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BUILDING STATISTICAL AREAS: DOES "BRICK" SIZE MATTER?

by

WILHELMINA R. REA, B.A.

A thesis submitted to the Faculty of Graduate Studies
and Research
in partial fulfilment of
the requirements for the degree of

Master of Arts
Department of Geography

Carleton University
Ottawa, Ontario
1 March, 1994
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submitted by Wilhelmina R. Rea, B.A.
in partial fulfilment of the requirements for
the degree of Master of Arts

Thesis Supervisor

Chair, Department of Geography

Carleton University
Date: May 13 1994

Abstract

This thesis compares two different methods for delineating Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs). CMA/CAs are currently delineated at Statistics Canada using Census Subdivisions (CSDs) as the basic building blocks. This CSD level delineation is compared to a delineation performed at the Enumeration Area (EA) level.

This thesis is related to other geographic work which looks at the influence of the underlying geographic framework on the subsequent analysis of data contained in it. This is often called the Modifiable Areal Unit Problem.

The thesis concludes that the similarity between CMA/CAs produced by the CSD and EA level delineations diminishes as one heads west across Canada. It also concludes that the CMA/CAs having small populations are characterized by the greatest lack of congruity in their CSD and EA level delineations. Recommendations are made for further study.

Acknowledgements

I would like to thank Statistics Canada for allowing me to use the data set comparing CSD and EA levels of CMA/CA delineation. Without this data, this thesis could not have been written.

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the difference between the Census variables which would be assigned to sample CMA/CAs if the CSD or EA level delineations were used.

CHAPTER 1

Introduction

The basic premise of this thesis is that, in order to overcome the Modifiable Areal Unit Problem (MAUP), spatial analysis should take place at the individual level. Since this is not often possible, an acceptable compromise may be the use of a very tightly defined geographic territory as a basic unit. In the context of the Census the extent to which a "tighter" CMA/CA can be delineated if Enumeration Areas are used as building blocks instead of Census subdivisions is explored.

This thesis compares two methods for delineating Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs). CMA/CAs are currently delineated at Statistics Canada using Census Subdivisions (CSDs) as the basic building blocks. (See figure 1 in the chapter on the CMA/CA program at Statistics Canada for a diagram showing the 1986 Census Geographic Hierarchy.) This CSD level delineation is compared to a delineation performed at the Enumeration Area (EA) level. The smaller EA should give a spatially more exact delineation. It

should also be more geographically precise in the sense that smaller geographic areas are more homogeneous. After all, it is a geographic truism that, "everything is related to everything else, but near things are more related than distant things." (Tobler, 1970 quoted in Gould, 1970, p44)

The data for this comparison were compiled by Stanton in 1985. This thesis takes another look at this data set by analysing different statistical measures in an attempt to produce results which assess the degree to which the EA level delineation is an improvement on the CSD level delineation.

In order to understand the concepts explored in this thesis it is necessary to be clear about the definition of some of the terms used. The chapter on the CMA/CA program at Statistics Canada provides a fuller look at the Census Geographic Areas used in this Study. Appendix 6 contains the full 1986 Census Dictionary definitions for each of these terms. Briefly, the Census Dictionary states, "the general concept of a CMA/CA is one of a large urbanized core, together with adjacent urban and rural areas which have a high degree of economic and social integration with that core." The urbanized core is described as, "a large urban area around which a CMA or a CA is delineated. The urbanized core must have a population (based on the previous census) of at least 10,000 in the case of a CA or 100,000 in the case of a CMA." CMAs differ from

CAs only in being larger.

CMA/CAs are one of the more important geographical areas produced by Statistics Canada. They are used internally by at least twenty divisions to publish social and economic data and population statistics. They are also used by the Federal, Provincial and Municipal levels of government and other institutional users to publish data and to administer programs. The use of the CMA/CA is discussed more fully in Chapter 3.

CSDs are defined in the Census Dictionary as "the general term applying to municipalities, Indian reserves, Indian settlements, and unorganized territories". They can be quite large in area and their boundaries are usually determined by local governing bodies in conjunction with provincial governments and not by Statistics Canada. Their boundaries are relatively stable. They only change when territory is annexed by a municipality or when there is a region or province-wide municipal reorganisation. CSDs are included in a CMA/CA if they meet certain criteria outlined in Chapter 3.

EAs, on the other hand, are usually smaller since they are defined as "the area usually canvassed by one census representative. Enumeration areas are normally the smallest geographic unit for which census data are available." EAs are

not at all stable since their boundaries are likely to change for each Census. EA boundaries must respect all higher level boundaries including those of CSDs and CMA/CAs.

In this thesis, EAs replace CSDs as the basic building block of CMA/CAs and the results are compared to the standard CSD delineation (see Chapter 4, "Methodology", for a description of how this comparison was done).

Since EAs are smaller than CSDs, delineation at the EA level should, all other things being equal, produce a spatially more exact delineation of CMA/CAs. Accuracy in delineation would reduce the possibility of areas whose economic and social integration with the core is unlikely to be significant being included in the CMA/CA. Lack of accuracy at the definitional level could result in erroneous conclusions being drawn from subsequent analyses of data compiled by CMA/CA. For example, a Statistics Canada publication entitled, "Housing Costs and other Characteristics of Canadian Households", 1991, states that the total number of private households in the CMA of Ottawa - Hull is 349,255. Of these, 154,930 are renters. The percentage of renters for Ottawa - Hull is, therefore, 44%. This percentage could be higher or lower depending upon the size of the CMA which would naturally have an impact upon the data used to calculate the percentage. If CMA/CAs can be considered to be a "package" or "unit" for data compiled by

Statistics Canada, it is essential to ensure that this package includes all of, but no more than, the territory that meets the definition of the geographic area. In the case of the CMA/CA, this means that, as far as is technically possible, all places within the CMA/CA must be "economically and socially integrated with the core". In other words, the package must be the right size and it must have the most carefully located boundary possible.

The overall problem of the influence of the underlying geographic framework on the analysis of data referenced to it has been discussed in geographic literature by, among others, Openshaw and is called the Modifiable Areal Unit Problem (MAUP). A discussion of his ideas is presented in Chapter 2.

Chapter 3 provides background to this study by describing the geographic areas used in this thesis. Summary statistics comparing the two levels of delineation for each CMA/CA were compiled and the results analyzed by region and by population size. A more detailed discussion of the methodology is found in Chapter 4. Chapter 5 contains a discussion of the results. Conclusions are drawn and recommendations for further research are made in Chapter 6, which also considers broad technical issues of spatial analysis in the era of GIS.

Finally, an addendum (Chapter 7) has been added which examines

the difference between the Census variables which would be assigned to sample CMA/CAs if the CSD or EA level delineations were used.

CHAPTER 2

A New Approach to Data Quality and the Modifiable Areal Unit Problem (MAUP)

Michael Goodchild, in his keynote address to Statistics Canada's Symposium on Spatial Statistics, (Nov. 12, 1991) said that hope for a solution to the underlying statistical problems in spatial analysis (specifically, the MAUP, Modifiable Areal Unit Problem) is to be found in the emergence of an "exploratory paradigm" to replace the present "confirmatory paradigm". This chapter examines this statement and attempts to show how adoption of the exploratory approach to data analysis could have a beneficial effect on the way we approach geographical research. Interestingly, it is the increasing importance of GIS within data analysis which has forced geographers to come to terms with the importance of the MAUP and to develop further an exploratory approach to data analysis.

This chapter first defines the terms, "confirmatory paradigm" and "exploratory paradigm" and discusses their significance within the context of spatial statistical analysis. It will

then discuss the Modifiable Areal Unit Problem (MAUP) and its effect on spatial statistical analysis. How pervasive is this effect and what solutions are possible? Finally, it will be seen how adoption of the exploratory paradigm will change the focus of geographical research so that we can develop a general understanding of the effects of the MAUP and how it affects individual applications before applying the rules of the confirmatory paradigm in a more traditional approach to geographic analysis. This type of problem solving approach is largely a result of the improved ability of GIS to process large amounts of data quickly. Ironically, it is the increasing use of GIS which has brought problems in the use of spatial statistics to the forefront of both statistical and geographic circles. Thus, the use of GIS is both the cause of, and will be seen to be the solution to, problems in spatial analysis involving the MAUP.

The Confirmatory Paradigm

The Dictionary of Human Geography defines confirmatory data analysis as, "statistical procedures used to test hypotheses, using the laws of probability and the methods of statistical inference". (Johnston, ed., 1986, p66) The dictionary goes on to state, "Within Positivism, a hypothesis is a statement not yet accepted as true; the purpose of the positivist methodology is to test its veracity. The goal is to establish

the truth of that statement by reference to empirical data...Hypothesis testing was promoted as the path to knowledge during geography's Quantitative Revolution." (ibid., p210) Thus, confirmatory data analysis involves the testing of a hypothesis by analyzing appropriate data. Once the hypothesis is defined, one must use the data to decide only whether the hypothesis can be accepted or rejected. This narrow approach reduces the likelihood that any other information will be gleaned from the data. This approach is especially limiting because in geographic studies social data have very seldom been collected with the particular study in mind. With the exception of some micro-scale studies, human geographers often use data collected by government agencies for a wide range of purposes. These data are likely to contain information which the confirmatory approach to data analysis will not uncover and can be based on areal units whose delineation may be only partly understood by the data user. To do it justice, the confirmatory approach does prevent the researcher from getting bogged down in too complex a study. Taking the narrow path ensures that the researcher will finish with at least one new piece of knowledge, i.e., the hypothesis will be either confirmed or rejected.

The Exploratory Paradigm

In contrast, exploratory data analysis is defined as, "A set

of procedures designed to describe the major features of a data set and generate ideas and hypotheses. Whereas many statistical analyses are undertaken to test hypotheses, following the rules of scientific inference, exploratory data analysis is undertaken with fewer preconceptions about the expected findings...Exploratory data analysis, with its emphasis on graphical display, allows researchers to penetrate their data-sets, appreciate their peculiarities, and draw conclusions which are not constrained by prior expectations and the limitations of chosen inferential statistical techniques." (ibid., p143-144) Thus, exploratory data analysis has the potential to provide a wide range of information about a study topic but the danger also exists that very little of substance will be learned, even after extensive data analysis.

A short digression is necessary here to discuss Goodchild's use of the word "paradigm". He uses it here in the sense of a "disciplinary matrix" (ibid., p338) which defines the underlying assumptions of geographic study. Thus, the confirmatory paradigm is the assumption that spatial data analysis must involve the testing of a hypothesis followed by either its acceptance or rejection. In contrast, the exploratory paradigm is the assumption that spatial analysis is best approached with few prior assumptions and that searching the data for patterns and trends will yield more

interesting, useful and accurate results.

The Modifiable Areal Unit Problem (MAUP)

The MAUP addresses the issue of the accuracy of spatial data analysis. It was the need to try to improve accuracy which led Goodchild to his conclusion that the adoption of the exploratory paradigm is necessary. In fact, the more recent articles about the MAUP are found in company with articles which discuss the accuracy of geographic data bases rather than, as previously, with articles on spatial statistical analysis. Perhaps this slight shift in orientation is partly responsible for the increased amount of attention now being paid to the MAUP. It is the growing use of GIS and the accompanying creation of more and more spatial data bases which has increased concern about their accuracy and hence about the MAUP.

The MAUP has been discussed in geographic literature for quite some time (see Gehlke and Biehl, 1934; Neprash, 1934; Robinson, 1956) but the overwhelming nature of its effects and the difficulty of doing anything about it without the aid of quick and inexpensive computer power combined to prevent it from becoming a prominent geographic issue.

Stan Openshaw has been the principal proponent of the necessity of recognizing the effects of the MAUP. In his

monograph, "The Modifiable Areal Unit Problem", (one of at least seven articles on this topic which he has written or co-authored in the last ten years) he states, "there are a large number of different spatial objects that can be defined and few, if any, non-modifiable units. Whereas census data are collected for essentially non-modifiable entities (people, households), they are reported for arbitrary and modifiable areal units (enumeration districts, wards, local authorities). The principal criteria used in the definition of these units are the operational requirements of the census, local political considerations, and government administration. As a result, none of these census areas have (sic) any intrinsic meaning. Yet it is possible, indeed very likely, that the results of any subsequent analyses depend on these definitions. If the areal units or zones are arbitrary and modifiable, then the value of any work based upon them must be in some doubt and may not possess any validity independent of the units being studied." (Openshaw, 1984a, p4)

Openshaw goes on to say, "The MAUP is in reality composed of two separate but closely related problems. The first of these is the well known **scale problem** which is the variation in results which can often be obtained when data for one set of areal units are progressively aggregated into fewer and larger units for analysis. For example, when census enumeration districts are aggregated into Wards, Districts, and Counties,

the results change with increasing scale. ... There is also the problem of alternative combinations of areal units at equal or similar scales. Any variation in results due to the use of alternative units of analysis when the number of units is held constant is termed the **aggregation problem.**" (ibid., p8)

Thus, the MAUP casts serious doubt on one of the most basic assumptions underlying geographic analysis - that the areal zones in which data are collected and disseminated have no effect on the results of the analysis of that data. In fact, as the following section will show, the areal units can have a profound effect. However, it is also true that their effect can be marginal and it is the capriciousness of the MAUP's behaviour which makes the exploratory paradigm a more suitable framework than the confirmatory paradigm for studying it.

Exploring the Problem

This section describes several studies which have been undertaken in an attempt to understand the MAUP better. Openshaw, in his 1984 contribution to the Geo Abstracts series entitled, "The Modifiable Areal Unit Problem", describes several early studies in addition to his own. The reader is referred to this work for a detailed picture of the data. The following is intended only to be a summary.

Openshaw describes work by Gehlke and Biehl (1934). "The 252 census tracts of Cleveland, USA, were grouped successively into larger units of approximately the same size and subject to contiguity restrictions. The correlation between male juvenile delinquency and median monthly income was then calculated using both absolute numbers and ratios." (ibid., p10) Correlation coefficients varied from $-.502$ for 252 units to $-.763$ for 25 units. Similarly, the ratio variables varied from $-.516$ to $-.621$. (see Table 1) "The principal effect of using ratio variables is to slow down the increase of the correlation coefficient due to increasing scale by standardising for the size of areas." (ibid., p10) Openshaw quotes Gehlke and Biehl as saying, "these results raise the question whether a correlation coefficient in census tract data has any value for causal analysis. Does it measure the inter-relation of traits in their ultimate possessors - individuals and families? A relatively high correlation might conceivably occur by census tracts when the traits so studied were completely dissociated in the individuals or families of those traits." Openshaw goes on to state, "they asked what is probably the most important question of all concerning whether a geographical area is an entity possessing traits or merely one characteristic of a trait itself? That is to say, are areal units entities or objects that can be studied or are they merely a variable that is proxy for geographical location?" (ibid., p 11)

Table 1 (Source: Openshaw, Stan (1984) "The Modifiable Areal Unit Problem" in CATMOG 38, Geo Abstracts, Norwich, UK)

Correlation coefficients for Cleveland, USA

<u>number of units</u>	<u>absolute numbers</u>	<u>rates</u>
252	-.502	-.516
200	-.569	-.504
175	-.580	-.480
150	-.606	-.475
125	-.662	-.563
100	-.667	-.574
50	-.685	-.579
25	-.763	-.621

Yule and Kendall (1950) also demonstrated that the absolute values of the correlation coefficients usually increase with scale. "They describe how the correlations between wheat yields and potato yields for the 48 counties of England increase as spatial aggregation reduces the number of areal units and increases their size and the scale of the analysis." (ibid., p11) As the number of geographical areas varies from 48 to 3, the correlation coefficients they obtained vary from .2189 to .9902. (see Table 2) In other words, by manipulating the zoning system it should be possible to obtain almost any value for the correlation coefficient.

