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The Population Ecumene of Canada: Exploring the Past and Present

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Cette publication est aussi disponible en français (n° 92F0138M au catalogue).

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Abstract

The term ecumene comes from the Greek word *oikoumene,* which means inhabited land or inhabited world. Geographers generally use the term to refer to land where people have made their permanent home, and to all work areas that are considered occupied and used for agricultural or any other economic purpose.

This working paper first examines the ecumene concept from a geographic viewpoint and highlights some of the geographic literature. It also examines the cartographic issues, such as the limitations of the choropleth map, and then provides an overview of Statistics Canada's use of the ecumene in its thematic mapping program. Finally, the paper provides details on the development of the population ecumene for the 2006 Census.

1. Introduction

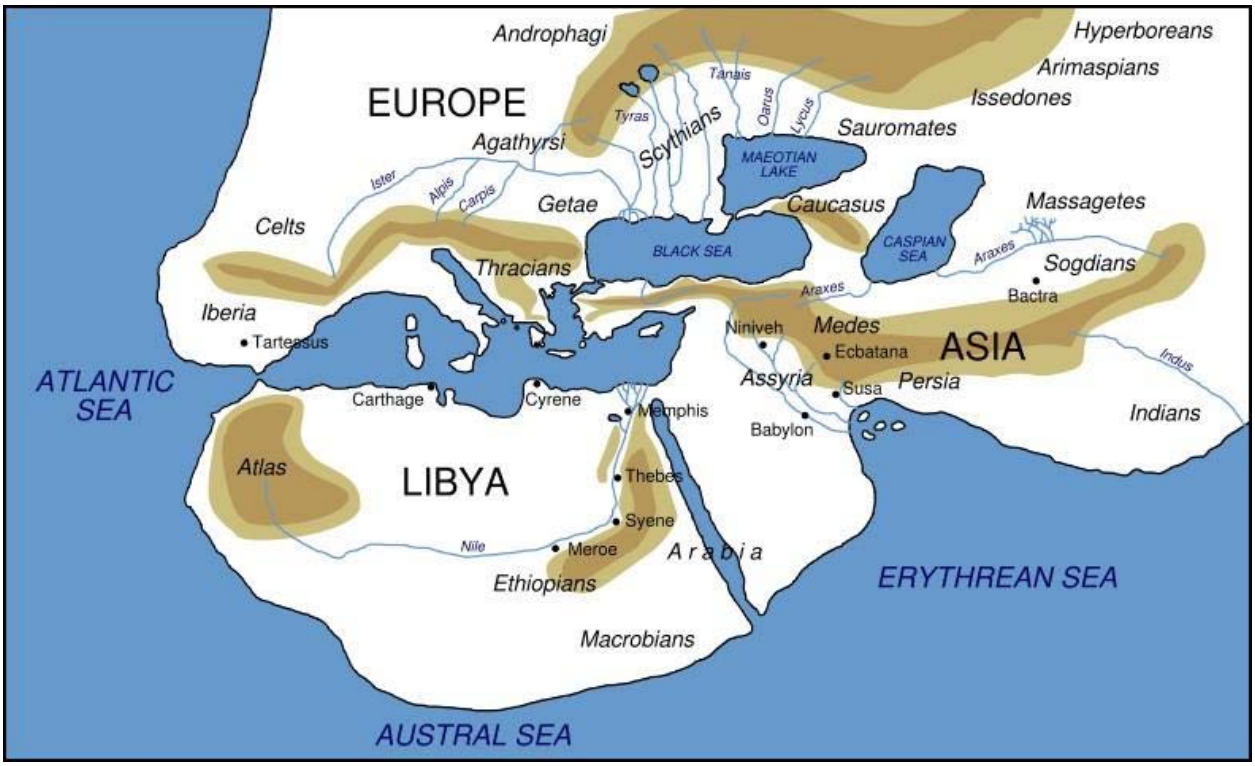
The term ecumene (sometimes spelled oecumene) comes from the Greek word *oikoumene* which means inhabited land or inhabited world. Geographers generally use the term to refer to land where people have made their permanent home, and to all work areas that are considered occupied and used for agricultural or any other economic purpose (Gajda 1960, p. 5).

This working paper first examines the ecumene concept from a geographic viewpoint and highlights some of the geographic literature. It also examines the cartographic issues, such as the limitations of the choropleth map, and then provides an overview of Statistics Canada's use of the ecumene in its thematic mapping program. Finally, the paper provides details on the development of the population ecumene for the 2006 Census.

2. Geographic context

From its Greek derivative, one can certainly infer that the ecumene concept is not new. The word *oikoumene* traditionally refers to the inhabited portion of the world known to the ancient Greeks. Figure 2.1 shows a reconstructed map of the *oikoumene* from Herodotus. Herodotus (ca. 484 B.C. – ca. 425 B.C.), a renowned Greek historian, is regarded as the 'Father of History'. However, others also note that he might be equally well called the 'Father of Geography', since his extensive travels yielded a considerable amount of written information about the geography of the places he visited (Jacobs 1899; Skocz 2004; Encarta® Online Encyclopedia n.d.).

Figure 2.1 Reconstruction of the *oikoumene* (inhabited world) based on Herodotus' description of the world, circa 450 B.C.



Note: The brown shading on the map indicates mountain ranges.
Sources: Wikipedia 2007, 2008.

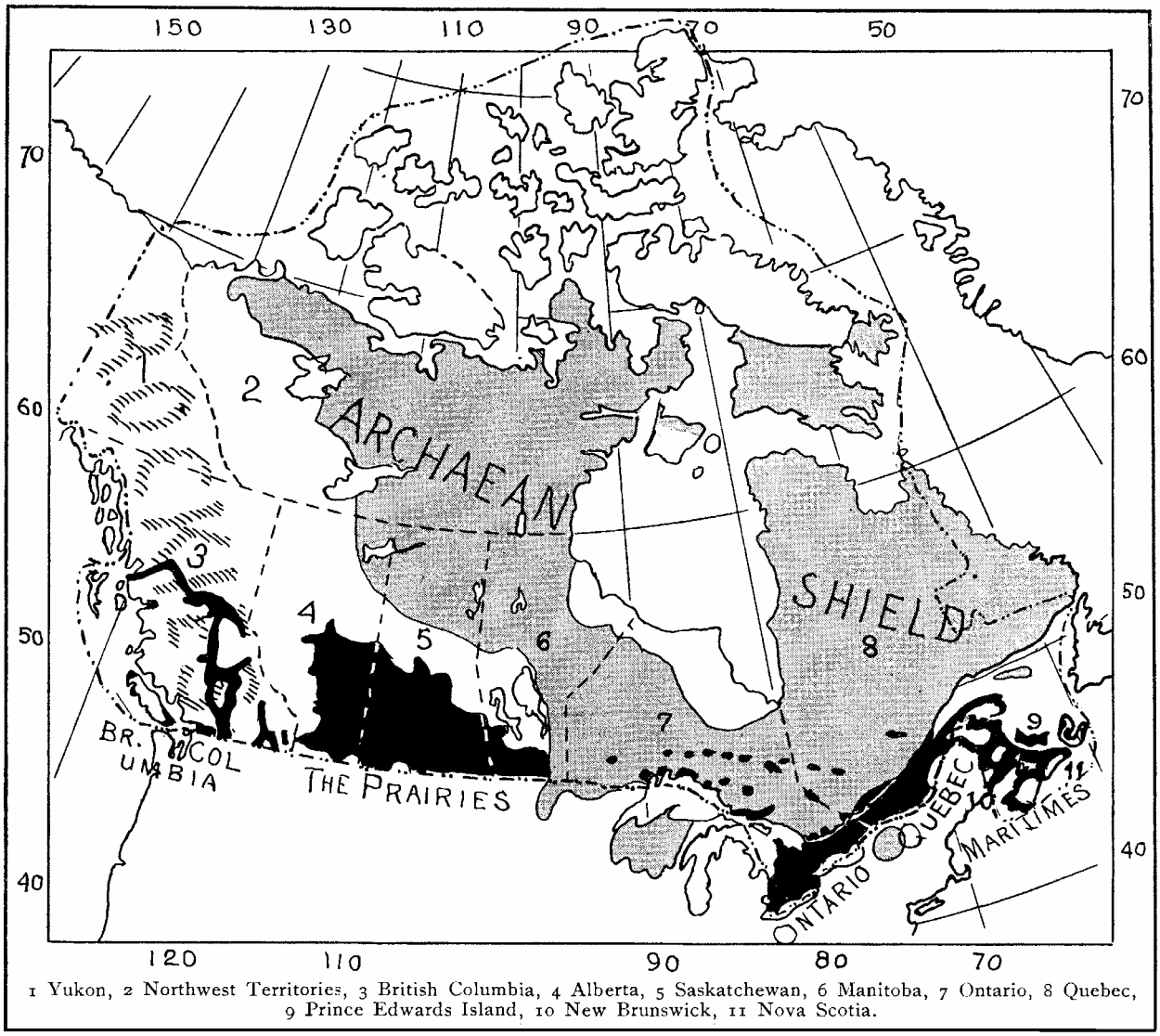
The more recent geographic literature reveals that the ecumene concept is generally examined in two basic ways: authors who delineate an ecumene and authors who merely refer to the concept in the context of their research.

Literature review – ecumene delineation

The settlement patterns of Canada that emerged have been moulded by the interaction of physical, cultural, historical and economic factors. To examine the characteristics of settlement patterns, geographers often describe and delineate the ecumene. The summary presented below reviews the delineation of three national ecumenes, one provincial ecumene and two ecumenes of Arctic Canada.

In an early geographic study, Jefferson (1934) explores ways of delineating Canada's ecumene. He suggests using 2 or 2.5 people per square mile (about 0.8 or 1 person per square kilometre) as well as population nuclei of 100 people (Jefferson 1934, p. 148). Figure 2.2 shows Canada's ecumene proposed by Jefferson.

Figure 2.2 The ecumene of Canada proposed by Jefferson



Note: The black shading represents the ecumene. The Archaean Shield is more commonly known as the Canadian Shield.

Source: Jefferson 1934, p. 150.

Based on 1931 data for nine provinces and two territories, Jefferson includes a table showing that Canada's land area is 3,542,000 square miles (9,173,738 square kilometres) and the Canadian ecumene is 326,000 square miles (844,336 square kilometres). He states that:

> "The real Canada, the Canada of the Ecumene, is a fringe of population along the northern border of the United States." (Jefferson 1934, p. 149)

He also notes that 99.87% of Canadians live in the most southern parts of the nine provinces, and that none of Canada's large cities is more than 65 miles (105 kilometres) from the United States (Jefferson 1934, p. 150). As well, he reports that Canada's road network coincides very well with the ecumene (Jefferson 1934, pp. 156-157).

