EVALUATION OF THE POTENTIAL HOUSING DEMAND PROJECTION MODEL: POPULATION PROJECTION COMPONENT

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DISCLAIMER

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ABSTRACT

This report evaluates the CMHC Potential Housing Demand (PHD) Projection Model, with a particular focus on the initial segment of the model which is used to generate population projections on a yearly basis for a 25-year period. Subsequent segments of the model convert the projected population values into forecasted housing demand. Potential refinements to the population projection methodology are suggested, as well as a number of additions to the associated output tables. The principal recommendations include: 1) the incorporation of a mechanism to allow for user-scheduled changes in fertility rates during the course of the projection; 2) the inclusion of a life table subprogram in the model that would generate survival ratios and associated measures of life expectancy from projected age-specific mortality rate files as an optional substitute for the existing system of projected survival ratio files that cannot be altered in any meaningful way by the user; and 3) the use of age-specific migration rates per unit of the population as an optional substitute for constant age-sex distributions of in- and out-migrants. The merits of these proposals and methods of implementation are discussed. Proposed additions to the output tables are designed to provide the user with a clearer understanding of the demographic processes, particularly those involving age structure change, that contribute to the projection results.

EXECUTIVE SUMMARY

This study evaluates the CMHC Potential Housing Demand (PHD) Projection Model, with a particular focus on the first segment of the model which is used to generate population projections. Subsequent segments of the model estimate the growth in housing demand from the projected population figures. The model is designed for use on DOS-based personal computers and is used to forecast housing demand over a 25-year period for Canada, the provinces, and lower-order areal units such as urban centres. The objective is to assess the strengths and weaknesses of the existing model and, where appropriate, to recommend ways in which the population projection methodology could be further refined. Potential modifications to the output tables which can be viewed on-screen or printed are also to be considered.

The existing PHD model was found to have many admirable features. It executes rapidly and is easy to use. Extensive back-up support from the Research Division of CMHC in the form of ready-made data files, that are periodically updated, greatly reduces the demands placed on users to acquire and manually enter the voluminous data that are needed to run the program. The methodology employed in the population projections is also essentially sound. However, there are ways in which the methodology could be further refined to enhance it on theoretical grounds and to make the model even more versatile. Additions to the output tables would also help the user to understand more clearly the demographic changes, particularly those associated with age structure, which affect the projection results.

The report examines the treatment of each of the three demographic variables, fertility, mortality, and migration, that enter into the population projections. Problems are assessed and, where relevant, potential changes in methodology are recommended. The principal recommendations are summarized below.

<u>Fertility</u>

The model should be restructured to permit user-scheduled changes in fertility rates during the course of the 25-year projection. Although the direct impact on the calculation of

projected housing demand would not be great, several reasons are offered in support of this recommendation.

Mortality

Although changes to the existing treatment of mortality could not be expected to alter, in a major way, the projection results, there is scope on theoretical grounds for a number of improvements in the way this variable is handled. Projected survival ratios for single year age-sex groups for each year in the 25-year sequence, produced by the Demography Division of Statistics Canada, are provided in ready-made data files for Canada and each province. Problems relating to the derivation of these survival ratios and the extent to which they reliably equate with projected changes in life expectancy are discussed in the report. These problems may be rectified by methodological changes currently being considered by the Demography Division of Statistics Canada. However, as long as data inputs are in the form of survival ratios, the option afforded the user of modifying the ready-made data sets is not a viable one. Users would have no way of meaningfully adjusting provincial survival ratios to allow for estimated deviations in the age-specific mortality rates of lower-order areal units. Nor could the impact on life expectancy of any adjustments to the survival ratios be assessed. The solution would be to employ age-specific mortality rates as data inputs and to incorporate within the PHD model a subprogram to generate life tables and associated survival ratios, as well as the accompanying measures of male and female life expectancy. Various aspects of this problem and the potential solution are discussed in the report.

Migration

The existing method of handling the migration variable in the PHD model, based on annual in- and out-migrant totals supplied by the user and the application of constant in- and out-migrant age-sex distributions supplied with the model for a variety of areal units, has much to commend it in relation to alternative procedures. The possibility of employing net migrants as data inputs is explored and rejected as a viable alternative. It is recommended that the existing procedures be retained. However, it is suggested that the user might also be given the option of having annual in- and out-migrant totals and their age-sex distribution derived through the use of age-sex specific migration rates. Under this procedure the total number of in-, out-, and net migrants, and their associated age structure, would adjust to changes in the total size and age structure of the population of the study area. A third option combining the two approaches, with the user scheduling the total number of in- and out-migrants but with the age distribution based on calculations employing migration rates, might also be considered. The merits and implications of the alternative ways of handling the migration variable are discussed in the report.

Output Tables

Suggested additions to the output tables associated with the population projections include: 1) a summary tabulation of changes in the percentage distribution of the projected population by aggregated age group; 2) a summary migration table displaying changes in the percentage composition of migrants by aggregated age group; and 3) a summary table showing the reproductive and migration components of population growth in the form of rates per unit of population. Other summary measures that should be incorporated in the output tables include male and female life expectancy and the total fertility rate. It is also suggested that at least some percentage distributions be incorporated in the output tables in the Household and Demand components of the model.

RÉSUMÉ

L'objet de la présente étude est d'évaluer le Modèle de projection de la demande éventuelle de logements (PHD) de la SCHL. L'accent est mis sur le premier segment du modèle qui sert à générer des projections démographiques. Les autres segments utilisent ces projections pour l'estimation du taux de croissance de la demande de logements. Le modèle, conçu pour tourner sur un ordinateur personnel utilisant DOS, sert à projeter la demande de logements sur une période de vingt-cinq ans pour le Canada, les provinces et, à une échelle géographique moins grande, des agglomérations comme les centres urbains. L'objectif est d'évaluer les forces et les faiblesses du modèle actuel et, au besoin, de suggérer des façons de perfectionner les méthodes de projection démographique. Il faudra également tenir compte des modifications potentielles des tableaux de résultats que l'on peut visualiser à l'écran et imprimer.

Le modèle PHD actuel possède d'excellentes fonctions. Il est rapide et facile à utiliser. Le service de soutien élaboré fourni par la Division de la recherche de la SCHL, sous forme de fichiers de données prêts à l'emploi et périodiquement mis à jour, réduit de beaucoup le travail que doivent accomplir les utilisateurs pour se procurer et entrer manuellement les données volumineuses nécessaires à l'exécution du programme. Les méthodes de projection de la population sont essentiellement bonnes. Cependant, il existe des moyens de les perfectionner et d'accroître leur valeur théorique, et ainsi rendre le modèle beaucoup plus souple. Des ajouts aux tableaux de résultats aideraient les utilisateurs à mieux comprendre les changements démographiques, surtout ceux relatifs à la structure par âge qui influent sur les résultats des projections.

Le rapport examine le traitement de chacune des trois variables démographiques, la fécondité, la mortalité et la migration, qui entrent dans les projections de la population. Après l'évaluation des difficultés, des modifications pertinentes aux méthodes sont proposées. Voici donc les principales recommandations :

Fécondité

Le modèle devrait être restructuré afin de permettre aux utilisateurs de modifier les taux de fécondité prévus pour les projections couvrant la période de vingt-cinq ans. Même si les effets directs sur le calcul de projection de la demande de logements seraient minimes, plusieurs raisons sont présentées à l'appui de cette recommandation.

Mortalité

Bien que l'on ne s'attende pas à ce que les modifications apportées au traitement actuel des taux de mortalité puissent changer de manière significative les résultats des projections, il y a théoriquement place à l'amélioration dans le traitement de cette variable. Les proportions projetées de survie des groupes d'âge-sexe pour chacune des vingt-cinq années sont produites par la Division de la démographie de Statistique Canada, et fournies sous forme de fichiers prêts à l'emploi pour le Canada et chaque province. Les difficultés rattachées au calcul de ces proportions de survie, ainsi qu'à leur degré de fiabilité dans la comparaison aux changements projetés de l'espérance de vie sont traités dans ce rapport. Il est possible de résoudre ces difficultés à l'aide des changements aux méthodes actuellement envisagés par la Division de la démographie de Statistique Canada. Cependant, aussi longtemps que les données d'entrée seront sous forme de proportions de survie, l'option que possède l'utilisateur de modifier les fichiers prêts à l'emploi n'est pas viable. Les utilisateurs n'auraient aucun moyen de modifier, de manière significative, les proportions de survie provinciales pour tenir compte des écarts estimés du taux de mortalité par âge précis des plus petites agglomérations, pas plus qu'il ne serait possible d'évaluer l'effet de la modification des proportions de survie sur l'espérance de vie. La solution serait de se servir des taux de mortalité par âge comme données d'entrée et d'incorporer un sous-programme au modèle PHD afin d'obtenir des tables de mortalité et les proportions de survie qui s'y rapportent, ainsi que les mesures de l'espérance de vie des hommes et des femmes. Ce rapport traite des divers aspects du problème et de sa solution possible.