Table 2 (Source: Openshaw, Stan (1984) "The Modifiable Areal Unit Problem" in CATMOG 38, Geo Abstracts, Norwich, UK)

Correlations between wheat and potato yield (English counties)

<u>number of geographical areas</u>	<u>correlation</u>
48	.2189
24	.2963
12	.5757
6	.7649
3	.9902

How, therefore, could anyone continue to place any faith in the correlation coefficient? The answer is that it was felt that comparison of correlation coefficients **over time** could still be useful. They must be thought of as specific to the zoning system used and not "capable of scientific generalisation or ... comparison with other correlations for the same variables but for different zones." (ibid., p 11)

However, these two studies and one by Robinson (1950) conclusively proved that "because correlations are modifiable they may not provide any useful guide to individual or more spatially disaggregated levels of correlations." (ibid., p10) Robinson obtained correlation coefficients between black population and illiteracy which varied between .203 for the 98 million individuals living in the USA, and .946 for 9 census divisions. (see Table 3)

Table 3 (Source: Openshaw, Stan (1984) *"The Modifiable Areal Unit Problem"* in CATMOG 38, Geo Abstracts, Norwich, UK)

Individual and ecological correlations (after Robinson, 1950)			
level of aggregation	number of units	correlations between:	
		negro and illiteracy	nativity and illiteracy
individual	98 million	.203	.118
state	48	.773	-.526
census division	9	.946	-.619

In 1977, Openshaw undertook a study which concentrated more on aggregation effects than on scale effects. (The above studies

looked at scale effects.) He studied the correlation between the numbers of early and mid-Victorian houses in South Shields, England using data related to 100 metre grid squares. These data were aggregated to 200m, 300m, 400m, 500m, 600m, 700m, 800m, 900m, and 1 km. squares and a number (Openshaw does not say how many) of different aggregations were obtained by shifting the origin of the 100 metre lattice. (see Table 4) When looking only at one aggregation for each scale, the correlations varied from .08 to .73 but did not always maintain their ascending order, i.e., the 300 metre correlation value of .43 is followed by a lesser value of .28 at the 400 metre level. Looking at the mean correlation values for aggregations at each scalar level produced values varying from .31 to .62. Openshaw states that the number of aggregations he creates does not approach the total number of possible aggregations which number in the millions. But it is clear that the aggregation effect uncovered here is not insignificant. The range of this effect would increase if more aggregations were added to the study.

Table 4 (Source: Openshaw, Stan (1984) "The Modifiable Areal Unit Problem" in *CATMOG 38, Geo Abstracts, Norwich, UK*)

<u>Scale and aggregation effects on the correlation between numbers of Early and Mid-Victorian houses in South Shields</u>			
<u>size of squares (metres)</u>	<u>scale effects</u>	<u>aggregation effects</u>	
		<u>mean correlation</u>	<u>standard deviation</u>
100	.08	-	-
200	.21	.31	.11
300	.43	.43	.06
400	.28	.47	.11
500	.55	.49	.16
600	.45	.52	.16
700	.20	.57	.18
800	.56	.58	.18
900	.66	.60	.19
1 km	.73	.62	.20

Openshaw decided to see if it is possible to determine the full extent of the variability of a given statistic due to the aggregation effect of the MAUP. In this way, he hoped to demonstrate the magnitude and severity of the MAUP. He developed an algorithm called the Automatic Zoning Procedure (AZP) which is characterized by the following series of steps. First the number of regions required in the final aggregation is decided. These regions are then randomly generated. Next, one of these regions is randomly selected and each bordering zone is tested for the effects on the objective function of moving zones from the bordering regions into it. Once an improvement is recorded for the objective function which is being optimised, then the possibility of moving the zone is checked; i.e., it must not destroy the internal contiguity of the region from which a zone is being moved. The move is either accepted or rejected. The process is repeated until each zone has been checked. This process is applied to a set

of zones which must be aggregated to a smaller number of larger zones. Openshaw states, "The objective function can be any general function and it need not be continuous. For example, the aim may be to maximise or minimise a correlation coefficient between two variables in order to identify the approximate limits of variability due to the MAUP." (ibid., p22) Using the AZP and a data set of the 99 Iowa counties, Openshaw demonstrated that, at the 6-zone level, it is possible to have a correlation coefficient which ranges in value from $-.99$ to $+.99$. (see Table 5)

Table 5 (Source: Openshaw, Stan (1984) *"The Modifiable Areal Unit Problem"* in *CATMOG 38*, Geo Abstracts, Norwich, UK)

Some approximate limits of the correlation coefficient due to different aggregations of the Iowa data								
number of zones	Iowa data		MN data		Z data		MP data	
	min r	max r	min r	max r	min r	max r	min r	max r
6	-.99	.99	-.99	.99	-.99	.99	-.99	.99
12	-.99	.99	-.97	.99	-.99	.99	-.98	.99
18	-.97	.99	-.97	.99	-.97	.99	-.92	.99
24	-.92	.99	-.98	.99	-.90	.99	-.89	.98
30	-.73	.98	-.93	.98	-.86	.98	-.78	.95
36	-.71	.96	-.93	.98	-.80	.98	-.61	.93
42	-.55	.95	-.92	.97	-.79	.96	-.52	.93
48	-.50	.90	-.87	.96	-.66	.95	-.39	.89
54	-.42	.82	-.85	.95	-.52	.91	-.32	.88

Notes: based on best of five different random zoning systems used as starting aggregations. MN, Z, MP are the three artificial Iowa data sets (see Table 8)

Openshaw also analyses this Iowa data set to look at other aspects of the MAUP. He states, "it has been suggested that the statistical distribution of a statistic due to sampling variability and its zoning distribution due to the choice of different zoning systems, are analogous. If the analogy could

be proven then it would be exceptionally convenient because it would allow the standard formulae for estimating sampling errors for simple random samples to be used to provide estimates of aggregational variability, presumably under the assumption of simple random zoning. In this sampling-zoning analogy, the number of zones in the zoning system would be regarded as equivalent to sample size." (ibid., p17)

Openshaw uses 1970 census data for the 99 counties in the state of Iowa and looks at two variables: percent Republican voters and percent population over 60 years of age. (see Figure 6) The value of the correlation at the 99 county level is 0.34. The mean correlations for 10,000 random samples of random zoning systems at various levels from 6 zones to 54 zones varied from 0.32 to 0.36. The mean correlations for 10,000 random samples of sampling distributions at various levels from 6 zones to 54 zones varied from 0.31 to 0.34. In addition, the standard deviations of the zoning distributions are considerably smaller than those for the corresponding sampling distributions but exhibit a greater degree of bias. From this he concludes that the sampling analogy is not upheld. "There is an additional risk involved in using standard error formulae for simple random sampling as estimates of the aggregational variability due to the use of simple random zoning systems." (ibid., p19)

Table 6 (Source: Openshaw, Stan (1984) "The Modifiable Areal Unit Problem" in *CATMOG 38*, Geo Abstracts, Norwich, UK)

<u>Sampling and zoning distributions of the correlation coefficient</u>					
number of zones	zoning distributions		sample size		
	mean	standard deviation		mean	standard deviation
6	.36	.218	6	.31	.429
12	.33	.161	12	.34	.273
18	.33	.139	18	.34	.209
24	.32	.122	24	.34	.172
30	.33	.110	30	.34	.144
36	.33	.102	36	.34	.125
42	.33	.092	42	.34	.109
48	.33	.082	48	.34	.097
54	.33	.073	54	.34	.086
99	.346			.346	

Another aspect of the failure of the sampling-zoning analogy concerns the use of inferential statistical techniques with zonal data. Openshaw states that it is seldom clear "what is the nature of the hypothesis that is being tested and what, if anything, the results signify." (ibid., p19) Zonal data cannot constitute a sample because there is no population from which the sample can have been taken. Statisticians sometimes invent a "super population" (for example, the Iowa data are a random sample of data for Iowa counties because they represent data randomly chosen at one point in time) but, once this is done, it is still difficult to identify what the significance tests mean and to construct sampling error estimation equations. This is a very strong argument against the use of hypothesis testing as characterised by inferential statistical techniques to solve the MAUP. Since these techniques form the operational arm of the confirmatory approach to problem solving, Openshaw's comments indicate that the limitations of

this approach were already being felt in 1984.

One final point which Openshaw makes in his exploration of the MAUP is that "it is impossible to predict the severity of the problem without access to individual data". (ibid., p16) Without this, one cannot know how close the value of a particular statistic comes to that found for individual level data. This problem is interesting because it is the basis of the ecological fallacy. Without the individual data to maintain integrity, erroneous assumptions can be made about individuals from analysis of aggregated data.

Openshaw goes on to state that it is "confidently expected that the aggregational variability in the range of possible results due to the choice of the first zoning system will exceed that of any subsequent re-aggregations of the data...Even if this assumption can be disproven, it is highly likely that the choice of the first zoning system has a crucial effect on the severity of any subsequent ecological fallacies". (ibid., p21) In other words, if the zonal configuration for the first aggregation could be manipulated in such a way that the statistic under study would be very close to that obtained with individual data, then greater accuracy would be maintained at subsequent levels of aggregation. One problem with this approach, however, is that a configuration which is appropriate for one statistic, say a

correlation coefficient, may not be appropriate for another, say a regression coefficient.

This problem emerges in a study by Amhrein and Flowerdew (1989). They examine Canadian migration data derived from income tax returns for the 266 census divisions defined by Statistics Canada in 1986. The data are manipulated in such a way that both scale and aggregation effects are studied. Four different models for aggregating the zones are used and several statistics are compared: the mean proportion of deviance, the square of the correlation coefficient, and the regression coefficients. Individual results varied but their overall conclusion was that "the nature and degree of the observed aggregation bias changes with the statistic chosen to describe the effect". (Amhrein and Flowerdew, 1989, p229)

This is in line with Openshaw's conclusions to another 1984 paper in which he states, "The results confirm that the ecological fallacy problem is important, but its severity depends on the methods of analysis employed, on the mode of interpretation afforded to the results, and even on the choice of variables. The problem is that at present there is no way of being able to predict or determine whether a particular areal data set is going to yield results which are close to the individual values." (Openshaw, 1984b, p30) Thus, the problem seems almost infinitely changing, depending as it does

on the variable studied and the method of analysis employed. Without individual level data (which are seldom available due to confidentiality restrictions) there is not even any standard from which to measure departure.. It is easy to see why a problem with such shifting effects would respond poorly to the hypothesis testing techniques of the confirmatory paradigm.

The Search for Solutions

There may be other ways to approach the MAUP. Fotheringham (1989) wonders whether, "given that space is continuous, is any discrete division of that space meaningful and will any such division yield data that are reliable for analysis". (Fotheringham, 1989, p222) He goes on to list the five possible approaches for dealing with the MAUP.

- "(i) the derivation of "optimal" zoning systems
 - (ii) the identification of basic entities
 - (iii) sensitivity analysis
 - (iv) abandonment of traditional statistical analysis
 - (v) shifting the emphasis of spatial analysis towards relationships that focus on rates of change"
- (ibid.,p222)

Note that these methods are not mutually exclusive. For

example, it is certainly possible to abandon traditional statistical techniques while at the same time attempting to identify basic entities. But for the sake of clarity, the following discussion centres on Fotheringham's approaches.

(i) The derivation of "optimal" zoning systems

This approach refers to systems like Openshaw's Automatic Zoning Procedure (AZP). Fotheringham raises the objection that "what constitutes optimal (sic) is clearly subjective both in definition and in operation". (ibid., p222) Thus, even if agreement can be reached on what constitutes "optimal", there can be difficulties in measuring when this optimality has been reached. For example, Openshaw uses variance to measure inter and intra zonal variation while Moellering and Tobler use spectral analysis to measure the same thing.

Another objection concerns the problem that what might be an optimal zoning system for one variable could be completely inappropriate for another. We have already seen how different statistics have different sensitivities to aggregation or scale effects. It is reasonable to suppose that different variables would also be differently affected by the zoning system in which they are packaged.

(ii) The identification of basic entities

This method is perhaps the easiest way of solving the MAUP. If data are analyzed at the individual level then there is no MAUP. Fotheringham cites "the trend in spatial interaction modelling in recent years from aggregate modelling to the modelling of individual choices of destination" (ibid., p223) as a useful way of removing the MAUP.

But it is not always possible to identify basic entities for some studies and, for those which can be identified, it is not always possible to collect data at this level. The study of population densities in an urban area is an example of the difficulty of identifying a basic entity. Density must be calculated by dividing population by area. It is, therefore, necessary to make decisions about areal definitions. These decisions create areas which are modifiable and are likely to interact with the population figures to influence the results of any analysis. The difficulty of determining the basic units for a study can be illustrated by the example of the problem of accurately defining the catchment area for a river. What basic units should we use to define this area? There is also the above mentioned problem for social scientists of data at the individual level being unavailable because of privacy constraints. There is another way of defining a "basic entity" which forms the premise for this thesis: that the MAUP can be rendered less significant by ensuring that the areal

unit chosen has been tightly defined so that every place within it meets the stated criteria for delineation. In the case of the CMA/CA, if using EAs as the building block instead of CSDs could produce a more tightly delineated CMA/CA, then subsequent data analysis at the CMA/CA level would be more reliable.

(iii) Sensitivity Analysis

Fotheringham states, "A third way forward from the MAUP is not to try to correct it but to recognize its existence and to report the sensitivity of a particular relationship to variations in both scale and level of aggregation. For example, when providing the results of a model calibration with one set of data it would be useful to provide the extreme results that could have been reported if different zoning systems had been used. Presumably, we would have more faith in estimates that were relatively insensitive to changes in the arbitrary units in which the data were reported." (ibid., p223)

There already exist various computer intensive significance testing procedures (Diaconis and Efron, 1983; Knudson and Fotheringham, 1986; Knudson, 1987) but these require data to be available at some more disaggregate level. However, if this type of data were available there would be no need to perform a sensitivity analysis to determine the effects of the

MAUP. One could simply use the disaggregated data instead.

There are at least two ways to partially overcome this difficulty. First, data could be aggregated up a level in different configurations and the sensitivity reported at this higher level. Fotheringham notes this assumes that aggregation effects are constant at all scales (something that the original significance testing procedures must also be assuming). However, it has been noted above that Openshaw believes the first aggregation displays greater aggregational variability than any subsequent aggregations. Both would probably agree that this is an area that needs further study.

Secondly, data at a lower aggregational level could be interpolated and used only for determining sensitivity results. This data would not be accurate enough for analysis but would be adequate for sensitivity analysis.

(iv) Abandonment of traditional statistical analysis

Fotheringham calls this approach speculative, yet Openshaw was advocating it in 1984. The theoretical contortions necessary to satisfy the constraints of inferential statistics and Openshaw's conclusions about the usefulness of these statistical techniques are described above. Its speculative nature must lie in the uncertainty about what can replace traditional statistical analysis. Fotheringham describes the

increased emphasis being placed on visualizing techniques by researchers such as Batty and Longley (1986, 1989) who claim that a visual or graphic model can depict more realistic patterns of spatial phenomena than a statistical reporting of performance. Another technique for visualizing data is Openshaw's GAM (Geographical Analysis Machine) which represents "the available data visually over a range of spatial scales in preference to performing a certain type of spatial analysis at only one level." (ibid., p224) The development of visualizing techniques is a growing field and one which will provide a useful way of approaching the MAUP. It also has great potential to contribute to the exploratory approach to spatial data analysis. What could be more exploratory than to visualize the same data at many different scales?

(v) Shifting the emphasis of spatial analysis towards relationships that focus on rates of change

Fotheringham asks the following question, "Given that variables and relationships change with changes in spatial scale, can we provide information on the rate of such change?" (ibid., p224) He wonders whether some variables and relationships might change erratically while others are more stable. In order to examine this possibility he proposes measuring the fractal dimension of a spatial distribution. He concludes that his method is relatively error-free but can

provide only limited information. In contrast, other statistical analyses have the potential to yield more information but they also have a correspondingly high potential for error. Fotheringham fails to clarify whether this means his technique is not worth developing further. However, there can be little doubt that the unique ability of fractal geometry to measure scaling relationships will have some effect on our approach to finding solutions for the MAUP.

Conclusion

It is apparent in the above discussion that there is uncertainty about how to solve the MAUP. Using spatial data gathered at the individual level whenever possible is the most obvious solution. Fotheringham has noted a recent trend in spatial interaction modelling from aggregate modelling to the modelling of individual choices of destination. (ibid., p 223) Rhind et al (1989) have written an article about an on-line data base system to handle the more than 20 million records which will result from the 1991 census of Great Britain. This article devotes much of its space to a discussion of data aggregated to user defined areas and to maintaining confidentiality for data gathered at the individual level. We will see the use of more and more individual level data and user-defined aggregations in the

future.

This chapter has also described the tentative steps towards the development of other spatial data handling methods. There is now more interest in exploring the effects of the MAUP rather than merely testing for its existence. Researchers are attempting to gauge its size, shape, and effect by using sensitivity analysis and visualizing techniques. Fotheringham has tried to look at the rate of change of the MAUP as followed through different scalar levels. Goodchild has likened these approaches to the use of a moving window of observation which can be re-positioned anywhere in the study space, including travelling through the almost infinite number of possible scales of study. Thus we are poised at the edge of a new way of doing spatial analysis - one which depends less on the statistical techniques developed in other disciplines to analyze non-spatial data, and more on techniques which consider the geographical nature of the data.

