.	% Error
33	2,275	2,301	26	1.1	2,317	42	1.8
34	3,025	2,920	- 105	- 3.5	2,900	- 125	- 4.1
35	6,450	7,341	891	13.8	6,991	541	8.4
36	4,060	4,934	874	21.5	4,529	469	11.6
37	2,345	2,433	88	3.8	2,412	67	2.8
38	2,000	2,239	239	12.0	2,070	70	3.5
39	2,105	2,198	93	4.4	2,168	63	3.0
40	1,870	1,907	37	2.0	1,756	- 114	- 6.1
41	1,305	1,284	- 21	- 1.6	1,306	1	0.1
42	1,305	1,345	40	3.1	1,347	42	3.2
43	1,465	2,468	1,003	68.5	1,537	72	4.9
44	1,955	2,072	117	6.0	2,039	84	4.3
45	2,590	2,771	181	7.0	2,700	110	4.2
46	2,535	2,624	89	3.5	2,607	72	2.8
47	1,500	1,492	- 8	- 0.5	1,490	- 10	- 0.7
48	1,425	1,422	- 3	- 0.2	1,415	- 10	- 0.7
49	1,420	1,312	- 108	- 7.6	1,306	- 114	- 8.0
50	2,940	2,817	- 123	- 4.2	2,860	- 80	- 2.7
51	1,550	1,520	- 30	- 1.9	1,531	- 19	- 1.2
52	1,730	1,845	115	6.6	1,840	110	6.4
53	1,920	1,991	71	3.7	2,025	105	5.5
54	2,345	2,228	- 117	- 5.0	2,225	- 120	- 5.1
55	1,470	1,450	- 20	- 1.4	1,456	- 14	- 1.0
56	1,830	1,817	- 13	- 0.7	1,827	- 3	- 0.2
57	970	971	1	0.1	972	2	0.2
58	1,670	2,068	398	23.8	1,790	120	7.2
59	2,795	3,010	215	7.7	2,842	47	1.7
60	1,455	1,420	- 35	- 2.4	1,420	- 35	- 2.4
61	6,640	7,036	396	6.0	6,291	- 349	- 5.2

[a]1971 Census of Canada Summary Tapes.

estimates within ± 5 per cent deviation, and seven estimates were in excess of ten per cent error. The average per cent error ($\bar{D}$) for all estimate areas was 3.2 using the modified technique as compared to 5.5 for the unmodified technique.

Estimation error by housing type is presented for the modified technique in Table 7.2, where comparisons of single-detached and appartment dwelling units with actual counts are shown. A relatively poorer performance is indicated, in that error exceeds five per cent for both types of housing with a -6.9 per cent deviation for the single house estimate and a 16.4 per cent error for the apartment unit. It should be noted, however, that in many cases the small numbers of units involved will yield a very high percentage. Notwithstanding this caution, it is suspected that the underestimation of single-houses is due partially to using an occupancy ratio estimate lower than what was actually experienced. Similarly, the estimated occupancy ratio for apartments was too high.

The trend toward construction of large, high rise complexes in Edmonton at the end of the estimation period may possibly contribute to the inflated estimates of occupied apartment units. In the earlier part of the estimation period, the walk-up apartment structure dominated the apartment construction. These smaller structures were

Table 7.2.--Comparison of Occupied Household Estimates by Housing Type With Actual Occupied Households for Sixty-One Estimate Areas, Edmonton: 1971

stimate Areas	Actual Occupied Single-Detached Units[a]	Single-Detached Units			Actual Occupied Apartment Units[a]	Apartment Units		
		Estimate	Difference	Per Cent Error		Estimate	Difference	Per Cent Error
otal	77,110	71,803	-5,307	- 6.9	43,640	50,779	7,139	16.4
1	3,025	3,167	142	4.7	200	302	102	51.0
2	2,130	1,969	- 161	- 7.6	280	324	44	15.7
3	955	959	4	0.4	290	359	69	23.8
4	710	704	- 6	- 0.8	190	150	- 40	- 21.0
5	605	583	- 22	- 3.6	695	661	- 34	- 4.9
6	2,335	2,265	- 70	- 3.0	585	530	- 55	- 9.4
7	1,150	1,107	- 43	- 3.7	415	403	68	16.4
8	1,450	1,486	36	2.5	145	108	- 37	- 25.5
9	765	742	- 23	- 3.0	20	60	40	200.0
10	1,410	1,256	- 154	- 10.9	280	369	89	31.8
11	580	497	- 83	- 14.3	1,105	1,164	59	5.3
12	1,285	1,030	- 255	- 19.8	380	535	155	40.8
13	1,450	1,283	- 167	- 11.5	995	1,269	274	27.5
14	1,860	1,621	- 239	- 12.8	465	668	203	43.6
15	1,225	1,187	- 38	- 3.1	200	228	28	14.0
16	1,550	1,486	- 64	- 4.1	240	319	79	32.9
17	1,135	1,046	- 89	- 7.8	215	337	122	56.7
18	1,305	1,124	- 181	- 13.9	310	439	129	41.6
19	1,225	1,046	- 179	- 14.6	665	729	64	9.6
20	1,045	854	- 191	- 18.3	420	784	364	86.7
21	845	776	- 69	- 8.2	1,230	1,378	148	12.0
22	705	629	- 76	- 10.8	745	831	86	11.5

Table 7.2.--Continued

Estimate Areas	Actual Occupied Single-Detached Units[a]	Single-Detached Units: Estimate	Single-Detached Units: Difference	Single-Detached Units: Per Cent Error	Actual Occupied Apartment Units[a]	Apartment Units: Estimate	Apartment Units: Difference	Apartment Units: Per Cent Error
23	805	797	- 8	- 1.0	75	81	6	8.0
24	1,175	1,105	- 70	- 6.0	235	336	101	43.0
25	1,135	1,082	- 53	- 4.7	275	364	89	32.4
26	915	875	- 40	- 4.4	690	738	48	7.0
27	910	763	- 147	- 16.2	3,815	4,149	334	8.8
28	335	231	- 104	- 31.0	1,185	1,233	48	4.0
29	790	496	- 294	- 37.2	1,540	2,030	440	27.7
30	1,120	1,069	- 51	- 4.6	185	328	143	77.3
31	1,185	1,164	- 21	- 1.8	5	4	- 1	- 20.0
32	1,600	1,576	- 24	- 1.5	50	24	- 26	- 52.0
33	1,500	1,193	- 307	- 20.5	710	1,063	353	49.7
34	895	714	- 181	- 20.2	2,030	1,983	- 47	- 2.3
35	420	297	- 123	- 29.3	5,930	6,644	714	12.0
36	740	600	- 140	- 18.9	3,290	3,852	562	17.1
37	1,955	1,966	11	0.6	350	395	45	12.8
38	1,140	1,123	- 17	- 1.5	850	918	68	8.0
39	1,410	1,434	24	1.7	680	718	38	5.6
40	1,435	1,406	- 29	- 2.0	205	305	100	48.9
41	860	809	- 51	- 5.9	425	467	42	9.9
42	1,275	1,288	13	1.0	15	53	38	253.3
43	810	815	5	0.6	625	719	94	15.0
44	325	327	2	0.6	1,605	1,704	99	6.2
45	1,065	780	- 285	- 26.7	1,480	1,903	423	28.6

Table 7.2.--Continued

Estimate Areas	Actual Occupied Single-Detached Units[a]	Single-Detached Units			Actual Occupied Apartment Units[a]	Apartment Units		
		Estimate	Difference	Per Cent Error		Estimate	Difference	Per Cent Error
46	1,765	1,545	- 220	- 12.5	735	968	233	31.7
47	860	801	- 59	- 6.9	605	683	78	12.9
48	1,040	978	- 62	- 6.0	170	226	56	32.9
49	900	886	- 14	- 1.2	510	388	- 122	- 23.9
50	2,190	2,178	- 12	- 0.5	535	426	- 109	- 20.4
51	1,225	1,081	- 144	- 11.8	305	427	122	40.0
52	1,240	1,070	- 170	- 13.7	445	761	316	71.0
53	775	642	- 133	- 17.2	1,110	1,353	243	21.9
54	1,655	1,576	- 79	- 4.8	655	583	- 72	- 11.0
55	1,170	1,155	- 15	- 1.3	290	295	5	1.7
56	1,830	1,812	- 18	- 1.0	5	15	10	200.0
57	940	943	3	0.3	30	29	- 1	- 3.3
58	1,365	1,300	- 65	- 4.8	120	364	244	203.3
59	1,765	1,751	- 14	- 0.8	655	774	119	18.2
[illegible]	945	821	- 124	- 13.1	270	345	75	27.8
61	4,900	4,537	- 363	- 7.4	930	1,104	174	18.7

[a]1971 Census of Canada Summary Tapes.

likely to be completed and occupied in a very short period of time. On the other hand, the larger apartment structure not only takes longer for completion, but likely will take longer for full occupancy as well. Hence, one could expect a much lower occupancy ratio for these larger apartment structures which would yield a lower number of occupied apartment units than what was actually estimated. Further research is required in this particular area in order to determine more appropriate occupancy ratios for these larger apartment structures. In addition, the town house complex may very well experience similar lower occupancy ratios.

The average per cent error for single-detached dwelling unit estimates was 5.5 as compared to 37.2 for apartment units regardless of size. It was expected that error would be greater for apartment unit estimates than for estimates of single-detached accommodation.

Cities and Census Metropolitan Areas

Comparison of occupied household estimates with actual occupied household counts was made for municipalities having had no annexation over the estimate period (Table 7.3). The average per cent error for estimates derived using the modified technique was 3.2, which was slightly less [illegible] estimates prepared by the unmodified method which had an average per cent error of 3.1.

Table 7.3.--Comparison of Occupied Household Estimates with Actual Occupied Households for Municipalities without Annexation, Canada: 1971.

City	Actual Occupied Households	Modified: Occupied Household Estimate	Modified: Difference	Modified: Per Cent Error	Unmodified: Occupied Household Estimate	Unmodified: Difference	Unmodified: Per Cent Error
[illegible]	5,593	5,776	183	3.3	5,917	324	5.8
Charlottetown	5,092	4,936	-156	- 3.1	5,035	- 57	- 1.1
Amherst	2,945	2,777	-168	- 5.7	2,792	-153	- 5.2
New Glasgow	3,121	3,051	- 70	- 2.2	3,063	- 58	- 1.9
[illegible]	4,070	3,886	-184	- 4.5	3,917	-153	- 3.8
[illegible]	3,914	3,816	- 98	- 2.5	3,902	- 12	- 0.3
Campbellton	2,444	2,359	- 85	- 3.5	2,378	- 66	- 2.7
Edmundston	3,084	3,052	- 32	- 1.0	3,085	1	0.0
Fredericton	7,367	7,287	- 80	- 1.1	7,440	73	1.0
Oromocto	2,551	2,719	168	6.6	2,702	151	5.9
Alma	4,943	4,717	-226	- 4.6	4,750	-193	- 3.9
Baie-Comeau	2,967	2,831	-136	- 4.6	2,775	-192	- 6.5
Beloeil	3,085	2,904	-181	- 5.9	2,965	-120	- 3.9
Chambly	2,820	2,784	- 35	- 1.2	2,773	- 47	- 1.7
Cowansville	3,130	2,979	-151	- 4.8	3,063	- 67	- 2.1
Hauterive	2,974	2,589	-385	-12.9	2,598	-376	-12.6
La Tuque	3,345	3,225	-120	- 3.6	3,225	-120	- 3.6
Magog	3,677	3,546	-131	- 3.6	3,572	-105	- 2.9
Matane	2,863	2,647	-216	- 7.5	2,703	-160	- 5.6
Montmagny	2,995	2,783	-212	- 7.1	2,783	-212	- 7.1
Noranda	2,798	2,763	- 35	- 1.2	2,767	- 31	- 1.1
Riviere-du-Loup	3,155	2,841	-314	-10.0	2,831	-324	-10.3
Rouyn	4,617	4,388	-229	- 5.0	4,399	-218	- 4.7

Table 7.3.--Continued

City	Actual Occupied Households[a]	Modified: Occupied Household Estimate	Modified: Difference	Modified: Per Cent Error	Unmodified: Occupied Household Estimate	Unmodified: Difference	Unmodified: Per Cent Error
Sorel	5,079	4,616	-463	- 9.1	4,857	-222	- 4.4
Tracy	2,859	2,858	- 1	0.0	2,858	- 1	0.0
Belleville	10,636	10,486	-150	- 1.4	10,730	94	0.9
Brockville	6,277	6,251	- 26	- 0.4	6,308	31	0.5
Cobourg	3,427	3,470	43	1.3	3,455	28	0.8
Cornwall	13,022	12,964	- 58	- 0.4	13,188	166	1.3
Georgetown	4,489	4,490	1	0.0	4,563	74	1.6
Kapuskasing	3,237	3,188	- 49	- 1.5	3,184	- 53	- 1.6
Kenora	3,287	3,279	- 8	- 0.2	3,277	- 10	- 0.3
Lindsay	3,943	3,925	- 18	- 0.5	4,042	99	2.5
Midland	3,328	3,190	-138	- 4.1	3,190	-138	- 4.1
Pembroke	4,573	4,321	-252	- 5.5	4,382	-191	- 4.2
St. Thomas	8,075	8,288	213	2.6	8,308	233	2.9
Stratford	7,626	7,611	- 15	- 0.2	7,653	27	0.4
Flin Flon	2,795	2,869	74	2.6	2,871	76	2.7
Portage la Prairie	3,632	3,698	66	1.8	3,738	106	2.9
Prince Albert	7,872	8,013	141	1.8	8,083	211	2.7
Grande Prairie	3,502	3,482	- 20	- 0.6	3,558	56	1.6
Nanaimo	5,042	5,024	- 18	- 0.4	5,023	- 19	- 0.4
Prince Rupert	4,297	4,325	28	0.7	4,146	-151	- 3.5
Vernon	4,184	4,166	- 18	- 0.4	4,229	45	1.1

[a]1971 Census of Canada, Households, Households by Size, Bulletin 2.1-[illegible], Table 1.

improvement in estimate error was in favour of the unmodified technique.

The performance of the modified technique yielded 34 estimates which fell within ± five per cent of the actual counts, while the unmodified technique produced 37 estimates within this range. Both techniques provided two estimates that deviated more than ten per cent from the actual parameter. It is interesting to note that the estimates of occupied households were considerably less accurate for Quebec municipalities than for any other province regardless of method used.

Table 7.4 portrays the estimates for municipalities which had experienced either annexation or amalgamation over the estimate period. As indicated, the unmodified estimation technique continued to yield more accurate estimates with an average per cent error ($\bar{D}$) of 4.5 as compared to 4.7 for the modified technique.

Of the 31 household estimates prepared using the modified technique, twenty estimates were within the ± five per cent deviation of the actual parameters and six estimates exceeded ten per cent. Five of these six estimates were for municipalities in the province of Quebec. The unmodified technique produced 21 estimates within the ± five

Table 7.4.--Comparison of Occupied Household Estimates with Actual Occupied Households for Municipalities with Annexation, Canada: 1971.

City	Actual Occupied Households[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Asbestos	2,478	2,813	335	13.5	2,913	435	17.6
Granby	9,569	8,282	-1,287	-13.4	8,427	-1,142	-11.9
Joliette	5,224	5,533	309	5.9	5,564	340	6.5
Lachute	3,291	3,285	- 6	- 0.2	3,306	15	4.6
Rimouski	6,549	5,685	- 864	-13.2	5,917	- 632	- 9.7
Ste. Hyacinthe	7,009	6,745	- 264	- 3.8	6,971	- 38	- 0.5
Sept Iles	5,636	4,968	- 668	-11.9	5,300	- 336	- 6.0
Thetford Mines	5,744	6,029	285	5.0	6,076	332	5.8
Val D'Or	4,487	3,970	- 517	-11.6	4,018	- 469	-10.5
Victoriaville	5,946	6,334	388	6.6	6,489	543	9.1
Barrie	8,339	8,351	12	1.4	8,446	107	1.3
Chatham	10,549	10,723	174	1.6	10,757	208	2.0
North Bay	13,079	12,432	- 647	- 4.9	12,557	- 522	- 4.0
Orillia	6,763	6,623	- 140	- 2.1	6,633	- 130	- 1.9
Owen Sound	5,863	5,897	34	5.8	5,903	40	0.7
Trenton	4,256	4,259	3	0.1	4,285	29	0.7
Woodstock	7,954	7,937	- 17	- 2.1	7,863	- 91	- 1.1
Brandon	9,471	9,455	- 16	- 1.7	9,481	10	0.1
Moose Jaw	9,984	10,493	509	5.1	10,385	401	4.0
Swift Current	4,685	4,803	118	2.5	4,711	26	0.6
Yorkton	4,147	4,240	93	2.2	4,142	- 5	- 0.1
Lethbridge	12,561	12,576	15	1.2	13,041	480	3.8
Medicine Hat	8,301	8,376	75	0.9	8,414	113	1.4
Red Deer	7,310	7,487	177	2.4	7,615	305	4.2

Table 7.4.--Continued

City	Actual Occupied Households[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Dawson Creek	3,162	3,312	150	4.7	3,308	146	4.6
Kamloops	7,493	7,736	243	3.2	7,569	76	1.0
Kelowna	6,415	7,055	640	10.0	7,053	638	9.9
Penticton	5,872	5,960	88	1.5	5,919	47	0.8
Port Alberni	5,687	5,959	272	4.8	5,965	278	4.9
Prince George	8,633	8,712	79	0.9	8,082	- 551	- 6.4
Trail	3,561	3,660	99	2.8	3,660	99	2.8

[a]1971 Census of Canada, Households, Households by Size, Bulletin 2.1-2, Table 1.

per cent range and only three estimates exceeded ten per cent error. All three estimates with errors in excess of ten per cent were within the province of Quebec.

Improvement was gained in the average per cent error ($\bar{D}$) when the municipalities that demonstrated excessive error were controlled for. An average per cent error of 2.9 was achieved for the modified technique when the six estimates in excess of ten per cent were removed, while the average per cent error declined to only 3.5 when this was done for the unmodified technique.

On the basis of the pattern of errors demonstrated by both the modified and unmodified estimation techniques, it would be expected that the population estimates portray a similar pattern. For example, it would be expected that the methods used would produce more accurate population estimates for Ontario municipalities than for municipalities in Quebec. The consistent excessive errors manifested by the Quebec estimates strongly suggests faulty data series provided to the Central Mortgage and Housing Corporation.