Migration

La méthode actuelle de traitement de la migration à l'aide du modèle PHD se base sur les totaux annuels d'entrants et de sortants fournis par l'utilisateur, et sur l'application des données relatives aux entrants et sortants par âge-sexe fournies avec le modèle pour divers logements situés dans de plus petites agglomérations. Par rapport à d'autres méthodes utilisant des procédures différentes, la méthode actuelle a beaucoup d'avantages. La possibilité de se servir de migrants nets comme données d'entrée a été examinée et rejetée. Il est donc recommandé de conserver les procédures actuelles. Toutefois, on laisse à l'utilisateur le choix de se servir des totaux annuels d'entrants et de sortants de même que des données réparties par âge-sexe recueillies à l'aide des taux de migration précis par âge-sexe. L'utilisation de cette procédure fait en sorte que le nombre total d'entrants, de sortants et de migrants nets, ainsi que la structure par âge qui s'y rapporte, s'ajusteraient aux changements de taille et de structure par âge de la population de la région à l'étude. On pourrait également étudier une troisième option regroupant les deux procédures. Elle permettrait à l'utilisateur de programmer le total d'entrants et de sortants avec cette fois une répartition par âge basée sur des calculs utilisant les taux de migration. Les avantages et les implications des solutions de rechange dans le traitement des variables de la migration sont présentées dans le rapport.

Tableaux de résultats

Les suggestions d'ajouts aux tableaux de résultats associés aux projections de la population comprennent : 1) une classification sommaire des changements du pourcentage de répartition de la population par groupes d'âge agrégés; 2) un tableau sommaire de la migration affichant les changements du pourcentage de la composition des migrants par groupes d'âge agrégés; et 3) un tableau sommaire des composantes de la procréation et de la migration relatives à l'accroissement de la population, lesquelles sont présentées sous forme de taux par unité de population. D'autres mesures sommaires qui devraient s'ajouter aux tableaux de résultats comprennent les taux d'espérance de vie pour hommes et femmes ainsi que les taux de fécondité. On suggère aussi d'incorporer quelques pourcentages de répartition aux tableaux de résultats des composantes Ménages et Demande du modèle.

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INTRODUCTION

The objective in this study is to evaluate the CMHC Potential Housing Demand (PHD) Projection Model, with a particular focus on the first segment of the model which is used to generate population projections. The following two segments of the model (Household and Demand components) convert the projected population into households employing age-specific headship rates and the households into housing demand, broken down by tenure and dwelling type. The model is designed to run on DOS-based personal computers.

The projections in the PHD model extend over a 25-year period and are based on one-year projection intervals. Since the model is designed to generate forecasts for each year in the 25-year progression, the population projections require the use of single year age-sex groups. The projected population figures are subsequently aggregated into 5-year and broader age categories for use in the Household and Housing Demand components of the model.

The terms of reference for this study include both an appraisal of the demographic methodology used in the PHD model population projections and a supplementary evaluation of the output tables which can be viewed on-screen and/or printed by the user. Strengths and weaknesses of the model are to be assessed. Where appropriate, suggestions are to be made regarding ways in which the existing model could be enhanced.

This report is divided into four sections. The first three sections deal in turn with the methodological treatment of the three demographic variables, fertility, mortality, and migration, that enter into the population projections. The final section discusses potential additions to the output tables. Two statistical appendices contain summary tables produced and employed in the evaluation of the fertility and migration variables.

The existing PHD model has been designed to minimize data inputs required of the user. An extensive array of ready-made data files has been prepared by the Research Division of CMHC and is supplied with the model. These files include: starting populations by one-year age-sex group for Canada, each of the provinces, and census metropolitan areas (CMAs); projected annual mortality levels (in the form of survival ratios) for single year age-sex groups for Canada and each of the provinces; the most up-to-date age-specific fertility rates available for Canada, the provinces, and CMAs; the proportional distribution of in- and out-migrants by one-year age-sex group for Canada, individual provinces and CMAs based on averages for a series of recent years; and age-specific propensities for a series of recent census years for households by type and the composition of dwelling units by tenure and type based on the household distributions. These files are periodically updated by the Research Division of CMHC. Users are therefore spared a great deal of effort in the acquisition of relevant information for use in the model and in the manual preparation of the data files that are used to run the model. If it were not for this extensive support from the Research Division of CMHC, a simpler type of data input would be preferable in the population projection component of the model. For example, user-supplied data files for the starting population, migrant age-sex distributions, and mortality levels could be based on 5-year, or even more aggregated, age-sex groups and mortality levels could be supplied in the data files for only the initial and terminal years. Mechanisms could be incorporated in the model to apportion the 5-year age-sex group data by single years of age and to interpolate mortality levels on an annual basis between the initial and terminal years. Suggestions of this sort to simplify the data inputs required of the user (with some associated loss of precision in the projections) have not been incorporated in the evaluation which follows. It has been assumed that the Research Division of CMHC will be prepared in the future to provide the same kind of back-up support in the preparation of data files that it does at present.

As a preface to the evaluation of methodology and output tables in this report, it should be noted that in the opinion of this reviewer the existing PHD model, including the population projection component, is basically sound and incorporates many admirable features. It executes rapidly and is easy to use. The recommendations which follow relating to possible further refinements to the model should be viewed in the light of this general assessment of the model as it is currently structured.

Suggested additions to the output tables are intended to provide the user with more insight into the demographic processes, such as age structure change, that contribute to the projection results. The modifications proposed in methodology would enhance the model on theoretical grounds and would add further to its versatility. However, it is unlikely that the methodological refinements would yield end results in the calculation of housing demand greatly different from those obtained with the present model. It is expected that decisions made by the user with respect to in- and out-migration levels or changes that a user might make to the base year rates in the Household and Demand components of the model would continue to have the most decisive effect on the results obtained in any given run of the model.

FERTILITY

In the PHD model, as it is currently structured, age-specific fertility rates (ASFR) for the seven female 5-year age groups 15-19 to 45-49 are held constant at the starting level throughout the 25 year projection. The particular set of ASFR selected for the projection has no impact on the projected number of households and dwelling units during the first 15 years of the projection. The same would be true if the model was restructured to permit the user to schedule changes in the ASFR during the 25 year period. It is only in the final 10 years of a 25 year period that those born during the first 10 years move progressively into the 15-19 and 20-24 age groups and begin to affect the total number of projected households. Nor is there any built-in mechanism in the model to adjust the proportional split of households into those with children versus those without, or the division of dwelling units between houses and apartments, as changes occur in the ratio of children to adults and in average household size. Any adjustments of this sort to the household and housing type propensities are left to the discretion of the user. Changes in the age composition of the population, including the ratio of children to adults, can of course be expected during a 25 year projection even when fertility rates are held constant at the starting level. The age structure of the population at the outset of any projection is a reflection not of the current fertility and mortality rates but of those which prevailed in previous time periods extending back many decades.

To assess the impact of different starting fertility rates on projected households and housing demand a set of five projection runs was made for the Toronto CMA, with all variables held constant between the variants except the ASFR. The base projection (Variant 1) employed the 1988 Toronto ASFR contained in the file FERT88TO.CSV. The 1988 ASFR constitute a Total Fertility Rate (TFR) of 1638 per 1000 females, well below the current replacement TFR of approximately 2080. With a TFR below the replacement rate, the natural increase rate (NIR), representing births minus deaths per 1000 population, will eventually become negative, but not within the span of a projection that extends only to the year 2011. In the base projection, with a TFR of 1638, the NIR dropped from about 9 per 1000 in 1989-90 to just under 4 per 1000 in 2011. The allowance for an annual net migration gain of 30,000 in the projections, with a strong weighting of young adults, slows down the rate of decline in the NIR relative to what would be experienced with no migration allowance. The other four projections (Variants 2-5) employed TFRs of 1600, 1800, 2000, and 2200 respectively. All variants started with the same base population of about 3.67 million in 1989. The results of the five fertility projection variants are summarized in Tables A1 and A2 of Appendix A.