It is easy to see why these developments are incompatible with the continued prominence of the confirmatory paradigm. One cannot enter an unexplored spatial data set and pluck an hypothesis from thin air. The spatial nature of the data gives it an extra dimension which non-spatial data sets do not have. All dimensions must be explored and understood before questions can be asked of the data. Only then can hypotheses

be raised and tested and a confirmatory approach brought into use. Thus, the confirmatory approach is not completely eliminated. It is simply reduced to the final stage of the exploratory paradigm. It no longer dominates our approach to data analysis but becomes a tool among many with which to approach spatial data analysis within the exploratory paradigm.

This thesis looks at one aspect of the idea that using basic entities for data analysis will reduce or eliminate the MAUP. This can mean not only data obtained at the individual level, but also data obtained for units that have some spatial integrity. CMA/CAs are defined by Statistics Canada as areas having social and economic links with the urban core around which they are distributed. A CMA/CA, because it uses CSDs as its building block, can include some areas which have little social or economic interaction with the core. This can happen when a CSD covers a large area as, for example, some townships do. It is postulated that a smaller building block such as the EA might provide a more precisely defined socially and economically cohesive area. The following chapters will examine the effects on CMA/CA delineations of using EAs as the building blocks.

CHAPTER 3

The Census Metropolitan Area/Census Agglomeration (CMA/CA) Program At Statistics Canada

Before embarking on an explanation of the methodology behind this study, it is necessary to provide background material about the 1986 Census Geographic Hierarchy used by Statistics Canada to collect and disseminate their data. This hierarchy is presented in Figure 1. The geographic areas mentioned in this thesis are:

Census Metropolitan Areas (CMAs)

Census Agglomerations (CAs)

Primary Census Metropolitan Areas (PCMAS)

Primary Census Agglomerations (PCAs)

Census Subdivisions (CSDs)

Enumeration Areas (EAs)

Urban Areas (UAs)

Census Consolidated Subdivisions (CCSs)

Figure 1 The 1986 Census Geographic Hierarchy

- (A) 5 urban areas cross provincial boundaries
 (B) 12 of the 25 CMAs and 2 of the 114 CAs are broken down into PCMAS/PCAs
 (C) All 25 of the CMAs but only 12 of the 114 CAs have a census tract program
 (D) Defined by Statistics Canada, in conjunction with the provincial authorities, as a statistical area

Official definitions of these geographic areas are provided in Appendix 6. They were taken from the 1986 Census Dictionary. (At the time this study was first undertaken the 1986 definitions were in force. There are no substantial differences between the 1986 and 1991 definitions.)

A short, more general discussion of each of these terms is provided here.

Census Metropolitan Area (CMA)

Generally, a CMA is a very large urbanized core, together with adjacent urban and rural areas which have a high degree of economic and social interaction with that core. The urban core must have a population of at least 100,000 and "economic and social interaction" is measured in terms of the commuting flows between that core and surrounding municipalities (CSDs).

CMAs are useful as an attempt to define how far the influence of an urban core extends. They are delineated in the same way all across the country and are, therefore, used for statistical comparison. For example, the Canadian Real Estate Board publishes sales data for the housing market which allow comparisons to be made between say, the CMA of Sherbrooke and the CMA of Winnipeg. Unlike the cities of the same names whose spatial extent is defined under provincial statute,

these two CMAs (like all CMAs) have been delineated using identical rules and can form the basis for quantitative statistical comparisons at the CMA level.

Every attempt is made to ensure that CMAs are also comparable over time. Delineation criterion number 6 states that CSDs are retained within CMAs even if their commuting flows do not meet the required thresholds of subsequent Censuses. In addition, commuting flow thresholds have been adjusted in response to changes in the compilation of commuting flow data so that historical comparability could be maintained.

CMAs and CAs are used by many Divisions of Statistics Canada to disseminate data. They include: Household Surveys; Education, Culture and Tourism; and Prices among many others. Population, economic and social statistics are all available by CMA/CA. Departments from other government levels and private corporations also use CMAs to publish their data.

However, other uses besides data dissemination exist which value rigorous delineation over comparability across time and space. In Quebec, residents of CMAs are assessed an additional transportation tax to pay for the increased public transportation costs found in more urbanized areas. In addition, Employment and Immigration Canada uses CMAs as the basis for 25 of their 62 Economic Areas which they use to

administer the Unemployment Insurance Program. Residents of Economic Areas have differing qualification and benefit periods depending upon the economic conditions within their areas.

These two users of the CMA concept are more interested in knowing that the CMA has been accurately delineated using appropriate criteria than they are in comparing data by CMA across the country. It is the relatively recent emergence of this type of use of the CMA which is putting pressure on Statistics Canada to explore ways to improve the extent to which CMAs represent a socially and economically integrated area.

Census Agglomeration (CA)

The CA is identical to the CMA except for the size of its urban core which only needs to have a population of at least 10,000. In addition, CAs are not used for the non-statistical purposes described above. CAs are used to disseminate statistical data by many of the same Statistics Canada divisions as those that publish CMA data.

Primary CMA and Primary CA (PCMA/PCA)

When two or more CMA/CAs are adjacent they can be grouped

together into a larger entity called a Consolidated CMA/CA. The individual CMA/CAs are then called Primary CMAs and Primary CAs. Consolidation can only take place if the total commuting interchange between the two CMA/CAs is equal to at least 35% of the employed labour force living in the smaller CMA/CA. For the purposes of this thesis, only individual, "stand alone" CMA/CAs and Primary CMA/CAs are considered. They will all be referred to as "CMA/CAs" and not as "PCMA/PCAs".

Census Subdivision (CSD)

CSD is a general term applying to municipalities, Indian reserves, Indian settlements, and unorganized territories. It is important to note that CSDs are Administrative Areas and, as such, are not defined or delineated by Statistics Canada. This is in contrast to CMAs, CAs, PCMAs, PCAs and EAs which are statistical areas and are delineated by Statistics Canada as described in the Census Dictionary. CSDs are legal entities defined under provincial statute.

Enumeration Area (EA)

An EA is the area usually canvassed by one Census Representative. It contains between 125 and 375 households and its boundaries usually follow easily identifiable ground

features such as roads or rivers. (This is in contrast to CSDs whose exact municipal boundaries are not always easy to identify on the ground.) An EA must respect the boundaries of all higher level geographical areas recognized by the Census (eg., CSDs, CMA/CAs). EA boundaries are, therefore, changed before each Census to reflect any higher level boundary changes which have occurred since the last Census.

CMA/CA Delineation Criteria

CMA/CAs are comprised of one or more CSDs which meet at least one of the following criteria:

- 1) The CSD falls completely or partly inside the urbanized core;
- 2) At least 50% of the employed labour force living in the CSD works in the urbanized core; or
- 3) At least 25% of the employed labour force working in the CSD lives in the urbanized core.
- 4) If the commuting flow is less than 100 persons, CSDs are excluded from the CMA/CA, even if criteria 2 or 3 apply.
- 5) Even if criteria 2, 3, or 4, apply, CSDs may be included or excluded to maintain the contiguity of the CMA/CA.
- 6) CSD components of census tracted CMAs and CAs are retained for historical comparability even if

they no longer meet criteria 2 or 3.

The criteria are ranked in priority order. A CSD which meets criteria for inclusion in two or more CMAs or CAs is included in the one in which it meets the highest ranked criterion. In the case of a tie, the decision is based on the population or number of commuters involved. Exceptions to the above delineation criteria may occasionally be made in certain special situations.

The significance of using CSDs or EAs to delineate CMA/CAs is not limited to questions of size (the EA is usually smaller) but extends into questions regarding the permanence of the building blocks and their origins and purpose. EAs are re-delineated before each Census and are, therefore, highly unstable from the point of view of historical comparability. Their delineation is, however, controlled by Statistics Canada and could perhaps, therefore, be made to incorporate criteria necessary for defining a collection area and also criteria necessary for use as a building block for CMA/CAs. These criteria have not yet been identified by Statistics Canada which has no immediate plans to switch to the use of the EA in CMA/CA delineation.

CSDs, on the other hand, usually change little from one census

to another. Now and then, however, they change considerably when regional or provincial re-organization occurs. It is also not unknown for municipalities to change their boundaries in order to engineer a CMA/CA boundary which better meets local needs. But, generally speaking, it is safe to say that CSD boundaries are far more likely to endure from Census to Census than EA boundaries.

Neither the CSD nor the EA is a building block specially designed to be used for delineating CMA/CAs. The EA's purpose (data collection) seems especially far removed. The CSD has the advantage of expressing the political goals and aspirations of those who live in it. To this extent it is geographically less arbitrary than the EA.

The question of whether using the EA for CMA/CA delineation is really an improvement on using the CSD is, of course, central to this thesis. Reducing the effects of the MAUP requires a smaller, more homogeneous building block. It should also require one with more geographical integrity. Notions of geographical integrity can play a large part in the conclusions we draw from the data which result from this comparison of CSD and EA level delineation methods. The next chapter deals with the methodology for this analysis.

CHAPTER 4

Methodology

The methodology for comparing CSD and EA delineations proceeded through several different steps briefly outlined as follows:

1. Obtain data.
2. Initial working values
3. Degree of Commonality calculations (including assessment of distribution at national, regional, and population size levels)
4. Net Over/Underboundedness calculations (including assessment of distribution at national, regional, and population size levels)
5. Over-and-underboundedness calculations - only for those CMA/CAs which are **both** over **and** underbounded (including assessment of distribution at national, regional, and population size levels)

Data

The data set was compiled using population data from the 1981 Census and interim 1984 CMA/CA boundaries. This thesis reworks that data set. These boundaries would form the basis for the 1986 CMA/CAs subject to any CSD updates which may have been performed by the municipalities. This data set was made available to me as a Statistics Canada employee, but is not available to the public. It was in Lotus 123 format and was subsequently converted into Excel. The processes that went into the production of this data set can best be explained by the following "walk through" of the delineation process for a sample CMA.

Delineating a CMA/CA: A sample "walk through" of the delineation of the Calgary CMA

The following is a "walk through" of the CSD level delineation of the CMA of Calgary. It is based on the CMA delineation criteria as found in Appendix 6 under the CMA definition. The EA level delineations were performed in the same way with small exceptions as outlined below. Refer to the map of Calgary found in Figure 2.

A note on CSD boundaries: CMA/CAs are delineated based on Place of Work commuting flow data from the previous decennial census. For this study, the 1981 commuting flows between 1981

CSDs were examined. But, as the data were originally studied in 1984, the CSD boundaries had been updated to those existing in that year. This means that, as CSD boundary changes occurred, commuting flow data were adjusted as required to suit the change. This process of adjustment was scheduled to stop on Census Day 1986 when 1986 CMA/CA boundaries would be frozen. This thesis is based on interim boundaries, the exact location of which cannot now be determined. The maps in Appendices 3, 4, and 5 are based on 1986 boundaries which are probably close enough to those of 1984 that their purpose, which is to give a rough idea of the difference between sample CSD and EA delineations, is served.

1. *Define urban core* Urban areas are delineated by Statistics Canada based on density and land use considerations. (See 1986 Census Dictionary definition in Appendix 6.) Those which have populations over 100,000 form the cores of CMAs. Those which have populations over 10,000 but less than 100,000 form the cores of CAs. Any CSD which is even partly within the urban core is included in the CMA/CA under criterion 1. The CSD included in the Calgary CMA under this criterion is: Calgary, C.

Note: All CSD names are followed by their type. For example, the CSD of Calgary is followed by the letter "C" which is an

abbreviation of "City". The CSD type is included in order to distinguish between two CSDs which have the same name. An example of this is Kingston, C and Kingston, TP. ("C" represents "City" and "TP" represents "Township") A list of CSD Types is found in Appendix 6 under the CSD definition.

2. *Forward Commuting Flow* Any CSD which sends at least 50% of its labour force to work in the core is included in the CMA under criterion 2. The commuting flow must be at least 100 people. (see criterion 4) The CSDs included in the Calgary CMA under this criterion are:

Chestermere Lake, SV

Rocky View No. 44, MD

Sarcee 145, R

Airdrie, C.

3. *Reverse Commuting Flow* Any CSD which attracts at least 25% of its labour force from the core is included in the CMA under criterion 3. The commuting flow must be at least 100 people. (see criterion 4) The CSD included in the Calgary CMA under this criterion is: Cochrane, T.
4. *Maintenance of Contiguity* Any CSD which is required to maintain the spatial contiguity of the CMA can be included if the commuting flow at the CCS level (Census Consolidated Subdivision) meets criterion 2 or 3. The

CCS definition is found in Appendix 6. In the CMA of Calgary, the CSD of Rocky View No. 44, MD has three "holes" namely Beiseker, VL; Crossfield, T; and Irricana, VL. These three CSDs are combined with Rocky View No. 44, MD into a CCS whose commuting flow meets the requirements for criterion 2. These three CSDs are, therefore, included in the CMA of Calgary under criterion 5.

5. *Historical Comparability* CSDs which no longer meet commuting flow requirements but which were part of census tracted CMA/CAs in the past are retained to maintain historical continuity under criterion 6. Calgary had no such CSDs.

Figure 2 Map of Calgary CMA to illustrate the delineation process.

The number of CSDs included in CMAs (but not CAs) under each criterion is outlined in the following table. (These data were taken from the 1986 CMA delineation files maintained at Statistics Canada.):

	Number of CSDs	Per Cent of Total
Criterion 1	267	54%
Criterion 2	126	26%
Criterion 3	12	3%
Criterion 5	76	16%
Criterion 6	6	1%
TOTAL	496	100%

Table 7 Number of CSDs included in 1986 CMAs under each criterion

EA Level Delineation: EA level delineations were compiled using essentially the same criteria as those discussed above and found in Appendix 6 under the CMA definition, with two exceptions.

Reverse commuting data (see criterion 3) are available at the CSD level but not at the EA level. EAs which might have been included on the basis of criterion 3 only could not,

therefore, be identified and were subsequently excluded from the EA level delineation process. Since only approximately 3% of CSDs are included in CMAs due to criterion 3, it is reasonable to assume that the effect of performing the EA level delineation without this criterion would be negligible. (see table above)

Secondly, since EA population values are likely to be so much smaller than CSD population values, the rule requiring a minimum of 100 commuters (criterion 4) was not applied. (For the 1986 Census, average CSD population was 4,212 while the average EA population for 1991 was 593.)

Initial working values

The initial step towards comparing CSD and EA level delineations involved the preparation and summation of population values for both CSD and EA levels, according to the specified delineation criteria. This step was completed by Paul Stanton in his original report of 1985.

The initial working values that were established for this investigation included:

- (a) the urbanized core population values (obtained from a specialized listing based on 1981 population values and 1984

geographic limits)

(b) the fringe population values (consisting of the population delineated within the CMA/CA boundaries but outside the urbanized core area, separate for CSD level delineations and again for EA level delineations)

(c) the total population values (consisting of the combined summary of fringe population and urbanized core area population values, again separate for CSD and EA level delineations)

(d) the EA population outside the CSD delineation area (included as part of the EA fringe population and EA total population values)

(e) the CSD population outside the EA delineation area (included as part of the CSD fringe population and CSD total population values)

The initial working values for all CMA/CAs in Canada are displayed in Appendix 1.

Degree of Commonality (D. of C.)

The D. of C. measures the population that the two levels of delineation have in common as a proportion of the total population covered by the two delineations (without double counting). Limiting values are 0 to 1.0. A value of zero is not possible in this study since this would mean that the two delineations had nothing in common. (Both delineations have at least their urbanized core in common.) A value of 1 indicates that both delineation methods produce identical CMA/CAs. The D. of C. was developed by Statistics Canada methodologists. The D. of C. for each CMA/CA in Canada is displayed as a column in Appendix 1. It is calculated using the following formula:

$$1 - \frac{\text{EA POP. OUTSIDE CSD} + \text{CSD POP. OUTSIDE EA}}{\text{TOTAL POP. (CSD LEVEL)} + \text{EA POP OUTSIDE CSD}}$$

The distributions of the D. of C. nationally, regionally, and by core population size of the CMA/CA are found in Figures 3, 6, and 9 respectively. These are found in the next chapter.

Over/underboundedness

The **overbounded** comparison results when more population is included for the fringe areas from the CSD level delineation

than is included for the EA level. (see maps, Appendix 3)
 The extremity of this situation can vary from no EA population at all to a significant overlap in the two population levels. (If the two population levels are identical then there is no over/ underboundedness and the D. of C. is equal to one.)