Accuracy of the central city estimates supports the research expectations, in that the modified technique proved superior to the unmodified technique. The average per cent error ($\bar{D}$) for estimates derived through the modified estimation procedures was 3.7 as compared to 4.2

for the unmodified procedures. For both techniques, eight estimates were within ± five per cent of the actual 1971 household figures. Two estimates were in excess of ten per cent error for the modified technique (Saint John and St. John's) while only one unmodified estimate exceeded ten per cent (St. John's). (Table 7.5)

Greater improvement in accuracy is attained for the modified technique when these estimates with extreme error are controlled for. The average per cent error declines to 1.7 for the modified technique and 3.2 per cent for the unmodified technique. All central cities included in this research had experienced annexation over the estimate period. Adjustments were made for each city utilizing census publications in order to account for the land area added to these cities. It is suggested that more refinement is required in the adjustment process, in that actual enumeration area maps should be utilized for allocation of population and household data. Household data were unavailable by enumeration area at the time of this study and the adjustments made incorporated larger statistical units. When smaller areal adjustments were required they simply were omitted because of lack of detailed information. Saint John and St. John's were two examples of central cities where these gross estimates had to be made.

Table 7.5.-- Comparison of Occupied Household Estimates with Actual Occupied Households for Selected Central Cities, Canada: 1971

Central City	Actual Occupied Households[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Edmonton	131,209	131,213	4	0.0	135,140	3,931	3.0
Halifax	34,324	35,024	700	2.0	35,810	1,486	4.3
Kitchener	33,522	34,480	958	2.8	34,541	1,019	3.0
London	71,344	69,399	-2,131	- 3.0	69,213	- 1,945	- 2.7
Montreal	394,777	396,003	1,276	0.3	397,562	2,835	0.7
Quebec	54,369	53,740	- 629	- 1.2	54,901	532	1.0
Saint John	24,102	26,782	2,680	11.1	26,144	2,042	8.5
St. John's	20,427	17,888	-2,539	-12.4	17,733	- 2,694	-13.2
Toronto	224,698	217,640	-7,058	- 3.1	214,534	-10,164	- 4.5
Windsor	59,798	60,541	743	1.2	60,613	815	1.4

[a]1971 Census of Canada, *Households, Households by Size*, Bulletin 2.1-2, Table 1.

Estimates were prepared for fifteen major urban areas in Canada, however, household data could only be adjusted for thirteen of these statistical areas. Major urban areas are somewhat analogous to census metropolitan areas, in that they also consist of a core city and its urban and rural fringe. Central Mortgage and Housing Corporation provided housing data for the major urban area's core city and urban fringe.

The methodological problem which confounded the estimation process was that Statistics Canada elected to revise the boundaries of these statistical areas for the 1971 Census, as well as the definition. In order to prepare adequate estimates, these changes in definition and boundaries necessitated adjusting the estimation area in 1966 to conform with the newly defined area in 1971. The investigator encountered difficulties in adjusting the population and household figures for small land area changes over the estimation period. Because of the potential for error due to areal adjustments, it was expected that the inflated household estimate produced by the unmodified method would be more accurate than the modified technique. This expectation was born out by the results portrayed in Table 7.6.

The average per cent error using the modified technique was 5.8 as compared to 4.1 with the unmodified

Table 7.6.--Comparison of Occupied Household Estimates with Actual Occupied Households for Selected Major Urban Areas, Canada: 1971

MUA	Actual Occupied Households[a]	Modified Estimate	Modified Difference	Modified Per Cent Error	Unmodified Estimate	Unmodified Difference	Unmodified Per Cent Error
Brampton	16,799	16,557	- 242	- 1.4	17,864	1,065	6.3
Brantford	19,965	20,155	190	1.0	20,394	429	2.1
Drummondville	11,435	10,835	- 600	- 5.2	10,980	- 455	- 4.0
Kingston	21,905	23,471	1,566	7.1	22,677	772	3.5
Moncton	17,030	17,461	431	2.5	17,506	476	2.8
Oshawa	31,665	32,852	1,187	3.7	32,596	931	2.9
St. Jean	11,505	11,092	- 413	- 3.6	11,209	- 296	- 2.6
St Jerome	8,940	6,811	-2,129	-23.8	9,150	21	2.3
Sarnia	20,475	21,128	653	3.2	21,057	582	2.8
Sherbrooke	23,930	23,634	- 296	- 1.2	24,033	103	0.4
Timmins	9,070	10,765	1,695	18.7	10,719	1,649	18.2
Trois Rivieres	25,225	25,655	43	1.7	25,894	669	2.7
Valleyfield	8,955	9,130	175	2.0	9,172	217	2.4

[a] 1971 Census of Canada, Housing, Dwellings by Tenure and Structural Type, Bulletin 2.3-2, Table 8.

technique. The difference between these measures of error reduces considerably when the estimates with error over ten per cent are removed. With this control applied, the error drops to 3.0 per cent for the modified technique and, correspondingly, 2.9 per cent for the unmodified technique. Eleven of the unmodified estimates were within ± five per cent, whereas, only nine of the modified estimates fell within this range. Estimates derived by the modified technique for St. Jerome and Timmins exceeded ten per cent error, while only the Timmins estimate was in excess of ten per cent using the unmodified technique.

Household estimates prepared for census metropolitan areas are presented in Table 7.7. The unmodified technique provided the more accurate estimates of occupied households than the modified technique. The average per cent error for estimates produced by the unmodified technique was 5.1 and, correspondingly, 6.0 for the modified technique.

In terms of error, the estimates for both techniques were very similar. For example, ten estimates prepared by the modified technique were within ± five per cent error and eleven unmodified estimates were located in this range. Each method yielded four estimates for the same major urban areas that were in excess of ten per cent error. When these four extreme estimates were controlled for, the average

Table 7.7.--Comparison of Occupied Household Estimates with Actual Occupied Households for Census Metropolitan Areas, Canada: 1971

CMA	Actual Occupied Households[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Calgary	121,290	123,310	2,020	1.7	127,896	6,606	5.4
Edmonton	144,810	141,247	- 3,563	- 2.5	145,841	1,031	0.7
Halifax	60,010	55,308	- 4,702	- 7.8	56,717	- 3,293	- 5.5
Hamilton	146,315	145,102	- 1,213	- 0.8	145,346	- 969	- 0.7
Kitchener	66,585	68,138	1,553	2.3	69,109	2,524	3.8
London	87,230	72,949	-14,281	-16.4	75,057	-12,173	-14.0
Montreal	806,025	781,521	-24,504	- 3.0	790,638	-15,387	- 1.9
Ottawa/Hull	171,040	154,861	-16,179	- 9.4	162,414	- 8,626	- 5.0
Quebec	127,510	117,935	- 9,575	- 8.0	120,393	- 7,117	- 5.6
Regina	42,595	43,020	425	1.0	42,744	149	0.3
Saint John	28,780	28,158	- 622	- 2.2	28,220	- 560	- 1.9
St. John's	29,755	25,259	- 4,496	-15.1	25,502	- 4,253	-14.3
Saskatoon	38,640	41,030	2,390	6.2	40,528	1,888	4.9
Sudbury	39,480	33,557	- 5,923	-15.0	35,080	- 4,400	-11.1
Toronto	774,465	736,073	-38,392	- 5.0	738,331	-36,134	- 4.7
Vancouver	346,215	332,751	-13,464	- 3.9	338,707	- 7,508	- 2.2
Victoria	66,510	63,908	- 2,602	- 3.9	64,593	- 1,917	- 2.9
Windsor	74,235	66,598	- 7,637	-10.3	66,706	- 7,529	-10.1
Winnipeg	166,670	166,359	- 311	- 0.2	170,864	4,194	2.5

[a]1971 Census of Canada, Households, Households by Size, Bulletin 2.1-2, Table 5.

per cent error for the modified and unmodified techniques declined to 3.9 and 3.2, respectively.

A similar methodological problem to that of the major urban areas confronted the investigator with the census metropolitan areas, in that the boundaries were modified for the 1971 census. This area modification made it extremely difficult to adjust the 1966 metropolitan areas accordingly, in that these boundary changes often involved splitting existing statistical areas. For this reason, it was expected that the unmodified technique would yield more accurate estimates of the household parameters. The census metropolitan areas with negative errors experienced boundary changes prior to the 1971 Census. With the exception of Winnipeg, improvement in estimate error was achieved with the unmodified technique. As with the major urban areas, lack of detailed data prevented greater refinements from being achieved in the adjustment for these boundary changes.

Control Variables and Estimate Accuracy

This section of the analysis will present the findings with respect to the performance of each method according to control variables. Since the eight propositions presented earlier should apply to the estimates of occupied households, discussion of findings will be organized according to each proposition.

> <u>Proposition 1</u>: It is expected that the modified housing unit method will yield more accurate postcensal occupied household estimates than will the unmodified housing unit method

Table 7.8 presents the summary measure U statistic for the major types of areas utilized in this research. The proposition is supported only for the Edmonton estimate areas and the ten central cities. The unmodified technique reflected slightly improved estimates of occupied households for the seventy-five selected municipalities. The improvement in unmodified estimates of occupied households

Table 7.8.-- Accuracy of Occupied Household Estimates for each Estimation Method by Type of Area

Estimate Area	N	Theil's U Statistic	
		Modified	Unmodified
Edmonton Sub-Areas	61	.026980	.055172
Selected Municipalities	75	.020485	.019469
Central Cities	10	.008661	.012425
Major Urban Areas	13	.026169	.019147
Census Metropolitan Areas	19	.022509	.018586

was greater than the modified estimates in the case of major urban areas and census metropolitan areas. This deviation from the proposition was expected as discussed in the previous section. It will be noted that, excluding the major urban areas and census metropolitan areas, estimate accuracy improved directly as population size increased.

<u>Proposition 2</u>: Estimate error will vary directly with the proportion of apartment units in the estimate area

Improvement in the estimates of occupied households derived through the modified estimation procedures in comparison to the unmodified technique is demonstrated in Table 7.9 for Edmonton sub-areas. The error in estimation using the modified technique tends to vary directly with the proportion of apartment units in the

Table 7.9.-- Accuracy of Occupied Household Estimates for each Estimation Method, by Proportion of Apartment Units Edmonton Sub-Areas: 1971

Proportion of Apartment Units	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 19.9	31	.022346	.047178
20.0 - 39.9	14	.017118	.022375
40.0 - 59.9	8	.019400	.093780
60.0 - 79.9	6	.034982	.062061
80.0 - 99.9	2	.039044	.062547

estimate area, with exception of areas with the lowest proportion of multiple units. The greatest accuracy in estimation of occupied households was found to be in areas with from twenty to sixty per cent multiple units.

Table 7.10 compares the accuracy of occupied household estimates for the selected municipalities, major urban areas, and central cities with respect to the modified and unmodified estimation techniques. The results are somewhat mixed for the selected cities, in that while the modified estimation procedure yields estimates with error that varies directly with the proportion of multiple units in the estimate area, the modified estimates are not consistently more accurate than the unmodified estimates. The modified estimates of occupied households are more accurate for cities with thirty to fifty per cent multiple units, while the unmodified estimates are more accurate for the other categories.

With the exception of areas with twenty to thirty per cent multiple units, the unmodified estimates for major urban areas yield greater accuracy than those produced by the modified technique. The pattern of estimate errors do not support the proposition with respect to major urban areas. The results for the major urban areas may be misleading because of the definitional and boundary adjustment problems.

Table 7.10.-- Accuracy of Occupied Household Estimates for each Estimation Method by Proportion of Apartment Units, Selected Cities, Major Urban Areas, and Central Cities: 1971

Proportion of Apartment Units	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
0.0 - 19.9	8	.014198	.009686	--	--	--	--	--	--
20.0 - 29.9	35	.016715	.015475	4	.014967	.017047	1	.006174	.006768
30.0 - 39.9	11	.019824	.021883	2	.063438	.061337	4	.010845	.017071
40.0 - 49.9	14	.026054	.035282	3	.027329	.015697	2	.015841	.023093
50.0 and over	4	.027070	.024741	4	.030370	.011113	3	.003794	.009410

The occupied household estimates derived with the modified estimation technique reflect greater accuracy than those produced by the unmodified technique regardless of proportion of multiple units in the central cities. The proposition, however, is not supported since central cities with the highest proportion of apartment units manifested estimates with the lowest error.

Table 7.11 reveals a similar pattern of estimation error for the census metropolitan areas. As with the central cities, the lowest estimate error for both estimation procedures was found in the census metropolitan

Table 7.11.-- Accuracy of Occupied Household Estimates for each Estimation Method by Proportion of Apartment Units Census Metropolitan Areas: 1971

Proportion of Apartment Units	N	Theil's U Statistic	
		Modified	Unmodified
20.0 - 29.9	6	.025863	.024451
30.0 - 39.9	9	.026275	.022934
40.0 - 49.9	3	.038561	.028090
50.0 +	1	.015435	.009637

areas having the highest proportion of multiple units. It will be noted, however, that the unmodified procedure yielded the lowest error of the two procedures employed. As noted in the previous section, the success of the unmodified method may be attributable to the difficulty in adjusting the 1966 metropolitan area to the new 1971 boundaries.

As indicated in Chapter IV, it was believed that the magnitude of home ownership would provide a relatively sound indicator of an area's stability. Conversely, the proportion of apartment units in an area would be an indication of the area's transiency or population turnover. In addition to the apartment variable already discussed, it was decided to include the home ownership variable. By including home ownership, a more definitive articulation etween rentership and ownership is possible. A certain proportion of single-detached dwelling units, double and duplex houses, and row housing that are classified as rental units would therefore be controlled for.

Interestingly for the Edmonton sub-areas, the pattern of estimate accuracy takes the form of a U curve with the lowest error reflected in the middle category (40.0 to 59.9 per cent ownership) while the higher rror is revealed in the two extreme categories (0.0 to .9 and

80.0 to 99.9 per cent). In every interval, the modified estimation technique yielded more accurate estimates than the unmodified procedures (Table 7.12). This pattern is difficult to explain, however, it is possible that the balance of housing type indicated by the middle category may yield the greatest accuracy simply because there tended to be over-estimation for occupied apartment structures and under-estimation of occupied single-detached dwelling units. Therefore, the over- and under-estimates would tend to offset each other and contribute to greater accuracy.

Table 7.12.-- Accuracy of Occupied Household Estimates for each Estimation Method by Proportion of Home Ownership, Edmonton Sub-Areas: 1971

Per Cent Home Ownership	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 19.9	5	.037781	.063192
20.0 - 39.9	7	.023822	.039847
40.0 - 59.9	16	.016132	.063472
60.0 - 79.9	28	.020636	.028567
80.0 - 99.9	5	.030186	.094856

Table 7.13 presents the same control variable for the selected cities, major urban areas, and central cities. The U shaped pattern does not emerge for these major types of cities. It will be noted that estimate accuracy did improve as the proportion of home ownership increased for the seventy-five selected cities. With the exception of the cities having high proportion of home ownership, the modified estimation procedure yielded the more accurate estimates of occupied households.

For both major urban areas and central cities, the greater error in estimation appeared in the areas which had from forty to sixty per cent home ownership, while the most accurate estimates were located in the extreme intervals. The modified estimation procedure yielded the more accurate estimates only in the major urban areas which had the highest proportion of home ownership. In comparison, the central city estimates were more accurate using the modified technique in all intervals with the exception of the city with twenty to forty per cent home ownership. It must be recognized, however, that only one city was so classified and the difference between the two estimates was small.

Table 7.13-- Accuracy of Occupied Household Estimates for each Estimation Method by Proportion of Home Ownership, Selected Cities, Major Urban Areas, and Central Cities: 1971

Per Cent Home Ownership	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
0.0 - 19.9	1	.028745	.031879	--	--	--	1	.001614	.003578
20.0 - 39.9	3	.020456	.023738	4	.030370	.011113	1	.005818	.004869
40.0 - 59.9	34	.021100	.023754	5	.035698	.028845	7	.015180	.021539
60.0 - 79.9	34	.017077	.016635	4	.014967	.017047	1	.006174	.006768

Table 7.14 presents census metropolitan area estimates in which the unmodified estimation procedure out-performed the modified method in every interval. Estimation error tended to increase as the proportion of home ownership increased. As stated before, the interpretation of estimate results must be tempered because of the boundary changes experienced by the census metropolitan areas.

Table 7.14.--Accuracy of Occupied Household Estimates for each Estimation Method by Proportion of Home Ownership, Census Metropolitan Areas: 1971

Per Cent Home Ownership	N	Theil's U Statistic	
		Modified	Unmodified
30.0 - 49.9	3	.016594	.010660
50.0 - 59.9	10	.026333	.022949
60.0 - 69.9	6	.024382	.023839

Proposition 3: Estimate error will vary inversely with the population size of the estimate area

Accuracy of occupied household estimates for Edmonton sub-areas by population size of area is presented in Table 7.15. In every size interval, the modified estimation procedure produced the more accurate occupied

Table 7.15.-- Accuracy of Occupied Household Estimates for each Estimation Method by Size of Area, Edmonton Sub-Areas: 1971

Population Size	N	Theil's U Statistic	
		Modified	Unmodified
Under 4,000	2	.022112	.022112
4,000 - 5,999	29	.018614	.061455
6,000 - 7,999	17	.018914	.037578
8,000 - 9,999	6	.036315	.064898
10,000 and over	7	.030232	.056655

household estimates. The pattern of estimate accuracy for the modified method does not support the proposition but suggests the form of a U shaped curve with error increasing as population size increases. In every category of size, the modified estimates were more accurate than those prepared by the unmodified method. The more accurate estimates were derived with the modified technique for those estimate areas with from 4,000 to 8,000 residents.