The population growth of almost 1.7 million during the 22 year period 1989-2011 in Variant 5 (with a TFR of 2200) exceeded the growth in Variants 1 and 2 (with TFRs of 1638 and 1600 respectively) by more than 400,000 or over 33 percent. As expected, however, all of the difference in growth was concentrated in the cohorts below 25 years of age (see Table A1). Table A2 demonstrates that the major differences in population growth between the fertility variants had virtually no impact on the projected growth in the number of households and associated dwelling units. The 22 year growth in projected households and dwelling units of about 639,000 in Variant 5 exceeded the projected numbers in the lowest fertility variants by only about 7000 or 1 percent. No difference in projected household numbers would occur until after the fifteenth year. Although projected average household size was greater with higher fertility rates, there was at most a minuscule difference between the variants by 2011 in the proportional breakdown of the total households and dwelling units by type. Although the difference was minuscule, it was also somewhat irrational in terms of what one might expect with more children and increased household size (i.e. an expectation of more couples with children and increased demand for houses versus apartments). The high fertility variants substantially increased the number of children in the population, but because the increased growth in households was concentrated in the 15-24 age groups it reduced (albeit very slightly) rather than increased the projected ratio of families with children to those with no children and the ratio of houses to apartments. There is some logic in this outcome stemmimg from the higher proportion of very young adults, but there is no counterbalancing recognition of the fact that with higher fertility fewer couples would be childless and that larger families would affect the relative attractiveness of houses versus apartment dwelling units.

It should be noted that if the model had allowed for a test run in which the TFR was gradually increased throughout the 22 year period to the 2200 level, rather than being set at this constant level in the starting year (1989) as in Variant 5, the impact on projected housing demand would be even less than what was described for Variant 5 above.

Recommendations

1. Despite the very minor impact that variations in fertility have on the calculation of projected housing demand in the PHD model, it is strongly recommended that the model be restructured to permit the user to schedule anticipated changes in fertility during the course of the projection. Four reasons for this recommendation are given below:
   (a) From a programming standpoint it would be a relatively simple addition that would need to be made to the model and one that would not significantly increase the time required for the program to execute.
   (b) It would be an important refinement to the model in terms of general population projection methodology.
   (c) For uses other than projecting housing demand, it would greatly increase the attractiveness and versatility of the Population Projection component of the model. In particular, the model would be an excellent one for projecting student enrolment by one-year age group at the pre-kindergarten, primary, secondary, and post-secondary school levels. CMHC might even want to consider spinning off the Population Projection component as a separate

program that could be marketed to school boards and other educational planners.

(d) Changes in the proportion of children and average household size, resulting from scheduled fertility changes, could be noted by a user in an initial test run of the model. Some users might wish to make use of this information in deciding on what adjustments, if any, might be appropriate to the family and dwelling type propensities in a subsequent set of projections.

2. It is recommended that no attempt be made to build into the model automatic adjustments to family type and dwelling type propensities in response to changes in the proportion of children in the population and associated average household size (discussed in 1(d) above). To derive a reliable set of adjustment factors, appropriate to all types of study areas, would be a formidable and probably hopeless task. It would seem more appropriate to leave any minor adjustments of this sort to the individual user, based on his/her evaluation of past trends in the family and dwelling type propensities in the given study area in relation to trends in the TFR and average household size. For this reason, it would be useful to incorporate the Average Household Size measure in the data files of historical propensities for the family and dwelling type variables.

   Although restructuring of the model to make built-in adjustments to family and dwelling type propensities in response to changes in average household size is <u>not</u> recommended, it might still be useful to carry out some background research on the issue. It might bring to light information that would enhance the type of advice which CMHC could offer to users. One avenue of research would be to use the Census Public Use Sample Tapes of individual families for each province and major CMA to determine dwelling type propensities for families with varying numbers of children, with a further breakdown by age of household head.

3. Regardless of whether the Population Projection model is revised to permit user-scheduled changes in fertility, the fertility

data files and screen display of the age-specific fertility rates should also include the TFR (i.e. the sum of the seven ASFR for the 5-year age groups 15-19 to 45-49 multiplied by 5, the number of years in each age cohort). With the TFR as a summary measure, the user could more readily assess past trends and how the level of fertility in the study area compares with other areal units. The TFR is most frequently expressed per 1000 females, but it could be left as a rate per female as long as it was carried to at least three decimal digits.

4. In the calculation of the number of births for each 12 month period, running from the middle of one year to the middle of the next, the ASFR in the existing model are multiplied by the population in each of the female 5-year age groups 15-19 to 45-49 at the beginning of the 12 month period. It would be preferable, from a theoretical standpoint, to use an average of the number of females in the 5-year age group at the beginning and end of the 12 month period, even though the impact on the total number of births calculated would be quite minor.

Suggested Methodology for Permitting a User to Schedule Changes in Fertility Throughout the Projection

Changes in fertility could be effected by letting the user schedule changes in the TFR for selected years, with values for intervening years interpolated using the same procedures currently employed for other variables (e.g. total annual migration). The seven age-specific fertility rates (ASFR) for each projection year would be derived in the following manner. Let the ASFR for the most recent year in the data file serve as a Standard set of ASFR, and the TFR calculated from these ASFR as a Standard TFR. For any given projection year the projected ASFR for each age group would be calculated by multiplying the Standard ASFR by the Projected TFR divided by the Standard TFR. Table A3 in Appendix A shows a sample calculation. The simplifying assumption here is that the relative profile or percentage distribution of ASFR amongst the seven 5-year age groups remains constant. Table A4 in Appendix A, using the national and Quebec ASFR as examples, shows that there was negligible change in this percentage distribution over the 5 years 1986-1990. The very slight shift towards a higher weighting for rates in the 30-34 and 35-39 age groups, associated with the postponement of child-bearing to a later age, would have a negligible impact on the birth estimating procedure, particularly compared to the impact of potential scheduled changes in the TFR as a whole. With the recent tendency for fertility rates to edge upwards again, it is also reasonable to suspect that the trend towards postponing child-bearing to a later age may have largely run its course.

MORTALITY

The PHD model currently uses life table survival ratios for single-year age-sex groups to age the population as it is projected forward in time. Projected annual changes in survival ratios, estimated by the Demography Division of Statistics Canada (for use in their own population projections), are supplied in data files for each province and Canada as a whole to allow for anticipated declines in mortality rates over time. The user is given the opportunity to modify the survival ratios if he/she so chooses.

The use of life table survival ratios to shift the population forward in time is a sound procedure in terms of demographic methodology. However, there are a number of questionable features associated with the projected sets of survival ratios currently supplied with the model. And the option of modifying the projected survival ratios, intended to add versatility to the model, is a feature which no user could meaningfully employ.

The essential issue to be addressed in evaluating the treatment of the mortality variable in the PHD model is whether the model should continue to use survival ratios as inputs or whether the inputs should be in the form of age-specific mortality rates, with a life table subprogram incorporated in the model to convert the mortality rates into survival ratios.

In the discussion which follows, it is assumed that CMHC will continue to rely on the Demography Division of Statistics Canada for projected sets of mortality probabilities for Canada and the provinces, either in the form of survival ratios or in the form of age-sex specific mortality rates. Extrapolation of trends in mortality for single-year age-sex groups is not an exacting type of operation, given the irregularities in past trends between age groups, sexes, and time periods and the problem of choosing between linear and exponential extension of the trends. Voluminous amounts of data have to be manipulated in the estimation procedure. It would be something that would be best left to the expertise in mortality projections which has been developed within the Demography Division of Statistics Canada.

In the past there would have been little possibility of using projected mortality rates in the PHD model, since the mortality projections carried out by the Demography Division did not yield a set of extrapolated mortality rates, only survival ratios. Although the method of estimating these survival ratios has been innovative, it has in my opinion a number of drawbacks. It would appear that the Demography Division shares similar concerns to my own with the methodology which they have employed in the past. They have indicated that they intend to shift to a new procedure for use in their population projections that employ 1991 as a base year. The population projections using 1990 as a starting year will continue to use survival ratios derived with the old estimation procedure. Under the planned new procedure, it should be possible to obtain projected mortality probabilities from the Demography Division in the form of either survival ratios or age-specific mortality rates. The old and new procedures are briefly described below.