Gajda's (1960) seminal study establishes the types of Canadian ecumene on the basis of the form and function of settlement. As Gajda puts it:

> "Broadly speaking, there are actually two Canadas: Northern Canada, which involves an immense area of over three million square miles or about six-sevenths of Canada's land area on which less than 2 per cent of the nation's population lives; and Southern Canada, an area of less than half a million square miles but occupied by more than 98 percent of the population." (Gajda 1960, pp. 8-9)

Similar to Jefferson (1934), Gajda (1960) also provides a table showing that Canada's land area is 3,549,960 square miles (9,194,354 square kilometres) and the Canadian ecumene is 438,900 square miles (1,136,746 square kilometres) for ten provinces and two territories. In order to map the occupied and unoccupied land across Canada, the unit areas used by Gajda (1960) include municipalities[1], and where necessary, enumeration areas[2]. To obtain a detailed distribution of population he uses large-scale topographic maps, air photographs, published documents, as well as information obtained by interviewing people familiar with the areas in question.

Gajda's map shows two basic ecumene types: the core, contiguous ecumene spanning the area of farmland and densely population zones in the south; and a strip-like pattern of ecumene following railways, roads and coastlines, as well as patches or enclaves of ecumene generally associated with mining (Figure 2.3).

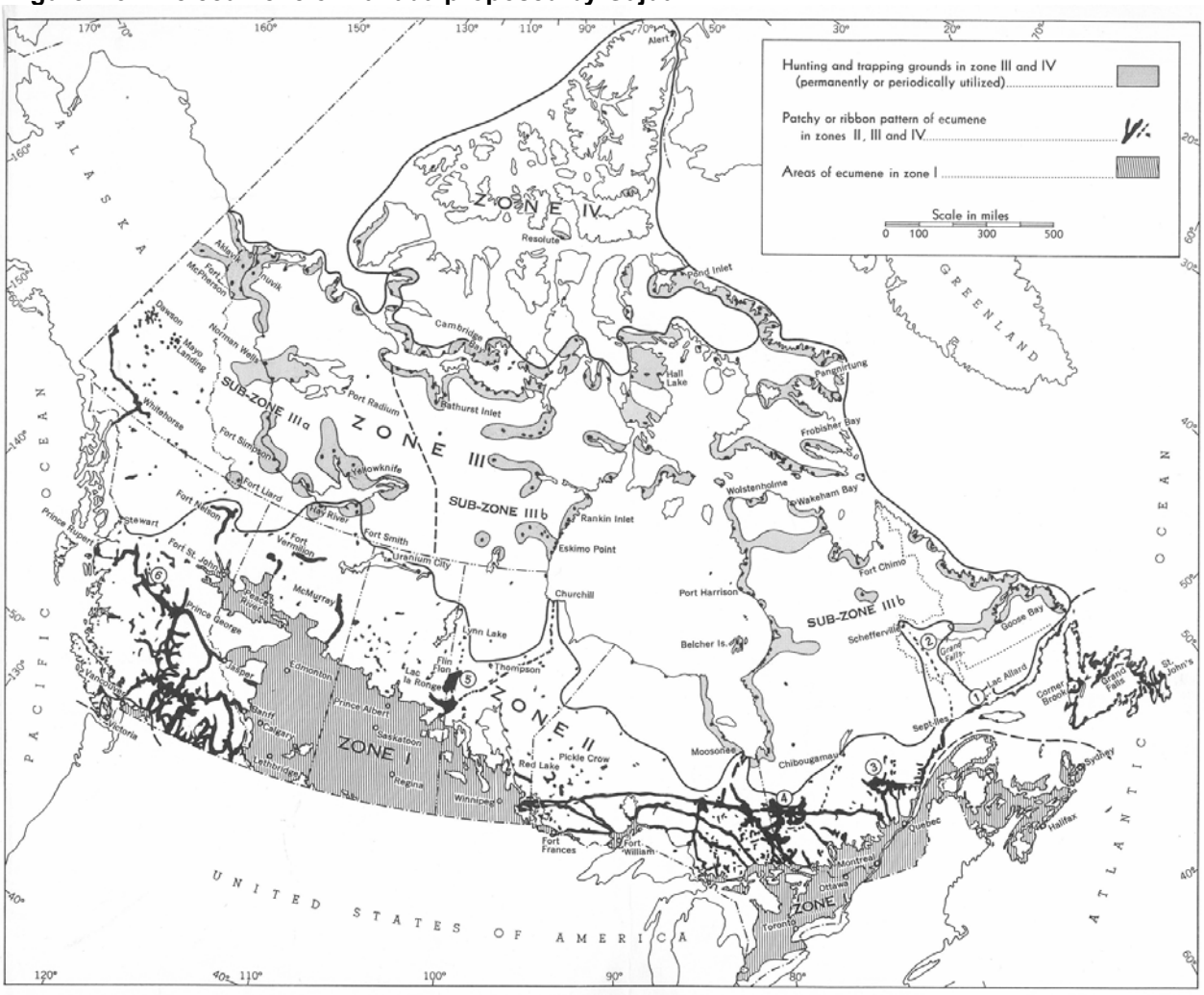
However, Gajda (1960) is reluctant to restrict the application of Canada's ecumene to the narrow, populous southern fringe. The map also depicts hunting and trapping grounds in the northern portions of three provinces (Newfoundland, Quebec and Ontario) and in the territories. He argues that Canada's north:

> "…can no longer be considered a useless and empty wasteland…The map of the northland…is no longer blank, but is an ecumene in a developing stage, which in many ways is similar in geographic and economic unity to the more developed southern regions." (Gajda 1960, p. 18)

Gajda (1960) further divides Canada into four different zones based on population distribution, settlement types and resource extraction. Zone I is densely populated and has utilized agricultural land. Zone II is semi-populated with the population pattern and land utilization following railways, roads and coastlines in a strip-like fashion or in small patches. Zone III is sparsely populated with the utilized land being confined to areas occupied by groups of people whose livelihood depends on mining, lumbering, hunting, trapping, fishing or fur trading. Zone IV is virtually empty except for a few settlements and a small number of meteorological stations or police posts.

1. A census subdivision (CSD) is the general term for municipalities (as determined by provincial/territorial legislation) or areas treated as municipal equivalents for statistical purposes (e.g., Indian reserves, Indian settlements and unorganized territories). (Statistics Canada 2007b)
2. An enumeration area (EA) – a geographic area canvassed by one census representative – was used for both census data collection and data dissemination. The dissemination area (DA) replaced the EA as a basic unit for dissemination starting with the 2001 Census. The collection unit replaced the EA as a basic unit for census collection for the 2006 Census.

Figure 2.3 The ecumene of Canada proposed by Gajda



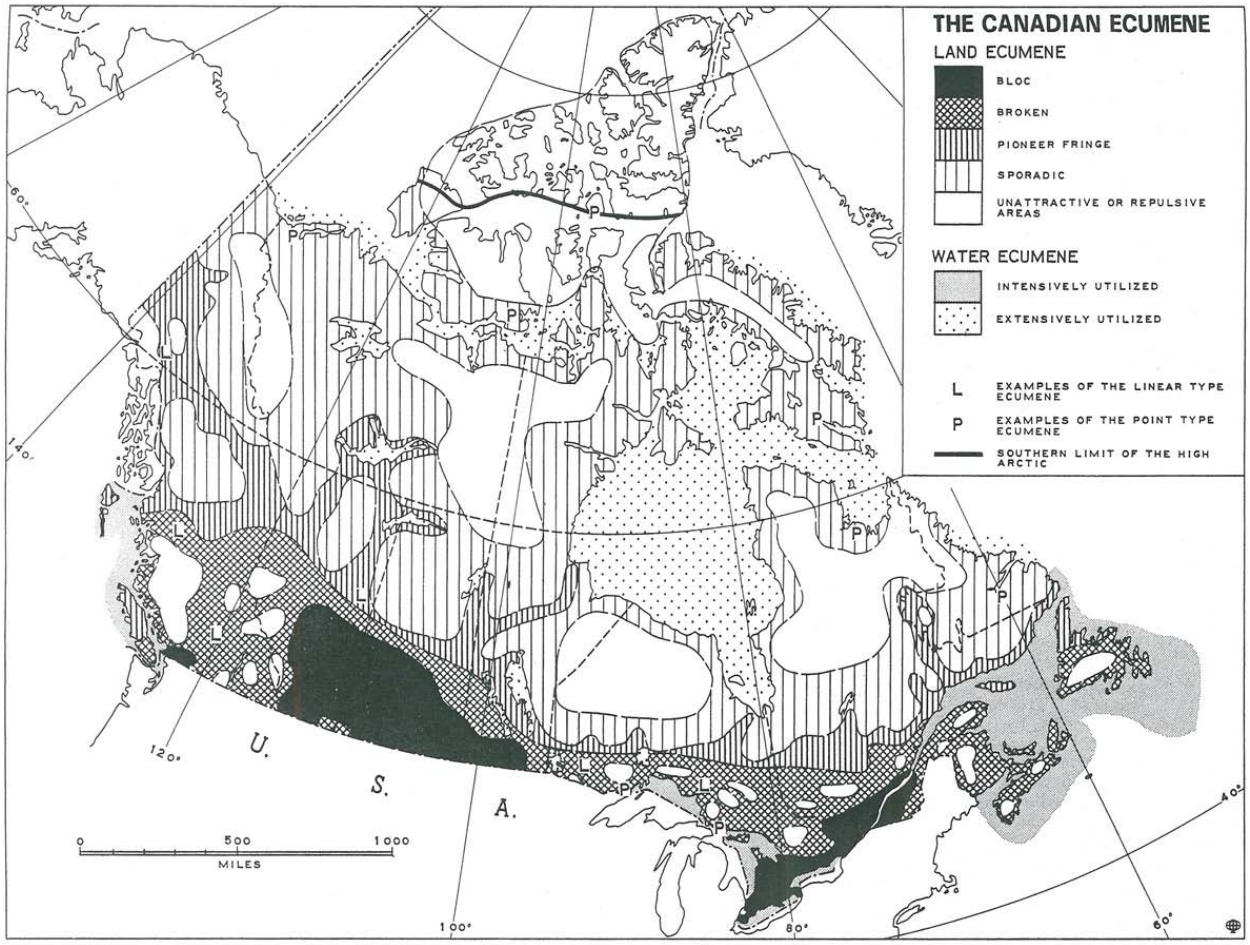
Source: Gajda 1960.
Reproduced with permission by Natural Resources Canada.

Hamelin (1972) also examines the ecumene on the basis of the form and function of settlement. He first describes four functional ecumene types: habitation ecumene – areas that consist of urban land use and urban services; exploitation ecumene – areas often adjacent to the habitation ecumene such as agricultural land and resource extraction; linking ecumene – such as roads, railways, pipelines, power and telephone lines that enable scattered habitation and exploitation ecumenes to develop; and sub-ecumene – small, 'unattractive' areas which interrupt the continuity of southern Canada, as well as immense empty areas in the interior of the Arctic and subarctic.

He further states that in certain cases there is a broad correlation between the functional types of ecumene and their form, such as elongated settlement forms along railways, and dispersed oasis type forms associated with resource extraction. Hamelin (1972) notes that the ecumene takes four general forms: bloc form – corresponds to an older type of settlement in which the physical environment enables expansion; linear form – occurs in each of the chief functional types of ecumene, and extends along railways, highways, valleys or shorelines; point form – villages and small towns that are either isolated, linked and temporary points throughout two-thirds of northern Canada; and dispersed form – refers to regions where people are scattered over a few dozen square miles.