Table 7.16 and 7.17 portrays the estimate accuracy by population size for selected cities, major urban areas, central cities, and census metropolitan areas. With few exceptions, the proposition tends to be supported for the cities, major urban areas, central cities and census

Table 7.16.-- Accuracy of Occupied Household Estimates for each Estimation Method by Size of Area, Selected Cities, Major Urban Areas, and Central Cities: 1971

Size of City	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Less than 10,000	3	.048136	.039623	--	--	--	--	--	--
10,000 - 24,999	54	.021909	.024707	--	--	--	--	--	--
25,000 - 49,999	18	.016783	.016524	7	.043772	.031632	2	.057864	.053501
50,000 - 99,999	--	--	--	6	.017857	.013034	6	.007028	.013794
100,000 - 499,999	--	--	--	--	--	--	2	.007916	.011647

Table 7.17.-- Accuracy of Occupied Household Estimates for each Estimation Method by Size of Area, Census Metropolitan Areas: 1971

Population Size	N	Theil's U Statistic	
		Modified	Unmodified
100,000 to 499,999	14	.033829	.029618
500,000 to 999,999	2	.034718	.020212
1 million and over	3	.020702	.017356

metropolitan areas for both modified and unmodified estimate accuracy. Generally, the unmodified technique provided the more accurate estimates for all types of cities. The notable exceptions where the modified estimation technique performed best were for selected cities from 10,000 to 24,999 in population size and the larger central cities. It should be noted that the highest estimate error recorded for the central city category included both St. John's and Saint John.

<u>Proposition 4</u>: Estimate error will vary directly with the population growth rates of the estimate area

<u>Proposition 5</u>: Estimate error will vary directly with the population decline rates of the estimate area

Estimate accuracy by population change in the estimate area over the estimation period for the Edmonton sub-areas is portrayed in Table 7.18. In every population change category, the modified estimation technique produced estimates of occupied households which were more accurate than those derived with the unmodified technique.

Table 7.18.-- Accuracy of Occupied Household Estimates for each Estimation Method by Population Change in the Estimate Area, Edmonton Sub-Areas: 1966 - 1971

Percentage Population Change	N	Theil's U Statistic	
		Modified	Unmodified
Decline			
-1.0 to -4.9	10	.018513	.098490
Stability			
-0.9 to 0.9	26	.015285	.017680
Growth			
1.0 to 4.9	14	.020921	.034558
5.0 to 9.9	8	.036731	.063616
10.0 and over	3	.029102	.065413

The pattern of estimate accuracy tends to support both propositions. The most accurate estimates, yielded by the modified method, were for those estimate areas which were relatively stable in terms of population change over the five year period. As revealed in the table, there was a slight increase in estimate error for those estimate areas experiencing population decline, as well as for those areas with increasing growth in population.

The estimate accuracy for the major types of municipalities, major urban areas, and census metropolitan areas by population change experienced between 1966 and 1971 is presented in Tables 7.19 and 7.20. The comparison of the accuracy of estimates produced by the two estimation procedures is somewhat inconsistent for all types of urban areas.

It will be noted that the modified estimation procedures produced occupied household estimates with greater accuracy than the unmodified technique for the stable selected cities. An unexpected finding was the better performance of the modified technique for those selected cities experiencing population growth in excess of ten per cent. Selected cities with either population decline or growth between one and ten per cent achieved better estimate accuracy with the unmodified technique.

The modified technique provided improved estimate accuracy for the major urban areas which had experienced

Table 7.19.-- Accuracy of Occupied Household Estimates for each Estimation Method by Population Change in the Estimation Areas, Selected Cities, Major Urban Areas, and Central Cities: 1966 - 1971

Per Cent Population Change	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Decline									
-1.0 to -4.9	5	.039805	.034005	--	--	--	--	--	--
Stability									
-0.9 to +0.9	30	.015963	.017071	6	.038801	.024420	1	.001614	.003578
Growth									
+1.0 +4.9	31	.017353	.015553	7	.014642	.015351	7	.013983	.020466
+5.0 to +9.9	6	.036384	.042520	--	--	--	1	.010094	.021188
+10.0 and over	3	.016658	.021636	--	--	--	1	.052669	.040640

Table 7.20.-- Accuracy of Occupied Household Estimates for each Estimation Method by Population Change in the Estimate Areas, Census Metropolitan Areas: 1966 - 1971

Percentage Population Change	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 1.9	8	.015779	.010805
2.0 - 2.9	6	.053361	.037391
3.0 - 3.9	4	.024240	.021880
4.0 and over	1	.008258	.026510

slight population growth over the estimate period, while for the stable areas the unmodified technique proved better. The central cities revealed that generally the modified estimation technique yielded the more accurate estimates with the exception of the city that had experienced the highest population change.

The propositions concerning population change are generally supported by the accuracy of occupied household estimates for the selected cities and central cities; and are not supported by the census metropolitan area estimates. There are too few categories of estimates for the major urban areas to be considered with respect to the propositions.

Proposition 6: Estimate error will vary directly with the territorial annexation experienced by the estimate area over the estimation period

This proposition applies only to a few categories of the study cities used in this investigation. The Edmonton sub-areas were excluded as they were not influenced by annexation policy. The major urban areas and census metropolitan areas were excluded from consideration as these were primarily statistical areas and their territorial change was influenced completely by re-definition of boundaries.

Table 7.21 presents the estimate accuracy for the total number of cities incorporated in this study by their annexation experience. It will be noted that when the central cities are combined with the smaller selected cities, the results are convincingly in favour of the modified estimation procedure over the unmodified estimation method. When the larger central cities are not considered, the unmodified estimation technique yielded more accurate estimates as was evidenced by the selected cities and cities without annexation categories. Improvement in estimate accuracy is noted in the direction of the proposition when only selected cities (.022808) with annexation and selected cities without annexation are compared (.016258).

Table 7.21.-- Accuracy of Occupied Household Estimates for each Estimation Method by Annexation Experience, Selected Cities and Central Cities: 1966 - 1971

Annexation Experience	N	Theil's U Statistic	
		Modified	Unmodified
Total Cities	85	.008881	.012526
Cities with annexation	41	.008835	.012514
Selected Cities	31	.022808	.021877
Central Cities	10	.008661	.012425
Cities without annexation	44	.016258	.015044

Proposition 7: Estimate error will vary directly with change in the average household size experienced by the estimate area over the estimation period

The proposition concerning household size is not supported by the pattern of estimate accuracy for the Edmonton sub-areas. Table 7.22 reveals a pattern of accuracy which is the reverse of the direction expected. In other words, estimate error decreased as change in household size increased for the estimate area. The modified estimation technique consistently provided the more accurate occupied household estimates in every category of change.

Table 7.22.-- Accuracy of Occupied Household Estimate for each Estimation Method by Change in Average Household Size in the Estimate Area, Edmonton Sub-Areas: 1966 - 1971

Absolute Change in Household Size	N	Theil's U Statistic	
		Modified	Unmodified
± 0.1	14	.083051	.162721
- 0.2 to -0.3	30	.052967	.149832
- 0.4 to -0.5	14	.051161	.103659
- 0.6 to -0.7	3	.026845	.077373

Table 7.23 and 7.24 portray the estimate accuracy by the control variable for the selected cities, major urban areas, central cities, and census metropolitan areas. With the exception of the census metropolitan areas, the pattern of estimate accuracy tends to support the proposition. For the selected cities, the modified estimation procedures yielded superior estimates for all categories except one (-0.2 to -0.3). The modified estimation technique produced more accurate occupied household estimates in every category for the major urban areas, in comparison with the unmodified estimates, estimate accuracy of the modified estimates was generally superior for the central citie. The unmodified estimate (Saint John) yielded greater accuracy in the lowest change category.

Table 7.23.-- Accuracy of Occupied Household Estimates for each Estimation Method by Change in Average Household Size in the Estimate Areas, Selected Cities, Major Urban Areas, and Central Cities: 1966 - 1971

Absolute Change in Average Household Size	Selected Cities			Major Urban Areas[a]			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
± 0.1	12	.018327	.020061	1	.018398	.014488	1	.052669	.040640
-0.2 to -0.3	37	.014551	.013901	7	.026841	.024728	7	.003219	.006528
-0.4 to -0.5	20	.029198	.029414	5	.029607	.011161	1	.066266	.070597
-0.6 to -0.7	6	.038906	.048886	--	--	--	1	.015956	.023140

Table 7.24.-- Accuracy of Occupied Household Estimates for each Estimation Method by Change in Average Household Size in the Estimate Area, Census Metropolitan Areas: 1966 - 1971

Absolute Change in Average Household Size	N	Theil's U Statistic	
		Modified	Unmodified
± 0.1	4	.023281	.027568
- 0.2	10	.019676	.013095
- 0.3	3	.025452	.023876
- 0.4	2	.042052	.032641

The census metropolitan area estimates produced by the modified estimation technique were inferior to those produced by the unmodified procedures with the exception of the lowest household size change category. Excluding the lowest category, the pattern of estimate accuracy for the remaining categories tend to support the proposition.

Proposition 8: Estimate error will vary inversely with the age of the estimate area

Table 7.25 reveals that modified technique provided the more accurate estimates than the unmodified technique regardless of the age of the estimate area. The pattern of estimate accuracy fails to support the proposition, however, the more accurate estimates are found in the youngest estimate area. Utilizing age of dwelling as an indicator of

Table 7.25.-- Accuracy of Occupied Household Estimat r each Estimation Method by Age of the Estimate Are Edmonton Sub-Areas

Age of Area[a]	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 9.9	42	.019193	.046392
10.0 - 19.9	8	.023229	.027933
20.0 - 29.9	5	.042651	.109194
30.0 - 39.9	2	.027201	.056622
40.0 - 49.9	4	.036504	.057268

[a]The indicator of area age is the percentage of dwelling units constructed prior to 1920 as reported in the census.

the age of the estimate area revealed that the majority of estimate areas (42) were young areas in the city of Edmonton. It is also noted that the youngest estimate areas had the lowest estimate error. The estimate areas with twenty to thirty per cent of their dwelling units constructed prior to 1920 had the highest estimate error.

A different indicator of age was used for the urban areas and cities in the study. Age of the selected municipalities and urban areas was determined by the census date that they were first recorded as attaining 10,000 population size. With the exception of the oldest area category, the pattern of estimate accuracy generally support the proposition for the selected cities and major urban areas. It will be noted that there was only one city and major urban area included in this category. There are too few cases for the central cities to reflect a convincing pattern of accuracy (Table 7.26). The modified technique yielded more accurate estimates for the central cities; however, the performance of the modified technique was inconsistent for the selected cities and major urban areas with respect to the age of the city.

The accuracy of estimates for the census metropolitan areas present a pattern which runs counter to that expected, in that estimate error increased as the age of the area increased. In the comparison of methods, the unmodified estimation procedure generally produced the more accurate results. It will be noted in Table 7.27 that the modified estimation procedure produced the more accurate estimates only for those census metropolitan areas in which the central cities achieved 10,000 population size at the turn of the century.

Table 7.26.-- Accuracy of Occupied Household Estimates for each Estimation Method by Age of the Estimate Areas, Selected Cities, Major Urban Areas, and Central Cities

Age of City[a]	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Pre - 1871	--	--	--	1	.034512	.017316	8	.009033	.012288
1881 - 1891	1	.014222	.013017	1	.006223	.002147	1	.006174	.006768
1901 - 1911	6	.011099	.013614	3	.009887	.013208	1	.000015	.014759
1921 - 1931	12	.014547	.015552	4	.026787	.024355	--	--	--
1941 - 1956	30	.022343	.020840	4	.037908	.020705	--	--	--
1961	26	.029626	.033999	--	--	--	--	--	--

[a]Age of city was determined by the census date that the city was first recorded as attaining 10,000 population.

Table 7.27.-- Accuracy of Occupied Household Estimates for each Estimation Method by Age of Estimate Area, Census Metropolitan Areas

Age of C.M.A.[a]	N	Theil's U Statistic	
		Modified	Unmodified
Pre - 1871	9	.022908	.018946
1881 - 1891	4	.020121	.014717
1901 - 1911	5	.012023	.017496
1921 - 1931	1	.081096	.059013

[a]Age of C.M.A. was determined by the census date that the central city was first recorded as attaining 10,000 population.

CHAPTER VIII

ACCURACY OF POSTCENSAL POPULATION ESTIMATES

Introduction

The previous chapter dealt with the accuracy of the occupied household estimates and this analysis section will concern the accuracy of the final postcensal population estimate. The final population estimate is developed in the second stage of the sequential process of estimation and is contingent upon the adequacy of the occupied household estimate derived in the first stage.

Once the occupied household estimate is attained, the appropriate population per household is applied which determines the estimate of the number of people living in occupied households. To this figure is added the estimate of collective and institutional population located in the estimate area. Assuming reasonable accuracy with regard to the estimate of households, the final population estimate can still be subject to error through faulty estimates of the average population per household factor and/or the estimate of the collective and institutional population.

To reiterate these key elements in the second stage, the population per household ratio for 1971 was determined through extrapolation procedures. The collective and institutional population figures from the previous census (1966) were used as the best estimate for 1971. For those cities and urban areas which experienced annexation, amalgamation, or definitional changes over the estimate period were adjusted accordingly for these territorial additions. These adjustments were determined through comparison of 1966 and 1971 census documents.

The prepared estimates using both the modified and the unmodified estimation procedures are presented with the 1971 census figures in the following tables. Series A post-censal estimates for Edmonton sub-areas appear in Table 8.1. It should be noted that the 1971 census figures have been subjected to the random rounding procedure currently used by Statistics Canada. The actual population parameters are randomly rounded to either 0 or 5. The actual count do not necessarily have to be close to either 0 or 5, for example, the random rounded figure of 16,580 could actually be 16,576, 16,584, or even 16,580. This is a particularly disturbing feature to contend with, particularly when dealing with small population counts. A difference between the actual parameter and the official random rounded figure

Table 8.1.--Series A Postcensal Population Estimates for Selected Metropolitan Sub-Areas by Estimation Technique, Edmonton, Canada: June 1, 1971

Estimate Area	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Total	427,245	428,494	453,881
1	16,580	17,269	16,780
2	11,265	9,787	8,489
3	5,785	5,198	4,870
4	5,025	4,706	4,071
5	6,285	5,620	5,689
6	13,320	12,627	11,209
7	6,130	5,734	5,479
8	8,690	8,276	6,821
9	3,585	3,644	3,043
10	6,555	6,612	5,979
11	4,350	4,398	5,724
12	4,895	5,414	5,332
13	8,090	8,130	8,845
14	8,105	8,079	7,696
15	5,825	5,597	4,970
16	7,660	7,189	6,625
17	4,255	5,021	4,650
18	5,185	5,895	5,509
19	5,755	6,389	6,441
20	5,370	5,171	5,861
21	5,355	6,216	7,580
22	5,170	5,070	5,548
23	4,155	3,597	3,418
24	5,360	5,329	5,064
25	5,370	5,623	5,193
26	4,740	5,201	5,560
27	11,580	11,524	17,068
28	3,025	4,013	5,521
29	6,905	6,424	9,453
30	4,045	5,255	4,844

Table 8.1.--Continued

Estimate Area	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
31	6,275	5,810	4,689
32	7,115	6,734	5,500
33	7,890	[illegible],552	7,978
34	7,180	8,126	10,212
35	12,800	14,766	24,939
36	8,595	10,305	16,485
37	7,420	9,109	8,113
38	6,890	6,500	7,419
39	7,805	7,386	7,329
40	8,365	6,749	6,508
41	4,665	4,367	4,274
42	4,915	5,412	4,443
43	4,665	5,536	8,959
44	4,385	4,907	7,132
45	6,400	6,885	9,144
46	7,860	8,801	8,892
47	4,345	4,616	4,933
48	5,300	5,403	4,771
49	5,245	4,604	4,430
50	11,965	10,831	9,313
51	4,935	5,340	5,016
52	5,345	5,891	6,108
53	4,745	5,435	6,676
54	6,850	7,847	7,352
55	5,065	5,413	4,877
56	7,705	7,537	6,076
57	4,135	3,999	3,282
58	7,350	6,609	6,882
59	9,810	10,351	10,303
60	5,545	5,330	4,927
61	27,265	21,335	23,581

[a]1971 Census of Canada Summary Tapes.

could contribute in itself to estimate error where small numbers are concerned.

Series B postcensal population estimates are presented in Tables 8.2 through 8.4 for the selected cities, major urban areas, central cities, and census metropolitan areas. For these political and statistical entities, the actual 1971 population counts were released by Statistics Canada.

The organization and procedures for assessing the accuracy of the population estimates will correspond to those utilized in the analysis of occupied household estimates. Additional tables presenting the average per cent error by control variables have been prepared and will be included in Appendix E. The basic accuracy measures will be simple per cent error, average per cent error (regardless of signs), and the Theil's U statistic. As with the occupied household estimates, accuracy by method will essentially be determined by the degree of agreement with the actual 1971 population parameters.