<u>Past Procedure for Deriving Projected Survival Ratios</u>

The projected survival ratios currently employed in the PHD model were derived in the following manner. Past trends in life expectancy at birth were first used to estimate future life expectancy at birth for males and females at 5-year intervals through to the year 2011. Survival ratios for single-year age-sex groups were then estimated from the projected life expectancies in a rather indirect way, by making adjustments to the age distribution of the stationary population in the L column of the base year life table. Survival ratios were subsequently calculated from these estimated age distributions. Interpolation was used to obtain survival ratios for the intervening years between the 5-year benchmark values.

As a general principle, as life expectancy increases the age structure of a life table stationary population (the L column of a life table) will change, with a higher percentage of the population falling into the older age groups. However, the precise distribution of the population by age group will depend on the variable rates of decline in mortality probabilities for all of the individual one-year age groups. Without actually producing a life table from a new set of mortality rates, the age distribution of the life table stationary population cannot be accurately determined. Two different sets of mortality rates could yield life tables with the same mean life expectancies at birth, but with somewhat different population age structures and associated survival ratios for individual age groups. Mortality declines for infants have a bigger impact on the life expectancy measure than a decline of comparable magnitude for an older age group. The procedure used by the Demography Division has been to estimate changes in the age composition of the stationary population in the L column of the life table that might be expected to occur with any given projected life expectancy at birth, using past trends in the relationship between the two variables as a guide. The problem with this approach is that if age-specific mortality rates were extrapolated forward in time and the projected rates used to produce a life table, they might yield a significantly different projected life expectancy at birth. Even if a fairly good match was obtained with the extrapolated life expectancy measure, the distribution of values in the stationary population L column and associated survival ratios could differ significantly from those which had been estimated.

In the PHD model, only the survival ratios that have been estimated by the Demography Division are incorporated in the data files and screen display. This is all that is needed to execute the projections. However, discerning users would want to know what the projected survival ratios were intended to reflect in terms of increased life expectancy over time or deviations in life expectancy of individual provinces from the national average. Adding the projected life expectancies of the Demography Division to the data files and screen display would be useful. But it would not guarantee that the displayed survival ratios and life expectancies were in close harmony with what one would expect if projected age-specific mortality rates had been used to derive these measures.

As an addendum to this discussion, it might be noted that the stationary population L values that have been estimated by the Demography Division could in theory be used to generate a set of age-specific mortality rates by working backwards from that point in the life table. First the ℓ column (number reaching the beginning of an age group) would be calculated, starting with age 1 and working upwards through the age pyramid. To determine the value for ℓ at age 1 (the number out of the original 100,000 births who survive to their first birthday) from the stationary population L value for age 0 (the number of infants less than 1 year old alive at any given point in time), one would need to know (or estimate) the Separation Factor that had been implicitly employed in the estimated L value for age 0. From this point on the calculations would be straightforward, since the L value (number alive in the age group) for one year age groups is simply assumed to be an average of the number surviving to the beginning of the age group and the beginning of the next year of age (i.e. ℓ_x and ℓ_{x+1}, where x stands for a single year age category). Since $L_x = (\ell_x + \ell_{x+1})/2$, then $\ell_{x+1} = 2L_x - \ell_x$. From the ℓ column, the deaths (D) in each age group could be derived. Finally, the mortality rates (M) for each age category could be produced using the equation $M = D/L$. These mortality rates, however, would be dependent on the estimation procedures initially used to distribute the population in the L column.

<u>Planned New Procedure for Deriving Projected Survival Ratios</u>

Under the new procedure, both life expectancy at birth and age-specific mortality rates would be extrapolated forward into the future in separate operations (presumably using, as in the past, 5-year projection intervals). Given the approximate nature of the extrapolation procedures, and the way that changes in mortality probabilities at different ages impact on the life expectancy measure, there would be little chance that the extrapolated mortality rates <u>for any given future year</u> would yield a life expectancy value identical to the life expectancy measure that had been independently extrapolated for that same year. Hopefully, major differences would not occur (i.e. differences of more than one year in mean life expectancy), since percentage increases in the aggregate measure of life expectancy at birth are of a smaller magnitude than the associated percentage declines in age-specific mortality rates. It takes a substantial difference in mortality rates to have much impact on the life expectancy measure. The present plan is to accept the life expectancy extrapolation as the most valid measure of projected mortality in the aggregate. Successive sets of the extrapolated mortality rates would then be used to produce life tables until a match could be found with the extrapolated life expectancy measure for each projection year. For example, if a life expectancy of 83 years had been extrapolated for the year 2011 and if the age-specific mortality rates extrapolated for the year 2007 were found to yield a life expectancy of 83 years when entered into the life table routine, then the 2007 mortality rates would be treated as the values for 2011. The survival ratios for 2011 would be derived from the life table constructed with the 2007 mortality rates. In this way, <u>the aggregate rate of decline in mortality</u> would be a function of the life expectancy extrapolation, but <u>the distribution of the rate of decline amongst age groups</u>, and the associated distribution of the stationary population in the L column from which the survival ratios are calculated, would be determined from the age-specific mortality rate projections. The mathematical linkage between the life expectancy measure, the age-specific mortality rates, the stationary population (L column) values and survival ratios would all be based on formal life table relationships.

The proposed new procedure seems to be a reasonable approach to a complex problem. There would also be scope for some flexibility in its application. Potentially, the extrapolated life expectancies could be re-examined, and perhaps adjusted, if they diverged too markedly from the life expectancy values produced with the extrapolated mortality rates for any given year.

For the new procedure, a computer program to generate life tables is required. A microcomputer life table program employing a LOTUS spreadsheet is being developed within the Demography Division.

Problem of Using Survival Ratios as Data Inputs in the PHD Model

The use of survival ratios as data inputs is essentially incompatible with the option that the user is given to alter the mortality probabilities in the data file. Firstly, a user would have no way of knowing how much impact a change in one or more survival ratios would have on the life expectancy measure. Secondly, unlike age-specific mortality rates, past trends in survival ratios for Canada and the provinces are not published and could not be used as a guide for any modifications that might be entertained. Thirdly, using the Indirect Standardization procedure, a user could determine how much age-specific mortality rates on the average for a subprovincial study area deviated from the mean provincial rates for each sex. This informaton could be used to make adjustments to age-specific mortality rates, but not to survival ratios. A short explanation of the Indirect Standardization procedure and how it might be employed by a user of the PHD model is included in the discussion of methodological issues at the end of the Mortality section of this report.

Merits of Using Age-Specific Mortality Rates as Data Inputs in the PHD Model

With age-specific mortality rates as the data inputs, and a built-in life table subprogram to produce survival ratios and the aggregate measure of life expectancy at birth, a user could not only alter the mortality probabilities on the basis of information on past trends or areal differences in standardized rates; one could also see in the screen display the impact of these changes on the life expectancy value. If it substantially exceeded, or fell short of, the user's expectations, the user would have the opportunity of modifying the changes which he/she had made in the mortality rates. Although the impact on projected housing demand, resulting from the use of different sets of mortality rates might be minor, the projection model would be considerably more versatile and satisfying from a demographic standpoint. Sensitivity analysis has not been used to assess the effect of varying mortality probabilities on projected housing demand, since there is no way of measuring or describing how great, in the aggregate, the differences might be between the data file sets of projected survival ratios for the individual provinces. Even if the projected life expectancies for Canada and the individual provinces were included in the PHD model data files, conclusions drawn from a sensitivity analysis using different survival ratio files would still hinge on the untestable extent to which the survival ratio sets accurately reflected the stated differences in projected life expectancy.

There are two potential problems to incorporating a life table subprogram in the PHD model. Firstly, it could slow down the execution of the program, though by how much is difficult to forecast. Some suggestions as to how this problem might be minimized are included in the recommendations which follow. Secondly, the use of age-specific mortality rates as inputs, with an associated life table routine, would represent a major modification, requiring considerable new programming.