Hamelin's zonal arrangement of the Canadian ecumene (Figure 2.4) is a modification of Gajda's ecumene. The categories in the legend represent a combination of the functional types of ecumene and their form.

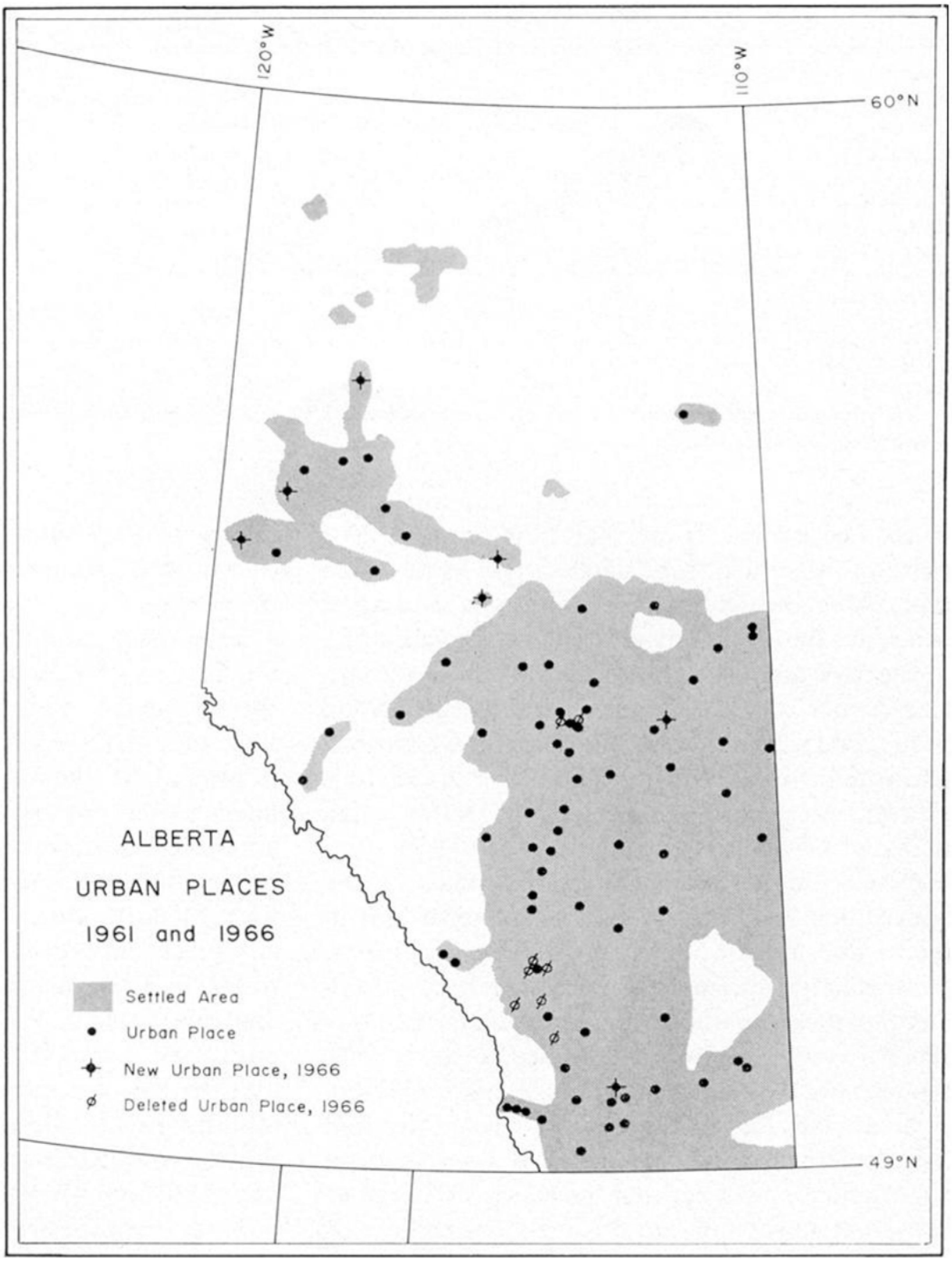
Figure 2.4 The ecumene of Canada proposed by Hamelin



Source: Hamelin 1972, p. 23.
Reproduced with permission by Louis-Edmond Hamelin and the Royal Society of Canada.

Kariel (1970) examines Alberta's settlement pattern by nearest neighbour analysis using the total area of the province and the settled area, or ecumene. Alberta's ecumene is denoted as 'settled area' on his map (Figure 2.5). Kariel notes that the settled area conforms closely to Gadja's map and corresponds with the agricultural area. He also reviews the parts of Alberta not included in the settled area, such as most of the Rocky Mountains and their foothills, the Badlands and extremely arid areas to the east, all of the Cypress Hills near the southeast corner, and so on. In keeping with the definition used in the Canadian census, he defines urban places as settlements with 1,000 persons or more (Kariel 1970, p. 124).

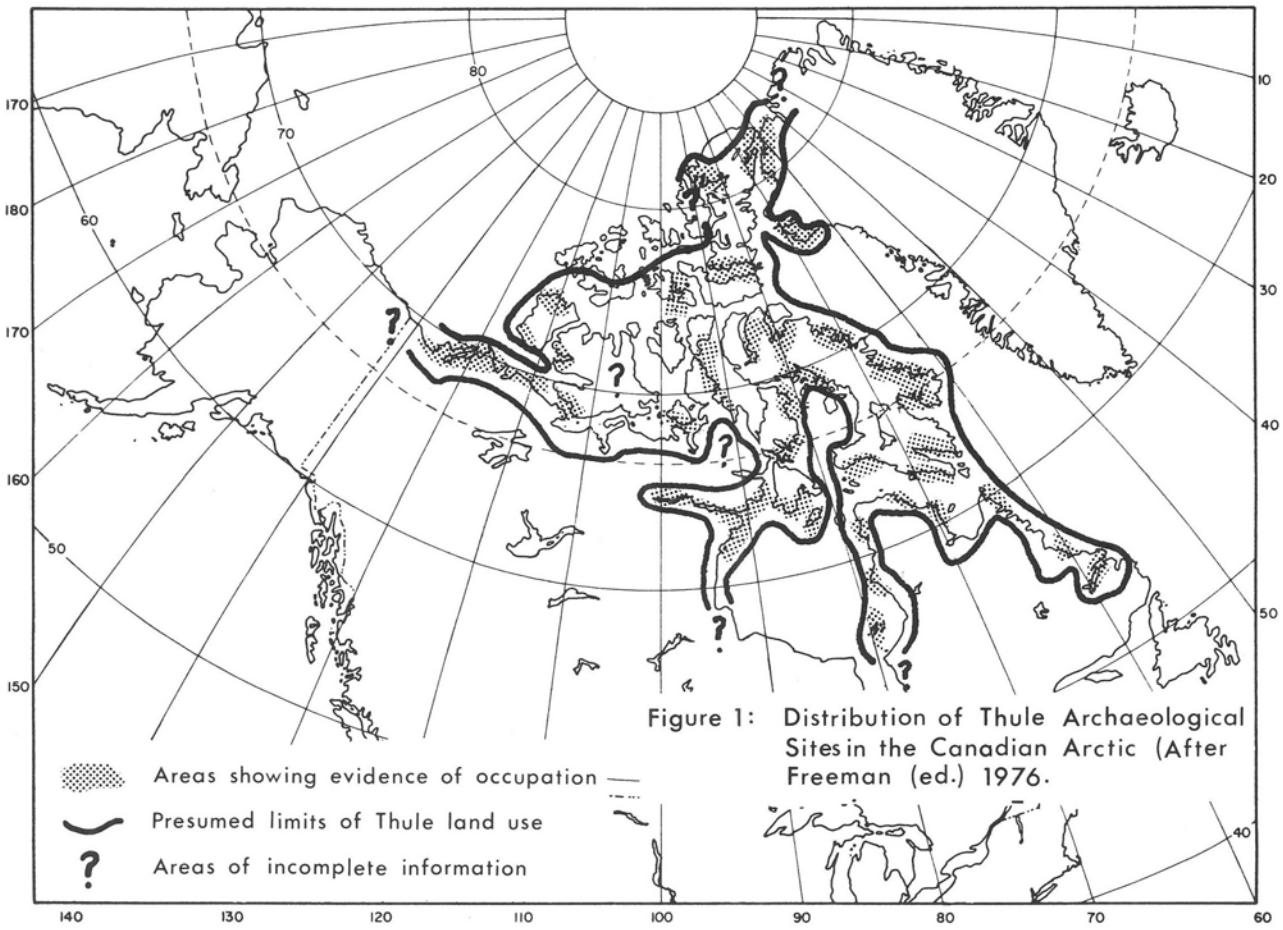
Figure 2.5 The ecumene (settled area) of Alberta proposed by Kariel



Source: Kariel 1970, p. 125.
Reproduced with permission by Blackwell Publishing and the Swedish Society of Anthropology and Geography.

The delineation of the ecumene is restricted to the Canadian Arctic by two authors. In his discussion of *Climate and the Thule Ecumene*, Jacobs (1979) examines the extent of Thule[3] occupation in relation to environmental factors to determine the environmental limits on human occupation of the region. He notes that the term ecumene in its most restricted sense means the entire domain of a particular people (Jacobs 1979, p. 529). He presents a simplified version of Milton Freeman's previously published map of the Thule ecumene (Figure 2.6).

Figure 2.6 The ecumene of Arctic Canada proposed by Jacobs



Source: Jacobs 1979, p. 536.
Reproduced with permission by the Canadian Museum of Civilization.