City Sub-Areas

Table 8.5 represents the comparison of the population estimates by method for all sub-areas within the city of Edmonton. It will be noted that there were nineteen sub-area population estimates within ± five per cent deviation

Table 8.2.--Series B Postcensal Population Estimates for Seventy-Five Selected Cities by Estimation Technique, Canada: June 1, 1971

City	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Newfoundland			
Cornerbrook	26,309	28,123	29,128
P.E.I.			
Charlottetown	19,133	19,938	19,290
Nova Scotia			
Amherst	9,966	11,118	9,470
New Glasgow	10,849	12,120	11,104
Truro	13,047	14,875	13,621
New Brunswick			
Bathurst	16,674	15,600	19,674
Cambellton	10,335	10,294	11,167
Edmundston	12,365	12,083	12,847
Fredericton	24,254	24,200	24,773
Oromocto	11,427	12,926	14,473
Quebec			
Alma	22,622	17,859	23,264
Asbestos	9,749	10,313	12,046
Baie-Comeau	12,622	10,778	10,549
Beloeil	12,274	12,167	13,308
Chambly	11,469	11,490	11,844
Cowansville	11,920	11,416	12,571
Granby	34,385	34,402	35,599
Hauterive	13,181	10,846	11,326
Joliette	20,127	20,924	21,900
La Tuque	13,099	12,412	13,678
Lachute	11,813	12,482	12,531
Magog	13,281	13,052	13,162
Matane	11,841	10,746	12,841
Montmagny	12,432	11,414	13,356
Noranda	10,741	10,408	11,253

Table 8.2.--Continued

City	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Rimouski	26,887	27,034	30,511
Riviere-du-Loup	12,760	11,917	12,147
Rouyn	17,821	16,235	18,328
Ste. Hyacinthe	24,562	25,042	25,173
Sept Iles	24,320	22,981	27,376
Sorel	19,347	19,130	20,688
Thetford Mines	22,003	22,194	22,771
Tracy	11,842	11,758	12,421
Val D'Or	17,421	17,046	18,658
Victoriaville	22,047	22,082	22,785
Ontario			
Barrie	27,676	29,708	28,213
Belleville	35,128	37,613	37,829
Brockville	19,765	22,743	20,724
Chatham	35,317	38,797	37,364
Cobourg	11,282	13,421	12,440
Cornwall	47,116	45,855	48,468
Georgetown	17,053	16,972	19,377
Kapuskasing	12,834	11,137	14,827
Kenora	10,952	12,549	11,409
Lindsay	12,746	14,718	12,683
Midland	10,922	11,824	11,249
North Bay	49,187	46,646	46,264
Orillia	24,040	25,064	22,445
Owen Sound	18,469	21,797	19,242
Pembroke	16,544	16,407	15,957
St. Thomas	25,545	29,596	25,751
Stratford	24,508	27,103	24,828
Trenton	14,589	16,121	15,733
Woodstock	26,173	29,[illegible]4	24,436
Manitoba			
Brandon	31,150	34,057	31,929
Flin Flon	9,344	9,422	9,759
Portage la Prairie	12,950	14,135	12,232

Table 8.2.--Continued

City	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Saskatchewan			
Moose Jaw	31,854	36,737	34,940
Prince Albert	28,464	27,439	30,125
Swift Current	15,145	16,393	16,379
Yorkton	13,430	14,937	13,575
Alberta			
Grande Prairie	13,079	12,623	14,262
Lethbridge	41,217	46,178	46,702
Medicine Hat	26,518	30,672	26,672
Red Deer	27,674	27,586	29,982
British Columbia			
Dawson Creek	11,885	11,882	13,535
Kamloops	26,168	26,741	26,357
Kelowna	19,412	23,737	22,045
Nanaimo	14,948	16,822	~~15,675~~
Penticton	18,146	20,394	18,488
Port Alberni	20,063	20,378	21,648
Prince George	33,[illegible]	28,407	34,363
Prince Rupert	15,787	13,954	16,801
Trail	11,149	11,967	11,826
Vernon	13,283	13,854	13,201

[a] 1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 7.

Table 8.3.--Series B Postcensal Population Estimates for Selected Central Cities and Major Urban Areas by Estimation Technique, Canada: June 1, 1971

Locality	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Central City			
Edmonton	438,152	443,727	473,766
Halifax	122,035	129,808	130,114
Kitchener	111,804	118,547	118,850
London	223,222	230,038	236,706
Montreal	1,214,352	1,384,268	1,704,499
Quebec	186,088	185,530	186,401
Saint John	89,039	92,899	91,354
St. John's	88,102	80,698	83,507
Toronto	712,786	750,603	764,959
Windsor	203,300	182,178	222,847
Major Urban Area			
Brampton	63,314	62,611	73,688
Brantford	80,284	84,919	83,202
Drummondville	46,524	41,942	42,760
Kingston	85,877	92,190	85,779
Moncton	71,416	74,197	71,036
Oshawa	120,318	118,590	112,780
St. Catherine's	124,787	130,834	126,758
St. Jean	47,044	42,844	41,931
St. Jerome	35,335	27,536	34,347
Sarnia	78,444	84,216	81,642
Sault Ste. Marie	81,270	77,085	85,736
Sherbrooke	84,570	85,632	89,625
Timmins	41,473	40,457	42,759
Trois Rivieres	97,930	96,004	99,260
Valleyfield	37,430	37,188	37,044

[a]1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 7.

Table 8.4.--Series B Postcensal Population Estimates for Selected Census Metropolitan Areas by Estimation Technique, Canada: June 1, 1971

C.M.A.	1971 Actual Population[a]	Modified Estimate	Unmodified Estimate
Calgary	403,319	395,990	442,623
Edmonton	495,702	508,340	521,130
Halifax	222,637	229,957	239,427
Hamilton	498,523	511,366	522,054
Kitchener	226,846	236,040	250,133
London	286,011	285,359	305,357
Montreal	2,743,208	2,904,524	2,838,933
Ottawa/Hull	602,510	593,782	615,275
Quebec	480,502	473,275	505,707
Regina	140,734	145,915	142,344
Saint John	106,744	107,727	108,865
St. John's	131,814	131,143	133,351
Saskatoon	126,449	135,985	136,682
Sudbury	155,424	161,119	159,511
Toronto	2,628,043	2,948,481	2,969,105
Vancouver	1,082,352	1,075,236	1,112,816
Victoria	195,800	193,716	197,288
Windsor	258,643	265,077	268,764
Winnipeg	540,262	566,066	566,910

[a] 1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 7.

Table 8.5.--Comparison of Modified and Unmodified Postcensal Estimates With Actual Populations for Sixty-One Metropolitan Estimate Areas, Edmonton, Canada: June 1, 1971

Estimate Areas	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Total Areas	427,245	428,494	1,249	0.3	453,881	26,636	6.2
1	16,580	17,269	689	4.2	16,780	200	1.2
2	11,265	9,787	- 1,478	- 13.1	8,489	- 2,776	- 24.6
3	5,785	5,198	- 587	- 10.1	4,870	- 915	- 15.8
4	5,025	4,706	- 319	- 6.4	4,071	- 954	- 19.0
5	6,285	5,620	- 665	- 10.6	5,689	- 596	- 9.5
6	13,320	12,627	- 693	- 5.2	11,209	- 2,111	- 15.8
7	6,130	5,734	- 396	- 6.5	5,479	- 651	- 10.6
8	8,690	8,276	- 414	- 4.8	6,821	- 1,869	- 21.5
9	3,585	3,644	59	1.6	3,043	- 542	- 15.1
10	6,555	6,612	57	0.9	5,979	- 576	- 8.8
11	4,350	4,398	48	1.1	5,724	1,374	31.6
12	4,895	5,414	519	10.6	5,332	437	8.9
13	8,090	8,130	40	0.5	8,845	755	9.3
14	8,105	8,079	- 26	- 0.3	7,696	- 409	- 5.0
15	5,825	5,597	- 228	- 3.9	4,970	- 855	- 14.7
16	7,660	7,189	- 471	- 6.1	6,625	- 1,035	- 13.5
17	4,255	5,021	766	18.0	4,650	395	9.3
18	5,185	5,895	710	13.7	5,509	324	6.2
19	5,755	6,389	634	11.0	6,441	686	11.9
20	5,370	5,171	- 199	- 3.7	5,861	491	9.1

Table 8.5.--Continued

Estimate Areas	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
21	5,355	6,216	861	16.1	7,580	2,225	41.5
22	5,170	5,070	- 100	- 1.9	5,548	378	7.3
23	4,155	3,597	- 558	- 13.4	3,418	- 737	- 17.7
24	5,360	5,329	- 31	- 0.6	5,064	- 296	- 5.5
25	5,370	5,623	253	4.7	5,193	- 177	- 3.3
26	4,740	5,201	461	9.7	5,560	820	17.3
27	11,580	11,524	56	- 0.5	17,068	5,488	47.4
28	3,025	4,013	988	32.7	5,521	2,496	82.5
29	6,905	6,424	- 481	- 7.0	9,453	2,548	36.9
30	4,045	5,255	1,210	30.0	4,844	799	19.8
31	6,275	5,810	- 465	- 7.4	4,689	- 1,586	- 25.3
32	7,115	6,734	- 381	- 5.4	5,500	- 1,615	- 22.7
33	7,890	7,552	- 338	- 4.3	7,978	88	1.1
34	7,180	8,126	946	13.2	10,199	3,019	42.0
35	12,800	14,766	1,966	15.4	24,939	12,139	94.8
36	8,595	10,305	1,710	19.9	16,485	7,890	91.8
37	7,420	9,109	1,689	22.8	8,113	693	9.3
38	6,890	6,500	- 390	- 5.7	7,419	529	7.7
39	7,805	7,386	- 419	- 5.4	7,329	- 476	- 6.1
40	8,365	6,749	- 1,616	- 19.3	6,508	- 1,857	- 22.2

Table 8.5.--Continued

Estimate Areas	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
41	4,665	4,367	- 298	- 6.4	4,274	- 391	- 8.4
42	4,915	5,412	497	10.1	4,443	- 472	- 9.6
43	4,665	5,536	871	18.7	8,959	4,294	92.0
44	4,385	4,907	522	11.9	7,128	2,743	62.6
45	6,400	6,885	485	7.6	9,144	2,744	42.9
46	7,860	8,801	941	12.0	8,892	1,032	13.1
47	4,345	4,616	271	6.2	4,933	588	13.5
48	5,300	5,403	103	1.9	4,771	- 529	- 10.0
49	5,245	4,604	- 641	- 12.2	4,430	- 815	- 15.5
50	11,965	10,831	- 1,134	- 9.5	9,313	- 2,652	- 22.2
51	4,935	5,340	405	8.2	4,983	48	1.0
52	5,345	5,891	546	10.2	6,108	763	14.3
53	4,745	5,435	690	14.5	6,676	1,931	40.7
54	6,850	7,847	997	14.6	7,352	502	7.3
55	5,065	5,413	348	6.9	4,877	- 188	- 3.7
56	7,705	7,537	- 168	- 2.2	6,076	- 1,629	- 21.1
57	4,135	3,999	- 136	- 3.3	3,282	- 853	- 20.6
58	7,350	6,609	- 696	- 9.5	6,882	- 468	- 6.4
59	9,810	10,351	541	3.5	10,303	493	5.0
60	5,545	5,330	- 215	- 3.9	4,927	- 618	- 11.1
61	27,265	21,335	- 5,930	- 21.7	23,581	- 3,684	- 13.5

[a] 1971 Census of Canada Summary Tapes.

from the actual parameters while only four unmodified estimates were this successful. Almost half (25) of the sub-area modified estimates exceeded ten per cent error. Correspondingly, about two-thirds of the unmodified estimates yielded error greater than ten per cent.

Of the 25 sub-area estimates produced by the modified method that deviated by more than ten per cent from the actual 1971 population counts, eight were under-estimates and seventeen were over-estimates. Over half (14) of these faulty estimates had occupied household estimates within ± five per cent deviation. This suggests that either the average population per household factor or the collective institutional population estimate was in error. The remaining eleven estimates with excessive error would require improvement in the occupied household estimates.

Overall, the modified estimation technique yielded more accurate population estimates than the unmodified procedures in 46 estimate areas -- about three-fourths of the 61 estimate areas. Nine of these improved estimates were in sub-areas where the modified procedures had yielded estimates with error in excess of ten per cent. When all estimate areas modified and unmodified estimates are summed and compared, it was found that the modified estimate deviated by only 0.3 per cent from the actual population while the unmodified estimate was in error by 6.2 per cent. This is a noteworthy level of accuracy for the modified technique in population estimation. It must be noted, however, that there was considerable variation in estimate accuracy for the estimate areas within the city.

Cities and Census Metropolitan Areas

Comparison of modified and unmodified population estimates with 1971 actual populations for the seventy-five selected cities is presented in Table 8.6. The performance of the modified technique in comparison with the unmodified technique is considerably poorer than what was expected. About half (37) of the modified estimates were superior to the unmodified estimates. Thirty modified estimates were within ± five per cent deviation while 37 unmodified estimates were within this range of error. The number of cities with estimate error exceeding ten per cent was 26 and 14 for the modified and unmodified procedures, respectively.

Regardless of annexation experience, the modified and unmodified techniques provided an equal number of superior estimates. For the 31 cities experiencing annexation, the modified procedures produced 16 better

Table 8.6.--Comparison of Modified and Unmodified Postcensal Estimates With Actual Populations for Seventy-Five Selected Cities, Canada: June 1, 1971.

City	1971 Actual Population[a]	Modified Estimate	Modified Difference	Modified Per Cent Error	Unmodified Estimate	Unmodified Difference	Unmodified Per Cent Error
Cornerbrook	26,309	28,123	1,814	6.9	29,128	2,819	10.7
Charlottetown	19,133	19,938	805	4.2	19,290	157	0.8
Amherst	9,966	11,118	1,152	11.6	9,470	- 496	- 5.0
New Glasgow	10,849	12,120	1,271	11.7	11,104	255	2.4
Truro	13,047	14,875	1,828	14.0	13,627	580	4.4
Bathurst	16,674	15,600	- 1,074	- 6.4	19,674	3,000	18.0
Cambellton	10,335	10,294	- 41	- 0.4	11,167	832	8.0
Edmundston	12,365	12,083	- 282	- 2.3	12,847	482	3.9
Fredericton	24,254	24,200	- 54	- 0.2	24,773	519	2.1
Oromocto	11,427	12,926	1,499	13.1	14,473	3,046	26.6
Alma	22,622	17,859	- 4,763	- 21.0	23,264	642	2.8
Asbestos	9,749	10,313	564	5.8	12,046	2,297	23.6
Baie-Comeau	12,622	10,778	- 1,844	- 14.6	10,549	- 2,073	- 16.4
Beloeil	12,274	12,167	- 107	- 0.9	13,308	1,034	8.4
Chambly	11,469	11,490	21	0.2	11,244	- 375	- 3.3
Cowansville	11,920	11,416	- 504	- 4.2	12,571	651	5.5
Granby	34,385	34,402	17	0.0	35,599	1,214	3.5
Hauterive	13,181	10,846	- 2,335	- 17.7	11,326	- 1,855	- 14.4
Joliette	20,127	20,924	797	4.0	21,900	1,773	8.8
La Tuque	13,099	12,412	- 687	- 5.2	13,678	579	4.4
Lachute	11,813	12,482	669	5.7	12,531	718	6.1
Magog	13,281	13,052	- 229	- 1.7	13,162	- 119	- 0.9
Matane	11,841	10,746	- 1,095	- 9.2	12,841	1,000	8.4
Montmagny	12,432	11,414	- 1,018	- 8.2	13,356	924	7.4

Table 8.6.--Continued

City	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Noranda	10,741	10,408	- 333	- 3.1	11,253	512	4.8
Rimouski	26,887	27,034	147	0.5	30,511	3,624	13.5
Riviere-du-Loup	12,760	11,917	- 843	- 6.6	12,147	- 613	- 4.8
Rouyn	17,821	16,235	- 1,586	- 8.9	18,328	507	2.8
Ste. Hyacinthe	24,562	25,042	480	2.0	25,173	611	2.5
Sept Iles	24,320	22,981	- 1,339	- 6.0	27,376	3,056	12.6
Sorel	19,347	19,130	- 217	- 1.1	20,688	1,341	6.9
Thetford Mines	22,003	22,194	191	0.9	22,771	768	3.5
Tracy	11,842	11,758	- 84	- 0.7	12,421	579	4.9
Val D'Or	17,421	17,046	- 375	- 2.2	18,658	1,237	7.1
Victoriaville	22,047	22,082	35	0.2	22,785	738	3.3
Barrie	27,676	29,70[illegible]	2,032	7.3	28,212	537	1.9
Belleville	35,188	37,613	2,485	7.1	37,829	2,701	7.7
Brockville	19,765	22,743	2,978	15.1	20,724	959	4.8
Chatham	35,317	38,797	3,480	9.9	37,364	2,047	5.8
Cobourg	11,282	13,421	2,139	19.0	12,440	1,158	10.3
Cornwall	47,116	45,855	- 1,261	- 2.7	48,468	1,352	2.9
Georgetown	17,053	16,972	- 81	- 0.5	19,377	2,324	13.6
Kapuskasing	12,834	11,137	- 1,697	- 13.2	14,827	1,993	15.5
Kenora	10,952	12,549	1,597	14.6	11,409	457	4.2
Lindsay	12,746	14,718	1,972	15.5	12,683	- 63	- 0.5
Midland	10,922	11,824	902	8.2	11,249	327	3.0
North Bay	49,187	46,646	- 2,541	- 5.2	46,264	- 2,923	- 5.9
Orillia	24,040	25,064	1,024	4.2	22,445	- 1,595	- 6.6
Owen Sound	18,469	21,797	3,328	18.0	19,242	773	4.2
Pembroke	16,544	16,407	- 137	- 0.8	15,957	- 587	- 3.5
St. Thomas	25,545	29,596	4,051	15.8	25,751	206	0.8

Table 8.6.--Continued

City	1971 Actual Population[a]	Modified Estimate	Modified Difference	Modified Per Cent Error	Unmodified Estimate	Unmodified Difference	Unmodified Per Cent Error
Stratford	24,508	27,103	2,595	10.6	24,828	320	1.3
Trenton	14,589	16,121	1,532	10.5	15,733	1,144	7.8
Woodstock	26,173	29,154	2,981	11.4	26,436	263	1.0
Brandon	31,150	34,057	2,907	9.3	31,929	779	2.5
Flin Flon	9,344	9,422	78	0.8	9,759	415	4.4
Portage la Prairie	12,950	14,135	1,185	9.2	12,232	- 718	- 5.5
Moose Jaw	31,854	36,737	4,883	15.3	34,940	3,086	9.7
Prince Albert	28,464	27,439	- 1,025	- 3.6	30,125	1,661	5.8
Swift Current	15,145	16,393	1,248	8.2	16,379	1,234	8.1
Yorkton	13,430	14,937	1,507	11.2	13,575	145	1.1
Grande Prairie	13,079	12,623	- 456	- 3.5	14,262	1,183	9.0
Lethbridge	41,217	46,178	4,961	12.0	46,702	5,485	13.3
Medicine Hat	26,518	30,672	4,154	15.7	26,672	154	0.6
Red Deer	27,674	27,586	- 88	- 0.3	29,982	2,308	8.3
Dawson Creek	11,885	11,882	- 3	- 0.0	13,535	1,650	13.9
Kamloops	26,168	26,741	573	2.2	26,357	189	0.7
Kelowna	19,412	23,737	4,325	22.3	22,045	2,633	13.6
Nanaimo	14,948	16,822	1,874	12.5	15,675	727	4.9
Penticton	18,146	20,394	2,248	12.4	18,488	- 342	1.9
Port Alberni	20,063	20,378	315	1.6	21,648	1,585	7.9
Prince George	33,101	28,407	4,694	14.2	34,363	1,262	3.8
Prince Rupert	15,787	13,954	- 1,833	- 11.6	16,801	1,014	6.4

Table 8.6.--Continued

City	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Trail	11,149	11,967	818	7.3	11,826	677	6.1
Vernon	13,283	13,854	571	4.3	13,201	- 82	- 0.6

[a]1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 7.

estimates than the unmodified technique. Correspondingly, the modified technique provided only twenty better estimates than the unmodified method for the 44 cities experiencing no annexation.