<u>Recommendations</u>

1. Even if the model continues to use survival ratios as basic data inputs, it is suggested that the associated measures of life expectancy at birth for each sex be included in the data files and screen display. As an alternative to adding life expectancy to the screen displays of annual projected survival ratios, a separate summary display of the projected life expectancy measure could be designed with values at 5-year intervals (census years).
2. Although the projected survival ratios for Canada and the provinces that will be produced by the Demography Division using its planned new methodology would be more reliable than anything that a user of the PHD model could be expected to estimate, these mortality probabilities might not be the most appropriate ones for a subprovincial study area. The population projection component of the model would be more sophisticated and flexible if it incorporated a life table and used age-specific mortality rates as the data inputs. I would therefore suggest that it be

modified along these lines. To ensure consistency of results, I would also recommend that the life table program be identical in its mathematical formulas to the one that is being developed by the Demography Division of Statistics Canada for its own use. For any given set of mortality rates, life tables can vary slightly depending on the type of mathematical smoothing operations applied to the mortality probabilities of the older age groups and the separation factor used to estimate the number of infants less than 1 year old in the stationary population L column. The cooperation of the Demography Division would be needed not only in making its program available for use in the CMHC Housing Projection model; the program would also have to be converted from a set of Lotus formulas into a microcomputer program in the C language. The programmer for the PHD model, who would not be familiar with the intricacies of life table methodology, would require assistance from the individuals in the Demography Division who had designed the LOTUS program. The program in the C language would need to be thoroughly tested with a number of mortality rate sets to ensure that it produced life tables with survival ratios and mean life expectancy measures identical to those derived with the original LOTUS program.

As an alternative, the mainframe computer program used by the Canadian Centre for Health Information, Statistics Canada for the production of national and provincial life tables could be used as a model for conversion into a C language microcomputer program. However, it would be better to employ the same program that the Demography Division will be using to generate survival ratios and life expectancy values from its projected mortality rates to ensure compatibility between mortality measures generated in the PHD model and any data file inputs acquired from the Demography Division.

3. With a built-in life table there are a variety of ways in which program execution time could be minimized. Several possibilities are suggested below:

(a) The data file could include projected age-specific mortality rates for only every fifth year (census years) in the 25-year projection period. Life tables for each sex and associated survival ratios would be generated only for these benchmark years. Survival ratios for intervening years would be interpolated from the 5-year interval values. If a user wanted to alter the projected mortality rates, the changes would be made to the 5-year interval values before sending them to the life table routine.

(b) In addition to age-specific mortality rate files which a user could modify on-screen, a set of pre-calculated annual survival ratio data files similar to the current files (but derived from the age-specific mortality rate files) could be retained for use in the model. If a user did not exercise the option of altering the age-specific mortality rates, the ready-made annual survival ratio files could be applied in the projection, without calling on the life table subprogram. In most instances this would be the option that a user would select.

(c) In the life table program it would not be necessary to calculate values for all of the one-year age groups in the T (cumulative stationary population) and E (remaining life expectancy) columns. Summing the L column would yield a total T value for all age groups which, when divided by 100,000 births, would yield the mean life expectancy at birth.

Supplementary Methodological Notes

1. Estimating mortality differentials with the Indirect Standardization procedure

For subprovincial areal units only the total annual number of deaths by sex are published, with no breakdown by age, apart from an infant mortality rate. The overall level of age-specific mortality in such areas can be measured by calculating an age-sex standardized mortality rate.

In the Indirect Standardization procedure, the total actual deaths recorded in an areal unit for all ages combined are compared with the total expected or predicted number that would have been recorded if the area had experienced the same age-specific mortality rates as the provincial average ones. The predicted number is obtained by applying the age-specific mortality rates of the province to the number of people in each corresponding age group in the study area. The calculations are carried out separately for males and females. They can be based on either single-year or 5-year population age groups and mortality rates. Since the age distribution of the population in the study area must be known, the procedure would be applied to mortality in a census year. To reduce the impact of chance annual fluctuations in the number of deaths, particularly for smaller areal units, the procedure could be applied to a 3-year period spanning a census year (e.g. 1990-92). The Standardized Mortality Rate = the Actual Deaths recorded in the area divided by the Predicted Deaths. Normally the ratio is multiplied by 100 to express it as a percentage. The Standardized Rate represents the average percentage deviation of the age-specific mortality rates in the study area from the mean provincial rates used as the standard or norm to calculate the predicted deaths. It eliminates as a variable the impact of the age structure of the population in a given areal unit on the total number of deaths in that unit.

As an example, let us assume that the male deaths actually recorded in a given study area in a given year totalled 10,800, while the predicted number based on the average provincial age-specific male mortality rates was only 10,000. The standardized male mortality rate for that areal unit would thus be 108 percent (or 1.08). An estimated set of age-specific male mortality rates for that study area could then be obtained by multiplying all of the provincial age-specific rates by a factor of 1.08.

A user could calculate an age-standardized mortality rate for each sex for a subprovincial areal unit for a base census year by importing into a spreadsheet the PHD model population data file for the study area and the provincial mortality rate file (assuming that the model was modified to employ age-specific mortality rate files). The population in each age group in the base census year would then be multiplied by the corresponding provincial age-specific mortality rate for the same year, using a spreadsheet formula that could be copied from one age group to all the others. It would be necessary to add the number of births to the spreadsheet to derive the infant deaths. The predicted deaths thus calculated would be summed for all age groups and compared to the number of deaths actually recorded in the study area.

It would be possible to incorporate a procedure to calculate standardized mortality rates for each sex right into the PHD model, as an optional feature that could be employed by users working with subprovincial study areas. However, this would not be a matter of high priority since they can be produced on a spreadsheet with very little data entry by importing ready-made population and mortality rate files from the PHD model.

The standardization procedure can also be applied to measure the overall percentage difference between the age-specific fertility rates in a lower-order areal unit and the age-specific fertility rates for a province as a whole. However, few users would have need for this, since files with unpublished age-specific fertility rates for individual census metropolitan areas are currently supplied with the PHD model.

2. <u>User alterations to the age-specific mortality rates</u>

Manual data entries could be greatly reduced if a user could supply a common multiplier that could be applied to the age-specific mortality rates for all age categories, with a separate multiplier for each sex. Allowance could also be made for a different multiplier to be applied to the infant mortality rate. For example, a male sex multiplier of .95, representing an age-sex standardized mortality rate for males for a particular study area, could be used to scale down all of the male age-specific mortality rates in the provincial data file by 5 percent. Normally a user would want to apply the same multiplier to each annual set of projected rates in the time series, but greater flexibility would be retained if the user was required to enter a multiplier for each year's set of rates which he/she wanted to alter. If the data file contained rates for only every fifth year, this would not be a very time-consuming task. Allowing for different magnitudes of alteration to the age-specific rates for each of the one-year age groups is unnecessarily unwieldy, since a user would have no information on which to base such detailed modifications. At the very most, in the interests of maximum flexibility, a user might be given the opportunity to supply separate multipliers (or adjustment factors) for a defined set of aggregated age categories (e.g. infants, age groups 1-9, 10-19, 20-39, 40-59, 60-79, 80+). The option of applying a common adjustment factor to the rates for all age groups (or all age groups other than infants) could still be retained. To apply different multipliers to different age groups would be essentially guesswork, but a user on some occasion might have a rationale for doing so. I would favour keeping the option as simple as possible, by restricting it to a single adjustment factor for all age groups other than infants. Unlike other age-specific mortality rates, infant rates are published for lower-order areal units.

MIGRATION

Migration allowances in the PHD model are made in the form of in-migrants and out-migrants, broken down by one-year age-sex group. From the in- and out-migrants, net migration values are calculated in the program and used in the population projections. In terms of data entry, the user needs only to supply the total annual number of in- and out-migrants. Ready-made files of in- and out-migrant age-sex distributions (proportions of total in- and out-migrants), supplied with the model, are used internally in the program to distribute the user-supplied totals amongst the one-year age-sex groups.

The migrant age-sex distribution files for in- and out-migrants are based on average distributions for a series of recent years (1985-90), using tabulations produced by the Demography Division of Statistics Canada. For domestic migrants, the Demography Division employs change-in-address data for aggregated age-sex groups supplied by Revenue Canada from the income tax records and various estimation procedures to break these values down further into one-year age-sex groups. Data for immigrants from abroad are derived from immigration statistics, while estimates of emigrants from Canada are based on family allowance records. The PHD model includes separate migration age-sex distribution files for Canada and each of the provinces. Similar files have been prepared by CMHC for individual CMAs. A user could create his/her own migration age-sex distribution file for a study area, but it would be an arduous task and would normally have to be based on guesswork or the acquisition of unpublished data from Statistics Canada at considerable cost.