The **underbounded** comparison results when more population is included for the fringe areas from the EA level delineation than is included for the CSD level. (see maps, Appendix 4)

Per cent over/underboundedness (net)

The net percentage by which a CMA/CA is over or underbounded is calculated using the following equation:

$$\frac{\text{TOTAL POP. (CSD LEVEL)} - \text{TOTAL POP. (EA LEVEL)}}{\text{TOTAL POP. (EA LEVEL)}} \times 100$$

This equation compares the difference between the total population at each delineation level to the total population at the EA level. The difference was not compared to the total population at the CSD level because the EA level, being smaller and more precise, is seen as the ideal. Per cent over/underboundedness (net) is displayed as a column in Appendix 1. Positive values represent overboundedness and negative values represent underboundedness. The value, zero, occurs where the two delineations are identical. Graphs

showing the distributions of this statistic nationally, regionally, and by population size of the CMA/CA are found in Figures 4, 7, and 10 respectively. These Figures are found in the next chapter.

Over-and-underboundedness occurring within the same CMA/CA

The **over-and-underbounded** CMA/CA results when both EA and CSD level fringe populations are found to exist, but not exclusively within the same geographic areas. (see map, Appendix 5) Two situations can arise. In one, the fringe population from the EA delineation is spatially separate from the fringe population from the CSD delineation. In the other, there is some overlap between the fringe populations from the EA and CSD delineations. Over-and-underbounded CMA/CAs have values greater than 0 in **both** of the following columns in Appendix 1: "EA POPULATION OUTSIDE CSD" and "CSD POPULATION OUTSIDE EA". Sixty out of the 158 CMA/CAs studied showed this characteristic. Note that CMA/CAs of this type also have a net over/underbounded value and are therefore included in the calculation of per cent over/underboundedness as described above. In addition to the above calculation, CMA/CAs of this type are subjected to the following additional analysis.

Per cent overboundedness

Overboundedness as a percentage of total over-and-under boundedness occurring in each CMA/CA which is both over and underbounded is calculated using this statistic:

$$\frac{\text{CSD POP. OUTSIDE EA}}{\text{CSD POP. OUTSIDE EA} + \text{EA POP. OUTSIDE CSD}} \times 100$$

Per cent underboundedness

Underboundedness as a percentage of total over-and-underboundedness occurring in each CMA/CA which is both over and underbounded is calculated using this statistic:

$$\frac{\text{EA POP. OUTSIDE CSD}}{\text{CSD POP. OUTSIDE EA} + \text{EA POP. OUTSIDE CSD}} \times 100$$

The sum of per cent overboundedness and per cent underboundedness is 100%. This study frequently examines only per cent overboundedness since per cent underboundedness can be inferred. Per cent over-and-underboundedness is displayed as two columns in Appendix 1. Graphs showing the distribution of per cent overboundedness nationally, regionally, and by population size of CMA/CA are found in Figures 5, 8, and 11 respectively. These figures are found in the next chapter.

CHAPTER 5

Results

The three statistics described in the previous chapter will be analysed at the national level, at the regional level, and by core population size group in this chapter. Refer to Appendix 1 for the national and regional results. For results sorted by core population size, refer to Appendix 2.

Briefly, the **Degree of Commonality** measures how similar the two delineations are. A value of 1.00 indicates that the CMA/CA is the same whether it is delineated using CSDs or EAs.

The **per cent over/underboundedness (net)** indicates how overbounded (positive values) or underbounded (negative values) the CMA/CA is. The total population values at each delineation level are compared. If there is both over and underbounding in the same CMA/CA then the net result is indicated.

Over-and-underboundedness is only calculated for those CMA/CAs

which have both over and underbounding. Sixty of the 162 CMA/CAs studied qualify. See the appropriate columns in the table in Appendix 1 for the names of these CMA/CAs. The CSD population outside the EA delineation (% overboundedness) and the EA population outside the CSD delineation (% underboundedness) are compared to the sum of these two values. (This is in contrast to per cent over/underboundedness where the difference between total populations at each delineation level are compared to the **total** population at the EA level delineation.) In fact, overboundedness and underboundedness are calculated separately under this heading. Only the analysis of the per cent overbounded statistic (nationally, regionally, and by population size) is discussed since per cent underboundedness is equal to [100 - per cent overboundedness] and can therefore be inferred.

I The National Picture

Degree of Commonality

The following table indicates the maximum and minimum D. of C. values for Canada.

Table 8 Degree of Commonality in Canada

	VALUE	CMA/CA
MAXIMUM	1.00	Gander, Corner Brook, Labrador City, Rivière-du-Loup, Thetford Mines, Saint Hyacinthe, Thompson, Kitimat
MINIMUM	0.34	Spruce Grove
AVERAGE	0.87	

Nationally, more than half the CMA/CAs (52%) have a D. of C. value greater than 0.9. In fact, 30% have a D. of C. value greater than 0.95. Thus, for slightly over half the CMA/CAs it matters very little whether delineation takes place at the CSD or EA level. However, 33% of CMA/CAs have a D. of C. value between 0.75 and 0.9 and 15% of CMA/CAs have a D. of C. value less than 0.75. See Figure 3.

Figure 3 Per Cent Distribution of Degree of Commonality across Canada

Per Cent Over/underboundedness

The most overbounded and the most underbounded CMA/CAs are displayed in the table below.

Table 9 Per Cent Over/underboundedness in Canada

	VALUE	CMA/CA
MAXIMUM	191.9	Spruce Grove (overbounded)
MINIMUM	-31.9	Fort St. John (underbounded)
AVERAGE	9.08	

Nationally, 58% of CMA/CAs are not over or underbounded to a degree of more than 10%. This is similar to the national picture for the D. of C. statistic for which more than half of CMA/CAs exhibited a Degree of Commonality of more than 0.9. Thus, for over half of CMA/CAs, over or underboundedness is

not significant. However, a total of 42% of CMA/CAs exhibit greater than 10% over or underboundedness. Especially troubling is the extreme nature of some (7%) of the overbounded values. Overboundedness goes as high as 191.9% for Spruce Grove, Alberta (compared to a maximum underbounded value of only -31.0% for Fort St. John, B.C.). The fact that overboundedness occurs more frequently and is more extreme than underboundedness is to be expected since the CSD level delineation uses larger "building blocks" than the EA level delineation. See Figure 4 below.

Figure 4 Per Cent Distribution of % Over/underboundedness across Canada

Over-and-underboundedness

The maximum and minimum D. of C. values for overboundedness and underboundedness are displayed in Tables 10 and 11 below.

Table 10 Overboundedness in Canada

	VALUE	CMA/CA
MAXIMUM	97.1	Québec
MINIMUM	0.7	La Tuque
AVERAGE	50.1	

Table 11 Underboundedness in Canada

	VALUE	CMA/CA
MAXIMUM	99.3	La Tuque
MINIMUM	2.9	Québec
AVERAGE	49.9	

Note: These two tables are mirror images of each other. For this reason, only overboundedness will be discussed in detail.

Nationally, per cent overboundedness is almost evenly distributed. Thus, overboundedness is no more likely to be large in magnitude than small. See Figure 5 below.

Figure 5 Per Cent Distribution of % Overboundedness across Canada

II The Regional Picture

Statistics Canada divides Canada into the following regions:

Atlantic (Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick)

Quebec (Québec)

Ontario (Ontario)

Prairies (Manitoba, Saskatchewan, Alberta)

Pacific (British Columbia, Yukon, Northwest Territories)

The names of the CMA/CAs within each region can be determined by consulting the table in Appendix 1 which lists each of the CMA/CAs in regional order starting in the east and moving west.

Four CMA/CAs cross regional boundaries. When this happens,

they have been assigned to the region in which they have the greatest population. They are:

Ottawa - Hull	<u>Ontario</u> /Quebec
Campbellton	<u>Atlantic</u> /Quebec
Hawkesbury	<u>Ontario</u> /Quebec
Pembroke	<u>Ontario</u> /Quebec

The region which has been underlined is the region to which the CMA/CA has been assigned.

Degree of Commonality

The following table shows the CMA/CAs having the maximum and minimum D. of Cs by region.

Table 12 Max and Min D. of C. by Region

	VALUE	CMA/CA
ATLANTIC		
Maximum	1.00	Gander, Corner Brook, Labrador City
Minimum	0.61	Sydney Mines
Average	0.89	
QUEBEC		
Maximum	1.00	Rivière-du-Loup, Thetford Mines, Saint-Hyacinthe
Minimum	0.72	La Baie
Average	0.94	
ONTARIO		
Maximum	0.99	Elliot Lake
Minimum	0.41	Newcastle
Average	0.85	

PRAIRIES		
Maximum	1.00	Thompson
Minimum	0.34	Spruce Grove
Average	0.87	
PACIFIC		
Maximum	1.00	Kitimat
Minimum	0.55	Terrace
Average	0.81	

Regionally, Quebec has the largest number of CMA/CAs exhibiting a very high degree of commonality and the smallest number exhibiting a very low degree of commonality. It is, therefore, the region where EA delineation is most similar to CSD delineation. The Prairies and the Atlantic Provinces follow closely, with Ontario next, and B.C. & Yukon with the worst correspondence. No distinct regional pattern emerges. See Figure 6 below.

Figure 6 Per Cent Distribution of Degree of Commonality by Region

Per cent over/underboundedness (net)

The following table indicates the most overbounded (net) and the most underbounded (net) CMA/CA for each region.

Table 13 Max and Min % Over/underboundedness (net) by Region

	VALUE	CMA/CA
ATLANTIC		
Maximum	65.2	Sydney Mines, NS (overbounded)
Minimum	-7.2	St. John's (underbounded)
Average	8.67	
QUEBEC		
Maximum	38.0	La Baie (overbounded)
Minimum	-5.5	Cowansville (underbounded)
Average	4.77	
ONTARIO		
Maximum	143.9	Newcastle (overbounded)

Minimum	-24.2	Leamington (underbounded)
Average	6.81	
PRAIRIES		
Maximum	191.9	Spruce Grove (overbounded)
Minimum	-24.4	Grande Prairie (underbounded)
Average	13.16	
PACIFIC		
Maximum	81.7	Terrace (overbounded)
Minimum	-31.9	Fort St. John (underbounded)
Average	15.48	

Regionally, the Atlantic Provinces and Quebec exhibit the smallest tendencies towards over or underboundedness. Neither region has any extremely underbounded cases (greater than 10% underbounded) and the extremely overbounded cases (over 50% overbounded) are at a minimum. These two regions also have the highest values in the 0-10% over/underbounded categories.

Next in severity is the Prairie region. Finally, Ontario and B.C. & Yukon are the two regions most affected by over/underboundedness. Ontario has the highest value in the extremely underbounded category and B.C. & Yukon has the highest values in the two extremely overbounded categories. However, Ontario also makes a significant overbounded showing and B.C. & Yukon has a relatively high number of underbounded cases. Generally, it appears that both over and underboundedness increase as one heads west but that the

correlation is less clearcut for underboundedness. See Figure 7 below.

Figure 7 Per Cent Distribution of % Over/underboundedness by Region

Over-and-underboundedness

The following table shows the maximum and the minimum values for both the % overbounded and the % underbounded statistics by region.

Table 14 Min and Max Overbounded and Underbounded CMA/CAs by Region

	OVERBNDDED VALUE	OVERBNDDED CMA/CA	UNDERBNDDED VALUE	UNDERBNDDED CMA/CA
ATLANTIC				
Maximum	78.7	Bathurst	85.7	St. John's
Minimum	14.3	St. John's	21.3	Bathurst
QUEBEC				
Maximum	97.1	Quèbec	99.3	La Tuque

Minimum	0.7	La Tuque	2.9	Québec
ONTARIO				
Maximum	96.4	London	93.8	Ottawa - Hull
Minimum	6.3	Ottawa - Hull	3.6	London
PRAIRIES				
Maximum	98.2	Saskatoon	79.4	Winnipeg
Minimum	20.6	Winnipeg	1.8	Saskatoon
PACIFIC				
Maximum	85.3	Duncan	95.6	Kelowna
Minimum	4 4	Kelowna	14.7	Duncan

- Note:
1. The overbounded and the underbounded portions of this table are mirror images of each other. For this reason, only overboundedness will be discussed in detail.
 2. The maximum overbounded value indicates the largest percentage by which the CSD delineation is greater than the EA delineation. Similarly, the maximum underbounded value indicates the largest percentage by which the EA delineation is greater than the CSD delineation.

Regionally, Quebec and the Prairies mimic the national picture, i.e., overboundedness is almost equally likely to be large or small. Ontario is similar but it is inclined towards more serious overbounding (a larger showing in the over 50% range than in the under 50% range). The Atlantic provinces are the most inclined towards serious overbounding in contrast to B.C. & Yukon which is the only region where overboundedness is less likely to be extreme. No distinct regional pattern emerges. See Figure 8 below.

Figure 8 Per Cent Distribution of % Overboundedness by Region

III By Core Population Size

Statistics Canada has standard population size groupings which are in use throughout the Bureau. They are:

10,000 - 24,999	82 CMA/CAs
25,000 - 49,999	33 CMA/CAs
50,000 - 99,999	19 CMA/CAs
over 100,000	24 CMA/CAs

CMA/CAs are divided into these groupings based on their core populations. These can be found in the appropriate column in the table in Appendix 2. Appendix 2 gives the same data as Appendix 1 but is sorted by core population size group.

Degree of Commonality

The following table shows the maximum and the minimum values of D. of C. for each population size group.

(See the definition of the PCMA/PCA in Appendix 6.)

It would be interesting to see how many of the worst cases would be eliminated if all PCMA/PCAs were grouped into their consolidated CMA/CAs and studied as a single unit. The PCMA/PCAs for 1986 and their D. of C. and % Over/underboundedness statistics are presented in Table 18. Shading indicates a D. of C. value less than 0.75, a % over/underbounded value greater than +/- 10%, or both.

Table 18 1986 PCMA/PCAs and their D. of C. and % Over/underbounded Values

PCMA/PCA	D. of C.	% OVER/UNDER-BOUNDED
Chicoutimi - Jonquière PCMA	0.96	-2.0
La Baie PCA	0.72	38.0
Edmonton PCMA	0.92	0.4
Leduc PCA	0.36	180.9
Spruce Grove PCA	0.34	191.9
Kelowna PCA	0.81	-17.6
Central Okanagan, Subd. B PCA	0.58	71.9
London PCMA	0.95	4.9
St. Thomas PCA	0.85	9.6
Montréal PCMA	0.98	-0.3
Beloeil PCA	0.95	5.2
Châteauguay PCA	0.97	2.9
Oshawa PCMA	0.84	-10.9

the smaller ones. See Figure 9 below.

Figure 9 Per Cent Distribution of Degree of Commonality by Core Population Size Groups

Per cent over/underboundedness

The following table indicates the maximum and minimum % over/underboundedness statistic for each core population size group.

Table 16 Max and Min % Over/underboundedness by Core Population Size Group

	VALUE	CMA/CA
10,000 - 24,999		
Maximum	191.9	Spruce Grove
Minimum	-31.9	Fort St. John
Average	15.3	

25,000 - 49,999		
Maximum	44.6	Maple Ridge
Minimum	-20.5	Woodstock
Average	4.3	
50,000 - 99,999		
Maximum	30.2	Matsqui
Minimum	-11.3	Prince George
Average	1.4	
OVER 100,000		
Maximum	11.4	St. Catharines - Niagara
Minimum	-11.6	Sudbury
Average	0.2	

From the point of view of population size, extreme over/underboundedness is clearly at a minimum in the larger centres (those over 50,000 in population). The medium sized centres (25-49,999 population) have higher levels of over/underboundedness but do not exhibit any of the extreme levels of overboundedness which characterize the smallest centres (10-24,999 population). In these centres, extreme overboundedness is the most pronounced characteristic. Generally, extreme over/underboundedness appears to be a characteristic of smaller centres with the very smallest centres having all of the most extremely overbounded cases. See Figure 10 below.

Figure 10 Per Cent Distribution of % Over/underboundedness by Core Population Size Group

Over-and-underboundedness

The following table shows the maximum and minimum values for both the % overbounded and the % underbounded statistics by core population size group.

Table 17 Max and Min Overbounded and Underbounded Values by Core Population size Groups

	OVERBNDDED VALUE	OVERBNDDED CMA/CA	UNDERBNDDED VALUE	UNDERBNDDED CMA/CA
10,000 - 24,999				
Maximum	87.3	Haileybury	99.3	La Tuque
Minimum	0.7	La Tuque	12.7	Haileybury
25,000 - 49,999				
Maximum	85.7	Rimouski	95.6	Kelowna
Minimum	4.4	Kelowna	14.3	Rimouski

50,000 - 99,999				
Maximum	91.1	Brantford	93.4	Prince George
Minimum	6.6	Prince George	8.9	Brantford
OVER 100,000				
Maximum	98.2	Saskatoon	95.3	Chicoutimi - Jonquière
Minimum	4.7	Chicoutimi - Jonquière	1.8	Saskatoon

- Note:
1. The overbounded and the underbounded portions of this table are mirror images of each other. For this reason, only overboundedness will be discussed in detail.
 2. The maximum overbounded value indicates the largest percentage by which the CSD delineation is greater than the EA delineation. Similarly, the maximum underbounded value indicates the largest percentage by which the EA delineation is greater than the CSD delineation.