It will be noted that the unmodified technique performed better for cities in P.E.I., Nova Scotia, Ontario, Manitoba, Saskatchewan, and British Columbia. Interestingly, the occupied household estimates were fairly accurate for Ontario, while the population estimates were in error. This inconsistent performance calls for extensive research into the pattern of change in household size over the estimate period as well as the adequacy of the institutional and collective population estimates.

Table 8.7 presents the comparison of individual population estimates for the ten central cities by estimation method. The modified estimation technique proved superior to the unmodified technique for six of the ten cities. Four of the modified estimates were within ± five per cent error while only two of the unmodified estimates fell in this range. Two of the central city estimates derived through the modified technique exceeded ten per cent error -- Montreal and Windsor.

The major urban area estimates by method are portrayed in Table 8.8. The modified estimation procedure produced

Table 8.7-- Comparison of Modified and Unmodified Postcensal Estimates With Actual Populations for Ten Selected Central Cities, Canada: June 1, 1971.

Central City	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Edmonton	438,152	443,727	5,575	1.3	473,766	35,614	8.1
Halifax	122,035	129,808	7,773	6.4	130,114	8,079	6.6
Kitchener	111,804	118,547	6,743	6.0	118,850	7,046	6.3
London	223,222	230,038	6,816	3.0	236,706	13,484	6.0
Montreal	1,214,352	1,384,268	169,916	14.0	1,704,499	490,147	40.4
Quebec	186,088	185,530	- 558	- 0.3	186,401	- 313	- 0.2
Saint John	89,039	92,899	3,860	4.3	91,354	2,315	2.6
St. John's	88,102	80,698	- 7,404	- 8.4	83,507	- 4,595	- 5.2
Toronto	712,786	750,603	37,817	5.3	764,959	52,173	7.3
Windsor	203,300	182,178	- 21,122	- 10.4	222,847	19,547	9.6

[a] 1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 9.

Table 8.8.--Comparison of Modified and Unmodified Postcensal Estimates With Actual Populations for Fifteen Selected Major Urban Areas, Canada, June 1, 1971.

MUA	1971 Actual Population[a]	Modified Estimate	Modified Difference	Modified Per Cent Error	Unmodified Estimate	Unmodified Difference	Unmodified Per Cent Error
Brampton	63,314	62,611	- 703	- 1.1	73,688	10,374	16.4
Brantford	80,284	84,919	4,635	5.8	83,202	2,918	3.6
Drummondville	46,524	41,942	- 4,582	- 9.8	42,960	- 3,764	- 8.1
Kingston	85,877	92,190	6,313	7.4	85,779	- 98	- 0.1
Moncton	71,416	74,197	2,781	3.9	71,036	- 380	- 0.5
Oshawa	120,318	118,590	- 1,728	- 1.4	112,780	- 7,538	- 6.3
St. Catherine's	124,787	130,834	6,047	4.8	126,758	1,971	1.6
St. Jean	47,044	42,844	- 4,200	- 8.9	41,931	- 5,113	- 10.9
St. Jerome	35,335	27,536	- 7,799	- 22.1	34,347	- 988	- 2.8
Sarnia	78,444	84,216	5,772	7.4	81,642	3,198	4.1
Sault Ste. Marie	81,270	77,085	- 4,185	- 5.1	85,736	4,466	5.5
Sherbrooke	84,570	85,632	1,062	1.2	89,625	5,055	6.0
Timmins	41,473	40,457	- 1,016	- 2.4	42,759	1,286	3.1
Trois Rivieres	97,930	96,004	- 1,926	- 2.0	99,260	1,330	1.4
Valleyfield	37,430	37,188	- 242	- 0.6	37,044	- 386	- 1.0

[a]1971 Census of Canada, Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 9.

only seven estimates that were superior to the unmodified estimates, however, eight of the fifteen modified estimates were within ± five per cent error. Only one modified estimate (St. Jerome) exceeded ten per cent error, while two unmodified estimates (Brampton and St. Jean) denoted this extreme error. The estimate accuracy of the two methods for the major urban areas was as inconsistent as the accuracy reported for the selected cities.

Census metropolitan area estimates are noted in Table 8.9 and reveal more favorable results for the modified technique. Fifteen of the nineteen reported estimates were more accurate when the modified technique was utilized. Sixteen of the modified estimates were within ± five per cent of the actual population figures reported by the census. Eleven unmodified estimates achieved this level of accuracy. One modified estimate exceeded ten per cent error (Toronto) while two unmodified estimates were this high (Kitchener and Toronto). The occupied household estimates prepared by the modified procedures for London, St. John's, Sudbury, and Windsor had a considerable negative error. Had these estimates of occupied households been within ± five per cent, then the population estimates for these census metropolitan areas would have manifested greater error.

Table 8.9.--Comparison of Modified and Unmodified Postcensal Estimates With Actual Populations for Nineteen Selected Census Metropolitan Areas, Canada: June 1, 1971.

CMA	1971 Actual Population[a]	Modified			Unmodified		
		Estimate	Difference	Per Cent Error	Estimate	Difference	Per Cent Error
Calgary	403,319	395,990	7,329	- 1.8	442,623	39,304	9.7
Edmonton	495,702	508,340	12,638	2.5	521,130	25,428	5.1
Halifax	222,637	229,957	7,320	3.3	239,427	16,790	7.5
Hamilton	498,523	511,366	12,843	2.6	522,054	23,531	4.7
Kitchener	226,846	236,040	9,194	4.0	250,133	23,287	10.3
London	286,011	285,359	- 652	- 0.2	305,857	19,846	6.9
Montreal	2,743,208	2,904,524	161,316	5.9	2,838,933	95,725	3.5
Ottawa/Hull	602,510	593,782	- 8,728	- 1.4	615,275	12,765	2.1
Quebec	480,502	473,275	- 7,227	- 1.5	505,707	25,205	5.2
Regina	140,734	145,915	5,181	2.7	142,344	1,610	1.1
Saint John	106,744	107,727	983	0.9	108,865	2,121	2.0
St. John's	131,814	131,143	- 671	- 0.5	133,351	1,537	1.2
Saskatoon	126,449	135,985	9,536	7.5	136,682	10,233	8.1
Sudbury	155,424	161,119	5,695	3.7	159,511	4,087	2.6
Toronto	2,638,043	2,942,481	320,438	12.2	2,967,105	341,062	13.0
Vancouver	1,082,352	1,075,236	- 7,116	- 0.6	1,112,816	30,464	2.8
Victoria	195,800	193,716	- 2,084	- 1.1	197,288	1,488	0.8
Windsor	258,643	265,077	6,434	2.5	268,764	10,121	3.9
Winnipeg	540,262	566,006	25,744	4.8	566,910	26,648	4.9

[a]1971 Census of Canada, *Population, Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations*, Vol. 1-Part 1, Bulletin 1.1-8, January, 1973, Table 9.

Population Estimate Accuracy by Control Variables

In order to simplify the presentation of findings in this analysis section, emphasis will focus on the patterns of estimate accuracy revealed by Theil's U statistic summary measure. The average per cent error ($\bar{D}$) patterns correspond to those of the U statistic and, therefore, these tables will be found in Appendix E. The average per cent error tables are important to include for future comparisons in that, this summary measure is commonly used in the analysis of estimate error. This measure will be reported where appropriate in the course of the analysis.

The eight propositions will serve as the organizing element for the remaining part of the analysis. Estimate accuracy for each area category will be presented in ascending order according to each proposition, i.e., from micro-level estimates to macro-level estimates.

> Proposition 1: It is expected that the modified housing unit method will yield more accurate postcensal population estimates than will the unmodified housing unit method

The U statistic summary measure for the major types of areas by method is presented in Table 8.10. The proposition is supported for all major categories with the exception of the 75 selected cities. The most accurate post-

Table 8.10.-- Accuracy of Population Estimates for each Estimate Method by Type of Area: 1971

Estimate Areas	N	Theil's U Statistic	
		Modified	Unmodified
Edmonton Sub-Areas	61	.067042	.149252
Selected Cities	75	.045511	.036186
Major Urban Areas	15	.026816	.027417
Central Cities	10	.054731	.141156
Census Metropolitan Areas	19	.041550	.041859

censal population estimates were produced by the modified procedures for the major urban areas and, conversely, the most inaccurate estimates were derived by the unmodified technique for the Edmonton sub-areas. The greatest improvement by method was found for the sub-areas and central cities with estimates prepared with the modified estimation technique.

<u>Proposition 2</u>: Estimate error will vary directly with the proportion of apartment units in the estimate area

With the exception of areas with extremely low proportions of apartment units, the summary measures presented in Table 8.11 tend to support the proposition for the sub-areas within Edmonton. The modified estimates were more accurate than the unmodified estimates for every category.

Table 8.11.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Apartment Units, Edmonton Sub-Areas: 1971

Proportion of Apartment Units	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 19.9	31	.074849	.080063
20.0 - 39.9	14	.042246	.048113
40.0 - 59.9	8	.052016	.170076
60.0 - 79.9	6	.059268	.229538
80.0 - 99.9	2	.069924	.315321

In the comparison of method performance, the more significant improvement in accuracy was achieved by the modified estimation procedures for sub-areas where the proportion of multiple-units was over forty per cent. For sub-areas where the percentage of apartment units was less than forty per cent, the difference in performance between the two methods was minimal. In constrast to unmodified estimate error, modified estimate error did not increase substantially as the proportion of apartment units increased. The estimates yielding the lowest error were for sub-areas that had from twenty to forty per cent apartment dwelling units.

Table 8.12 compares the accuracy of population estimates for the selected cities, major urban areas, and central cities with respect to the two methods used. For the selected cities, the unmodified technique provided the more accurate estimates for all except the thirty to forty per cent category. In contrast to the pattern revealed for Edmonton sub-areas, the estimate accuracy improves somewhat as the proportion of multiple units increase in the cities. The pattern of summary measures for the selected cities does not support the proposition.

With the exception of areas with twenty to thirty per cent multiple units, the unmodified estimates for major urban areas yield greater accuracy than those produced [illegible] the modified technique. The pattern of estimate error[illegible] not support the [illegible] with respect to major urban areas. Modified population estimates for areas with thirty to forty per cent apartment units yielded the lowest error.

Central city estimates reflect an estimate accuracy pattern which tends to support the proposition. Windsor having the lowest proportion of apartment units manifested low estimate accuracy, hence, proving an exception to the proposition. The modified technique generally produced the more accurate estimates with the greatest improvement in accuracy reflected in those cities with more than fifty per cent apartment units.

Table 8.12.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Apartment Units, Selected Cities, Major Urban Areas, and Central Cities: 1971

Proportion of Apartment Units	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
0.0 - 19.9	8	.048922	.040472	--	--	--	--	--	--
20.0 - 29.9	35	.050077	.035242	6	.022745	.030900	1	.054794	.045869
30.0 - 39.9	11	.031538	.036155	2	.009425	.011941	4	.012923	.036754
40.0 - 49.9	14	.039923	.039052	3	.032691	.021349	2	.026000	.035218
50.0 and over	4	.021141	.013537	4	.033240	.022744	3	.064587	.166219

Table 8.13 reveals an erratic pattern of estimation error for the census metropolitan areas by method. The modified estimation procedure yielded more accurate population estimates than the unmodified technique for all categories except the area with fifty per cent or more apartment units. The most accurate estimates were produced by the modified method for census metropolitan areas with from forty to fifty per cent apartment dwelling units. The pattern of estimate accuracy fails to support the proposition that estimate error will vary directly with the proportion of multiple units in the estimate area.

Table 8.13.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Apartment Units, Census Metropolitan Areas: 1971

Proportion of Apartment Units	N	Theil's U Statistic	
		Modified	Unmodified
20.0 - 29.9	6	.014050	.021292
30.0 - 39.9	9	.050489	.054190
40.0 - 49.9	3	.009592	.027345
50.0 and over	1	.028563	.017148

As with the analysis of the occupied household estimates, the estimates of postcensal populations were analyzed with respect to the proportion of home ownership in the estimate area. Table 8.14 reveals the pattern of estimate accuracy by method for the Edmonton sub-areas. It will be noted that the accuracy of unmodified estimates by home ownership tends to increase as the proportion of home ownership increases thus supporting the proposition. The pattern of accuracy for modified estimates is not as well-defined, in that the sub-areas with from sixty to eighty per cent home ownership reveal an increase in estimate error.

Table 8.14.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Home Ownership, Edmonton Sub-Areas: 1971

Proportion of Home Ownership	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 19.9	5	.063502	.277773
20.0 - 39.9	7	.056929	.167798
40.0 - 59.9	16	.040862	.094365
60.0 - 79.9	28	.083346	.081090
80.0 - 99.9	5	.022892	.062328

As discussed in Chapter VII, the pattern of estimate accuracy for the modified method displayed a U curve suggesting that the extreme category (80.0 to 99.9 per cent home ownership) may possibly be the deviant case. Twelve of the 28 sub-areas revealed under-estimates in excess of ten per cent and only six sub-areas had over-estimates over ten per cent. The majority of under-estimates in this category suggests that a partial explanation for the unexpected high estimate error may be due to error in estimating the change in household size for single-detached dwelling units between 1966 and 1971.

It was found that the most accurate population estimates were produced by the modified procedures for sub-areas with the highest proportion of home ownership. With the exception of the previously discussed category (60.0 to 79.9), the modified estimation procedures yielded the more accurate population estimates for the sub-areas in the remaining categories.

Estimate accuracy of population estimates for the selected cities, major urban areas, and central cities are portrayed in Table 8.15. The pattern of estimate accuracy (modified) for only the major urban areas tends to support the proposition. For the selected cities and the central cities, the accuracy pattern of estimates produced by the modified technique reveals an increase in error as the proportion of home ownership increases. The performance of

Table 8.15.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Home Ownership, Selected Cities, Major Urban Areas, and Central Cities: 1971

Proportion of Home Ownership	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
0.0 - 19.9	1	.061553	.117606	--	--		1	.065387	.167925
20.0 - 39.9	3	.025236	.026082	4	.033240	.022744	1	.001502	.000840
40.0 - 59.9	34	.039957	.034763	5	.030075	.019987	7	.022574	.035589
60.0 - 79.9	34	.050721	.035699	6	.022745	.030900	1	.54794	.045869

both methods was inconsistent in most categories. It is noted, however, that the unmodified technique yielded more accurate estimates for the selected cities with home ownership proportions in excess of forty per cent.

As can be seen in Table 8.16, the modified estimates were more accurate than the unmodified estimates for census metropolitan areas having more than fifty per cent home ownership. The unmodified procedures produced more accurate estimates for the areas with low proportions of home ownership. With the exception of the lowest category, both procedures yield estimates which improve in accuracy as the proportion of home ownership increases. The greatest accuracy was demonstrated by the modified technique for census metropolitan areas with from sixty to seventy per cent home ownership. The greatest error was found in areas where a balance between home ownership and rentership was evident.

Table 8.16.-- Accuracy of Population Estimates for each Estimate Method by Proportion of Home Ownership, Census Metropolitan Areas: 1971

Proportion of Home Ownership	N	Theil's U Statistic	
		Modified	Unmodified
30.0 - 49.9	3	.028133	.017653
50.0 - 59.9	10	.050553	.054166
60.0 - 69.9	6	.013343	.025511

Proposition 3: Estimate error will vary inversely with the population size of the estimate area

The proposition is not supported by the pattern of accuracy revealed by estimates prepared by both methods for the Edmonton sub-areas as will be noted in Table 8.17. Again, the pattern of accuracy takes the form of a U curve with the greatest accuracy achieved in sub-areas with a population size between 6,000 and 8,000. For all categories of size, the estimates prepared with the modified technique were more accurate than those derived through the unmodified technique.

Table 8.17.-- Accuracy of Population Estimates for each Estimate Method by Size of Area, Edmonton Sub-Areas 1971

Population Size	N	Theil's U Statistic	
		Modified	Unmodified
Less than 3,000	2	.097886	.232307
4,000 - 5,999	29	.051749	.120197
6,000 - 7,999	17	.049021	.099955
8,000 - 9,999	6	.057570	.183233
10,000 and over	7	.081968	.166466

Tables 8.18 and 8.19 portray the estimate accuracy for the selected cities, major urban areas, central cities, and census metropolitan areas by population size. The U

Table 8.18.-- Accuracy of Population Estimates for each Estimate Method by Size of Area, Selected Cities, Major Urban Areas, and Central Cities: 1971

Population Size	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Less than 10,000	3	.037100	.068278	--	--	--	--	--	--
10,000 - 24,999	54	.047868	.038057	--	--	--	--	--	--
25,000 - 49,999	18	.043879	.034044	7	.039621	.045586	--	--	--
50,000 - 99,999	--	--	--	7	.022630	.022942	2	.033626	.020661
100,000 - 499,999	--	--	--	1	.023656	.007836	6	.021311	.036267
500,000 and over	--	--	--	--	--	--	2	.058360	.150446

shaped pattern of accuracy is suggested by the summary measure for the major urban areas and central cities. The estimate accuracy for the selected cities, however, reveals a bell-shaped pattern with the greater error found in city estimates where the population size was between 10,000 and 50,000. On the other hand, the pattern of accuracy for the census metropolitan area estimates reveals a decline in estimate accuracy as population size increases.

Table 8.19.-- Accuracy of Population Estimates for each Estimate Method by Size of Area, Census Metropolitan Areas: 1971

Population Size	N	Theil's U Statistic	
		Modified	Unmodified
100,000 - 499,999	14	.012241	.030048
500,000 - 999,999	2	.016681	.017952
1 million and over	3	.043619	.043327

The unmodified estimation technique yielded estimates with greater accuracy for selected cities over 10,000 population size. The modified estimates were more accurate for the fourteen major urban areas between 25,000 and 100,000 population size and for central cities between 100,000 and 500,000 population size. The modified estimates evidenced the greater accuracy for the sixteen census metropolitan areas under one million population size.

Proposition 4: Estimate error will vary directly with the population growth rates of the estimate area

Proposition 5: Estimate error will vary directly with the population decline rates of the estimate area

Both propositions are supported by the estimate accuracy revealed by the modified estimation technique for the Edmonton sub-areas in Table 8.20. Population estimates prepared by the modified technique were superior in accuracy to those developed by the unmodified method in every change category except for estimate areas which experienced population change in excess of ten per cent.