In the PHD model the user can schedule changes in the total annual number of in- and out-migrants throughout the 25-year projection. The same percentage age-sex distributions would be applied to the new annual totals. However, if the user were to alter the ratio of total in-migrants to out-migrants, even without changing the total net migration, this would result in changes in the age-sex composition of the calculated net migrants, since the migrant distribution files do not have the same proportional breakdown by age and sex for in- and out-migrants. Users can also make changes to the in- and out-migration values for individual age groups on-screen once these values have been calculated from the total in- and out-migrant data entries and migrant age-sex distribution file.

The evaluation of the PHD model, with respect to the migration variable, has proceeded along the following lines. First, the migrant age-sex distribution files have been examined in some detail to assess the nature and magnitude of the differences between areal units and to assess how stable and reliable the distributions might be by comparing them with other sources of information on the age-sex composition of migrants. Sensitivity analysis has then been employed to measure the impact of using different migrant age-sex distributions on projected housing demand. In part, the objective here is to determine how important it might be for a user to have access to a migrant distribution file unique to a particular sub-provincial study area as opposed to using one of the provincial files. It relates also to any concern that might be felt regarding the use of a constant migrant age-sex distribution throughout the 25-year projection. In this sense, it also has some bearing on the subsequent discussion of the potential use of per capita migration rates as data inputs in the model. A comparison is also made with the relative impact on net migration age distributions and projected housing demand of changing the ratio of total in-migrants to out-migrants, while holding total net migration constant. The relative effects on population growth and housing demand of variations in total annual net migration are also assessed. The next section in the evaluation of the migration component assesses the potential impact of using per capita in- and out-migration rates, as opposed to absolute numbers of migrants, as data inputs in the PHD model and discusses the pros and cons of such an approach. Finally, the merits and problems involved in using net migration values, rather than in- and out-migrant numbers and proportions, as data inputs in the model are examined.

Migrant Age-Sex Distributions

To facilitate comparison of in- and out-migrant age distributions for different areal units, the data for one-year age-sex groups in the files for Canada, the individual provinces, and the Toronto CMA have been aggregated into six broader age categories (-1-9, 10-19, 20-29, 30-39, 40-64, and 65+), combining values for the two sexes. Separate tabulations have been made for the in-migrants and out-migrants. The aggregated age composition values have then been consolidated in a single table (Table B1) contained in Appendix B.

As expected, younger adults make up the largest component in both the in- and out-migrant streams for all areal units. The 20-29 and 30-39 age groups combined constitute about half of the incoming and outgoing migrants for Canada, each of the provinces, and the Toronto CMA. The most significant difference is the above-average proportion (36.6 percent) of young adults age 20-29 amongst the in-migrants to Toronto and the below-average proportion (25.6 percent) for the same age group amongst Toronto's out-migrants. For provincial areal units and Canada as a whole, the inflow and outflow proportions for the 20-29 age group are more closely in balance. This contributes to a particularly heavy weighting of the 20-29 age group in Toronto's net migration gains. It is a pattern generally typical of large metropolitan centres. Inflows to the major metropolitan areas also tend to include more single young adults, while outflows contain more married couples with children. Further reference will be made to this in the sensitivity analysis in which the impact of substituting national or Ontario migrant age distributions for those of Toronto is assessed in a set of projections for the Toronto study area. The 65+ age category accounts for only a few percent of the in- and out-migrants for all areal units in the table, with a high of 6 percent for in-migrants to British Columbia. In general, there is not a great difference between the age composition of the migrants for the various areal units. For Canada's two most populous provinces, Ontario and Quebec, the age structure of the in-migrants is essentially identical and the out-migrant age distributions exhibit only slight differences.

For three areal units, Ontario, British Columbia, and Toronto, a comparison was made between the migrant age distributions in the files for the PHD model and the age structure of migrants recorded in the 1981 Census for the 5-year period 1976-81. The purpose was to check on how great the differences in age composition might be, not only between data sources but also between time periods when the pattern of regional migration exchanges was quite different. During the 1970s, including the 1976-81 intercensal period, Ontario and Toronto experienced much lower net migration gains than in the previous two decades or, more recently, during the 1980s. Immigration from abroad was lower in the late 1970s and, within Canada, there was a major westward movement from Ontario to Alberta and B.C.. The loss to the West was only partly counterbalanced by a substantial inflow to Ontario of anglophones from Quebec. Ontario's total net migration gain, including net immigration from abroad, for the 1976-81 period was less than 100,000 compared to about 400,000 for the 5-year period 1985-90 on which the age distribution of the migrants in the PHD model file is based. The Toronto CMAs net migration gain for the 1976-81 period was only about one-half the average level for 5-year periods in the 1950s, 1960s, and 1980s. The total net migration gain for B.C. in the 1985-90 period was just a little lower than what it had been for 1976-81.

The comparison in Table B2 is based on migrants 5 years and over, since the Census data representing changes in place-of-residence over the 5-year period exclude children less than 5-years old. The migration age distribution files for the PHD model incorporate both domestic and international migrants, whereas the Census tabulations include the international or foreign component only for the in-migrants. Another difference between the two data sets is that the Census figures are based on the age of the migrants at the end of the 5-year migration interval, while the PHD model values represent the age of migrants at the beginning of the year in which the migration occurred.

Despite the substantial differences between the two time periods in the overall magnitude and spatial pattern of net migration, as well as some definitional differences between the two data sources in the classification of migrants, the age distributions of in- and out-migrants for the 1976-81 and 1985-90 periods are strikingly similar for each of the three areal units that were examined. Within the limited 10-year time span, there was also no consistent trend towards an increased proportion of migrants in the 65+ age category that could be linked to the gradual aging of the population throughout Canada.

From the foregoing, one can draw the following conclusions:

1. The age distribution data for in- and out-migrants in the PHD model files for provinces and CMAs are as reliable as anything which one could ever hope to get.
2. The age distributions of in- and out-migrants for individual areal units tend to remain quite stable over time, even when major changes occur in the ratio of in- to out-migrants and in the total net migration.

Migration Sensitivity Analysis

The Toronto CMA has been used as the study area in assessing the impact of varying assumptions relating to migration on population growth, projected household formation, and housing demand. Seven projection variants have been run, employing a common set of assumptions for all variables except the migration factor. The common elements include the 1988 Toronto fertility rates (TFR = 1638), projected Ontario survival ratios, and constant base year (1986) propensities for headship, family proportions, and dwelling choice. Variants 1, 2, and 3 all assume a total annual net migration gain of 30,000, with 100,000 in-migrants and 70,000 out-migrants. In Variant 1 the in- and out-migrants are distributed by age-sex group using the proportions in the Toronto migrant distribution file, while Variants 2 and 3 apply the age-sex composition of the migrants in the files for the Province of Ontario and Canada as a whole. Variants 4 and 5 use the same total annual net migration of 30,000 and the Toronto age-sex composition of migrants as in Variant 1, but the absolute numbers of migrants and the ratio of in- to out-migrants is changed. In Variant 4, the total in- and out-migrants are reduced to 60,000 and 30,000 respectively, while in Variant 5 the values are raised to 200,000 and 170,000. Although the total numbers of in- and out-migrants used to yield the net total of 30,000 are unrealistically high in Variant 5, it serves to illustrate the profound differences which can arise in the age structure of the net migration flows with different ratios of in- to out-migrants, even when the total net migration for all age groups combined is held constant as well as the age distribution of the in- and out-migrants. The final two Variants, 6 and 7, use moderately different total annual net migration values, 35,000 and 25,000 respectively, while holding all other factors constant relative to Variant 1. In Variants 6 and 7, the total in- and out-migrants are set to yield a ratio as close as possible to the 70 out per 100 in employed in Variant 1.

A summary of the assumptions used for all variables in the seven projection variants, including the differences in their migration inputs, is provided in Table B3 and the notes which precede it in Appendix B. The next four tables (B4 to B7) in Appendix B also relate to these projections.