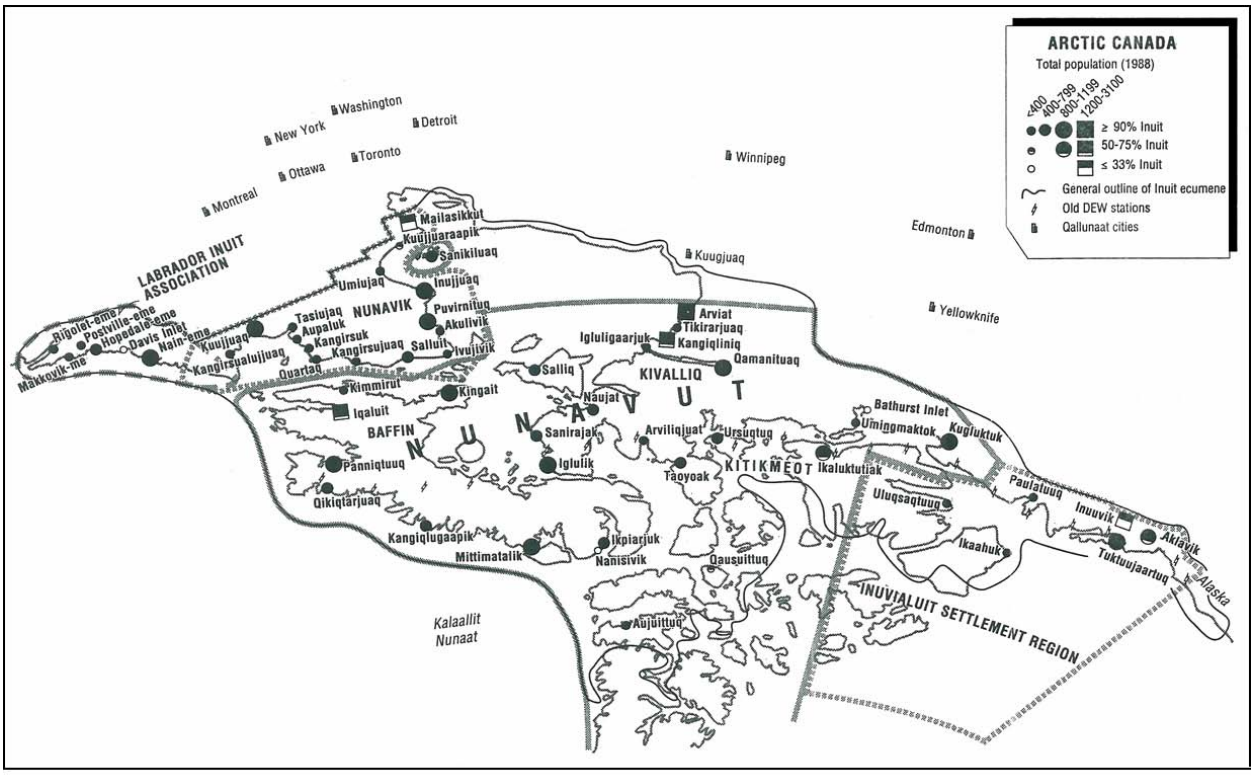
Rundstrom (1992) suggests that the Arctic should be viewed in the context of its aboriginal population:

> "Unlike the southern view, the Inuit Arctic is filled with numerous points of habitation interconnected with lines of wildlife and human activity. Caribou paths, traplines, and an extensive network of travel routes for hunting, visiting, and recreation constitute the ordinary landscape of Inuit life." (Rundstrom 1992, p. 11)

3. The term Thule is often referred to by anthropologists to mean the prehistoric (or prehistoric through historic) Inuit who bore Thule culture (McCartney 1979, p. 3).

Northern Labrador, northern Quebec and two-thirds of the Northwest Territories[4] comprise the Inuit ecumene of Arctic Canada (Figure 2.7). The map presents an unusual view, in that it looks south from above the North Pole, and the scale is larger in the north and then progressively decreases toward the south.

Figure 2.7 The Inuit ecumene of Arctic Canada proposed by Rundstrom



Note: In the legend, DEW refers to Distant Early Warning and Qallunaat refers to white, Euro-North American cities.
Source: Rundstrom 1992, p. 12.

Literature review – reference to ecumene

As previously mentioned, some authors merely refer to the ecumene concept in the context of their research. Several papers, which are presented in chronological order, are summarized below to demonstrate that this notion is quite popular and not as esoteric as one might think.

In his treatise of population geography, Trewartha (1953) argues that population distribution involves dividing the land portions of the earth into permanently inhabited (ecumene) and uninhabited or temporarily inhabited (non-ecumene) parts. He further describes that the non-ecumene is composed of extensive contiguous areas as well as smaller non-contiguous holes imbedded within the ecumene (Trewartha 1953, p. 92).

4. Rundstrom's paper was written before the official establishment of Nunavut (April 1, 1999).

Enequist (1960) discusses the concept of *oecumene* and *non-oecumene* in the introduction of his study on the advance and retreat of rural settlement in northwestern Sweden. He notes that the analysis at the margin of rural settlement "…often calls for the antithesis Oecumene/Non-Oecumene" (Enequist 1960, p. 211).

In his analysis of transportation and politics in Canada, Wolfe (1962) discusses the major modes of transportation (waterways, railroads, highways and airways) and how they are affected by Canadian/U.S. politics and the international border. Near the end of his paper, he discusses the Canadian ecumene. Wolfe agrees with Jefferson's (1934) observation that the ecumene is a narrow fringe stretching along the U.S. border (with a northward narrow extension on the prairies), and concurs with Gajda's assertion that it should not be restricted to the narrow, populous southern fringe (Wolfe 1962, p. 187). Even though there is some economic development in Canada's north, he laments that:

> "All these developments have begun to give Canada the north-south dimension that has been lacking since the heyday of the fur trade, a century and a half ago. It may be argued, however, that insofar as Canada's ecumene is concerned, this dimension is still lacking…The limits of Jefferson's ecumene hold true today…" (Wolfe 1962, p. 188)

In an unusual study, Carter (1969) attempts to determine the extent of the medieval Serbian ecumene and the centrality of successive capital cities. He applies three main methods: connectivity analysis (a branch of graph theory); determining eigenvalues; and measuring accessibility whereby actual distance between settlements is measured and tested against the accessibility of the transportation network as a whole (Carter 1969, p. 39).

Burghardt (1972) calculates income density (income per square mile) for every county in the conterminous United States, noting that census income data is the most satisfactory available statistic to indicate an aggregation of all forms of economic productivity (Burghardt 1972, p. 455). He further states that the two areas of counties with income density values higher than one-tenth of the mean form the nation's ecumene. His resulting income density map shows that the conterminous United States is composed of a "large eastern ecumene" comprising 52% of the area, a "narrow western ecumene" with 6% of the area and an "intervening non-ecumene" with 42% of the area (Burghardt 1972, p. 459).

Storrie and Jackson (1972) examine Canada's environments, notably the physical landscape and three basic human landscapes that they identify as "…the cities, the settled rural areas, and the wildscape of the North" (Storrie and Jackson 1972, p. 309). In the introduction, they briefly refer to the ecumene concept—zones of permanently-established living areas joined by integrated transportation systems—to emphasize that 35% of the Canadian population lives on less than a hundredth of the total area and that most Canadians live within 100 miles of the United States border at the time of the 1966 Census (Storrie and Jackson 1972, p. 309, 312). They also refer to the rural ecumene of Canada, which they believe offers a wide range of issues to geographers. For example, they address the concern of minimum viable size. They pose the question of the criteria for determining the size of community so that it can provide a sufficient range of services and opportunities, thus permitting it to remain self-sustaining (Storrie and Jackson 1972, p. 322).

In the analysis of Canadian resource towns, McCann (1980) examines the location and internal structure of these settlements. He not only discusses their location in relation to Canada's physical landscape (such as the Canadian Shield and Great Plains), but also in relation to the ecumene. McCann reviews Gajda's four ecumene zones and includes a generalized version of his ecumene zones (see Gajda's original map in Figure 2.3). McCann notes that Zone II contains most of Canada's resource-based towns and Zone III contains only a few (McCann 1980, p. 217).

3. Cartographic issues

The choropleth map is a 'staple' in the cartographic repertoire of thematic mapping. Indeed, over the years the popularity of choropleth maps has increased since this map type is very easy to produce by GIS and cartographic software.

The standard choropleth technique is a method of cartographic representation that employs a distinctive colour or shading that is applied to predefined areal units (Dent 1999, p. 139). For example, the units can be census divisions or census tracts, and the areal symbols cover the entire geographic unit.

Limitations of choropleth maps

An underlying assumption of choropleth mapping is that the data are homogenously or uniformly spread over each geographic unit (MacEachren 1985, p. 42; Dent 1999, p. 141). This assumption is implied by a single colour applied across each unit (Figure 3.1). However, the complete unit or at least a large portion of the unit may be uninhabited, thus producing very misleading spatial patterns (Dorling 1993, p. 170; Crampton 2004, p. 41). In fact, Holloway, Schumacher and Redmond (1997) note that when socioeconomic data are mapped by choropleth techniques:

> "…the results often tell us more about the size and shape of the enumeration unit, than about the people actually living and working within them." (Holloway, Schumacher and Redmond 1997, p. 2)

Langford and Unwin (1994) endorse this viewpoint by elaborating:

> "Although the effects of modifiable boundary location and class interval selection have traditionally been considered the most serious in choropleth mapping, we believe that simple variability in the size and shape of areal units may be of equal importance." (Langford and Unwin 1994, p. 23)

This is illustrated in Figure 3.1. The dark green colour representing the highest data class completely and utterly overpowers the entire map because it covers the larger census divisions in six provinces and two territories. In fact, the largest census division (Baffin located in Nunavut) is about 5,391 times larger in land area than the smallest census division (L'Île-d'Orléans in Quebec).

Ecumene applications at Statistics Canada

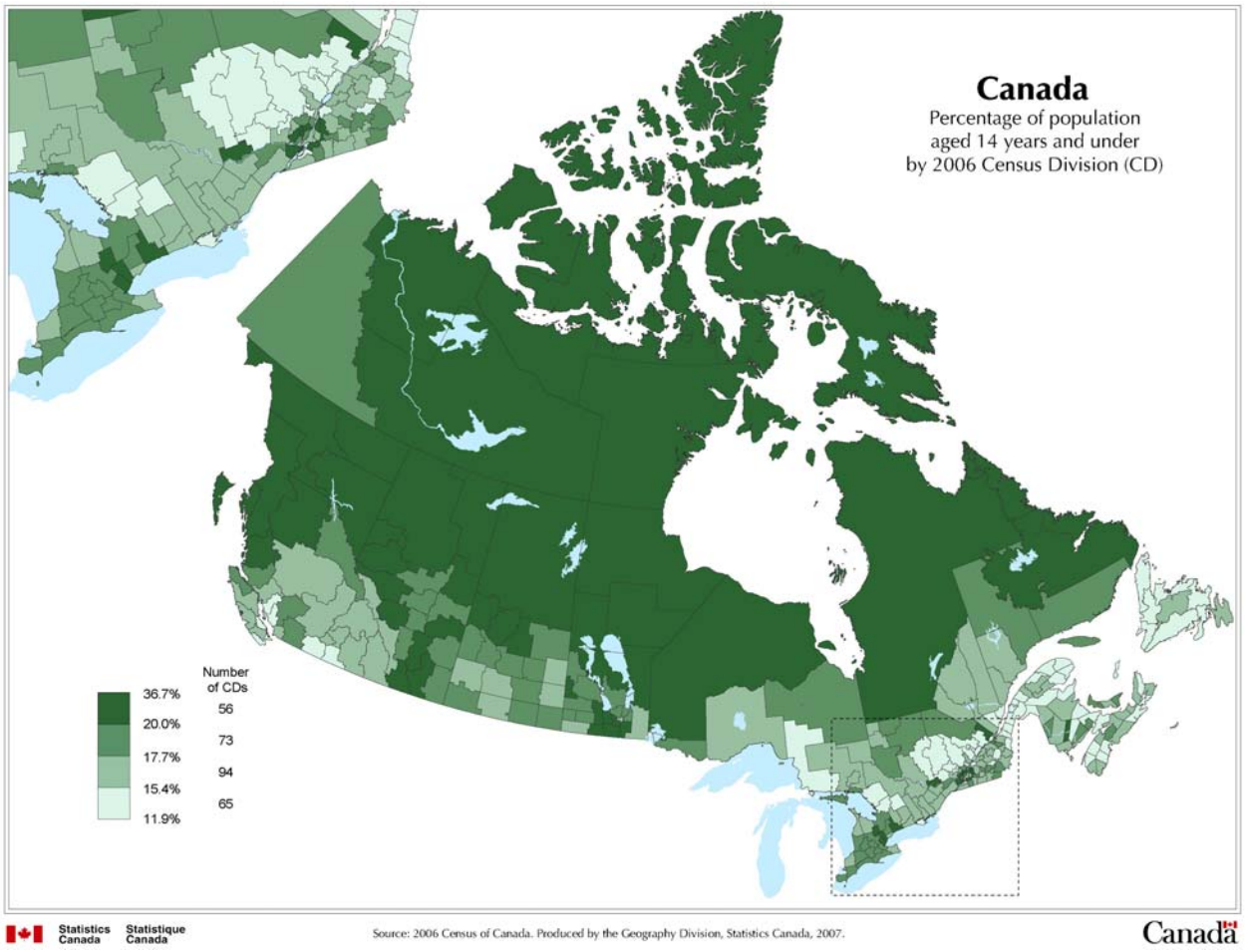
The approach taken by Statistics Canada is to use 'generic' ecumenes, such as a population ecumene or an agricultural ecumene. Generic ecumenes confine the statistical distributions to the same areas, and thus render the maps (or map series) more comparable. This goal could not be achieved by using dasymetric maps (Haythornthwaite, Weiss and Heimbecker 1989, p. 192, 194). The dasymetric map is made from the same initial data used for the simple choropleth map. It differs from the choropleth map in that the areas mapped are not bounded solely by predefined census boundaries. Instead, 'natural' boundaries are also taken into account and averages are calculated for each subdivision that is created (Robinson et al. 1995, p. 519, 523).