Looking at the effect of population size on overboundedness, the largest centres (over 100,000) are most likely to have very high or very low levels of overboundedness. The second largest centres (50-99,999) are most likely to have intermediate levels of overboundedness. The second smallest centres (25-49,999) are fairly evenly distributed. And the smallest centres (10-24,999) are most likely to have high levels of overboundedness. No distinct pattern based on population size emerges. See Figure 11 below.

Figure 11 Per Cent Distribution of % Overboundedness by Core Population Size Group

CHAPTER 6

Conclusions

Although for slightly over 50% of CMA/CAs the method of delineation makes little difference, there is no doubt that the two delineation methods produce different results, occasionally very different results.

For the most part, the Degree of Commonality and the per cent over/underbounded statistic reinforce each other. A high Degree of Commonality for a CMA/CA is almost always accompanied by a low per cent over/underbounded statistic. CMA/CAs of low D. of C. and high per cent over/underboundedness are quite likely to be found in the Ontario or B.C. & Yukon regions. They are also extremely likely to be small in population size.

Regionally, there is a trend towards less congruence between the two delineations as one moves west across Canada. However, this trend is not consistent, which suggests that its

causes are more complex than mere regionality. (From the point of view of CMA/CA delineation, regionality means the difference in the CSD structure from province to province.)

Although a regional trend is not clear from the analysis of the three statistics discussed in chapters 3 and 4, there appears to be some correlation. Fifty per cent of the values of D. of C. less than 0.70, i.e., the CMA/CAs with the least amount of commonality, are from the part of Canada west of Ontario. (Only 35% of the CMA/CAs studied are from this area.) In addition, forty-six per cent of the values of the % over/underbounded statistic occur west of Ontario. Since fewer CMA/CAs are located in the west, these percentages indicate a tendency for greater differences between the two levels of delineation to be found there.

Looking at the data by population size yields clearer results. It makes little difference which delineation method is used for the largest CMA/CAs. Smaller centres, however, are more likely to have lower values for the Degree of Commonality statistic. The % over/underbounded statistic is of less use in determining the extent of over/underboundedness because an excess of, say 100 people, forms a higher percentage of a small population than a higher one.

It is the existence of a difference between the two levels of

delineation which is important and not whether that difference is over- or underbounded in nature. Due to the difference in size between CSDs and EAs, one would expect overboundedness to occur more often than underboundedness and, in fact, overboundedness occurs 57% of the time and underboundedness occurs 39% of the time. This is entirely a function of the size of the building blocks and does not seem to depend on location or population size. Larger CSDs simply overbound more often than small EAs. Distinguishing between overboundedness and underboundedness does not yield more information, as an examination of the per cent overbounded statistic aggregated by region and core population shows.

However, those CMA/CAs which are both over and under bounded are the most interesting for further study since the structure of their delineations is quite different geographically from the rest of the CMA/CAs. This has not been well documented by this study which has been more statistical in focus. It is this geographical aspect which will affect the dissemination of Census variables and subsequent data analysis. For example, the CMA of Halifax has a D. of C. of 0.99, a % over/underbounded statistic of 0.1%, and over-and-underbounded statistics of 55.0% and 45.0% respectively. The first two statistics indicate that it is one of those CMA/CAs which is almost identical no matter which delineation method is chosen. A glance at the map of Halifax in Appendix 5 shows that the

822 people who form the EA population outside the CSD delineation and the 1003 people who form the CSD population outside the EA delineation are geographically separate. The calculations for the D. of C. and the % over/underboundedness statistics produce a net result (only 181 people involved) which diminishes the difference between the two delineations. But the people involved are completely different. They live in different places and will have given different answers to the Census questions. This will affect the Census variables disseminated by CMA/CA which are summaries of all the EAs found within the CMA/CA boundary (whether this boundary was determined by using EA or CSD level delineations). Thus, the over-and-underbounded variable, while not contributing statistically to this study has been useful in indicating those CMA/CAs which are worthy of further study.

While performing the analysis for this study, it was noted that many of the "worst cases" (i.e., those whose D. of C. was low or whose % over/underbounded statistic was extreme) were Primary CMA/CAs (PCMA/PCAs). This concept was introduced for the 1986 Census but had not been finalised when the data for this study were compiled. Briefly, adjacent CMAs and CAs are grouped together into consolidated CMA/CAs when the commuting interchange between them reaches 35% of the employed labour force of the smallest CMA/CA. The CMA/CAs which are in consolidated CMA/CAs are called primary CMA/CAs (PCMA/PCA).

(See the definition of the PCMA/PCA in Appendix 6.)

It would be interesting to see how many of the worst cases would be eliminated if all PCMA/PCAs were grouped into their consolidated CMA/CAs and studied as a single unit. The PCMA/PCAs for 1986 and their D. of C. and % Over/underboundedness statistics are presented in Table 18. Shading indicates a D. of C. value less than 0.75, a % over/underbounded value greater than +/- 10%, or both.

Table 18 1986 PCMA/PCAs and their D. of C. and % Over/underbounded Values

PCMA/PCA	D. of C.	% OVER/UNDER-BOUNDED
Chicoutimi - Jonqui�re PCMA	0.96	-2.0
La Baie PCA	0.72	38.0
Edmonton PCMA	0.92	0.4
Leduc PCA	0.36	180.9
Spruce Grove PCA	0.34	191.9
Kelowna PCA	0.81	-17.6
Central Okanagan, Subd. B PCA	0.58	71.9
London PCMA	0.95	4.9
St. Thomas PCA	0.85	9.6
Montr�al PCMA	0.98	-0.3
Beloeil PCA	0.95	5.2
Ch�teauaguay PCA	0.97	2.9
Oshawa PCMA	0.84	-10.9

Newcastle PCA	0.41	143.9
Ottawa - Hull PCMA	0.93	-6.0
Buckingham PCA	0.84	19.8
Kanata PCA	0.50	101.0
St. Catharines - Niagara PCMA	0.90	11.4
Fort Erie PCA	0.57	74.0
St. John's PCMA	0.90	-7.2
Conception Bay South PCA	0.92	9.2
Sudbury PCMA	0.77	-11.6
Valley East PCA	0.83	20.7
Sydney PCA	0.68	4.0
Sydney Mines PCA	0.61	65.2
Toronto PCMA	0.98	1.6
Halton Hills PCA	0.55	80.3
Milton PCA	0.71	41.5
Orangeville PCA	0.95	-4.9
Vancouver PCMA	0.91	4.8
Maple Ridge PCA	0.69	44.6
Victoria PCMA	0.98	-0.8
Sidney PCA	0.71	40.3

From the above table it is easy to see how many of the "extreme" cases are PCMA/PCAs. Any further study should examine consolidated CMA/CAs and not PCMA/PCAs.

This study has concentrated on examining differences in size based on population. But size is more commonly understood to mean space or, in the case of a CMA/CA, land area. It might be possible for the two levels of delineation to produce very

similar delineations in terms of population but vastly different ones in terms of physical size. Williams Lake, B.C. is an example of a CA whose CSD level delineation includes large tracts of bush where few people live. These CAs (they are not likely to be CMAs) should be identified and studied to ascertain how pervasive this effect is. It should be noted that, if the definition of a CMA/CA is a "socially and economically integrated area", and if this integration is measured using commuting flows, then CAs which include large areas of bush from which it would be impossible to commute to the core are not meeting the definition as well as CMA/CAs which do not include such areas.

Finally, this study could serve as the basis for an examination of the effect of the MAUP on data published by Statistics Canada. If the size and shape of the geographic unit used to disseminate data has an effect on that data, and if there are now two different CMA/CA delineations, then it should be possible to examine some of the Census variables and quantify this effect. If the effect proves to be large then it would be worthwhile for Statistics Canada to investigate the possibility of using EAs to delineate CMA/CAs. It should be kept in mind that one of the biggest barriers to this is the instability of the EA from Census to Census and the relative stability of CSDs.

CHAPTER 7

Addendum

This is an examination of the effect of using the EA level delineation of CMA/CAs instead of the CSD level delineation on two Census variables disseminated by Statistics Canada. This was not originally within the planned scope of this thesis. However, taking a look at the effect of using an alternate delineation on data disseminated by Statistics Canada will emphasize the significance of this study.

Twelve CMA/CAs and two Census variables were selected. The CMA/CAs were selected for the ease with which the EAs which comprise the two levels of delineation could be identified on the delineation maps. In fact, only CAs were chosen because the manual tabulation of EAs and data for larger centres was too time consuming.

The first Census variable was selected randomly. The second was selected because it was beside the first on the microfiche in which the 1981 data are stored. This simplified a tedious data retrieval. The two variables are "Total Families" and "Total Husband - Wife Families" from the table entitled

"Census Families in Private Households by Family Structure and Family Type, 1981 (based on 100% data)". The actual variables have no theoretical significance. They are for test purposes only.

Per cent change was calculated in the following way:

$$\frac{\text{VARIABLE (EA LEVEL)} - \text{VARIABLE (CSD LEVEL)}}{\text{VARIABLE (CSD LEVEL)}} \times 100$$

This compares the variable at the EA level to the variable at the CSD level. (The CSD level variable is the one currently in use since CMA/CAs are delineated using CSDs.) Therefore, per cent change indicates the change which would take place in the variable if the EA level delineation were adopted.

Table 19 Census Variables for EA and CSD Level Delineations

CMA/CA NAME	CSD LEVEL	EA LEVEL	% CHANGE
Truro, NS			
Total Families	7140	4440	-38%
Total Husband - Wife Families	6455	3975	-38%
Dolbeau, Que			
Total Families	3855	2985	-23%
Total Husband - Wife Families	3370	2585	-23%
Leduc, Alta			
Total Families	9660	3235	-67%
Total Husband - Wife Families	9075	2970	-67%

Williams Lake, BC			
Total Families	6490	4860	-25%
Total Husband - Wife Families	5935	4415	-26%
Summerside, PEI			
Total Families	3790	3860	2%
Total Husband - Wife Families	3355	3420	2%
Sorel, Que			
Total Families	11860	12005	1%
Total Husband - Wife Families	10410	10545	1%
Lindsay, Ont			
Total Families	4615	5385	17%
Total Husband - Wife Families	4080	4820	18%
Portage La Prairie, Man			
Total Families	3195	4255	33%
Total Husband - Wife Families	2775	3790	37%
Cranbrook, BC			
Total Families	4250	5510	30%
Total Husband - Wife Families	3700	4870	32%
Kamloops, BC			
Total Families	16530	17510	6%
Total Husband - Wife Families	14470	15395	6%
Sarnia, Ont			
Total Families	22450	22735	1%
Total Husband - Wife Families	20195	20460	1%
Campbellton, NB			
Total Families	4245	4115	-3%
Total Husband - Wife Families	3565	3440	-4%

Even though the CAs sampled represent only a small subset of

all the CAs, the results are interesting. The % change between the two delineation levels varied from a low of -67% to a high of 37%. The negative values belong to the overbounded cases (where the CSD delineation is larger than the EA delineation) which would decrease in size if the EA level delineation were adopted.

Since these CAs are mainly from the smallest core population size group, large differences between the two delineations are to be expected. The population size groups are represented by the following CAs:

10,000 - 24,000	Summerside, Williams Lake, Campbellton, Dolbeau, Leduc, Portage La Prairie, Lindsay, Cranbrook, Truro
25,000 - 49,999	Sorel
50,000 - 99,999	Kamloops, Sarnia
over 100,000	none

The two variables present related information. In fact, since "total husband-wife families" is a subset of "total families", the value of one is usually proportional to the other. This should mean that the values of % change should be the same for each variable in a CA. However, this is not always the case. The values of % change for Portage La Prairie and Cranbrook both differ by more than one percentage point. If variables for all the CMA/CAs had been calculated there would probably

Manitowish	Que.	419	10012	620	2393	10632	12405	620	2393	0.77	16.7	79.4	20.6
Quebec	Que.	421	528143	43395	55815	571538	583820	377	12797	0.98	2.1	97.1	2.9
Saint Georges	Que.	428	16720	0	2598	16720	19318	0	2598	0.87	15.5	-	-
Thetford Mines	Que.	430	26519	7798	7642	34317	34161	156	0	1.00	-0.5	-	-
Shawville	Que.	433	103735	20550	20689	124285	124424	709	848	0.99	0.1	54.5	45.5
Magog	Que.	435	15002	2919	3147	17921	18149	156	384	0.97	1.3	71.1	28.9
Conversville	Que.	437	12127	1303	566	13430	12693	850	113	0.93	-5.5	11.7	88.3
Victoriaville	Que.	440	28665	7558	7762	36223	36427	84	288	0.99	0.6	77.4	22.6
Trois-Rivières	Que.	442	103233	11713	21096	114946	124329	1600	10983	0.90	8.2	87.3	12.7
Shawville	Que.	444	52646	9789	10706	62435	63352	1312	2229	0.95	1.5	62.9	37.1
La Tuque	Que.	446	11556	2969	2453	14545	14009	540	4	0.96	-3.7	0.7	99.3
Drummondville	Que.	447	51931	10664	11968	62595	63899	0	1304	0.98	2.1	-	-
Granby	Que.	450	39081	9488	9058	48569	48139	3768	3338	0.86	-0.9	47.0	53.0
Saint-Hyacinthe	Que.	452	41106	6332	6332	47440	47440	0	0	1.00	0.0	-	-
Sorel	Que.	454	40885	6658	6145	47543	47030	513	0	0.99	-1.1	-	-
Levis	Que.	456	28735	5952	5726	34687	34461	1672	1446	0.91	-0.7	46.4	53.6
Bouchard	Que.	458	33743	0	1743	33743	35486	0	-1743	0.95	5.2	-	-
St. Jean-sur-Richelieu	Que.	459	50741	7878	7439	58619	58180	3557	3118	0.89	-0.7	46.7	53.3
St. Jean	Que.	462	2655101	160233	152332	2815334	2808033	27988	20687	0.98	-0.3	42.5	57.5
Châteauguay	Que.	463	54843	0	1602	54843	58445	0	1602	0.97	2.9	-	-
Salaberry-de-Valleyfield	Que.	465	37111	1206	2380	38317	39491	0	1174	0.97	3.1	-	-
Lachapelle	Que.	468	10455	709	1274	11164	11729	709	1274	0.84	5.1	64.2	35.8
Saint-Jovite	Que.	475	36089	6272	6710	42361	42789	1609	2047	0.92	1.0	56.0	44.0
Shawville	Que.	477	10234	0	2022	10234	12256	0	2022	0.84	19.8	-	-
Val-d'Or	Que.	480	20697	2836	4972	23533	25669	0	2136	0.92	9.1	-	-
Rouville	Que.	485	25005	11167	10411	36172	35416	1128	372	0.96	-2.1	24.8	75.2
Châteauguay	Que.	490	10441	0	291	10441	10732	0	291	0.97	2.8	-	-
ONTARIO REGION													
Colborne	Ont.	501	46144	9672	5891	55816	52035	3781	0	0.93	-6.8	-	-
Shawville	Ont.	502	11294	2754	0	14048	11294	2754	0	0.80	-19.6	-	-
Shawville	Ont.	505	627713	108596	64636	736309	692349	47100	3140	0.93	-6.0	6.3	93.8
Shawville	Ont.	506	19506	0	19710	19506	39216	0	19710	0.50	101.0	-	-
Shawville	Ont.	512	21200	10747	14459	31947	35659	792	4504	0.85	11.6	85.0	15.0
Shawville	Ont.	515	15906	8078	6880	24014	22816	1337	139	0.94	-5.0	9.4	90.6
Shawville	Ont.	521	84810	28841	30172	113651	114982	2200	3531	0.95	1.2	61.6	38.4
Shawville	Ont.	522	58607	28018	26875	86625	85482	1952	809	0.97	-1.3	29.3	70.7

have been more cases. This illustrates the point made in the conclusion that people living in different areas can have different characteristics. The use of a different geographic area to tabulate Census variables has resulted, not only in different values for these variables, but also in a different relationship between two very closely related variables. A more detailed study of the effect of different delineations on the tabulation of Census variables should yield even more examples of this type of effect.