Table B4 uses five aggregated age categories (0-19, 20-29, 30-39, 40-64, and 65+) to compare the age distribution of in- and out-migrants based on the Toronto age distribution file, used in all but two of the seven variants, with the Ontario and Canada migrant age distributions employed in Variants 2 and 3. In the same table, the distributions of net migrants resulting from the varying assumptions are displayed for the five aggregate age categories for Variants 1 to 5, which all share the same total annual net migration value of 30,000. The differences in the age structure of the net migrants, which impact on the population growth, are quite striking. In Variant 1 the 20-29 age group accounts for 62 percent of the total net migration, while in Variants 2 and 3 only about one-third of the total net gain can be attributed to this age group. Variant 3 has significantly larger net gains for the 65+ age category (8 percent of the 30,000 total) than any of the other variants, since it is based on the Canada migrant age distribution representing immigrants from abroad net of emigrants. In Variant 4, using the Toronto in and out age distribution but with lower volumes of total in- and out-migrants and the ratio of outflows reduced to 50 percent of the inflows, the 62 percent contribution of the 20-29 age group observed in Variant 1 drops to 48 percent. The impact in Variant 5 of raising the total volume of in- and out-migrants, with an associated increase to 85 percent in the ratio of outflows to inflows, is extreme. The 20-29 age group has a net inflow equivalent to 99 percent of the 30,000 total, with minor net gains for the 30-39 and 40-64 age categories and modest net losses for children and the age group 65+. The net loss of over 2000 in Variant 5 for the 0-19 age group masks a net gain of several thousand for the 15-19 age category and a loss of over 5000 for children below age 15, largely concentrated in the 0-4 age group. The net outflow for the 0-4 age group cannot be discounted as a complete anomaly, since cohort survival estimates of net migration for the Toronto CMA for intercensal periods generally include a similar feature, though of a much lower magnitude, associated with the out-migration of families with children. The distribution of net migrants by age group is not shown in Table B4 for Variants 6 and 7 which assumed total annual net migration gains of 35,000 and 25,000, but with the same 70 percent ratio of out-migrants to in-migrants as in Variant 1. The percentage distribution of the net migrants by aggregated age group in both these variants was the same as in Variant 1, even though the total number of in- and out-migrants was higher in Variant 6 (117,000 and 82,000) and lower in Variant 7 (83,000 and 58,000).

Clearly, for any given total annual net migration radical differences can arise in the age distribution of the net migrants in response to the inputs supplied by the user of the PHD model for the total in- and out-migrant components of the net sum. Tables B5, B6, and B7 in the Appendix assess the impact of the different migration assumptions used in the seven projection variants on projected population growth, household formation, and dwelling choice. The tables summarize the total projected growth and changes in the composition of housing demand over the 22-year period 1989-2011. The magnitude of the changes would of course be of a lower magnitude for intervening years in the 22-year progression.

Table B5 compares both the projected population growth and age structure changes for the projection variants. All seven variants show a modest decline in the proportion of the population in the 0-14 age group from 19.3 percent in 1989 to just under 17 percent 22 years later. For Toronto, the impact of the low fertility rates on the child age groups is partly offset by the high net migration gains for young adults which slow down the decline in the crude birth rate. The percentage of the population in the 65+ age category increases from 9.7 percent to 13 to 14 percent in all of the variants, except Variants 3 and 5 in which the gains of the 65+ group are of a slightly higher and lower magnitude. This can be related to the difference of several thousand per year between Variants 3 and 5 in the net migration values for the 65+ age category.

From a starting population of about 3.7 million in 1989, the projected 22-year growth ranges from a low of about 1.1 million in Variant 7, with an annual net migration of 25,000, to a high of about 1.4 million in Variant 6, with an annual net migration of 35,000. For the first five variants, with an annual net migration gain of 30,000, the population growth ranges from 1.17 million in Variant 3 to 1.35 million in Variant 5. The variations in population growth amongst the first five projections result from the variable proportions of the net migrants in the young adult age categories which affect the annual number of births and deaths. The 22-year population growth in Variant 5, with its extreme weighting towards young adults in the net migration values, is about 100,000 greater than in Variant 1 in which the 20-29 age group accounted for 62 percent of the net migration inflows.

Table B6 assesses the effect of these differences in population growth and age structure change on the growth in the number of households, which also represents the growth in the required number of dwelling units. With the decline in the proportion of the population in the 0-14 age category, the percentage growth in the number of households exceeds the percentage growth in population by a substantial margin in all projection variants. The same was true of the projections described in Appendix A involving the fertility variable. However, the differences between the growth in the number of households in the migration projection variants are far greater than they were for the fertility variants. For the fertility variants the maximum difference was only about 7000 or 1 percent, whereas for the first five projection variants, with a common total annual net migration of 30,000, the difference in household growth is just over 100,000 or almost 20 percent. For Variants 1, 4, and 5 in Table B6, the growth in the number of households (in thousands) was 631.7, 610.5, amd 684.8 respectively or a difference of about 75,000 between the highest and lowest. These three projections all employed the same total annual net migration and the same percentage distributions of the in-migrants and out-migrants by age and sex. They differed only in the ratio of total in-migrants to out-migrants used to yield the 30,000 annual net migration total. The growth in households in Variant 5, with its extreme weighting on the 20-29 age group in the net migration gains, is as great as the growth in Variant 6 which had a total net migration gain 5000 greater per year or 110,000 greater summed over a 22-year period. Variants 2 and 3, using the Ontario and Canada age distributions for in- and out-migrants, have a growth in the number of households as low as Variant 6 which assumed an annual net migration gain of only 25,000 but employed the Toronto migrant age distribution.

Although the differences between projection variants in the growth in the number of households are of a fairly substantial magnitude, Table B6 shows that there is little difference between them in the projected distribution of households by type, either in the percentage split between families and non-families or in the division of families between couples with and without children and lone parents. This is because the changes in the overall age structure of the population in all of the variants is relatively similar. The evolving age structure is much more a function of the fertility and mortality trends of past time periods in relation to current and projected levels than it is of the annual net migration age distributions. Over the longer term, the impact of a concentrated annual net migration input in the young adult group is partly tempered by the gradual aging and shift of the migrants from previous decades into the middle and older age classes.

Table B7 provides a breakdown of projected growth in dwelling units between owners and renters and by type of dwelling unit. Over the 22-year period, in association with the shift in population age structure, there is a substantial increase in the projected percentage of owners and a related decline in the proportion of apartment-dwellers relative to those occupying single detached homes. However, as with the breakdown of households by type, there is not much difference between the projection variants in the distribution of growth by tenure or dwelling type. Variant 5, with its high net inflow of young adults has a lower percent of the total growth in the owner tenure class and in the single detached house category than the other variants, but the difference is extremely slight. It should be emphasized that Table B7 shows the percentage distribution of the 22-year growth in dwelling units by type rather than the percentage breakdown of the total dwelling units in the terminal year 2011. For example, in Variant 1 with owners accounting for about 68 percent of the growth, their share of the total would rise from 58.1 percent in 1989 (bottom row of Table B7) to 61.5 percent in 2011. Similarly, with about 50 percent of the growth, the share of the single detached homes would increase from 43.1 percent of the total dwelling units in 1989 to 45.3 percent in 2011.

To summarize the results of the migration sensitivity analysis, the following conclusions can be drawn:

1. Differences in the migration inputs can significantly affect the projected growth in the number of dwelling units, but the effects on the composition of the dwelling units by type are likely to be of minor magnitude. Variation in the migration inputs will have a much greater effect on the growth in dwelling units than any differences that a user might be likely to introduce in the fertility inputs. The impacts of variation in

the mortality inputs could also be expected to be of a much lower magnitude than those attributable to the migration variable. However, the structure of the existing PHD model precluded the application of a meaningful sensitivity analysis to the mortality factor.

2. The distribution of the net migrants by age group can be just as important as differences in the total annual magnitude of net migration in affecting the growth in the projected number of dwelling units.
3. For any given total annual net migration value, the age distribution of the net migrants can be as much a function of the ratio of total in-migrants to out-migrants as it is of the age structure of the in- and out-migrants themselves.