Population ecumene

Since the 1976 Census, Statistics Canada has applied a population ecumene in its thematic mapping program, primarily for national maps at the census division level[5]. The use of an ecumene limits the display to only those areas where population is found, resulting in a more accurate depiction of the spatial distribution of data. Dorling (1993, p. 170), Langford and Unwin (1994, p. 23) and others also recommend shading only the inhabited parts of the map.

5. Census division (CD) is the general term for provincially legislated areas (such as county, *municipalité régionale de comté* and regional district) or their equivalents. Census divisions are intermediate geographic areas between the province/territory level and the municipality (census subdivision). (Statistics Canada 2007b)

Figure 3.1 Standard choropleth map



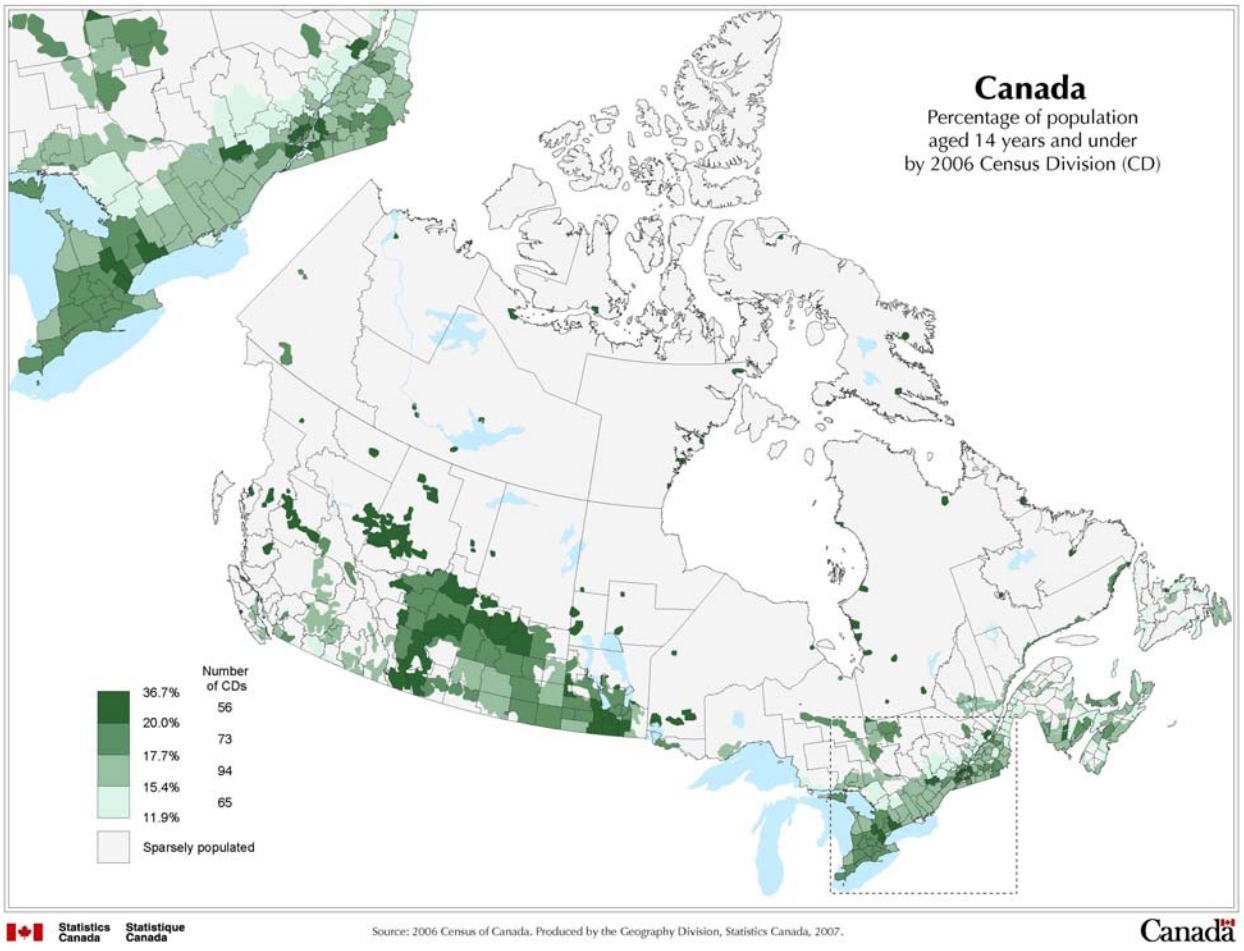
Note: This map was not published or disseminated for the 2006 Census. It was generated without a population ecumene especially for this working paper.

The methodology for delineating the population ecumene was refined over time. For the 1976 Census, the ecumene was a very rough 'approximation' using 1:7,500,000 population density maps in the fourth edition of the *National Atlas of Canada* (Natural Resources Canada 1974). The ecumene was generated by delineating those areas that were equal to or greater than one person per square mile (0.4 persons per square kilometre) and then creating a buffer around the areas because the population density maps were based on 1961 data. The population ecumenes for the 1981 and 1986 Censuses were updated to account for population increases, population decreases and minor errors found in the 1976 ecumene.

For the 1991 and 1996 Censuses, the ecumene was defined using the enumeration area as a 'building block', and for the 2001 Census it was defined using a very small geographic unit, the block. The enumeration area and the block are considered to be part of the ecumene if the population density is at least 0.4 persons per square kilometre (about one person per square mile). Section 4 provides further details on the delineation methodology for the 2006 Census.

Figure 3.2 illustrates one of the thematic maps disseminated for the 2006 Census. Note that the population ecumene restricts the data representation to the populated areas. This virtually eliminates the visual perception in Figure 3.1 that larger rural and sparsely populated areas are of greater importance.

Figure 3.2 Choropleth map with 2006 population ecumene (2006 Census of Population data)



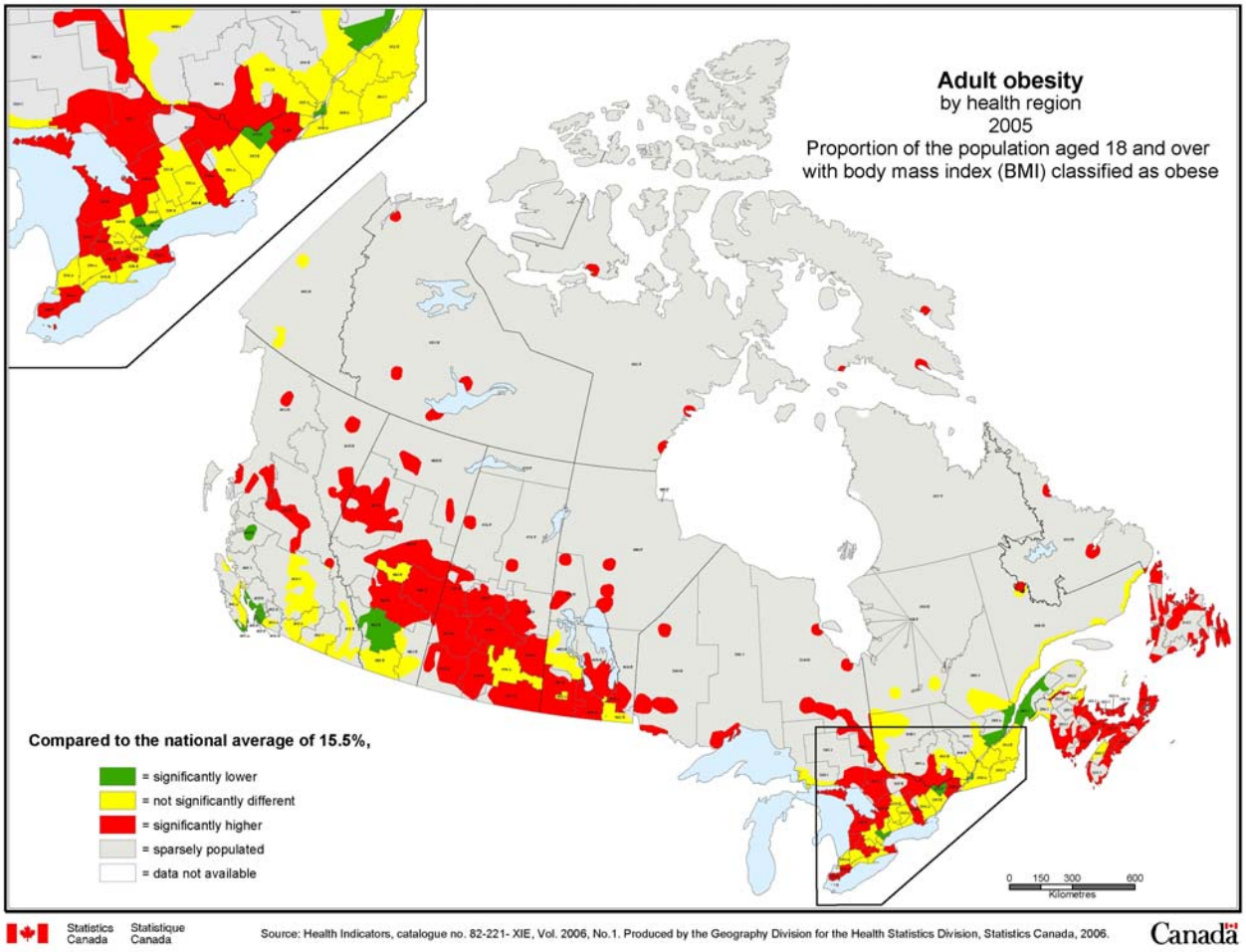
Source: Statistics Canada 2007c.