Table 8.20.-- Accuracy of Population Estimates for each Estimate Method by Population Change in the Estimate Area, Edmonton Sub-Areas: 1966-1971

Per Cent Population Change	N	Theil's U Statistic	
		Modified	Unmodified
Decline			
- 1.0 to -4.9	10	.065463	.153152
Stability			
- 0.9 to +0.9	26	.045034	.085548
Growth			
+ 1.0 to +4.9	14	.051237	.115782
+ 5.0 to +9.9	8	.060878	.252600
+10.0 and over	3	.097865	.061302

The most accurate estimates were determined with the modified technique and are for the stable sub-areas with less than one per cent population decline or growth. The greatest improvement in estimate accuracy between methods was found for sub-areas experiencing between five and ten per cent population growth over the estimate period. Estimate accuracy improved to .060878 with the modified method from .252600 using the unmodified technique.

The estimate accuracy for the selected municipalities, major urban areas and central cities by population change experienced between 1966 and 1971 is portrayed in Table 8.21. The proposition is not supported by the pattern of accuracy manifested by the selected city estimates. In contrast, the estimate accuracy of the modified technique evidenced improvement for cities experiencing decline and growth. For sixty-one of the selected cities, the unmodified method yielded the more accurate estimates. This improvement is noted for sub-areas classified as stable and for those which had experienced low growth (1.0 - 4.9 per cent).

The modified estimates for major urban areas in the low growth category were superior to the unmodified estimates, while the reverse was the case for the area classified as stable. While the accuracy pattern of the

Table 8.21.-- Accuracy of Population Estimates for each Estimate Method by Population Change in the Estimate Area, Selected Cities, Major Urban Areas and Central Cities: 1966 - 1971

Per Cent Population Change	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Decline									
- 1.0 to -4.9	5	.042291	.080017	--	--	--	--	--	--
Stability									
- 0.9 to +0.9	30	.044159	.028658	6	.032548	.006656	1	.065387	.167925
Growth									
+ 1.0 to +4.9	31	.051220	.037820	9	.024090	.032204	7	.024248	.035694
+ 5.0 to +9.9	6	.043178	.047434	--	--	--	1	.030864	.032041
+10.0 and over	3	.023323	.028154	--	--	--	1	.021216	.012833

unmodified estimates tend to support the proposition that estimate error will increase as growth in the estimate area increases, the proposition is not supported by the modified estimates.

Nine of the ten central city modified estimates were more accurate than the estimates prepared with the unmodified technique. While the pattern of accuracy of the modified estimates tends to support both propositions, there are too few cases in each category to form any firm conclusions.

It will be noted that the population change intervals are different for the census metropolitan areas as indicated in Table 8.22. No census metropolitan area experienced decline in population over the estimate period and the majority (14) experienced less than three per cent population change. The most accurate estimates were produced by the modified technique for the metropolitan areas which experienced between two and three per cent growth. The accuracy pattern of the population estimates does not support the proposition that estimate error will increase as the population growth rate increases. The unmodified method yielded superior estimates to those produced by the modified method for the census metropolitan areas that experienced the lowest population change over the estimate period.

Table 8.22.-- Accuracy of Population Estimates for each Estimate Method by Population Change in the Estimate Area, Census Metropolitan Areas: 1966-1971

Per Cent Population Change	N	Theil's U Statistic	
		Modified	Unmodified
0.0 to +1.9	8	.027881	.017894
+2.0 to +2.9	6	.007454	.019689
+3.0 to +3.9	4	.052761	.056261
+4.0 and over	1	.009169	.046462

<u>Proposition 6</u>: Estimate error will vary directly with the territorial annexation experienced by the estimate area over the estimation period

This proposition is applicable only to the selected cities in this investigation. The Edmontón sub-areas are not affected by annexation and the major urban areas and census metropolitan areas are excluded as these are essentially statistical areas and any territorial change is determined entirely through re-definition. In essence, only the city as a political unit is considered in this part of the analysis.

Table 8.23 presents the estimate accuracy by method used for the total number of incorporated cities in terms of their annexation experience. It will be noted that when

Table 8.23.-- Accuracy of Population Estimates for each Estimate Method by Annexation Experience, Selected Cities and Central Cities: 1966-1971

Annexation Experience	N	Theil's U Statistic	
		Modified	Unmodified
Total Cities	85	.054713	.140392
Cities with annexation	41	.054665	.140706
Selected Cities	31	.045689	.037062
Central Cities	10	.054731	.141156
Cities without annexation	44	.045251	.034892

just the smaller cities (excluding central cities) are considered, the population estimates prepared by the unmodified estimation method yield the greater accuracy. When the larger central cities are included, however, the estimate accuracy of the modified technique exceeds that of the modified method. When considering the estimate accuracy for the selected cities alone, the proposition is supported, in that, accuracy is higher for cities without annexation regardless of method used.

As noted in Chapter VII, difficulty was encountered with the methodological problem of controlling for the annexations experienced by the 31 selected cities. For several cities it was necessary to accept partial information on these annexed parcels of land, thereby, under-estimating the population which should have been included in the annexation adjustment. It would be expected that estimate accuracy would be better for cities in which annexation adjustments were exact. It was possible through census documents to determine accurately the 1966 population resident in annexed parcels for eleven of the 31 selected cities which had experienced annexation. This comparison is revealed in Table 8.24 where the summary accuracy measures are presented by method for controlled and under-estimated annexations. The modified method did provide the most accurate estimates for cities where the annexation experience was controlled.

Table 8.24.-- Accuracy of Population Estimates for each Estimate Method by Annexation Experience Control, Selected Cities: 1966-1971

Annexation Experience	N	Theil's U Statistic	
		Modified	Unmodified
No annexations	44	.045251	.034892
With annexations	31	.045689	.037062
Controlled	11	.018380	.037811
Estimated	20	.055841	.055648

Proposition 7: Estimate error will vary directly with change in the average household size experienced by the estimate area over the estimation period

The proposition concerning change in household size is not supported by the pattern of estimate accuracy for the Edmonton sub-areas. Table 8.25 portrays a pattern of estimate accuracy which is the reverse of the direction expected, i.e., estimate error decreased as change in average household size increased. The modified population estimates were more accurate than the estimates prepared by the unmodified technique for sub-areas in every change category. The pattern of accuracy demonstrated by the modified technique suggests that the estimate of household size utilized in the estimation procedure was fairly close to the actual average household size in 1971.

Table 8.25.-- Accuracy of Population Estimates for each Estimate Method by Change in Average Household Size in the Estimate Area, Edmonton Sub-Areas: 1966-1971

Absolute Change in Average Household Size	N	Theil's U Statistic	
		Modified	Unmodified
± 0.1	14	.029849	.057223
-0.2 to -0.3	30	.026326	.044139
-0.4 to -0.5	14	.019363	.073665
-0.6 to -0.7	3	.012141	.039934

Tables 8.26 and 8.27 presents the estimate accuracy by the control variable for the selected cities, major urban areas, central cities, and census metropolitan areas. The unmodified method generally provided more accurate estimates for the selected cities than the modified technique. For cities which experienced a decline in average household [illegible]e of from four to five-tenths of a point, the modified [illegible]thod provided the superior estimates. For the major urban areas and central cities, the modified estimates were more accurate in areas where the decline in average household size was modest (0.2 to 0.3). As with the Edmonton sub-areas, a fairly close estimate of average household size change used in the modified procedures would have influenced this improvement in estimate accuracy.

The pattern of estimate accuracy [illegible]he major urban areas is consistent with the propo[illegible] while the accuracy patterns for the selected cities and the central cities are not. The census metropolitan area accuracy pattern for the modified method tend toward supporting the proposition, however, the two metropolitan areas (Quebec and St. John's) experiencing the most change in household size had population estimates with the greatest accuracy.

Table 8.26.-- Accuracy of Population Estimates for each Estimate Method by Change in Average Household Size in the Estimate Area, Selected Cities, Major Urban Areas, and Central Cities: 1966 - 1971

olute Change n Average sehold Size	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
.1	12	.052960	.026793	1	.007233	.002668	1	.021216	.012833
2 to -0.3	37	.044008	.034254	9	.027764	.028735	7	.060185	.155445
4 to -0.5	20	.028571	.046365	5	.032130	.026540	1	.043863	.026776
6 to -0.7	6	.064284	.047903		--	--	1	.025842	.035306

Table 8.27.-- Accuracy of Population Estimates for each Estimate Method by Change in Average Household Size in the Estimate Area, Census Metropolitan Areas: 1966-1971

Absolute Change in Average Household Size	N	Theil's U Statistic	
		Modified	Unmodified
± 0.1	4	.009880	.039285
± 0.2	10	.025496	.017532
± 0.3	3	.057116	.0[illegible]724
± 0.4	2	.007336	.024726

The modified estimates for census metropolitan areas which experienced the lowest change and the greatest change in average household size over the estimation period manifested the greater accuracy (.009880 and .007336). The unmodified method proved superior to the modified technique for the majority of estimates in metropolitan areas having experienced slight change in average household size (±0.2).

<u>Proposition 8</u>: Estimate error will vary inversely with the age of the estimate area

As demonstrated in Table 8.28, the accuracy of estimates derived by the modified technique proved superior to the population estimates prepared by the unmodified technique in every category. The proposition that estimate error will vary inversely with the age of the estimate area

Table 8.28.-- Accuracy of Population Estimates for each Estimate Method by Age of Estimate Area, Edmonton Sub-Areas

Age of Area[a]	N	Theil's U Statistic	
		Modified	Unmodified
0.0 - 9.9	42	.044227	.079136
10.0 - 19.9	8	.101622	.103995
20.0 - 29.9	5	.074026	.266719
30.0 - 39.9	2	.044092	.129175
40.0 - 49.9	4	.072911	.296350

[a]Proportion of dwelling units constructed prior to 1921.

was not supported by the sub-area estimates. It is likely that age of area may have little relationship to the accuracy of population estimates for sub-areas within a city. According to the scale of age, the youngest areas (42) yielded relatively accurate estimates as did older sub-areas with thirty to forty per cent dwelling units constructed prior to 1921.

Age of the study municipalities and other urban areas was determined by the census date that they were first recorded as attaining 10,000 population size. With the exception of the oldest selected cities, the proposition tends to be supported that estimate accuracy will increase as the cities become older. There is a similar

Table 8.29.-- Accuracy of Population Estimates for each Estimate Method by Age of Estimate Areas Selected Cities, Major Urban Areas, and Central Cities

Age of City[a]	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Pre - 1871	--	--	--	1	.035453	.000571	8	.056925	.146917
1881 - 1891	1	.073466	.004016	1	.006240	.029019	1	.054794	.045869
1901 - 1911	6	.055694	.028096	6	.017987	.019832	1	.006322	.039054
1921 - 1931	12	.038195	.033075	3	.035481	.030574	--	--	--
1941 - 1956	30	.044707	.031709	4	.043430	.047405	--	--	--
1961 +	26	.047332	.054402	--	--	--	--	--	--

[a]Age of city was determined by the census date that the city was first recorded as attaining 10,000 population.

supporting pattern of accuracy revealed for the major urban areas with the exception of the oldest major urban area classified. A reverse pattern of accuracy is noted for the central cities, although there are too few cases to be convincing. (Table 8.29)

An inconsistent pattern of estimate accuracy is revealed in Table 8.30 for the census metropolitan areas. The greater error in estimates produced by both methods is revealed for the oldest census metropolitan areas which does not support the proposition. If the oldest category is eliminated then the pattern of accuracy for the modified estimates is consistent with expectations, however, half of the metropolitan estimates are in the oldest category.

The modified estimates were more accurate than the estimates produced by the unmodified technique for those census metropolitan areas that achieved 10,000 population size at the turn of the century (1881-1911). The unmodified estimates were superior for the oldest metropolitan areas and the youngest.

Table 8.30.-- Accuracy of Population Estimates for each Estimate Method by Age of Estimate Area, Census Metropolitan Areas

Age of City[a]	N	Theil's U Statistic	
		Modified	Unmodified
Pre - 1871	9	.043881	.043726
1881 - 1891	4	.010972	.016403
1901 - 1911	5	.014373	.036549
1921 - 1931	1	.017991	.012977

[a]Age of census metropolitan area was determined by the census dates that its central city was first recorded as attaining 10,000 population.

CHAPTER IX

CONCLUSIONS AND IMPLICATIONS

The intent of this research has been to develop and empirically assess the accuracy of a modified censal ratio technique in the estimation of municipality and small area postcensal populations. The study objectives were three-fold:

1. the development of a modified estimation technique;
2. the application of the modified estimation technique to metropolitan sub-areas and municipalities;
3. the assessment of the accuracy of estimates derived utilizing the modified estimation technique.

The modified estimation technique was developed to satisfy the planning needs of both public and private sectors of the municipality. The essential requirements considered in this development of a useful method were that it must be simple in concept and procedure, efficient, inexpensive, reliable, and that it utilize a readily available and continuous series of symptomatic data.

The censal ratio technique employed in this research was a modified version of the housing unit method for estimating populations at postcensal dates. This technique involved the determination of relationships between a symptomatic indicator and the population of an estimate area for the most recent census date. This ratio was then applied to the selected symptomatic indicator assembled over the estimate period. For this technique, housing change over the estimate period was assumed to be symptomatic of population change.

The modification of this censal ratio technique involve two basic improvements regarding the symptomatic indicator and the estimation procedures. The first improvement was to utilize dwelling unit completions rather than dwelling unit starts which serves to eliminate the time lag between an initial building permit start and the completion of construction. The second modification refined the estimation procedures by differentiating major dwelling unit types and applying appropriate ratios. Since the ratio, or population per household, varies by dwelling type, this modification permitted greater sensitivity toward construction shifts in the housing industry over the estimation period.

Indicators were assembled from the building permit records of the City of Edmonton for use in the estimation of metropolitan sub-area populations. The population estimates prepared for municipalities over 10,000 population size employed housing data made available by the Central Mortgage and Housing Corporation. Postcensal estimates were produced for 119 municipalities and urban areas and 61 metropolitan sub-areas.

For each of the estimate areas, the modified and unmodified estimation techniques were employed resulting in two postcensal estimates of population. These estimates were then compared to the actual 1971 census figures for the estimate area. The difference between population estimates and actual parameters was translated in terms of percentage error, average per cent error by control variable, and Theil's U statistic. These summary measures permitted an assessment of accuracy between estimation methods for both the occupied household estimates and population estimates.

The estimation technique employed in this research involves a sequential process in the development of post-censal population estimates. The first stage of this process is concerned with the preparation of an estimate of occupied households. The second stage applies the average population per household estimate to the occupied household estimate resulting in a final estimate of population in occupied households. To this latter estimate is added the best estimate of institutional and collective population. The sequential stages are represented in the following diagram:

<u>Stage 1</u>:	Total Household Estimate	(X)	occupancy ratio	=	occupied household estimate			
<u>Stage 2</u>:	Occupied Household Estimate	(X)	household size estimate	(+)	Collective/ institutional population estimate	=	final post-censal estimate	

The following propositions were set forth for testing in this research:

> <u>Proposition 1</u>: It is expected that the modified housirg unit method will yield more accurate postcensal population estimates than will the unmodified housing unit method

> <u>Proposition 2</u>: Estimate error will vary directly with the proportion of apartment units in the estimate area

> <u>Proposition 3</u>: Estimate error will vary inversely with the population size of the estimate area

> <u>Proposition 4</u>: Estimate error will vary directly with the population growth rates of the estimate area

> <u>Proposition 5</u>: Estimate error will vary directly with the population decline rates of the estimate area

> <u>Proposition 6</u>: Estimate error will vary directly with the territorial expansion experienced by the estimate area over the estimate period

Proposition 7: Estimate error will vary directly with change in the average household size experienced by the estimate area over the estimation period

Proposition 8: Estimate error will vary inversely with the age of the estimate area

Conclusions

The modified estimation technique produced more accurate population estimates for the metropolitan sub-areas, major urban areas, central cities, and the census metropolitan areas. The central city and metropolitan sub-area estimates revealed the greatest improvement in accuracy when the modified technique was used. The unmodified technique yielded estimates with greater accuracy for the selected cities (Table 9.1).

The performance of both estimation techniques was better in estimating the occupied households, however, the unmodified technique provided superior estimates for the selected cities, major urban areas, and census metropolitan areas. The modified method yielded the best population and household estimates for the sub-areas and central cities. The most accurate occupied household estimates were found in the central cities, while the best population estimates were found in the major urban areas.

Generally, the postcensal population and occupied household estimates prepared for the mc ropolitan sub-areas

Table 9.1.-- Comparison of Estimate Accuracy by Estimation Method for Population and Occupied Household Estimates, Major Study Areas: 1971

Estimate Areas	Postcensal Population Estimates			Postcensal Occupied Household Estimates		
	N	Modified	Unmodified	N	Modified	Unmodified
Edmonton Sub-Areas	61	.067042	.149252	61	.026980	.055172
Selected Cities	75	.045511	.036186	75	.020485	.019469
Major Ur'an Areas	15	.026816	.027417	13	.026169	.019147
Central Cities	10	.054731	.141156	10	.008661	.012425
Census Metropolitan Areas	19	.041550	.041859	19	.022509	.018586

and central cities were in the direction expected and the modified technique produced estimates with considerable improvement over the unmodified estimates. A partial explanation for this is that the symptomatic indicators collected and assembled at the local level were subjected to rigorous quality control which could not be applied to the C.M.H.C. data sources. In addition, the use of occupancy ratios by housing type was a methodological refinement incorporated in the preparation of sub-area estimates only. Available comparative data from census documents permitted refinement in the adjustment for central city annexations which was more difficult to achieve for other municipalities in the study.

Tables 9.2 and 9.3 portray comparative average per cent error by method for the major estimate area categories. The modified estimation procedure yielded lower average per cent error than the unmodified method for the metropolitan sub-areas, central cities, and census metropolitan areas. The estimates with the lowest average per cent error were found for the metropolitan sub-areas and, generally, average per cent error increased as size of the estimate area increased.