APPENDIX 1

Initial working Values

INITIAL WORKING VALUES

PCMA/PCA	PROV- INCE	PCMA/PCA CODE	CORE POPULATION	FRINGE EA LEVEL	POPULATION CSD LEVEL	TOTAL EA LEVEL	POPULATION CSD LEVEL	EA POP OUTSIDE CSD	CSD POP OUTSIDE EA	DEGREE OF COMMONALITY	% OVER/UNDER BOUNDEDNESS (NET)	OVER AND UNDER BOUNDEDNESS %OVER %UNDER
ATLANTIC REGION												
St. John's	Nfld.	001	115992	35997	25003	151989	140995	13194	2200	0.90	-7.2	14.3 85.7
Conception Bay S.	Nfld.	002	12664	0	1161	12664	13825	0	1161	0.92	9.2	-
Carbonear	Nfld.	005	10209	1446	2774	11655	12983	0	1328	0.90	11.4	-
Grand Falls	Nfld.	010	14407	10151	12172	24558	26579	0	2021	0.92	8.2	-
Gander	Nfld.	011	10294	762	762	11056	11056	0	0	1.00	0.0	-
Corner Brook	Nfld.	015	24204	11008	11008	35212	35212	0	0	1.00	0.0	-
Lafayette City	Nfld.	025	14688	0	5	14688	14693	0	5	1.00	0.0	-
Charlottetown	P.E.I.	105	28053	19918	20591	47971	48644	0	673	0.99	1.4	-
Summersville	P.E.I.	110	10570	4663	4406	15233	14976	257	0	0.98	-1.7	-
Walter	N.S.	205	226114	50361	50542	276475	276656	822	1003	0.98	0.1	55.0 45.0
Truro	N.S.	215	18989	10336	20769	29325	39758	0	10433	0.74	35.6	-
New Glasgow	N.S.	220	23580	11802	15837	35382	39417	0	4035	0.90	11.4	-
Sydney	N.S.	225	34620	17671	19757	52291	54377	9001	11087	0.68	4.0	55.2 44.8
Sydney Mines	N.S.	230	18297	3099	17051	21396	35348	0	13852	0.61	65.2	-
Moncton	N.B.	305	75809	22801	22545	98610	98354	4226	3970	0.92	-0.3	48.4 51.6
St. John's	N.B.	310	91822	24910	29190	116732	121012	0	4280	0.96	3.7	-
St. John's	N.B.	320	42803	18856	19339	61459	61942	2446	2929	0.92	0.8	54.5 45.5
St. John's	N.B.	328	16533	11808	18478	28341	35011	2473	9143	0.69	23.5	78.7 21.3
St. John's	N.B.	330	11512	3413	3096	14925	15508	599	1182	0.89	3.9	66.4 33.6
St. John's	N.B.	335	16800	7302	8315	24102	25115	0	1013	0.96	4.2	-
QUEBEC REGION												
Que.	Que.	403	13612	2649	2027	16261	15639	1509	887	0.86	-3.8	37.0 63.0
Que.	Que.	404	30319	10262	14595	40581	44914	866	5199	0.87	10.7	85.7 14.3
Que.	Que.	405	13459	9006	8962	22465	22421	44	0	1.00	-0.2	-
Que.	Que.	406	26851	6254	6836	33105	33689	0	582	0.98	1.8	-
Que.	Que.	408	112354	27735	22421	140089	137294	5064	250	0.96	-2.0	4.7 95.3
Que.	Que.	410	25661	1669	4672	27330	30333	0	3003	0.90	11.0	-
Que.	Que.	411	11846	0	3602	11846	15448	0	3602	0.77	30.4	-
Que.	Que.	412	28464	4812	6116	31276	32580	0	1304	0.96	4.2	-
Que.	Que.	413	15171	0	5764	15171	20935	0	5764	0.72	38.0	-

Montréal	Que.	419	10012	620	2393	10632	12405	620	2393	0.77	16.7	79.4	20.6
Quebec	Que.	421	526143	43395	55815	571538	583820	377	12797	0.98	2.1	97.1	2.9
Saint Georges	Que.	428	16720	0	2598	16720	19318	0	2598	0.87	15.5	-	-
Therford Mines	Que.	430	26519	7798	7642	34317	34161	156	0	1.00	-0.5	-	-
Sharnbrook	Que.	433	103735	20550	20689	124285	124424	709	848	0.99	0.1	54.5	45.5
Magog	Que.	435	15002	2919	3147	17921	18149	156	384	0.97	1.3	71.1	28.9
Cometville	Que.	437	12127	1303	566	13430	12693	850	113	0.93	-5.5	11.7	88.3
Victoriaville	Que.	440	28665	7558	7762	36223	36427	84	288	0.99	0.6	77.4	22.6
Trois-Rivières	Que.	442	103233	11713	21096	114946	124329	1600	10983	0.90	8.2	87.3	12.7
Shawinigan	Que.	444	52646	9789	10706	62435	63352	1312	2229	0.95	1.5	62.9	37.1
La Tuque	Que.	446	11556	2989	2453	14545	14009	540	4	0.96	-3.7	0.7	99.3
Dumontville	Que.	447	51931	10664	11968	62595	63899	0	1304	0.98	2.1	-	-
Grenby	Que.	450	39081	9498	9058	48569	48139	3768	3338	0.86	-0.9	47.0	53.0
Saint-Hyacinthe	Que.	452	41108	6332	6332	47440	47440	0	0	1.00	0.0	-	-
Sorel	Que.	454	40865	6658	6145	47543	47030	513	0	0.99	-1.1	-	-
Joliette	Que.	456	28735	5952	5728	34687	34461	1672	1446	0.91	-0.7	46.4	53.6
Beloeil	Que.	458	33743	0	1743	33743	35486	0	-1743	0.95	5.2	-	-
St-Jean-sur-Richelieu	Que.	459	50741	7878	7439	59619	59180	3557	3118	0.89	-0.7	46.7	53.3
Mc. Joli	Que.	462	2655101	160233	152332	2815334	2808033	27988	20687	0.98	-0.3	42.5	57.5
Châteauguay	Que.	463	54843	0	1602	54843	56445	0	1602	0.97	2.9	-	-
Saint-Valéry	Que.	465	37111	1206	2380	38317	39491	0	1174	0.97	3.1	-	-
Lachute	Que.	468	10455	709	1274	11164	11729	709	1274	0.84	5.1	64.2	35.8
Saint-Vincent	Que.	475	36089	6272	6710	42361	42799	1609	2047	0.92	1.0	56.0	44.0
Granby	Que.	477	10234	0	2022	10234	12256	0	2022	0.84	19.8	-	-
Val-d'Or	Que.	480	20697	2836	4972	23533	25689	0	2136	0.92	9.1	-	-
Rouy	Que.	485	25005	11167	10411	36172	35416	1128	372	0.96	-2.1	24.8	75.2
Châteauguay	Que.	490	10441	0	291	10441	10732	0	291	0.97	2.8	-	-
ONTARIO REGION													
Orillia	Ont.	501	46144	9672	5891	55816	52035	3781	0	0.93	-6.8	-	-
Timberbury	Ont.	502	11294	2754	0	14048	11294	2754	0	0.80	-19.6	-	-
Orillia - Hill	Ont.	505	627713	108596	64636	736309	692349	47100	3140	0.93	-6.0	6.3	93.8
Kenna	Ont.	506	19506	0	19710	19506	39216	0	19710	0.50	101.0	-	-
Brudenell	Ont.	512	21200	10747	14459	31947	35659	782	4504	0.85	11.6	85.0	15.0
Brudenell	Ont.	515	15936	8078	6880	24014	22816	1337	139	0.94	-5.0	9.4	90.6
Orillia	Ont.	521	84610	28841	30172	113651	114982	2200	3531	0.95	1.2	61.6	38.4
Orillia	Ont.	522	58607	28018	26875	86625	85482	1952	809	0.97	-1.3	29.3	70.7

Cobour	527	13131	6238	8809	19369	21940	1101	3672	0.79	13.3	76.9	23.1
Peterborough	Ont.	61825	22061	23878	83886	85703	2268	4085	0.93	2.2	64.3	35.7
Lindsay	Ont.	13596	5676	3240	19272	16836	2436	0	0.87	-12.6	-	-
Newcastle	Ont.	13215	0	19014	13215	32229	0	19014	0.41	143.9	-	-
Oshawa	Ont.	149100	24077	5117	173177	154217	24077	5117	0.84	-10.9	17.5	82.5
Toronto	Ont.	2870830	134393	182566	3005223	3053396	11452	59625	0.98	1.6	83.9	16.1
Hamilton	Ont.	500421	28202	41674	528623	542095	0	13472	0.98	2.5	-	-
St. Catharines - Niagara	Ont.	276739	9229	41810	285968	318549	0	32581	0.90	11.4	-	-
Fort Erie	Ont.	13800	0	10216	13800	24016	0	10216	0.57	74.0	-	-
Kitchener	Ont.	266345	18302	21456	284647	287801	7253	10407	0.94	1.1	58.9	41.1
Brantford	Ont.	73415	6314	14015	79729	87430	838	8539	0.89	9.7	91.1	8.9
Woodstock	Ont.	26603	6879	0	33482	26603	6879	0	0.79	-20.5	-	-
Thamesburg	Ont.	10495	1529	0	12024	10495	1529	0	0.87	-12.7	-	-
Simcoe	Ont.	13128	650	1198	13778	14326	650	1198	0.88	4.0	64.8	35.2
Milton	Ont.	19842	0	8225	19842	28067	0	8225	0.71	41.5	-	-
Hilton Mills	Ont.	19649	0	15782	19649	35431	0	15782	0.55	80.3	-	-
Quincy	Ont.	71207	5097	7249	76304	78456	2159	4311	0.92	2.8	66.6	33.4
Orangeville	Ont.	13740	701	0	14441	13740	701	0	0.95	-4.9	-	-
Stratford	Ont.	28262	2679	0	28941	26262	2679	0	0.91	-9.3	-	-
St. Thomas	Ont.	28169	6788	10153	34957	38322	1284	4649	0.85	9.6	78.4	21.6
London	Ont.	260443	14547	28049	274950	288492	529	14031	0.95	4.9	96.4	3.6
Chatham	Ont.	41198	6119	0	47317	41198	6119	0	0.87	-12.9	-	-
Leamington	Ont.	12514	3983	0	16497	12511	3983	0	0.76	-24.2	-	-
Windsor	Ont.	216886	26747	34841	243413	251307	0	7884	0.97	3.2	-	-
Welland	Ont.	11514	3400	0	14914	11514	3400	0	0.77	-22.8	-	-
Sherrill	Ont.	77147	7891	6803	85038	83950	3084	1986	0.94	-1.3	39.3	60.7
Owen Sound	Ont.	19845	9450	7412	29295	27257	2841	803	0.88	-7.0	22.0	78.0
Collingwood	Ont.	12064	2330	0	14394	12064	2330	0	0.84	-16.2	-	-
Barrie	Ont.	50434	9262	10837	59696	61271	1582	3167	0.92	2.6	66.5	33.5
Orillia	Ont.	23955	12288	6805	36243	30900	6152	769	0.81	-14.7	11.1	88.9
Midland	Ont.	18218	9373	15707	27591	33925	0	6334	0.81	23.0	-	-
North Bay	Ont.	51240	8098	6607	59338	57847	2201	710	0.95	-2.5	24.4	75.6
Wesley East	Ont.	16832	0	3501	16832	20433	0	3501	0.83	20.7	-	-
Quincy	Ont.	111238	42194	24450	153432	135688	27236	9492	0.77	-11.6	25.8	74.2
Essex Lake	Ont.	15822	3224	3112	19046	18934	112	0	0.99	-0.6	-	-
Haliburton	Ont.	11949	2577	3419	14526	15368	143	985	0.93	5.8	87.3	12.7

Richard Lake	Ont.	585	11488	2569	731	14057	12219	1838	0	0.87	-13.1	-	-
Timmins	Ont.	586	32723	0	13391	32723	46114	0	13391	0.71	40.9	-	-
Kapuskasing	Ont.	587	10435	4539	1579	14974	12014	2960	0	0.80	-19.8	-	-
Sault Ste. Marie	Ont.	590	74512	17486	12450	91998	86962	5036	0	0.95	-5.5	-	-
Thunder Bay	Ont.	595	109365	15690	12583	125055	121948	3351	244	0.97	-2.3	6.8	93.2
Kemora	Ont.	598	11680	5215	3857	16895	15537	1358	0	0.92	-8.0	-	-
PRAIRIES REGION													
Winnipeg	Man.	602	56368	40131	28393	603799	592061	15954	4116	0.97	-1.9	20.6	79.4
Saskatoon	Man.	604	10037	2230	0	12267	10037	2230	0	0.82	-18.2	-	-
Portage la Prairie	Man.	607	13086	4153	0	17239	13086	4153	0	0.76	-24.1	-	-
Brandon	Man.	610	36314	2647	6	38961	36320	2641	0	0.93	-6.8	-	-
Flinton	Man.	625	9891	324	6	10215	9897	318	0	0.97	-3.1	-	-
Thompson	Man.	640	14288	31	31	14319	14319	0	0	1.00	0.0	-	-
Regina	Sask.	705	162986	4571	10613	167557	173599	0	6042	0.97	3.6	-	-
Yorkton	Sask.	710	15339	1745	3005	17084	18344	0	1260	0.93	7.4	-	-
Moos Jaw	Sask.	715	35179	253	880	35432	36059	0	627	0.98	1.8	-	-
Swift Current	Sask.	720	14747	399	0	15146	14747	399	0	0.97	-2.6	-	-
Saskatoon	Sask.	725	154217	11360	20848	165577	175065	182	1670	0.94	5.7	98.2	1.8
North Battleford	Sask.	735	17597	606	0	18203	17597	606	0	0.97	-3.3	-	-
Prince Albert	Sask.	745	31380	6049	6702	37429	38082	0	653	0.98	1.7	-	-
Medicine Hat	Alta.	805	44269	1355	5387	45624	49656	0	4032	0.92	8.8	-	-
Lethbridge	Alta.	810	54072	3417	0	57489	54072	3417	0	0.94	-5.9	-	-
Calgary	Alta.	825	592801	38867	33223	631668	626024	9373	3729	0.98	-0.9	28.5	71.5
Red Deer	Alta.	830	46393	5780	0	52173	46393	5780	0	0.89	-11.1	-	-
Canmore	Alta.	833	12570	1559	0	14129	12570	1559	0	0.89	-11.0	-	-
Edmonton	Alta.	835	617217	39522	42193	656739	659410	26434	29105	0.92	0.4	52.4	47.6
Lacombe	Alta.	836	12471	0	22565	12471	35036	0	22565	0.36	180.9	-	-
Sylvan Lake	Alta.	837	16782	0	32200	16782	48982	0	32200	0.34	191.9	-	-
Stettin	Alta.	840	15031	2252	0	17283	15031	2252	0	0.87	-13.0	-	-
Okotoks	Alta.	850	24263	7844	0	32107	24263	7844	0	0.76	-24.4	-	-
Fort McMurray	Alta.	860	31000	0	12385	31000	43395	0	12385	0.71	40.0	-	-
B. C. AND YUKON REGION													
Carleton Place	B.C.	905	15941	4943	0	20884	15941	4943	0	0.76	-23.7	-	-
Trail	B.C.	910	15584	6517	7368	22081	22932	0	851	0.96	3.9	-	-
Port Moody	B.C.	913	23418	6089	14100	29507	37518	0	8011	0.79	27.1	-	-
Kelowna	B.C.	915	46890	34682	20348	81572	67238	15031	697	0.81	-17.6	4.4	95.6