The population ecumene developed for census thematic maps is also applied to other Statistics Canada data, such as health data. For example, it was used for the three *Mortality Atlases of Canada* co-published by Health and Welfare Canada and Statistics Canada in the early 1980s and 1990s (Health and Welfare Canada and Statistics Canada 1980a, 1980b, 1991). In late 2001, maps were added to *Health Indicators*, an online compilation of data produced jointly by Statistics Canada and the Canadian Institute for Health Information. The maps use the population ecumene at the health region level[6] (Figure 3.3).

From time to time, the population ecumene may be applied to maps based on data for the Annual Survey of Manufactures (Figure 3.4).

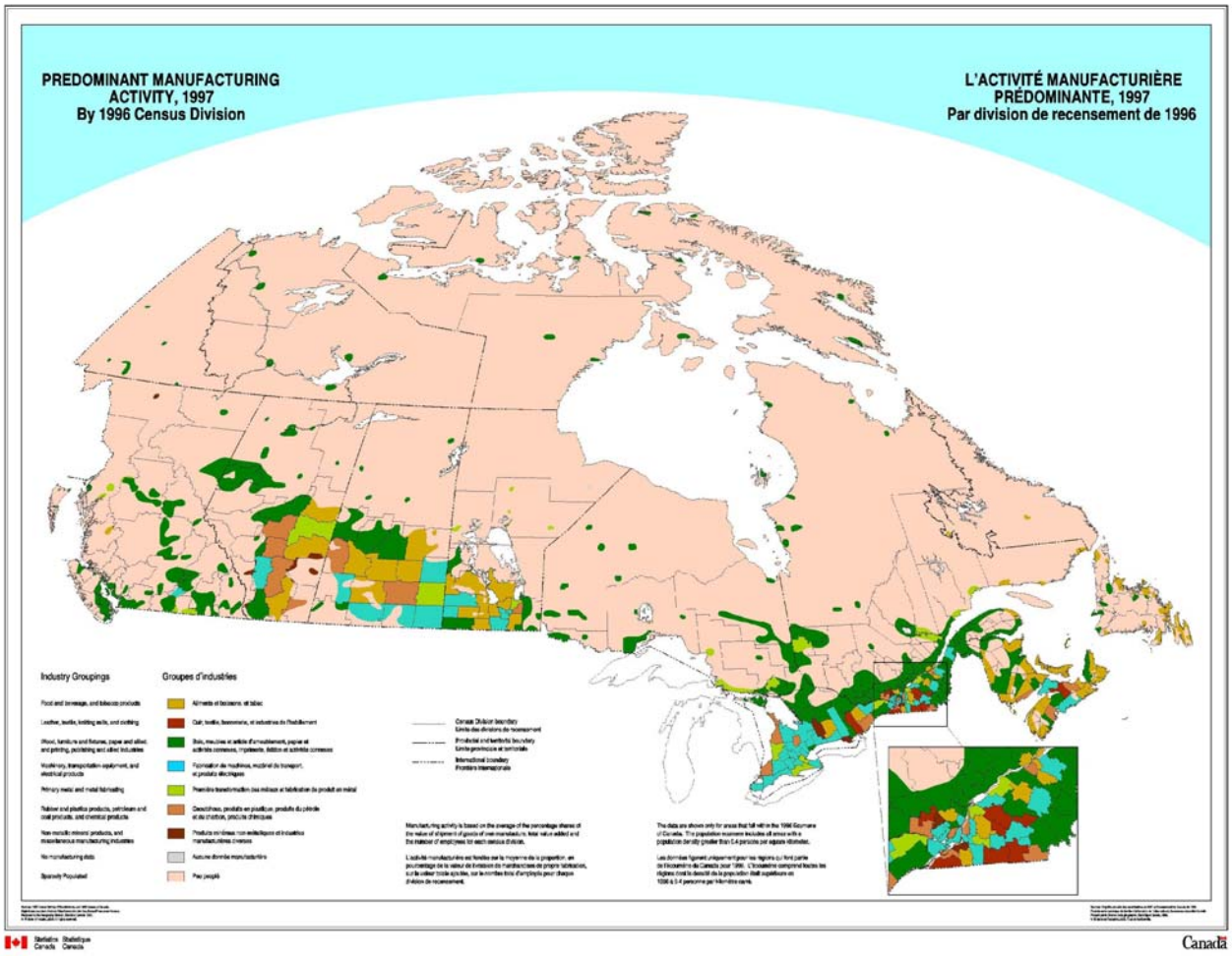
6. The population ecumene is modified slightly in Quebec for a health region that is in multiple parts (Terres-Cries-de-la-Baie-James).

Figure 3.3 Choropleth map with 2001 population ecumene (2005 health data)



Source: Statistics Canada and Canadian Institute for Health Information 2006.

Figure 3.4 Choropleth map with 1996 population ecumene (1997 Annual Survey of Manufactures data)



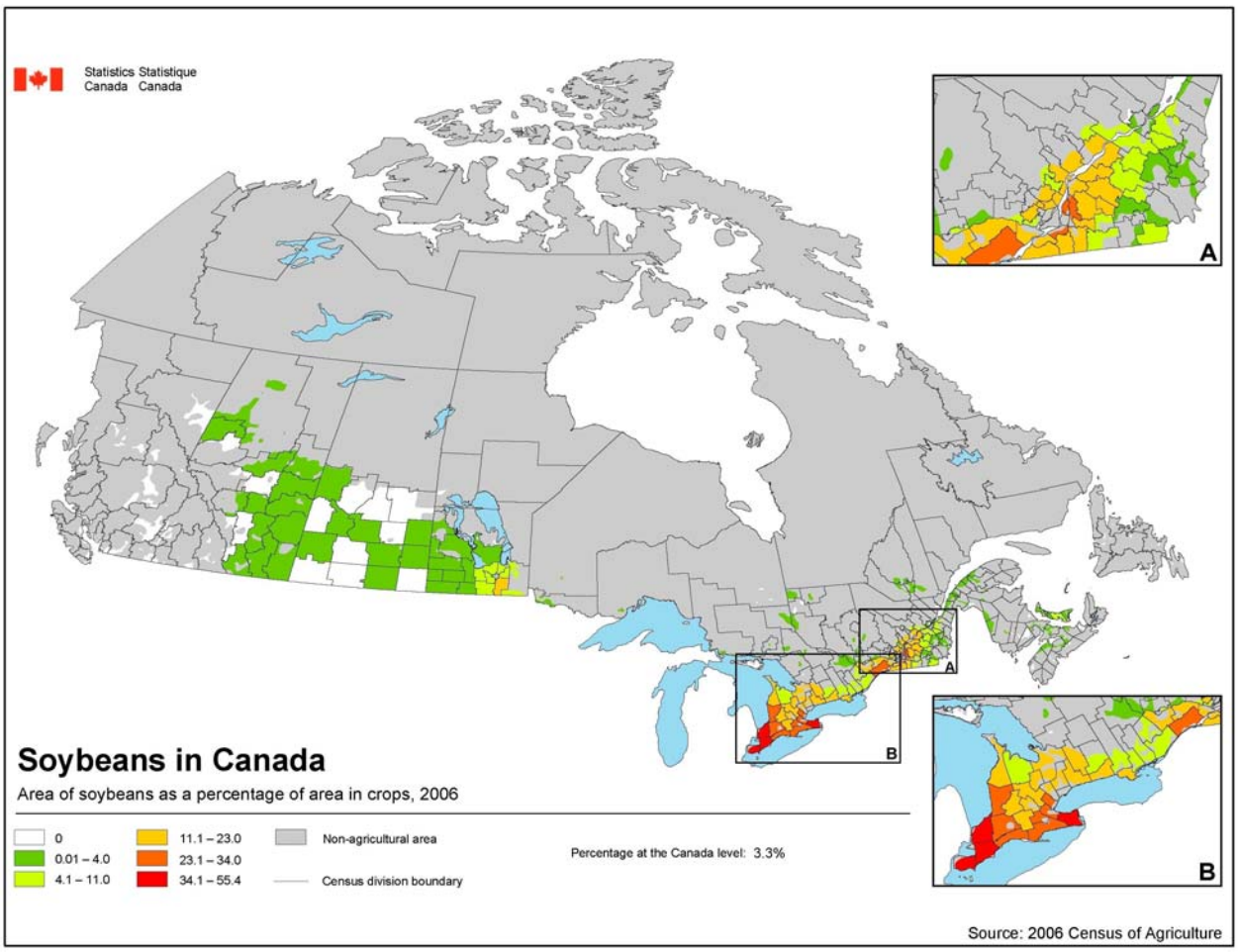
Source: Fleming and Rowell 2000.

Agricultural ecumene

Since the 1976 Census, Statistics Canada has also applied an agricultural ecumene for its thematic maps, primarily for national coverage at the census division level. For example, three atlases were produced based on the 1976, 1981 and 1986 Censuses of Agriculture (Statistics Canada 1979, 1984, 1989). Similar to the population ecumene, the agricultural ecumene restricts the data to those areas in which agricultural activity occurs – thereby reducing misinterpretation and visual bias. The atlases for the 1976 and 1986 Censuses also contain dot maps. The ecumene prevents the dots from being randomly spread over entire unit areas or in non-agricultural land.

The methodology for delineating the agricultural ecumene was refined over time. For the earlier censuses, it was created using the enumeration area as the 'building block' (Werschler 1995). By the 2001 Census the ecumene was defined using a small geographic unit, the dissemination area[7]. It includes all dissemination areas with 'significant' agricultural activity (Figures 3.5 and 3.6). Agricultural indicators, such as the ratio of agricultural land on census farms relative to total land area, and total economic value of agricultural production, are used. Regional variations are also taken into account. The ecumene is generalized for small-scale mapping[8] (Statistics Canada 2003, p. 3-4; Statistics Canada 2007b).