When estimate areas with extreme error are removed, both methods provided reasonably accurate estimates within

Table 9.2.-- Comparison of Occupied Household Estimate Accuracy by Estimation Method Using Average Per Cent Error for All Estimate Areas and for Estimate Areas with Less Than Ten Per Cent Error: 1971

Estimate Areas	Total Estimate Areas				Estimate Area Within ± 10 per cent			
	N	Modified	N	Unmodified	N	Modified	N	Unmodified
Edmonton Sub-Areas	61	3.2	61	5.5	59	2.9	54	3.0
Selected Cities	75	3.8	75	3.6	67	2.8	70	3.0
Major Urban Areas	13	5.8	13	4.1	11	3.0	12	2.9
Central Cities	10	3.7	10	4.2	8	1.7	9	3.2
Census Metropolitan Areas	19	5.1	19	6.0	15	3.9	15	3.2

Table 9.3.-- Comparison of Population Estimate Accuracy by Estimation Method Using Average Per Cent Error for All Estimate Areas and for Estimate Areas with Less than Ten Per Cent Error: 1971

Estimate Areas	Total Estimate Areas				Estimate Areas with less than 10 per cent			
	N	Modified	N	Unmodified	N	Modified	N	Unmodified
Edmonton Sub-Areas	61	9.3	61	21.3	36	4.7	23	6.5
Selected Cities	75	7.6	75	6.6	49	4.0	61	4.5
Major Urban Areas	15	5.6	15	4.8	14	4.4	13	3.4
Central Cities	10	5.9	10	9.2	8	4.4	9	5.8
Census Metropolitan Areas	19	3.2	19	5.0	18	2.7	17	4.2

± five per cent. The unmodified method, however, produced more accurate estimates for the major urban areas and census metropolitan areas.

The average per cent error for the population estimates was lowest for the census metropolitan areas and highest for the metro~~politan~~ sub-areas when the modified technique was used. The estimates prepared by the modified yielded lower average per cent error for the sub-areas, central cities, and census metropolitan areas. When the estimate areas with extreme error are controlled for, all areas manifest average per cent error within ± five per cent.

In summary, improved occupied household estimates were provided by the modified method for the metropolitan sub-areas and central cities, only. The modified technique produced improved population estimates for the metropolitan areas, major urban areas, central cities, and census metropolitan areas. All estimate areas with modified estimates manifested average per cent error within ± five per cent when areas with extreme error were controlled for.

Table 9.4 presents a summary of the findings with respect to the research propositions for the modified method by estimate area category. With the exception of

Table 9.4.-- Summary of Findings with Respect to Research Propositions for Major Categories of Estimate Areas

Proposition	Findings Tend to Support Proposition									
	Sub-Areas		Selected Cities		Major Urban Area		Central Cities		Census Metropolitan Area	
	Popu-lation	House-holds	Popu-lation	House-holds	Popu-lation	House-holds	Popu-lation	House-holds	Popu-lation	House-holds
1. Method	X	X			X		X	X	X	
2. Multiple-Units	X	X		X			X			X
3. Size	U	U		X	U	X	U	X	R	X
4. Population Increase	X	X		X				X		
5. Population Decline	X	X	R	X	(1)	(1)	(1)	(1)	(1)	(1)
6. Annexation	(2)	(2)	X	X	(2)	(2)	(2)	(2)	(2)	(2)
7. Household Size	R	R		X	X	X		X	X	
8. Age of Area			X	X	X	X				

X - Proposition supported
U - U shaped curve
R - Reverse direction
(1) - no data
(2) - not applicable

proposition three which states that estimate error will vary inversely with population size, all propositions were partially confirmed by the data.

Both occupied household and population estimate patterns of estimate accuracy for metropolitan sub-areas tended to support propositions one, two, four, and five. Estimate error increased in magnitude as the proportion of multiple-units in the estimate area increased, and increased in areas of population growth and decline. Error was expected to decrease as the population size of the estimate area increased. A U shaped pattern of accuracy was evident for the sub-area estimates, however, where larger estimate error was found in sub-areas with small and large numbers of population.

Findings in a reverse direction were found when change in average household size was controlled. Since Edmonton sub-areas had experienced a decline in household size between 1961 and 1966 (Chapter III) and continued this trend to 1971, it is likely that the extrapolated estimate used in the modified technique was very close to the actual size of household. If this was the case, the proposition would likely not be supported.

For the selected cities, the pattern of accuracy for the population estimates tended to support only propositions six and eight. Estimates for cities experiencing no annexation were only slightly more accurate than estimates for cities experiencing annexation. City estimates for both occupied households and population tended to increase in accuracy with age of city. The accuracy of occupied household estimates tended to support the propositions concerned with population change, change in household size, and proportion of multiple-units. Population estimate accuracy, however, failed to support any of these propositions for the selected cities.

The change in household size and age of area propositions were supported by the major urban area estimates of population and occupied households. The performance of estimate accuracy was quite inconsistent with respect to the remaining propositions to make any convincing statements.

Central city population estimate accuracy tended to decrease as the proportion of multiple-units increased. The remaining propositions were not supported by the population estimate accuracy. The estimates of occupied households did agree with the expected direction of error for the propositions concerning multiple-units, change in household size, and population change.

Results were very inconsistent for census metropolitan area estimates. The only proposition supported by the pattern of population estimate accuracy was concerning change in average household size. The estimate accuracy of the occupied household estimates, however, supported propositions two and three (multiple-units and population size).

Methodological Problems and Recommendations

One of the more salient findings of this research was the determination of construction trends in the City of Edmonton by structural-type. As indicated in Chapter III, construction patterns definitely shifted to an emphasis on multiple unit structures toward the end of the estimate period. An interesting feature of this trend is that at the beginning of the estimate period construction of two to three storey "walk-up" apartment structures were relatively dominant; however, toward 1971 the larger, more complex multiple-unit structure became more frequent. This essentially is a trend from medium density to high density construction within the metropolitan area. For the smaller cities, a trend toward row housing as the construction mode was evident from C.M.H.C. tabulations.

These housing trends lend support to the preparation of population estimates by housing type in the modified estimation procedures. The overall population per household ratio used in the unmodified estimation technique would be biased toward the single-house ratio, hence, inflating the population estimates. The use of population per household ratios by dwelling type would be more aligned with the actual housing construction patterns that exist over the estimate period.

In the actual preparation of the occupied household estimates, it was noted that use of completion data on housing activity was only a partial answer to lag-time effects. Use of completion data only accounts for part of the lag-time that must be controlled for in order to gain greater accuracy in occupied household estimates. There are additional lag-times that should be estimated in order to derive accurate occupied household estimates. There is the time-lag between the final completion permit and the time it is actually ready for occupancy and, secondly, the lag-time betweeen being ready for occupancy and the actual occupancy of the unit. Lack of a reasonable estimate of these two lag-times will contribute to an over-estimation of multiple-units.

A recommended refinement which was only utilized in the preparation of metropolitan sub-area estimates was the incorporation of differential occupancy ratios by type and size of structure. C.M.H.C. quarterly vacancy survey data for Edmonton were made available by the Planning Department. These data permitted the application of differential occupancy ratios by type and size of structure over the estimate period. For example, every newly constructed multiple-unit structure was classified according to size (number of units) and the aggregation of units by size category was then subjected to the appropriate occupancy ratio. The result would be a more accurate account of net occupied units by size category.

In the analysis of the accuracy of occupied household estimates, it was found that the derived estimates of multiple-units tended to over-estimate the actual counts provided by the census for Edmonton sub-areas. The possible explanation for this is that either the vacancy data provided by C.M.H.C. was in error or that time-lag between completion and occupancy is an important element to consider in further refinement. It is suggested that the vacancy ratios are unrealistic particularly in light of the larger, multiple-unit structures built toward the end of the estimate period. For example, a large multiple-unit structure could have been completed toward the latter stage of the estimate period and, accordingly, the appropriate 82 per cent occupancy ratio applied. In actuality, however, this large apartment structure may take a considerably longer period of time beyond the limits of the estimate period to be ready for occupancy and then may even experience a much lower occupancy ratio. It is recommended that further research be undertaken in the area of differential occupancy ratios and the influence of the lag-time factor by size of structure.

It will be noted in Figure 9.1 that fewer sub-areas evidenced occupied household estimates with error greater than ± five per cent. This graphic presentation of estimate error reveals that areas with under-estimates were primarily residential single-house areas on the periphery of the city. On the other hand, areas with over-estimates were predominantly apartment areas in the inner area of the city. More accurate estimates of the lag-time factors and occupancy ratios would likely achieve further reduction of these household estimate errors.

Figure 9.2 portrays the population estimate error by sub-area within the city. The population estimate error is magnified in those areas having excessive occupied household error (Figure 9.1). It is significant

Figure 9.1

MODIFIED METHOD OCCUPIED HOUSEHOLD ESTIMATE ERROR BY SUB-AREA, EDMONTON: 1971

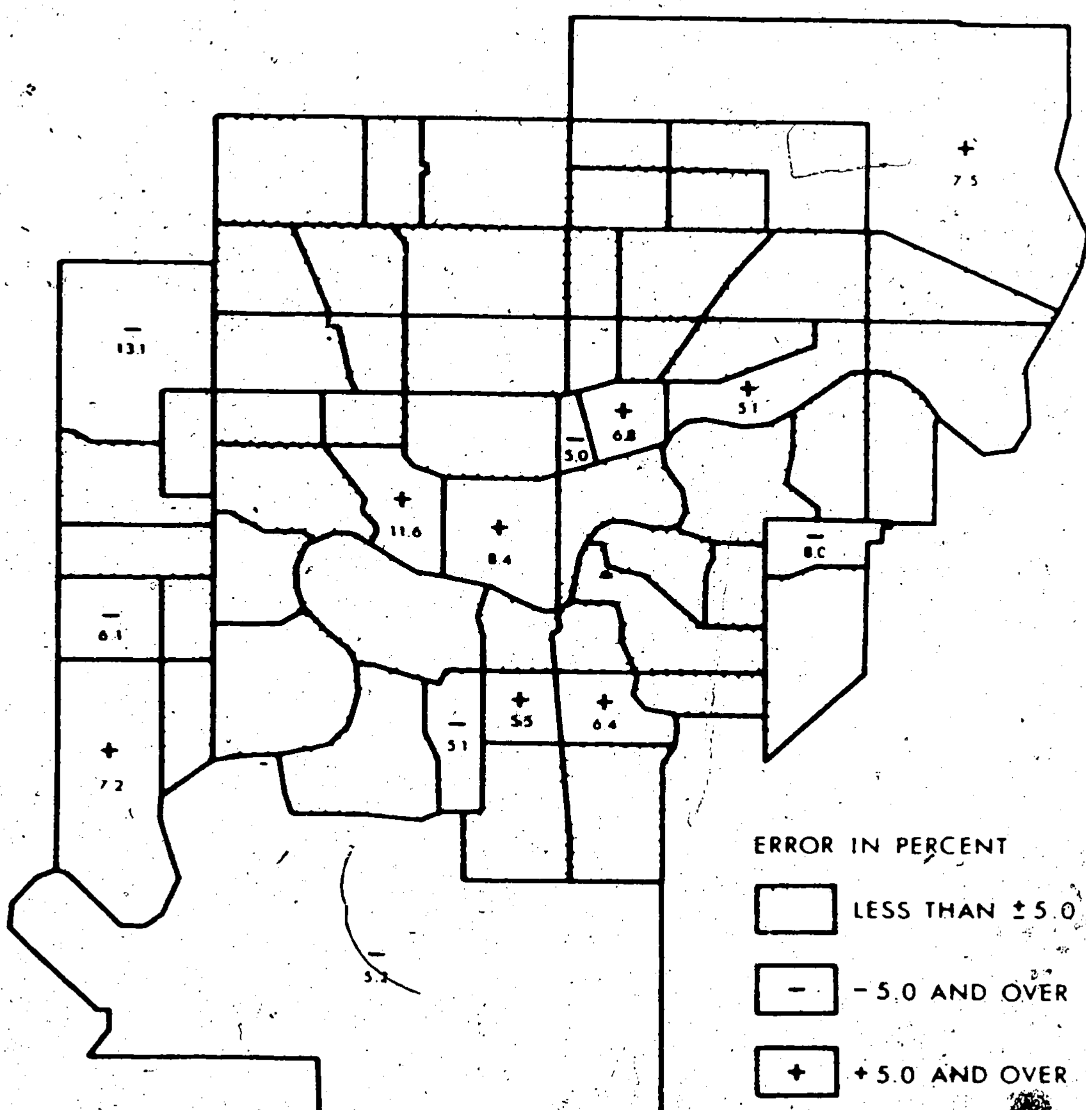
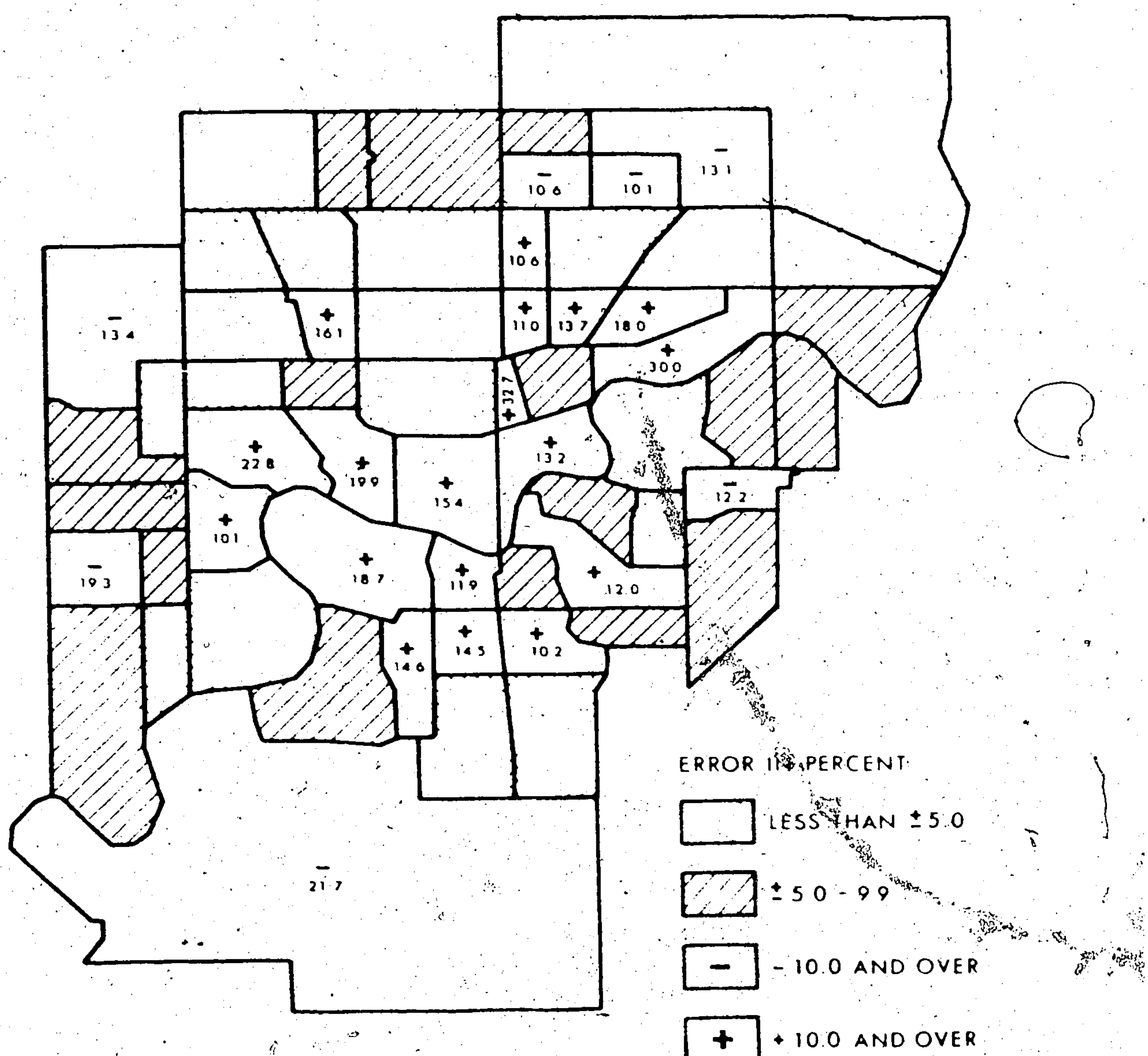


Figure 9.2

MODIFIED METHOD
POPULATION ESTIMATE ERROR
BY SUB-AREA, EDMONTON: 1971



that sub-areas with sizable collective and institutional populations and apartments are generally over-estimated. Sub-areas which have experienced zoning changes permitting higher density construction also evidence over-estimation. Peripheral sub-areas which manifested under-estimation experienced considerable mixed housing developments -- low income row housing -- and university housing. This suggests needed refinement with regard to row housing and appropriate population ratios, as well as improvement in the estimation of collective and institutional populations.

Notable deviations between occupied household estimates derived through either method and the actual census counts strongly suggest the possibility of error in the 1971 census results for several sub-areas. This type of error could have either been in terms of the total count of households, mistabulation in the field, or misclassification of housing type.

Error in census enumeration could have considerable implications in the assessment of estimate accuracy where census results are utilized as the "true" parameters. If there was census error of any magnitude at the small area level, then estimate error could be more apparent than real. Previous postcensal estimation analyses have not questioned the accuracy of the census figures utilized in testing

(California, 1957; Goldberg, 1964; Morrison, 1971; Schmitt and Crosetti, 1954; Siegel, Shryock and Greenberg, 1954; Starsinic and Zitter, 1968; Zitter and Shryock, 1964).

The greatest risk of census error is likely to be found in areas which contain the more difficult populations to enumerate, such as the transients, the collective and institutional populations, and the mobile, young adults. These populations are found in greater proportions in the central areas of the city (McVey, 1973). In light of the methodological consequences that census error would have in any estimation assessment design using census figures, it would be recommended that validity checks be made in the areas of high risk.

These validity checks could be in the nature of a sample housing and population survey conducted as near as possible to the estimate date. In the event that postcensal estimates are prepared for sub-areas in municipalities where annual civic censuses have been conducted, then the local census accuracy check areas could be utilized to provide the "true" parameters for assessment of estimate accuracy. Where civic census materials are unavailable, the postcensal accuracy test results prepared by Statistics Canada could be used to provide a measure of the magnitude of census error likely to be found at the small area level.

These excessive errors in postcensal estimation at the micro-level are not acceptable as these are the very sub-areas that the planner is most concerned with. The refinements suggested should improve the population estimates for these more dynamic areas of the inner and outer city. As the data reveal, the occupied household estimates are the more accurate of the two estimates. This indicates that the greater improvement remains to be made in the second stage of the sequential process. It is suggested that a sampling design could be employed in order to achieve a more accurate estimate of the average household size by housing type for use in the estimation procedures. This would be increasingly important as the estimate date becomes further removed from the base census year.