Cent. Okanagan Subd. B		916	10470	0	7529	10470	17999	0	7529	0.58	71.9	-	-
Vernon	B.C.	918	22416	11852	19742	34268	42158	0	7890	0.81	23.0	-	-
Kamloops	B.C.	925	52268	14529	12369	66797	64997	3310	1150	0.93	-2.7	25.8	74.2
Chilliwack	B.C.	930	31522	2924	17899	34446	49421	0	14975	0.70	43.5	-	-
Maple Ridge	B.C.	931	26658	0	11890	26658	38548	0	11890	0.69	44.6	-	-
Nasquit	B.C.	932	57794	0	17470	57794	75264	0	17470	0.77	30.2	-	-
Vancouver	B.C.	933	1142366	30803	87269	1173169	1229635	25422	81886	0.91	4.8	76.3	23.7
Victoria	B.C.	935	210302	18792	16956	229094	227258	3493	1657	0.98	-0.8	32.2	67.8
Sudney	B.C.	936	10121	0	4077	10121	14198	0	4077	0.71	40.3	-	-
Duncan	B.C.	937	11219	6685	11155	17904	22374	934	5404	0.73	25.0	85.3	14.7
Nanaimo	B.C.	938	47334	11079	10360	58413	57694	1405	686	0.96	-1.2	32.8	67.2
Port Alberni	B.C.	940	22229	6209	9450	28438	31679	0	3241	0.90	11.4	-	-
Cowichan	B.C.	943	17039	12858	18179	29697	35218	0	5321	0.85	17.8	-	-
Campbell River	B.C.	944	20519	1103	10057	21622	30576	0	8954	0.71	41.4	-	-
Powell River	B.C.	945	13423	4455	5941	17878	19364	0	1486	0.92	8.3	-	-
Williams Lake	B.C.	950	11347	11576	22011	22923	33358	0	10435	0.69	45.5	-	-
Quesnel	B.C.	952	11286	9654	12121	20940	23407	0	2467	0.89	11.8	-	-
Prince Rupert	B.C.	955	15446	350	2956	15796	18402	0	2606	0.86	16.5	-	-
Kitimat	B.C.	960	12462	352	352	12814	12814	0	0	1.00	0.0	-	-
Terrace	B.C.	965	15245	2473	16951	17718	32196	0	14478	0.55	81.7	-	-
Prince George	B.C.	970	60206	15320	7353	76126	67559	9213	646	0.37	-11.3	6.6	93.4
Dawson Creek	B.C.	975	11373	2970	0	14343	11373	2970	0	0.79	-20.7	-	-
Port St. John	B.C.	977	13881	3512	0	20403	13881	6512	0	0.68	-31.9	-	-
Whitehorse	Yukon	990	14814	861	0	15675	14814	861	0	0.95	-5.5	-	-

APPENDIX 2

Initial Values sorted by Core Population Size

INITIAL WORKING VALUES SORTED BY CORE POPULATION SIZE

PCMA/PCA	PROV. INCE	PCMA/PCA CODE	CORE POPULATION	FRINGE EA LEVEL	POPULATION CSD LEVEL	TOTAL EA LEVEL	POPULATION CSD LEVEL	EA POP OUTSIDE CSD	CSD POP OUTSIDE EA	DEGREE OF COMMONALITY	% OVER/UNDER BOUNDEDNESS (NET)	OVER AND UNDER BOUNDEDNESS %OVER %UNDER
10,000 TO 24,999												
Flinton	Man.	625	9891	324	6	10215	9897	318	0	0.97	-3.1	-
Montmagny	Que.	419	10012	620	2393	10632	12405	620	2393	0.77	16.7	79.4 20.6
Salem	Man.	604	10037	2230	0	12267	10037	2230	0	0.82	-18.2	-
Sidney	B.C.	936	10121	0	4077	10121	14198	0	4077	0.71	40.3	-
Carleton Place	Nfld.	005	10209	1446	2774	11655	12983	0	1328	0.90	11.4	-
Buckingham	Que.	477	10234	0	2022	10234	12256	0	2022	0.84	19.8	-
Gander	Nfld.	011	10294	762	762	11056	11056	0	0	1.00	0.0	-
Kapuskasing	Ont.	587	10435	4539	1579	14974	12014	2960	0	0.80	-19.8	-
Chibougamau	Que.	490	10441	0	291	10441	10732	0	291	0.97	2.8	-
Lachute	Que.	468	10455	709	1274	11164	11729	709	1274	0.84	5.1	64.2 35.8
Cent. Ontario Subd. B	B.C.	916	10470	0	7529	10470	17999	0	7529	0.58	71.9	-
Thornburg	Ont.	546	10495	1529	0	12024	10495	1529	0	0.87	-12.7	-
Summerside	P.E.I.	110	10570	4663	4406	15233	14976	257	0	0.98	-1.7	-
Duncan	B.C.	937	11219	6685	11155	17904	22374	934	5404	0.73	25.0	85.3 14.7
Queneau	E.C.	952	11286	9654	12121	20940	23407	0	2467	0.89	11.8	-
Hastings	Ont.	502	11294	2754	0	14048	11294	2754	0	0.80	-19.6	-
Williams Lake	B.C.	950	11347	11576	22011	22923	33359	0	10435	0.69	45.5	-
Duncan Creek	B.C.	975	11373	2970	0	14343	11373	2970	0	0.79	-20.7	-
Richmond Lake	Ont.	585	11488	2569	731	14057	12219	1838	0	0.87	-13.1	-
Campanella	N.B.	330	11512	3413	3896	14925	15508	599	1182	0.89	3.9	66.4 33.6
Wellesburg	Ont.	561	11514	3400	0	14914	11514	3400	0	0.77	-22.8	-
La Tuque	Que.	446	11556	2889	2453	14545	14009	540	4	0.96	-3.7	0.7 99.3
Kemora	Ont.	598	11680	5215	3857	16895	15537	1358	0	0.92	-8.0	-
Dobson	Que.	411	11846	0	3602	11846	15448	0	3602	0.77	30.4	-
Halifax	Ont.	584	11949	2577	3419	14526	15368	143	985	0.93	5.8	87.3 12.7
Collingwood	Ont.	567	12014	2330	0	14394	12064	2330	0	0.84	-16.2	-
Chapmanville	Que.	437	12111	1303	566	13430	12693	850	113	0.93	-5.5	11.7 88.3
St. Catharines	B.C.	960	12462	352	352	12814	12814	0	0	1.00	0.0	-
Laford	Aha.	836	12471	0	22565	12471	35036	0	22565	0.36	180.9	-
Lambton	Ont.	557	12514	3983	0	16497	12511	3983	0	0.76	-24.2	-

Sydney Mines	N.S.	230	18297	3099	17051	21396	35348	0	13952	0.61	65.2	-	-
Thuro	N.S.	215	18989	10336	20769	29325	39758	0	10433	0.74	35.6	-	-
Kensia	Ont.	506	19506	0	19710	19506	39216	0	19710	0.55	101.0	-	-
Hutton Hills	Ont.	549	19649	0	15782	19649	35431	0	15782	0.55	80.3	-	-
Milton	Ont.	548	19842	0	8225	19842	28067	0	8225	0.71	41.5	-	-
Owen Sound	Ont.	566	19845	9450	7412	29295	27257	2841	803	0.88	-7.0	22.0	78.0
Campbell River	B.C.	944	20519	1103	10057	21622	30576	0	8954	0.71	41.4	-	-
Val d'Or	Que.	480	20697	2636	4972	23533	25669	0	2136	0.92	9.1	-	-
Brookville	Ont.	512	21200	10747	14459	31947	35659	792	4504	0.85	11.6	85.0	15.0
Port Alberni	B.C.	940	22229	6209	9450	28438	31679	0	3241	0.90	11.4	-	-
Vernon	B.C.	918	22416	11852	19742	34268	42158	0	7890	0.81	23.0	-	-
Parkton	B.C.	913	23418	6089	14100	29507	37518	0	8011	0.79	27.1	-	-
New Glasgow	N.S.	220	23580	11802	15837	33382	39417	0	4035	0.90	11.4	-	-
Oxley	Ont.	569	23955	12288	6905	36243	30900	6152	769	0.81	-14.7	11.1	88.9
Corner Brook	Nfld.	015	24204	11008	11008	35212	35212	0	0	1.00	0.0	-	-
Grande Prairie	Alta.	850	24283	7844	0	32107	24263	7844	0	0.76	-24.4	-	-
25,000 TO 49,999													
Rouyn	Que.	485	25005	11167	10411	36172	35416	1128	372	0.96	-2.1	24.8	75.2
Alma	Que.	410	25661	1669	4672	27330	30333	0	3003	0.90	11.0	-	-
Steele	Ont.	553	26262	2679	0	28941	26262	2679	0	0.91	-9.3	-	-
Sault Ste. Marie	Que.	412	26464	4812	6116	31276	32580	0	1304	0.96	4.2	-	-
Thetford Mines	Que.	430	26519	7798	7642	34317	34161	156	0	1.00	-0.5	-	-
Windsor	Ont.	544	26603	6879	0	33482	26603	6879	0	0.79	-20.5	-	-
St. Catharines	B.C.	931	26658	0	11890	26658	38548	0	11890	0.69	44.6	-	-
St. John's	Que.	406	26851	6254	6836	33105	33689	0	582	0.98	1.8	-	-
St. John's	P.E.I.	105	28053	19918	20591	47971	48644	0	673	0.99	1.4	-	-
St. John's	Ont.	554	28189	6788	10153	34957	38322	1284	4649	0.85	9.6	78.4	21.6
Victoria	Que.	440	28665	7558	7762	36223	36427	84	288	0.99	0.6	77.4	22.6
Johns	Que.	456	28735	5852	5726	34687	34461	1672	1446	0.91	-0.7	46.4	53.6
Pierceland	Que.	404	30319	10262	14595	40581	44914	866	5199	0.87	10.7	85.7	14.3
Port Moresby	Alta.	860	31000	0	12385	31000	43385	0	12385	0.71	40.0	-	-
Port Alberni	Sask.	745	31380	6049	6702	37429	38082	0	653	0.98	1.7	-	-
Chapleau	B.C.	930	31522	2924	17899	34446	49421	0	14975	0.70	43.5	-	-
Thetford Mines	Ont.	586	32723	0	13391	32723	46114	0	13391	0.71	40.9	-	-
St. John's	Que.	458	33743	0	1743	33743	35486	0	1743	0.95	5.2	-	-
Sydney	N.S.	225	34620	17671	19757	52291	54377	9001	11087	0.68	4.0	55.2	44.8

Moose Jaw	Sask.	715	35179	253	880	35432	35059	0	627	0.98	1.8	-	-
Saint-Jerome	Que.	475	36089	6272	6710	42361	42799	1609	2047	0.92	1.0	56.0	44.0
Brandon	Man.	610	36314	2647	6	38961	36320	2641	0	0.93	-6.8	-	-
Sal de Valleyfield	Que.	465	37111	1206	2380	38317	39491	0	1174	0.97	3.1	-	-
Granby	Que.	450	39081	9488	9058	48569	48139	3768	3338	0.86	-0.9	47.0	53.0
Sorel	Que.	454	40885	6658	6145	47543	47030	513	0	0.99	-1.1	-	-
Saint-Hyacinthe	Que.	452	41108	6332	6332	47440	47440	0	0	1.00	0.0	-	-
Chatham	Ont.	556	41198	6119	0	47317	41198	6119	0	0.87	-12.9	-	-
Fredericton	N.B.	320	42603	18856	19339	61459	61942	2446	2829	0.92	0.8	54.5	45.5
Medicine Hat	Alta.	805	44269	1355	5387	45624	49656	0	4032	0.92	8.8	-	-
Comwall	Ont.	501	46144	9672	5891	55816	52035	3781	0	0.93	-6.8	-	-
Red Deer	Alta.	830	46393	5780	0	52173	46393	5780	0	0.89	-11.1	-	-
Kelowna	B.C.	915	46980	34682	20348	81572	67238	15031	697	0.81	-17.6	4.4	95.6
Nanaimo	B.C.	938	47334	11079	10360	58413	57694	1405	686	0.96	-1.2	32.8	67.2
50,000 TO 99,999													
Barrie	Ont.	568	50434	9262	10837	59696	61271	1592	3167	0.92	2.6	66.5	33.5
St-Jean-sur-Richelieu	Que.	459	50741	7678	7439	58619	58180	3557	3118	0.89	-0.7	46.7	53.3
North Bay	Ont.	575	51240	8098	6607	59338	57847	2201	710	0.95	-2.5	24.4	75.6
Drummondville	Que.	447	51931	10664	11968	62595	63899	0	1304	0.98	2.1	-	-
Kamloops	B.C.	925	52268	14529	12369	66797	64997	3310	1150	0.93	-2.7	25.8	74.2
Shawinigan	Que.	444	52646	9789	10708	62435	63352	1312	2229	0.95	1.5	62.9	37.1
Lebelville	Alta.	810	54072	3417	0	57489	54072	3417	0	0.94	-5.9	-	-
Chatham	Que.	463	54843	0	1602	54843	56445	0	1602	0.97	2.9	-	-
Montreal	B.C.	932	57784	0	17470	57794	75264	0	17470	0.77	30.2	-	-
Shawinigan	Ont.	522	58607	28018	26875	86625	85482	1952	809	0.97	-1.3	29.3	70.7
Prince George	B.C.	970	60208	15820	7353	76126	67559	9213	646	0.87	-11.3	6.6	93.4
Peterborough	Ont.	529	61825	22061	23878	83896	85703	2268	4065	0.93	2.2	64.3	35.7
Quebec	Ont.	550	71207	5097	7249	76304	78456	2159	4311	0.92	2.8	66.6	33.4
Brandon	Ont.	543	73415	6314	14015	79729	87430	838	8539	0.89	9.7	91.1	8.9
Sault Ste. Marie	Ont.	590	74512	17486	12450	91998	86982	5036	0	0.95	-5.5	-	-
Moncton	N.B.	305	75809	22801	22545	98610	98354	4226	3970	0.92	-0.3	48.4	51.6
Shawinigan	Ont.	562	77147	7691	6803	85038	83950	3084	1996	0.94	-1.3	39.3	60.7
Kingston	Ont.	521	84810	28841	30172	113651	114982	2200	3531	0.95	1.2	61.6	38.4
Saint John	N.B.	310	91822	24910	29190	116732	121012	0	4280	0.96	3.7	-	-
OVER 100,000													
Trois-Rivieres	Que.	442	103233	11713	21096	114946	124329	1600	10983	0.90	8.2	87.3	12.7

St. Catharines - Niagara	Que.	433	103735	20550	20689	124285	124424	709	848	0.99	0.1	54.5	45.5
Thunder Bay	Ont.	595	109365	15690	12583	125055	121948	3351	244	0.97	-2.5	6.8	93.2
Sault Ste. Marie	Ont.	580	111238	42194	24450	134332	135688	27236	9492	0.77	-11.6	25.8	74.2
Chicoutimi - Jonquiere	Que.	408	112354	27735	22421	140089	137294	5064	250	0.96	-2.0	4.7	95.3
St. John's	Nfld.	001	115992	35997	25003	151989	140995	13194	2200	0.90	-7.2	14.3	85.7
Oshawa	Ont.	532	149100	24077	5117	173177	154217	24077	5117	0.84	-10.9	17.5	82.5
Sudborton	Sask.	725	154217	11360	20848	165577	175065	182	9670	0.94	5.7	98.2	1.8
Regina	Sask.	705	162966	4571	10613	167557	173599	0	6042	0.97	3.6	-	-
Victoria	B.C.	935	210302	18792	16956	229094	227258	3493	1657	0.98	-0.8	32.2	67.8
Windsor	Ont.	559	216666	26747	34641	243413	251307	0	7894	0.97	3.2	-	-
Halifax	N.S.	205	226114	50361	50542	275475	276656	822	1003	0.99	0.1	5.0	45.0
London	Ont.	555	260443	14547	28040	274990	288492	529	14031	0.95	4.9	96.4	3.6
Kitchener	Ont.	541	266345	18302	21456	284647	287801	7253	10407	0.94	1.1	58.9	41.1
St. Catharines - Niagara	Ont.	539	276739	9229	41810	285968	318549	0	32581	0.90	11.4	-	-
Hamilton	Ont.	537	500421	28202	41674	528623	542085	0	13472	0.98	2.5	-	-
Quebec	Que.	421	528143	43395	55815	571538	583820	377	12797	0.98	2.1	97.1	2.9
Winnipeg	Man.	602	563668	40131	28393	603799	592061	15854	4116	0.97	-1.9	20.6	79.4
Calgary	Alta.	825	592801	38867	33223	631668	626024	9373	3729	0.98	-0.9	28.5	71.5
Edmonton	Alta.	835	617217	39522	42193	656739	659410	26434	29105	0.92	0.4	52.4	47.6
Ottawa - Hull	Ont.	505	627713	106596	64636	736309	692349	47100	3140	0.93	-6.0	6.3	93.8
Vancouver	B.C.	933	1142566	30803	87269	1173169	1229635	25422	81888	0.91	4.8	76.3	23.7
Montreal	Que.	462	2655101	160233	152932	2815334	2808033	27988	20687	0.98	-0.3	42.5	57.5
Toronto	Ont.	535	2870830	134393	182566	3005223	3053396	11452	59625	0.98	1.6	83.9	16.1

APPENDIX 3

Maps Showing Sample Overbounded Cases

Truro, NS

Dolbeau, Que

Newcastle, Ont

Leduc, Alta

Williams Lake, BC

CMA/CA Boundary using CSDs CMA/CA boundary using EAs

APPENDIX 3 Sample Overbounded Case Dolbeau, Que

APPENDIX 3 Sample Overbounded Case Leduc, Alta

APPENDIX 3 Sample Overbounded Case Williams Lake, BC

APPENDIX 4

Maps Showing Sample Underbounded Cases

Summerside, PEI

Sorel, Que

Lindsay, Ont

Portage La Prairie, Man

Cranbrook, BC

CMA/CA Boundary using CSDs [REDACTED]

CMA/CA Boundary using EAs [REDACTED]

APPENDIX 4 Sample Underbounded Case Summerside, PEI

APPENDIX 4 Sample Underbounded Case Lindsay, Ont

APPENDIX 4 Sample Underbounded Case Portage La Prairie, Man

APPENDIX 4 Sample Underbounded Case Cranbrook, BC

APPENDIX 5

Maps Showing Sample Over and Underbounded Cases

Halifax, NS

Trois-Rivières, Que

Ottawa - Hull, Ont

Calgary, Alta

Nanaimo, BC

CMA/CA Boundary using CSDs CMA/CA Boundary using EAs

APPENDIX 5 Sample Over and Underbounded Case Halifax, NS

APPENDIX 5 Sample Over and Underbounded Case Trois-Rivières,

Que

APPENDIX 5 Sample Over and Underbounded Case Ottawa - Hull,
Ont

APPENDIX 5 Sample Over and Underbounded Case Calgary, Alta

APPENDIX 6**1986 Definitions for Statistics Canada's Geographic Areas:**

Census Metropolitan Area (CMA)

Census Agglomeration (CA)

Primary Census Metropolitan Area (PCMA)

Primary Census Agglomeration (PCA)

Census Subdivision (CSD)

Enumeration Area (EA)

Urban Area (UA)

Census Consolidated Subdivision (CCS)

Census Metropolitan Area (CMA)

Concept and General Criteria

The general concept of a census metropolitan area (CMA) is one of a very large urbanized core, together with adjacent urban and rural areas which have a high degree of economic and social integration with that core.