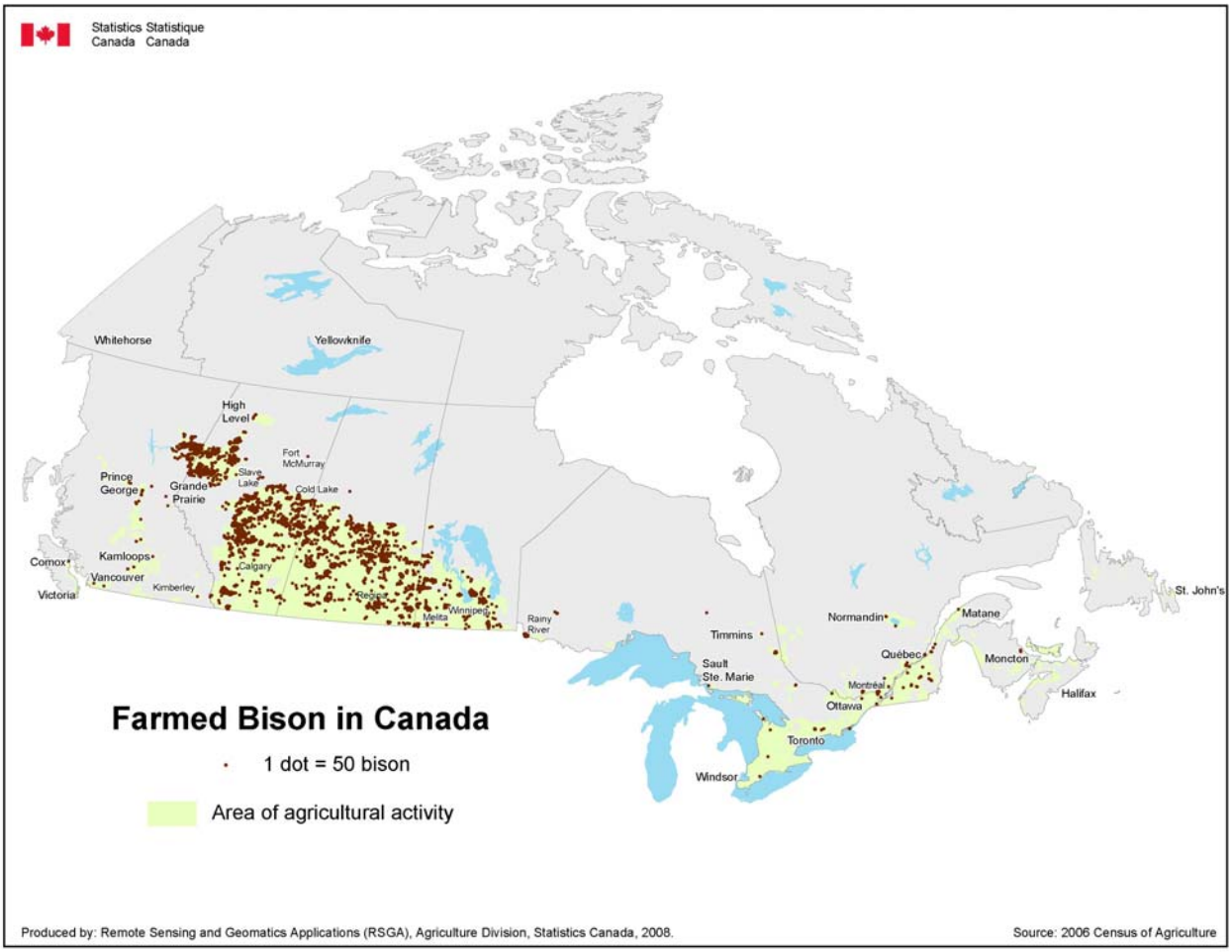
Figure 3.5 Choropleth map with 2001 agricultural ecumene (2006 Census of Agriculture data)



Source: Dorff 2007, p. 4.

7. A dissemination area (DA) is a small, relatively stable geographic unit composed of one or more adjacent dissemination blocks. It is the smallest standard geographic are for which all census data are disseminated. DAs cover all the territory of Canada (Statistics Canada 2007b).
8. The 2006 agricultural ecumene (to be released in Spring 2008) uses the same delineation criteria as the 2001 ecumene.

Figure 3.6 Dot map with 2001 agricultural ecumene (2006 Census of Agriculture data)



Source: Firmage-O'Brien 2008, p. 4.

4. Methodology

This section highlights the methodology for creating the 2006 population ecumene. Before providing the details, however, it is pertinent to relate the current methodology (which is very similar to the 2001 approach) to the geographic and cartographic issues described in Sections 2 and 3.

Three points stand out. Firstly, the ecumene concept is certainly not new, and the Geography Division is continuing a long-standing geographic tradition. Secondly, the Canadian ecumene delineated by Gajda (1960) and the settled area of Alberta defined by Kariel (1970) are quite similar to Statistics Canada's population ecumene. However, since the initial delineation of the population ecumene over 30 years ago for the 1976 Census, the vast expansion and improvements of our spatial digital database, the increased use of GIS software and the introduction of the block program for the 2001 Census all contribute to a more accurate and detailed ecumene. Thirdly, because the choropleth map has limitations, the use of a population or agricultural ecumene limits the statistical data to only where population or agriculture are found — resulting in a more accurate depiction of spatial distributions.

Overview

Spatial and attribute data from the Geography Division's Spatial Data Infrastructure (SDI)[9] is used to generate the population ecumene, namely dissemination blocks[10] as well as population counts, population density and land area of the dissemination blocks.

The population ecumene is constructed by selecting those dissemination blocks having a minimum population density of 0.4 persons per square kilometre (about one person per square mile). It is the small spatial extent of these blocks that allows an extremely detailed ecumene to be generated. The detailed ecumene limits are generalized to ensure visibility for small-scale thematic mapping. Where appropriate, edges are smoothed, small, neighbouring ecumene pockets are aggregated to form larger areas, small, isolated ecumene pockets are exaggerated in size, and extremely minute pockets are eliminated. There is at least one ecumene pocket (polygon) in every census division.

The *Population Ecumene Census Division Cartographic Boundary File, Reference Guide* includes details on the product as well as technical information for users (Statistics Canada 2007a). While Appendix 1 contains a technical description of the processing steps, the following section on generating the ecumene provides a more detailed explanation of the generalization procedures.

Ecumene creation

Using the dissemination block boundaries, every block is classified as being either an ecumene block (population density of at least 0.4 persons per square kilometre) or a non-ecumene block (population density less than 0.4 persons per square kilometre). This results in a population ecumene that is far too detailed for small-scale thematic mapping (Figure 4.1).

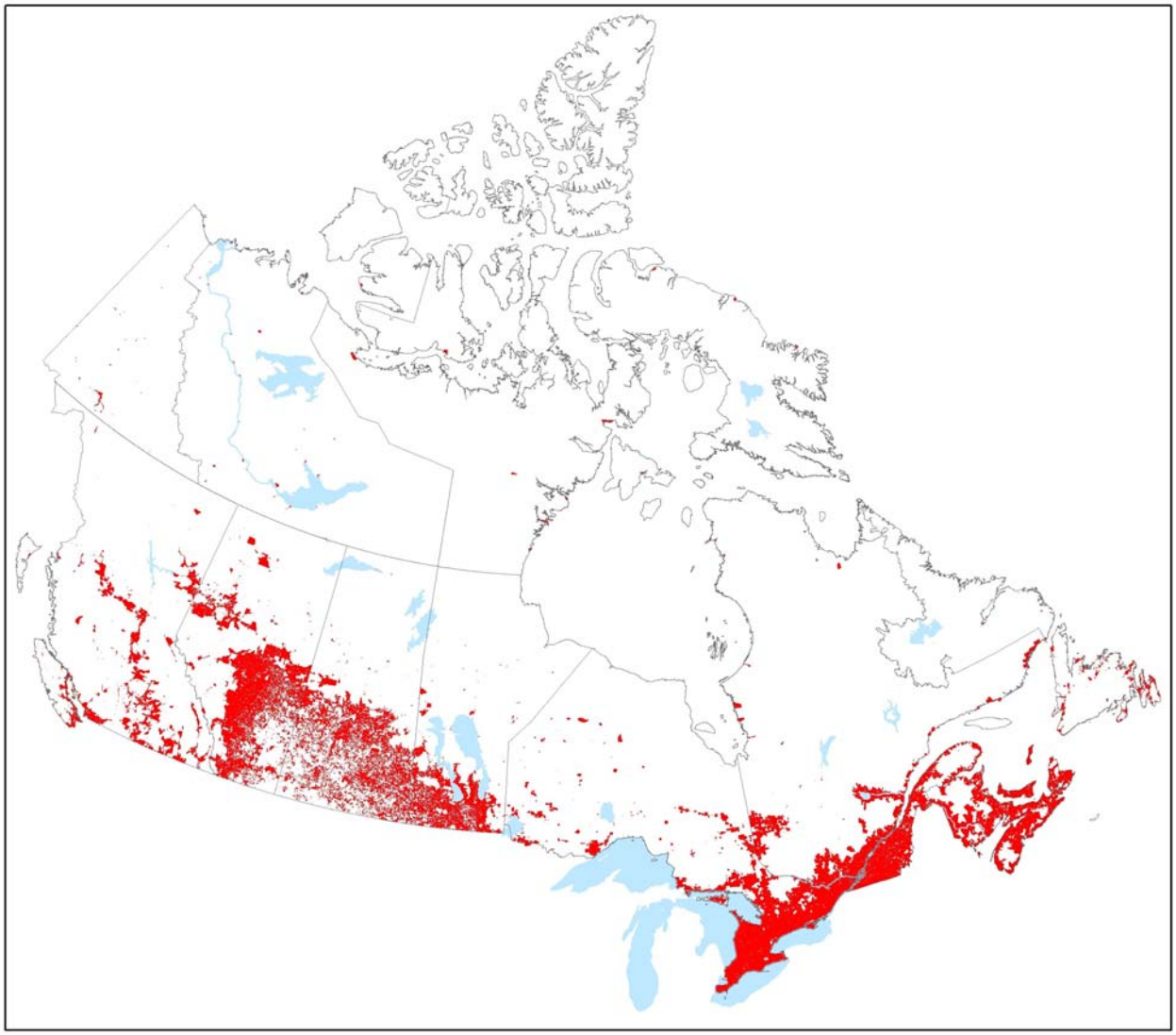
A series of generalization steps are necessary to render the ecumene more suitable for small scales. Contiguous blocks having the same classification are merged to create larger polygons. Three layers are created from this master file: the core ecumene, ecumene pockets outside the core ecumene and non-ecumene pockets inside the core ecumene.

The layer for the **core ecumene** is generated by selecting the merged dissemination blocks that are equal to or greater than 1,000 square kilometres. The size criterion assists in recognizing and detecting the large, core ecumene. Neighbouring polygons are further aggregated using the AREAAGGREGATE command. Part of the aggregation step involves converting the layer from vector to grid format according to a specified cell size and merges polygons based on a given distance between polygons. In all cases, this distance must be greater than the cell size[11]. The polygons are assigned a minimum cell size of 4,000 square metres and a distance between cells is set at 4,001 metres. Polygons less than 4,000 square metres are eliminated, resulting in a less complex pattern.

Unnecessary detail is removed using line smoothing (Environmental Systems Research Institute 1996, p. 4). The BENDSIMPLIFY option retains the essence of the original lines as opposed to the POINTREMOVE option. BENDSIMPLIFY reduces a line by detecting and removing extraneous bends from the original line, therefore preserving the main shape of the feature and cartographic quality (Environmental Systems Research Institute 2000, p. 7). The blocks are then 'cleaned' to remove any resulting slivers, buffered to 7 kilometres and the outline smoothed. Testing reveals that 7 kilometres produces the optimal generalization effect.