Another improvement that should be considered concerns the estimate of the collective and institutional population. The 1966 census figure for this non-household population was used in the preparation of final population estimates; however, an extrapolation technique should provide a more sensitive estimate.

Significant methodological problems that are strongly suspected of influencing the findings of this research are centered in the secondary data sources of the Central Mortgage and Housing Corporation and Statistics

Canada. As discussed in Chapter IV, concern was expressed with regard to the inconsistent classification systems used by both governmental agencies, definitional changes in housing and statistical areas, and the modifications made in the 1971 census publication program. Even the 1971 census summary tape did not provide comparable detail in data to that provided in 1961 and 1966. All of these modifications hamper research relying on data comparability, particularly for small areas. These modifications were the more serious shortcomings of the assembly of symptomatic indicators for the preparation of the selected city and urban area estimates. It is paradoxical that agencies charged with the responsibility of providing comparable and useful data for analytical research will introduce changes in procedure which defeat their aims.

Central Mortgage and Housing Corporation is dependent upon the local municipality for the provision of building permit data. It is evident that in order to have reliable data to summarize and distribute in the form of official publications, there must be conscientious co-operation on the part of the data suppliers -- the local municipality. In an effort to assess the reliability of C.M.H.C. data, a questionnaire was forwarded to 187 municipalities throughout Canada eliciting housing data identical to those provided C.M.H.C. (Appendix F). A little over a third of the municipalities responded (70), of which, none provided data which was in agreement with data reported in the C.M.H.C. official documents. Several responding municipalities either did not understand the questionnaire, could not provide the data due to staff shortages, did not maintain records on completion data at all, or did not maintain completion data by housing type. These limited results cast further doubt upon the efficacy of the basic symptomatic indicator data provided by C.M.H.C.

It must be noted, however, that with few exceptions every responding municipality expressed high interest in a postcensal estimation technique. Correspondingly, in order to utilize the postcensal estimation technique the primary requisite is the availability of a continuous data series. A most important condition is that the data series itself must be reliable and accurate.

Very few problems of a methodological nature were encountered in the assembly of building permit data in Edmonton. In questionable cases, the permit was checked against the actual situation in the field and without exception the permit was correct. The series was continuous and was not influenced by changes in definition. In addition, sufficient detail was available to produce estimates by several more housing types than what was actually done. It is felt that the adequacy of this data series accounted for the significant overall difference between the results of the modified and unmodified estimates.

Further research is required concerning the influence of the time-lag factor and differential occupancy ratios in the first stage of the sequential process. In terms of the postcensal population estimates, it is recommended that improvement is required with respect to achieving more adequate estimates of average population size by housing type and the collective/institutional population for the estimate date.

Generally, it is recommended that the utility and efficiency of the modified estimation procedure be judged on the basis of symptomatic indicator adequacy. The research results suggest that the estimation technique's future appears more promising for estimate areas where data quality is high, such as in the case of Edmonton as opposed to secondary sources.

A more fruitful strategy in evaluation would be in controlling for refinement in the modified method itself. It is suggested, for example, that a careful evaluation of demolitions be conducted. In the course of the research it was found that in the majority of instances the demolition had been unoccupied for a considerable length of time prior to initiation of the permit. In this event, unnecessary deletion would be made from the occupied household estimate which could result in under-estimation.

Controls could be used to assess improvement in estimate accuracy when various refinements, such as time-lag factors, differential occupancy ratios, and varying estimates of household size and non-household populations are incorporated.

It is further recommended that research be conducted concerning the efficiency and accuracy of the modified technique for a series of estimate dates following the census year. This can only be done in local areas that conduct censuses in order to have available the actual parameters for testing. The current research results in several estimates that were quite accurate (within ± five per cent) considering the five-year estimation period. These results compared favorably with other research efforts in postcensal population estimation (California, 1957; Zitter and Shryock, 1964; Starsinic and Zitter, 1968). The results suggest increased accuracy for the modified method the closer the estimate date is to the census date.

In conclusion, it can be stated that a reliable continuous series of symptomatic indicators can be established and maintained. For many municipalities, it is evident that an acceptable estimation program will necessitate considerable improvement in the reporting systems now in operation. The preparation of postcensal population estimates for small areas is contingent upon the availability and accuracy of the symptomatic indicators. Local government can insure the continuous collection of these data and standardization of definitions to maintain comparability. As a consequence of this research, while more improvement is indicated for the modified technique, its performance manifests promise for small area estimation.

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APPENDIX A

THEIL'S U STATISTIC: A METHODOLOGICAL NOTE

Theil's U statistic is one of several statistical forecast evaluators. This statistic is a summary measure based upon the comparison of estimated parameter and actual parameter. This comparison may be made against the actual parameter for the estimate date, or the change observed (1966-1971) may be compared with the estimated change (Chisholm and Whitaker, 1971, pp. 161-162).

The denominator of the statistic normalizes it so that its domain is the closed interval of zero to one. Obviously, U = 0 is a perfect estimate, since the estimate would equal actual and $P_i - A_i = 0$ for all i. At the other extreme, U = 1 would be a case of all incorrect estimates (Chisholm and Whitaker, 1971, p. 162).

No rigorous test has been developed to judge whether the difference between two U coefficients is statistically significant. In the comparison of two estimate models, the model yielding the lower U statistic would be better than the other estimation model in estimating the true parameter.

APPENDIX B

Table B.1.-- Comparability of 1966 and 1971 Census Tracts with Study Estimate Areas, Edmonton: 1971

Estimate Areas	Census Tract Numbers	
	1966	1971
1	51	75,76,77
2	2	72,73,74
3	52	71
4	54	69
5	53	70
6	1	67,68
7	35	66
8	55	65
9	36	64
10	3	63
11	4	62
12	5	61
13	6	60
14	7	59
15	50	58
16	49	42
17	12	57
18	11	56
19	10	55
20	9	54
21	8	53
22	37	52
23	56	51
24	57	50
25	38	49
26	13	48
27	14	46,47
28	15	45
29	39	44
30	16	43

Table B.1.-- Continued

Estimate Areas	Census Tract Numbers	
	1966	1971
31	42	41
32	41	40
33	27	39
34	20	34
35	19	32,33
36	18	30,31
37	17	29
38	58	28
39	59	27
40	60	26
41	61	25
42	21	24
43	22	23
44	23	22
45	24	21
46	25	20
47	26	35
48	48	36
49	43	38
50	47	19,37
51	32	17
52	31	14
53	30	13
54	29	11
55	28	10
56	40	9
57	62	8
58	63	7
59	33	12
60	34	15
61	45	1,2,3,4,5

1971 census tracts 6, 16, 18, 78, and 90 were deleted because of either annexation or boundary changes between 1966 and 1971.

APPENDIX C -- Tabulation Form for Retrieval of City Permit Records

TITLE ______________________ TABLE ______

SOURCE EDMONTON BUILDING INSPECTION BRANCH

	ADDRESS	~~AREA~~	TYPE OF HOUSING						PERMIT STATUS				
			Detached	Attached	Double	Duplex	Row	Apt.	Number	Issued	Complete		
1													
2													
3													
4													
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APPENDIX D

COLLECTIVE HOUSEHOLDS

1. Health and Welfare Institutions

   a. Convalescent hospitals
   b. General hospitals (including staff residences)
   c. Homes for the aged and infirm
   d. Hospitals and homes for veterans
   e. Hospitals and homes for incurables
   f. Maternity hospitals
   g. Nursing homes
   h. Sanatoria
   i. Tuberculosis hospitals
   j. Children's Aid Society Shelters
   k. Orphanages

2. Corrective and Penal Institutes

   a. Industrial schools and farms
   b. Jails and penitentiaries
   c. Prison and prison farms
   d. Reformatories

3. Religious and Educational Institutions

   a. Boarding-schools
   b. Convents and Monasteries
   c. Residential schools for the blind and deaf
   d. University and college residences

4. Hotels, Lodging-Houses, etc.

   a. Clubs with living quarters
   b. Hotels which accept transient guests
   c. Lodging-houses with ten or more lodgers
   d. Missions and hostels
   e. Motels
   f. Tourist cabins and camps
   g. Y.M.C.A.'s, Y.W.C.A.'s, etc.

5. Camps

   a. Construction camps
   b. Lumber camps
   c. Military camps
   d. Mining camps

6. Hutterite Colonies

7. Merchant Vessels

8. Diplomatic Residences

(Dominion Bureau of Statistics, 1966a, p. 135)

APPENDIX E

Table E.1.-- Summary of Comparative Average Percentage Error for Study Control Variables by Estimation Method, Edmonton Sub-Areas: 1971

Control Variable	Edmonton Sub-Areas		
	N	Modified	Unmodified
Apartment Units			
0.0 - 19.9	31	8.7	13.2
20.0 - 39.9	14	8.1	9.8
40.0 - 59.9	8	10.0	32.9
60.0 - 79.9	6	12.4	55.4
80.0 - 99.9	2	13.6	78.7
Home Ownership			
0.0 - 19.9	5	12.2	67.7
20.0 - 39.9	7	11.6	40.5
40.0 - 59.9	16	8.0	15.5
60.0 - 79.9	28	9.6	12.6
80.0 - 99.9	5	5.0	15.0
Household Size Change			
±0.1	14	10.4	21.1
-0.2 to -0.3	30	10.2	25.1
-0.4 to -0.5	14	8.6	16.0
-0.6 to -0.7	3	4.4	16.0
Age of Area			
0.0 - 9.9	42	7.1	13.2
10.0 - 19.9	8	13.2	16.1
20.0 - 29.9	5	14.1	56.9
30.0 - 39.9	2	9.0	24.4
40.0 - 49.9	4	18.3	70.5

Table E.1.-- Continued

Control Variable	Edmonton Sub-Areas		
	N	Modified	Unmodified
Population Size			
Less than 3,000	2	17.2	48.8
3,000 - 5,999	29	9.1	18.0
6,000 - 7,999	17	8.6	17.9
8,000 - 9,999	6	8.4	25.8
10,000 and over	7	10.3	30.4
Population Change			
- 1.0 to -4.9	10	12.4	26.0
- 0.9 to +0.9	26	8.2	13.6
+ 1.0 to +4.9	14	8.5	20.7
+ 5.0 to +9.9	8	9.6	45.7
+10.0 and over	3	10.7	9.4

Table E.2.-- Summary of Comparative Average Percentage Error for Study Control Variables by Estimation Method, Selected Cities, Major Urban Areas, and Central Cities: 1971

Control Variable	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Apartment Units									
0.0 - 19.9	8	6.0	7.3	--	--	--	--	--	--
20.0 - 29.9	35	9.3	5.6	6	4.3	6.2	1	10.4	9.6
30.0 - 39.9	11	6.8	9.0	2	1.5	2.0	4	4.7	6.4
40.0 - 49.9	14	6.3	6.8	3	6.7	3.8	2	5.9	7.0
50.0 and over	4	3.2	2.4	4	8.8	4.6	3	6.2	14.4
Home Ownership									
0.0 - 19.9	1	13.1	26.6	--	--	--	1	14.0	40.4
20.0 - 39.9	3	5.0	4.7	4	8.8	4.6	1	0.3	0.2
40.0 - 59.9	34	6.9	6.9	5	4.6	3.1	7	5.0	6.0
60.0 - 79.9	34	3.5	5.4	6	4.3	7.0	1	10.4	9.6
Population Size									
Less than 10,000	3	9.4	11.0	--	--	--	[illegible]	--	--
10,000 - 24,999	54	7.6	6.7	--	--	--	--	--	--
25,000 - 49,999	18	7.7	5.5	7	7.0	6.1	--	[illegible]	--
50,000 - 99,999	--	--	--	7	4.3	3.9	2	6.4	3.9
100,000 - 499,999	--	--	--	1	4.8	1.6	6	4.6	6.2
500,000 and over	--	--	--	--	--	--	2	9.7	23.8

Table E.2.-- Continued

Control Variable	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Population Change									
- 1.0 to -4.9	5	6.9	12.9	--	--	--	--	--	--
- 0.9 to +0.9	30	7.8	5.7	6	6.4	1.5	1	14.0	40.4
+ 1.0 to +4.9	31	8.5	6.0	9	5.0	6.9	7	5.0	6.1
+ 5.0 to +9.9	6	4.2	9.8	--	--	--	1	6.4	6.6
+10.0 and over	3	3.9	4.4	--	--	--	1	4.3	2.6
Annexation									
With annexation	44	7.3	6.7	N/A	N/A	N/A	N/A	N/A	N/A
No annexation	31	7.8	6.4	N/A	N/A	N/A	N/A	N/A	N/A
Controlled	11	2.4	7.8	N/A	N/A	N/A	N/A	N/A	N/A
Estimated	20	10.0	6.1	N/A	N/A	N/A	N/A	N/A	N/A
Household Size Change									
± 0.1	12	10.7	3.7	1	1.4	6.3	1	4.3	2.6
-0.2 to -0.3	37	7.8	5.8	9	5.2	5.1	7	5.9	11.0
-0.4 to -0.5	20	4.9	9.3	5	7.1	3.9	1	8.4	5.2
-0.6 to -0.7	6	10.1	8.1	--	--	--	1	5.3	7.3

Table E.2.-- Continued

Control Variable	Selected Cities			Major Urban Areas			Central Cities		
	N	Modified	Unmodified	N	Modified	Unmodified	N	Modified	Unmodified
Age of Area									
Pre - 1871	--	--	--	1	7.4	0.1	8	6.0	9.3
1881 - 1891	1	15.8	0.8	1	1.2	-6.0	1	10.4	9.6
1901 - 1911	6	11.2	4.0	6	3.3	2.0	1	1.3	8.1
1921 - 1931	12	6.4	5.1	3	4.5	7.4	--	--	--
1941 - 1956	30	7.3	5.1	4	9.7	7.7	--	--	--
1961 +	26	7.3	9.7	--	--	--	--	--	--

Table E.3.-- Summary of Comparative Average Percentage Error for Study Control Variables by Estimation Method, Census Metropolitan Areas: 1971

Control Variable	Census Metropolitan Areas		
	N	Modified	Unmodified
Apartment Units			
20.0 - 29.9	6	3.0	3.3
30.0 - 39.9	9	3.5	6.4
40.0 - 49.9	3	1.9	4.9
50.0 and over	1	5.9	3.5
Home Ownership			
30.0 - 49.9	3	3.6	5.4
50.0 - 59.9	10	3.6	5.7
60.0 - 69.9	6	2.4	3.7
Household Size Change			
± 0.1	4	1.9	3.8
- 0.2	10	3.2	4.3
- 0.3	3	6.5	10.3
- 0.4	2	1.0	3.2
Age of Area			
Pre - 1871	9	3.2	5.1
1881 - 1891	4	2.2	3.1
1901 - 1911	5	3.9	6.9
1921 - 1931	1	3.7	2.6
Population Size			
100,000 - 499,999	14	2.6	4.9
500,000 - 599,999	2	3.1	3.5
1 million and over	3	6.2	6.4
Population Change			
0.0 to +1.9	8	3.9	4.5
+2.0 to +2.9	6	1.4	3.1
+3.0 to +3.9	4	4.8	7.8
+4.0 and over	1	1.8	9.7

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APPENDIX F

29 June 1973

Dear Sir:

I am currently completing a Ph.D. dissertation which essentially involves developing and testing an estimation technique for the purpose of determining current population estimates for small areas and municipalities. The estimation technique being researched is a modified housing unit method which is contingent upon residential construction information. Previous city estimates prepared utilizing the housing unit method have depended primarily upon gross building permit data, i.e., dwelling unit starts, as the indicator of population change. It is my intention to modify the procedures, in that, component estimates by housing type would be developed for each municipality over 10,000 population size in Canada. In this way, shifts in residential construction activity over the estimation period can be accounted for in the development of city population estimates which use housing as an indicator of change. The housing type categories -- single-detached, semi-detached and duplex, row, and apartment -- would conform to the housing definitions stated in Canadian Housing Statistics publications of the Central Mortgage and Housing Corporation. For this research effort, I have selected the five-year interval between June 1, 1966 and June 1, 1971 as the estimation period.

In addition to generating a series of 1971 city estimates using the modified housing unit method, a second series of estimates will be developed using the unmodified procedures. Comparison of these two estimates with 1971 Census of Canada figures will permit a test of accuracy and the assessment of any improvement gained with the modified technique. It is hoped that this research will generate a post-censal technique of estimation that would have practical application in municipalities throughout Canada. The following criteria are serving as my guidelines in this research:

1. Development of a post-censal estimation technique with known levels of accuracy;

2. Development of a technique that is simple in concept and procedure requiring non-demographic expertise;

3. Development of a technique that is not time-consuming in its computational form;

4. Development of a technique that is inexpensive to use; and

5. Development of a technique that utilizes a readily available and continuous series of symptomatic data at the local level.

At this time, I am soliciting the cooperation of all Canadian municipalities over 10,000 population in size in order to obtain historical data on residential construction activity. My data needs are compatible with the reports on dwelling unit starts, dwelling units completed, and dwelling units under construction solicited by Central Mortgage and Housing Corporation for their annual reports. The additional refinement that I require is that the foregoing information be classified by housing type, i.e., single-detached, semi-detached and duplex, row, and apartment over the estimation period. In addition, information on the number of housing units by type destroyed by fire or demolished would be instrumental in the refinement of the post-censal estimates. The attached documents specify exactly the research requirements with regard to building permit data. It is my intention to provide each municipality with a summary report which will indicate a procedural documentation of the post-censal estimation technique, as well as, the results of the empirical tests.

In the event that your municipality maintains monthly tabulations of building permit information by housing type, I would be willing to reimburse your office for any Xeroxing charges in order to expedite this request. As I only have two months to complete this research, I place my trust in your judgment and gratefully appreciate any assistance your office can provide.

Sincerely yours,

Wayne W. McVey, Jr.
Population Research Laboratory

WMW:bw
enclosures

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(1) Population Trends, Cities and Towns, State of Washington, 1900-1962. Seattle: Washington State Census Board, 1962. Collaborator only.

(2) Population Trends, Cities and Towns, State of Washington, 1900-1963. Seattle: Washington State Census Board, 1963. Collaborator only.

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