A CMA is defined as the main labour market area of an urban area (the urbanized core) of at least 100,000 population, based on the previous census. Once an area becomes a CMA, it is retained in the program even if its population subsequently declines.

Smaller labour market areas, centred on urbanized cores of at least 10,000 population, are included in the census agglomeration (CA) program.

CMAs are comprised of one or more census subdivisions (CSDs) which meet at least one of the following criteria:

- (1) the CSD falls completely or partly inside the urbanized core;
- (2) at least 50% of the employed labour force living in the CSD works in the urbanized core; or
- (3) at least 25% of the employed labour force working in the CSD lives in the urbanized core.

Regular and Consolidated CMAs

In some parts of the country, adjacent CMAs and CAs are socially and economically interrelated. When this occurs, they are grouped into a single consolidated CMA. A regular CMA, on the other hand, is free-standing. It is either not adjacent to another CMA or CA or not sufficiently related to another CMA or CA to be consolidated.

To be eligible for consolidation, the total commuting interchange between the adjacent CMAs and CAs must be equal to at least 35% of the labour force living in the smaller CMA or CA. After consolidation, the original CMAs and CAs become subregions (called primary CMAs and CAs) within the consolidated CMA.

Additional Criteria and Procedures for Inclusion of CSDs in CMAs

In addition to criteria (1), (2) and (3) outlined above, the following criteria are applied to determine if a CSD is to be included in the CMA:

- (4) If the commuting flow is less than 100 persons, CSDs are excluded from the CMA, even if criteria (2) or (3) apply.
- (5) Even if criteria (2), (3) or (4) apply, CSDs may be included or excluded to maintain the contiguity of the CMA.
- (6) CSD components of census tracted CMAs are retained for historical comparability even if they no longer meet criteria (2) or (3).

All the above criteria have been ranked in priority order. A CSD meeting the criteria for two or more CMAs/CAs is included in the one for which it has the highest ranked

criterion. If the CSD meets criteria that have the same rank, the decision is based on the actual population or on the number of commuters involved.

Exceptions to the above delineation criteria may occasionally be made in certain special situations.

Users should be aware that CMA boundaries may not conform precisely with the main labour market area, since CMAs must respect CSD limits. CMAs may also differ from metropolitan areas designated by local authorities for planning or other purposes.

Censuses: 1986, 1981*, 1976, 1971**, 1966***, 1961***

Remarks: The number of CMAs by province and territory appears in Figure 16 on page 122.

While the concept remains unchanged, several modifications have been made to the delineation criteria since 1981. To be included in a CMA, a CSD now requires a commuting flow of at least 50%, up from 40% in 1981. In addition, the flow must be at least 100 persons. Finally, adjacent CMAs and CAs which are closely interrelated will now be combined into a single, larger CMA because of the consolidation criterion. Refer to Appendix G for a complete list of CMAs and CAs with their constituent PCMs and PCAs.

Sherbrooke, Quebec, becomes Canada's 25th CMA in 1986 as a result of population growth in its urbanized core.

- * The change to the commuting flow criterion between 1981 and 1986 was implemented in part in order to maintain historical comparability. It was also required to control differences in the processing of place of work data between the 1971 and the 1981 Censuses.
- ** In 1971, CMAs were defined as main labour market areas but were delineated according to alternate criteria based on labour force composition, population growth rate and accessibility.
- *** In 1966 and 1961, CMAs were delineated around cities of 50,000 or more population, provided that population density and labour force composition criteria were met and that the total CMA population was at least 100,000.

Census Agglomeration (CA)

Concept and General Criteria

The general concept of a census agglomeration (CA) is one of a large urbanized core, together with adjacent urban and rural areas which have a high degree of economic and social integration with that core.

A CA is defined as the main labour market area of an urban area (the urbanized core) of at least 10,000 population, based on the previous census. Once a CA attains an urbanized core population of at least 100,000, based on the previous census, it becomes a census metropolitan area (CMA).

CAs are comprised of one or more census subdivisions (CSDs) which meet at least one of the following criteria:

- (1) the CSD falls completely or partly inside the urbanized core;
- (2) at least 50% of the employed labour force living in the CSD works in the urbanized core; or
- (3) at least 25% of the employed labour force working in the CSD lives in the urbanized core.

Regular and Consolidated CAs

In some parts of the country, adjacent CAs are socially and economically interrelated. When this occurs, they are grouped into a single consolidated CA. A regular CA, on the other hand, is free-standing. It is either not adjacent to another CA or not sufficiently related to another CA to be consolidated.

To be eligible for consolidation, the total commuting interchange between the adjacent CAs must be equal to at least 35% of the labour force living in the smaller CA. After consolidation, the original CAs become subregions (called primary CAs) within the consolidated CA.

Additional Criteria and Procedures for Inclusion of CSDs in CAs

In addition to criteria (1), (2) and (3) outlined on the previous page, the following criteria are applied to determine if a CSD is to be included:

- (4) If the commuting flow is less than 100 persons, CSDs are excluded from the CA, even if criteria (2) or (3) apply.
- (5) Even if criteria (2), (3) or (4) apply, CSDs may be included or excluded to maintain the contiguity of the CA.
- (6) CSD components of census tracted CAs are retained for historical comparability even if they no longer meet criteria (2) or (3).

All the above criteria have been ranked in priority order. A CSD meeting the criteria for two or more CMAs/CAs is included in the CMA or CA for which it has the highest ranked criterion. If the CSD meets criteria that have the same rank, the decision is based on the actual population or on the number of commuters involved.

Exceptions to the above delineation criteria may occasionally be made in certain special situations.

Users should be aware that CA boundaries may not conform precisely with the main labour market area, since CAs must respect CSD limits.

Censuses: 1986, 1981*, 1976**, 1971**, 1966***, 1961***

Remarks: The number of CAs by province and territory appears in Figure 16 on page 122.

While the concept remains unchanged, several modifications have been made to the delineation criteria since 1981. To be included in a CA, a CSD now requires a commuting flow of at least 50%, up from 40% in 1981. In addition, the flow must be at least 100 persons. CAs composed of a single CSD are now permitted, whereas in 1981 at least two CSD components were required for all but census tracted CAs. This change has added several new CAs to the program. Finally, adjacent CAs which are closely interrelated will now be combined into a single larger CA because of the consolidation criterion. Refer to Appendix G for a complete list of CMAs and CAs with their constituent PCMA's and PCAs.

* The change to the commuting flow criterion between 1981 and 1986 was implemented in part in order to maintain historical comparability. It was also required to control differences in the processing of place of work data between the 1971 and the 1981 Censuses.

** In 1976 and 1971, CAs were comprised of at least two adjacent municipal entities. These entities had to be at least partly urban and belong to an urbanized core having a population of 2,000 or more. The urbanized core included a largest city and remainder, each with a population of 1,000 or more, and had a population density of at least 1,000 persons per square mile (386 per square kilometre).

*** In 1966 and 1961, CAs were called Major Urban Areas when larger than 25,000 and Urbanized Areas when smaller.

Primary Census Metropolitan Area (PCMA)**Primary Census Agglomeration (PCA)**

Refers to a labour market subregion within a larger consolidated census metropolitan area (CMA) or census agglomeration (CA).

Adjacent CMAs and CAs are consolidated into a single CMA or CA if the total commuting interchange between the two is equal to at least 35% of the employed labour force living in the smaller CMA or CA. After consolidation, the original CMAs or CAs become PCMA's or PCA's within the new consolidated CMA or CA.

Censuses: 1986

Remarks: The number of PCMA's and PCA's by province and territory appears in Figure 16 on page 122.

This is a new concept for the 1986 Census. See also the definitions for CENSUS METROPOLITAN AREA and CENSUS AGGLOMERATION. A complete list of CMAs, CAs, PCMA's and PCA's is shown in Appendix G.

Census Subdivision (CSD)

Refers to the general term applying to municipalities, Indian reserves, Indian settlements and unorganized territories.

In Newfoundland, Nova Scotia and British Columbia, the term also describes geostatistical areas that have been created by Statistics Canada in co-operation with the provinces as equivalents for municipalities.

Censuses: 1986, 1981, 1976, 1971, 1966, 1961

Remarks: The number of CSDs by type, by province and territory appears in Figure 16 on page 122.

The 1986 Census was taken according to the municipal boundaries in effect on January 1, 1986.

It should be noted that the parts of Flin Flon located in Manitoba and Saskatchewan and the parts of Lloydminster located in Saskatchewan and Alberta are treated as separate CSDs.

A number of CSD boundary revisions, in addition to the normal changes to status and limits, took place between 1981 and 1986.

In Prince Edward Island, the 1983 Municipalities Act introduced the CSD type - community. This includes villages and communities. The latter were not previously recognized as CSDs. However, for the 1986 Census, only those communities located within the Area Regional Planning Boards of Charlottetown and Summerside have been delineated.

In Quebec, numerous revisions have been made to the Unorganized CSDs in order to respect the limits of the "municipalités régionales de comté" (MRC).

In Saskatchewan, two new CSD types, namely Northern Hamlet and Northern Village, are now recognized in accordance with the Northern Municipalities Act (1983).

In British Columbia, several CSDs have been revised in co-operation with provincial authorities to facilitate more meaningful CA delineations.

In the Yukon Territory, settlements have been classified as CSDs for the first time.

Summaries of CSD changes are available in the form of two bulletins:

- (1) Changes to Municipal Boundaries, Status and Names (Catalogue No. 12-201, Annual); and
- (2) Standard Geographical Classification, 1986, Vol. III (Catalogue No. 12-557, Occasional).

CENSUS SUBDIVISION TYPE

Census subdivisions are classified into various types, according to official designations adopted by provincial or federal authorities. With the exception of unorganized territories, Indian reserves and Indian settlements, hamlets in the Northwest Territories and settlements in the Yukon Territory, the type indicates the municipal status of a CSD. The following list indicates the abbreviations used for the most common CSD types:

BOR Borough
 C City - Cité
 CM County (Municipality)
 COM Community
 CT Canton (Municipalité de)
 CU Cantons unis (Municipalité de)
 DM District (Municipality)
 HAM Hamlet
 ID Improvement District
 LGD Local Government District
 LOT Township and Royalty
 MD Municipal District
 NH Northern Hamlet
 NV Northern Village
 P Paroisse (Municipalité de)
 PAR Parish
 R Indian Reserve - Réserve indienne
 RM Rural Municipality
 RV Resort Village
 SA Special Area
 SCM Subdivision of County Municipality

SD Sans désignation (Municipalité)
 S-E Indian Settlement - Établissement indien
 SET Settlement
 SRD Subdivision of Regional District
 SUN Subdivision of Unorganized
 SV Summer Village
 T Town
 TP Township
 UNO Unorganized - Non organisé
 V Ville
 VC Village Cri
 VK Village Naskapi
 VL Village
 VN Village Nordique

Censuses: 1986, 1981, 1976, 1971, 1966, 1961

Remarks: The number of CSDs by type by province and territory appears in Figure 16 on page 122.

For the 1986 Census, all Prince Edward Island CSDs called Village (VL) in 1981 have been changed to Community (COM). In Quebec, Village (V) has been subdivided into Village (VL), Village Cri (VC), Village Naskapi (VK) and Village Nordique (VN). In Saskatchewan, two new CSD types are now recognized for 1986; they are Northern Hamlet (NH) and Northern Village (NV); Municipal Corporation (MC) has been dropped for 1986. All of the CSDs in the Yukon Territory that were called Local Improvement District (LID) in 1981 have been changed to Village (VL) or Town (T) for 1986.

One major change in the 1981 Census was the unilingualism of CSD types by province of origin. Only those types federally created or found in all provinces are bilingual.

Enumeration Area (EA)

An enumeration area (EA) is the geographic area canvassed by one census representative.

Censuses: 1991,* 1986,* 1981,* 1976,* 1971,** 1966,** 1961**

Rules and Operational Procedures:

EA criteria are defined by Survey Operations Division for field collection requirements.

EAs are to be as compact as possible to minimize travel and optimize census representative work. EAs are delineated so that the census representative may locate them with as little difficulty as possible. Therefore, wherever possible, EAs follow easily recognizable physical features (such as the road network and rivers).

Enumeration area (EA) criteria include:

- (1) **Dwellings** – the number of dwellings in an enumeration area generally varies between a maximum of 375 dwellings in large urban areas to a minimum of 125 in rural areas
- (2) **Limits** – an enumeration area never cuts across any geographic area recognized by the census.

Special Notes, Quality Statements and Applications:

Enumeration areas (EAs) are primarily census collection units; they are not designed as dissemination areas. Nonetheless, the EA is the smallest geographic unit for which census data are usually available.

EAs may change limits from census to census. Approximately 40% of the 1991 EAs remained identical to 1986 limits; however, the balance changed due to:

- (a) population growth;
- (b) a redistribution of federal electoral district (FED) boundaries in 1987;
- (c) changes to geographic limits recognized by the census;
- (d) the extension of the "mail-back" collection methodology into the 1986 "pick-up" areas;
- (e) changes in delineation criteria.

Remarks: The number of EAs by province and territory appears in Figure 23A on page 173

- The number of dwellings per EA rarely exceeded 400.
- The number of dwellings per EA rarely exceeded 300.

Urban Area (UA)

Refers to a continuously built-up area having a population concentration of 1,000 or more and a population density of 400 or more per square kilometre, based on the previous census. To be considered as continuous, the built-up area must not have a discontinuity exceeding two kilometres.

In addition to the above, many other commercial, industrial and institutional land uses may be considered as urban even though they do not meet the population and density requirements. Examples include commercial and industrial areas, railway yards, airports, parks, golf courses, cemeteries, etc.

Censuses: 1986, 1981, 1976*, 1971**, 1966**, 1961**

Remarks: The number of Urban Area by province and territory appears in Figure 16 on page 122.

- * In 1976, the population density criterion was 1,000 persons per square mile (386 per square kilometre), with a maximum discontinuity of one mile (1.6 kilometres).
- ** For the 1971, 1966 and 1961 Censuses, urban areas included (1) all incorporated cities, towns and villages with a population of 1,000 or over; (2) all unincorporated places of 1,000 population or over having a population density of at least 1,000 per square mile; and (3) the urbanized fringe of (1) and (2) where a minimum population of 1,000 and a density of at least 1,000 persons per square mile existed.

Census Consolidated Subdivision (CCS)

A census consolidated subdivision is a geographically contiguous group of census subdivisions.

Three rules are applied in delineating census consolidated subdivisions:

- (1) all census subdivisions smaller than 25 square kilometres are grouped with a larger subdivision;
- (2) if a census subdivision greater than 25 square kilometres is surrounded on more than half its perimeter by another subdivision, it is included as part of the CCS formed by the other subdivision; if not, the census subdivision forms a CCS on its own; and
- (3) a census subdivision with a population greater than 100,000 forms a CCS on its own if it is surrounded by rural CSDs.

Censuses: 1986, 1981, 1976, 1971*, 1966*

Remarks: The number of CCSs by province and territory appears in Figure 16 on page 122.

* In 1971 and 1966, the "Reference Code" served a similar function by permitting the grouping within a rural municipality of all territory geographically located in the municipality.

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