9. The Spatial Data Infrastructure (SDI) is an internal database containing spatial and attribute data that support a wide range of census operations. It is also the source for generating geography products for the 2006 Census (Statistics Canada 2007b).
10. A dissemination block (DB) is an area bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which population and dwelling counts are disseminated. Dissemination blocks cover all the territory of Canada. For the 2001 Census, the term 'block' was used (Statistics Canada 2007b).
11. This specification follows the recommended use of the AREAAGGREGATE command: select a cell size that will not cause features to shift too much, yet is not so small that it compromises processing time (Environmental Systems Research Institute 2000, p. 11).

Figure 4.1 Ungeneralized population ecumene



The layer for the **ecumene pockets outside the core ecumene** is generated by selecting the merged dissemination blocks that are less than 1,000 square kilometres. The size criterion assists in recognizing and detecting the ecumene pockets outside the core ecumene. The pockets are enlarged using a buffer of 5 kilometres[12]. The aggregation procedure merges groups of neighbouring pockets (Environmental Systems Research Institute 1996, p. 4) to create larger, more visible ecumene pockets that would be suitable for small-scale thematic mapping. The aggregation step is similar to that used for the core ecumene, by selecting a minimum cell size of 4,000 square metres and a distance between cells of 4,001 metres. Polygons less than 4,000 square metres are eliminated. As a result some census divisions no longer have an ecumene pocket; in these cases the pockets are reinstated. The grid layer is then converted back into a vector file.

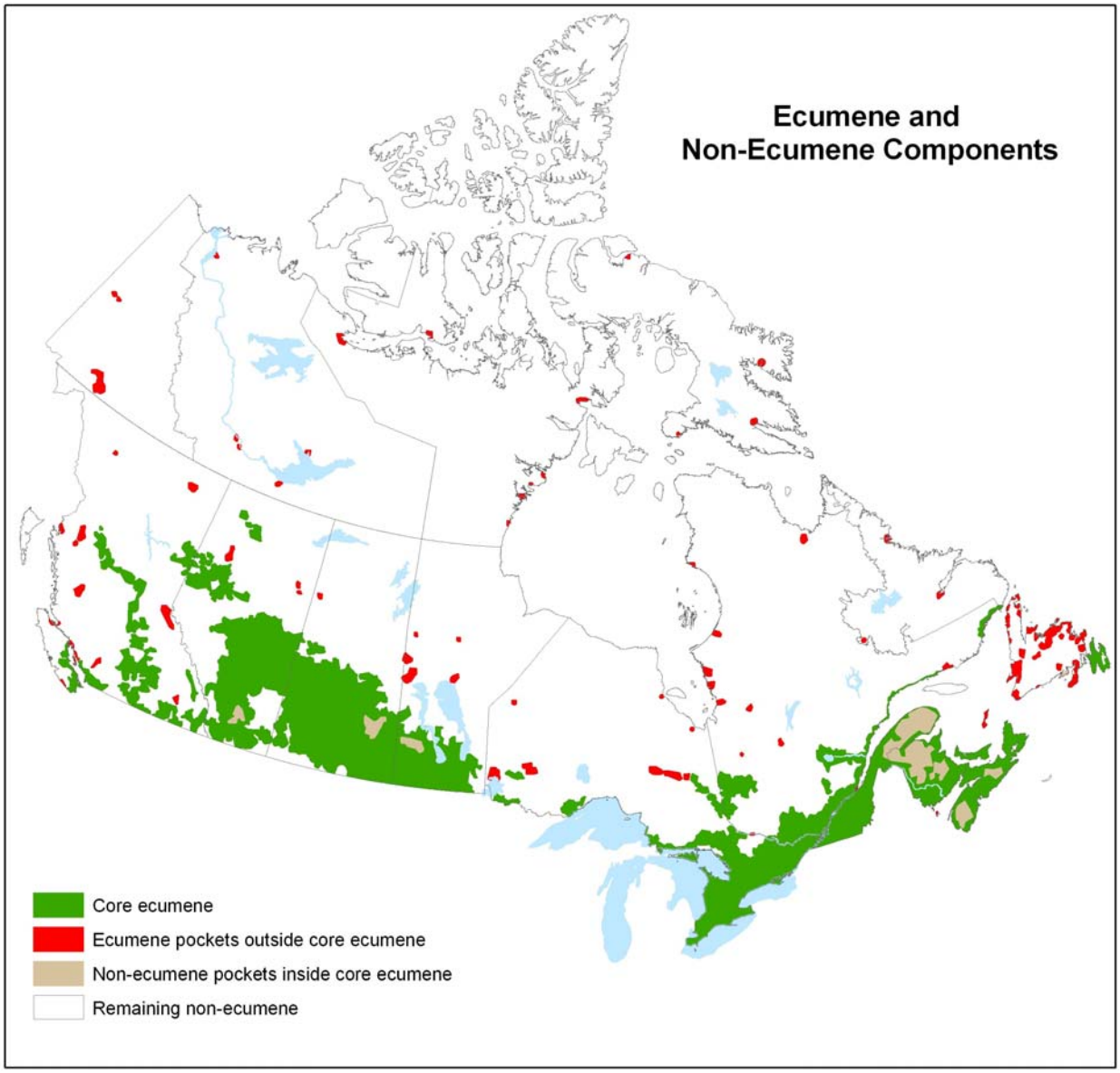
12. Selected ecumene pockets representing important northern communities (such as Inuvik, Iqaluit and Cape Dorset) are buffered to 10 kilometres so that they are visible at small scales.

The layer for the **non-ecumene pockets inside the core ecumene** is generated by selecting the merged pockets that are equal to or greater than 2,000 square kilometres. The size criterion assists in recognizing and detecting the non-ecumene pockets inside the core ecumene. The aggregation procedure is similar to that used for the core ecumene and the ecumene pockets outside the core ecumene. In this case a minimum cell size of 2,000 square metres is assigned and the distance between cells is set at 2,001 metres. The non-ecumene pockets are then buffered to 2 kilometres and smoothed.

Additional non-ecumene pockets inside the core ecumene are created when the 7 kilometre buffer is applied to the core ecumene, thereby closing off any gaps.

The three layers are merged (Figure 4.2) and the resulting single layer is visually checked. Finally, an inspection is undertaken to ensure that at least one ecumene pocket exists in every census division. The resulting output is clipped to a generalized shoreline to produce the population ecumene cartographic boundary file.

Figure 4.2 Ecumene and non-ecumene components



5. Conclusion

This working paper shows that the ecumene concept is well-established in the field of geography. It also provides an historic overview on Statistics Canada's use of the population and agricultural ecumenes since the 1976 Census. More importantly, however, it reveals that the application of an ecumene to census thematic maps can greatly reduce misunderstandings or visual bias about the spatial extent of statistical distributions.

We conclude by citing two very eloquently worded precepts, illustrating that great care is required to produce effective census thematic maps.

> "…a map is an ideal presentation device. A well designed map is convincing because it implies authenticity. People believe maps. It is this general acceptance of maps…that makes maps a powerful presentation device, but one that must be constructed and used with care." (MacEachren 1994, p. 9)

> "The census was made for mapping. It contains more spatially referenced information than any other social survey and allows yet more (geographical) information to be meaningfully mapped by providing a base against which this can be done. If we are to do justice to the representation of the people we are claiming to show, then great care is needed in the design of these images." (Dorling 1993, p. 179)

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Appendix 1. Processing steps

There are six phases for creating the ecumene, using Microsoft® Access (Version 10.0) and ESRI® ArcGIS™ (Version 9.1) software.

Phase 1. Prepare ecumene master file and attribute data

1. Import Statistics Canada's dissemination block (DB) boundary file as an ArcInfo® coverage.
2. Import the population counts and land area, and then calculate the population density – all in Access.
3. Import the output table into ArcGIS™ and add an ecumene flag. For each dissemination block, impute the flag with a Boolean value of 1 = ecumene (population density is greater than or equal to 0.4 persons per square kilometre) and set the flag value to 0 = non-ecumene for the remaining blocks (population density is less than 0.4 persons per square kilometre).
4. Merge contiguous ecumene polygons having the same Boolean value using the DISSOLVE function.

Phase 2. Create three ecumene coverages

1. Core ecumene: select the merged dissemination blocks that are equal to or greater than 1,000 square kilometres.
2. Ecumene pockets outside the core ecumene: select the merged dissemination blocks that are less than 1,000 square kilometres.
3. Non-ecumene pockets inside the core ecumene: select the merged pockets that are equal to or greater than 2,000 square kilometres.

Phase 3. Generalize the core ecumene

1. Generalization procedure: further aggregate neighbouring polygons using the AREAAGGREGATE command, selecting a minimum cell size of 4,000 square metres and a distance of 4,001 metres between cells. Then buffer to 7 kilometres. and smooth the outer edge using the GENERALIZE command, selecting the BENDSIMPLIFY option.
2. Visually inspect the output for quality. When major non-ecumene pockets are absorbed into the core ecumene, select and export the pocket in question to create a new file containing only the core ecumene. Update the ecumene flag from 1 to 0, then buffer to 2 kilometres. Smooth using the GENERALIZE command with the BENDSIMPLIFY option. A WEED tolerance of 40,000 metres is used.
3. Attributes are lost during the manipulation. To remedy this, convert the shapefile to a coverage. Using ArcGIS™ employ ADDITEM to add the ecumene field. Then utilize the CALC command in INFO to convert to ecumene = 1.
4. Visually inspect the output for quality. Small polygons which are present in the core ecumene but should be non-ecumene must be converted using the CALC command, setting the value to 0. Any small polygons and slivers with a value of 0 must be absorbed into the core ecumene.
5. Convert the coverage back to a shapefile.

Phase 4. Generalize the ecumene pockets outside the core ecumene

1. Generalization procedure A: manually remove extraneous small polygons. (This part of the procedure is not automated to ensure important communities are not removed.) Select ecumene island pockets using printed maps of the 2001 ecumene and the current core ecumene (CE), displaying the 2006 CD boundaries for reference. Due to the large number of polygons that needs to be selected, this procedure is done three times (covering different geographical areas—north, east and west). Merge the three coverages using the APPEND command.
2. Generalization procedure B: further aggregate neighbouring polygons using the AREAAGGREGATE command, selecting a minimum cell size of 4,000 square metres and a distance of 4,001 metres between cells.
3. Select coastal polygons which are to be clipped by the shoreline, and BUFFER them by 5 kilometres.
4. Visually inspect the output for quality. Put back any small polygons that are dropped during the AREAAGGREGATE procedure by selecting the missing polygons.
5. Convert the coverage back to a shapefile.

Phase 5. Generalize the non-ecumene pockets inside the core ecumene

1. Generalization procedure: further aggregate neighbouring polygons using the AREAAGGREGATE command, selecting a minimum cell size of 2,000 square metres and a distance of 2,001 metres between cells.
2. Exaggerate the non-ecumene pockets using BUFFER to 2 kilometres. Smooth the outline using the BENDSIMPLIFY option of the GENERALIZE command.
3. Convert the coverage back to a shapefile.

Phase 6. Assemble final ecumene

1. Integrate the final three layers to produce the final product with a two-step process. Use IDENTITY to merge the core ecumene and the ecumene pockets outside the core ecumene. Use IDENTITY to insert the non-ecumene pockets inside the core ecumene.
2. CLEAN and BUILD the resulting shapefile.