Potential Use of Per Capita Migration Rates in the Projections

The PHD model uses absolute numbers of in- and out-migrants as data inputs in the population projections. It could be argued that in projecting migration levels forward in time the use of per capita migration rates would be more realistic since, all other things being equal (socio-economic and other such factors), the absolute number of out-migrants should change in proportion to changes in the size of the population "at risk" of moving. All other things being equal, the number of in-migrants should also be proportional to population size, in this case the population of the destination. Since the propensity to migrate varies greatly with age, it could be further argued that for out-migrants at least, if migration rates were to be used they should be age-sex specific. In the case of in-migrants, the rationale is weaker for using age-sex specific rates to project changes in numbers over time. To a limited extent, and for more localized destinations, individuals such as young adults or retirees may be attracted to areas where they can co-mingle with many others of their same age. However, in my view, the primary justification for applying age-sex specific rates to in-migration would be that general trends in the age structure of the population in the areas of destination, associated with nation-wide fertility trends, are likely to be paralleled by similar changes in the age composition of the population in the areas of origin from which the in-migrants are drawn. Thus, if the percentage of population in the young adult age groups declines in the area of destination, one could expect a decline in the in-migrants of this age, since the source regions from which the young adults are drawn would also be experiencing a drop in their potential supply of out-migrants of this age. Similarly, an increase in the percent of population in the 65+ age group throughout the nation as a whole would increase the number of in-migrants as well as out-migrants in this age category. There is clearly an element of approximation in this type of reasoning, given some variation between areas in the progression of the national age structure trends. One component of in-migration in which the application of age-sex specific rates can find little rationale is the segment representing immigrants from abroad. This constitutes the entire in-migration when projections are being made for Canada as a whole and an extremely important component for a number of the larger CMAs and some provinces. With the aging of Canada's population, immigration policy could increasingly favour the selection of young adults and, with health-care costs a consideration, could attempt to reduce the inflow of elderly dependents. The effects on the age composition of immigrants would be just the reverse of those that would result from the use of age-specific in-migration rates. Even a non-age-specific rate, per unit of the total population, is of questionable value in projecting immigration levels over the next several decades, particularly on a year-to-year basis. Higher levels of immigration are anticipated, but the annual increases are not likely to be closely proportional to the growth in Canada's total population.

If migration rates were to be used in the PHD model, the choice then would be between age-sex specific rates or aggregate in- and out-migration rates per unit of the total population. To apply age-sex specific rates to the out-migrants and a rate for all age groups combined to the in-migrants would be, in my view, self-defeating in its complexities, with too many uncontrollable and possibly bizarre impacts on the net migration values. It is assumed that rates would initially be derived from total in- and out-migrant numbers for the starting year, supplied by the user as in the present model. The calculation and application of the rates is discussed in the next two paragraphs.

For age-sex specific rates, the total in- and out-migrant values, supplied by the user , would first be distributed amongst the single year age-sex groups as they are in the present PHD model using one of the national, provincial, or CMA migrant distribution files provided with the model or a similar file substituted by the user. Per capita rates for each age-sex group would be calculated by dividing the migrants by the base year population values in the corresponding age-sex group using the base year (i.e. starting year) population file. The migration rates thus calculated would be applied to the projected starting population in each subsequent year to calculate the absolute numbers of in- and out-migrants by age-sex group for that year. Using this constant set of age-sex specific rates throughout the projection would yield new absolute numbers of in- and out-migrants in each age-sex group as the population grew (or declined) in size and changed in its age-sex composition. Changes in the age composition of the population would result in different rates of growth (or decline) in the total number of in-migrants relative to out-migrants and in the total net migration, as well as in the age distribution of the net migrants. The percentage increase in the total number of in- or out-migrants over time would differ from the percentage growth in the total population. In other words, the aggregate rate of in- or out-migration per unit of the total population would change in response to the use of a constant set of age-sex specific migration rates in the calculations. Normally, the total number of migrants would increase more slowly than the total population, as a larger share of the population shifted into the older age groups which are characterized by lower migration rates. The proportional distribution of the in- and out-migrants by age-sex group would change over time and would no longer equate with the values in the migrant distribution file that were used initially to derive the rates. But the age-sex specific migration rates themselves would remain constant. A procedure could be added that would allow a user to change the age-sex specific rates during the course of the projection to reflect hypothesized changes in socio-economic conditions in the study area. However, it would be exceedingly cumbersome and, I think, pointless to allow for anything more than a single adjustment coefficient that would be applied to the rates for all of the single year age-sex groups (with separate coefficients for in- and out-migration rates). For example, an in-migrant adjustment coefficient of 1.2 entered for the year 2001 would result in an across-the-board 20 percent increase in the in-migration rates for all age-sex groups. Linear interpolation could be applied to migration rates for intervening years or they could be held constant until a new adjustment factor entry was encountered in the time series.

If aggregate in- and out-migration rates per unit of the total population were used, rather than age-sex specific rates, then these rates would first be derived by dividing the total number of in- or out-migrants supplied by the user for the initial year by the total base year population. These aggregate rates would be applied to the starting population in each projection year to calculate the total in- and out-migrants for that year. The totals would then be distributed by age-sex group using the migrant distribution file most appropriate to the particular study area. The procedure would be identical to the current treatment of migrants in the PHD model, except that the total numbers of in- and out-migrants, as well as the net migrants, would grow (or decline) in exact proportion to the projected growth or decline in the total population of the study area. For example, with a starting in-migration of 50,000, out-migration of 30,000, and net migration of 20,000, a 20 percent growth in population, with a constant pair of aggregate in- and out-migration rates, would automatically raise the migration totals by 20 percent to 60,000 in-migrants, 36,000 out-migrants, and 24,000 net migrants. In the process, age-sex specific migration rates would be undergoing variable rates of change, but these would be hidden from the user and would not enter into the migration calculations. Changes in aggregate migration rates per unit of the total population could be introduced in the same way as changes in age-sex specific rates discussed in the preceding paragraph.

Clearly, the use of a single aggregate migration rate per unit of the total population for in- or out-migrants is a simpler procedure, with more predictable results, but conceptually, at least for out-migrants, it is analogous to projecting births and deaths for future years using a constant crude birth rate and crude death rate instead of age-specific fertility and mortality rates. No allowance is being made for the impact of age structure changes in the population on the projected migration values. In essence, the application of an aggregate rate per unit of the total population, with the resultant total number of in- or out-migrants distributed by age-sex group using a constant set of proportions, would add very little that is new to the PHD model. The user could accomplish much the same thing with the existing model by entering new in- and out-migration totals at intervals throughout the time series to allow for the effects of total population growth on the total volume of migration. The only difference is that the user-supplied values would not be quite as precisely proportional to population growth as values that could be calculated internally in the projection program.

Canada as a whole and Toronto have been used as sample study areas to illustrate the type of effect which the use of age-sex specific migration rates would have on projected in-, out-, and net migration values. The projected values are estimates, but they should closely approximate those that would be generated if actual runs of the PHD model could be made using age-sex specific migration rates as inputs. For these estimates, the PHD model was first used to project population forward, using an annual net migration value of 100,000 for Canada (150,000 in-migrants and 50,000 out-migrants) and an annual net migration of 30,000 for Toronto (with 100,000 in-migrants and 70,000 out-migrants). The Toronto projection was the same one employed as Variant 1 in both the fertility and migration sensitivity analyses. For each of the two study areas, the annual projected populations by one-year age-sex group were saved and imported into a spreadsheet. After deleting rows containing the projected population values for all years except the base year (1990 for Canada and 1989 for Toronto) and the census years at 5-year intervals between 1991 and 2011, the absolute numbers of in- and out-migrants by one-year age-sex group for the base year, as calculated in the PHD model, were imported into the same spreadsheet. Age-sex specific migration rates per capita were then calculated from the base year population and migration numbers. These in- and out-migration rates for one-year age-sex groups were next applied to the projected populations for the five census years from 1991 to 2011 to calculate the absolute numbers of in-, out-, and net migrants for these years. The projected population used in these calculations would be slightly different if migration rates, instead of constant absolute numbers, could have been used in the original projections. However, the impact of any such differences on the calculated numbers of migrants should be minimal. The results of these calculations are summarized in Tables B8 and B9 in Appendix B. To simplify these tables, values are included only for the initial year (1990 or 1989), the terminal year 2011, and the census year 2001 midway through the projection.

As expected, the shift in population age structure towards the middle and upper age groups, which experience lower migration rates, resulted in a percentage increase in total in-, out-, and net migration that was substantially lower than the percentage growth in the total population. The percentage rates of increase also varied between total in-, out-, and net migrants. Had aggregate in- and out-migration rates for all age groups combined been used, the same percentage increase would have been recorded for in-, out-, and net migrants, as well as for the total population growth. With aggregate rates, there would also have been no change in the age-sex composition of the in-, out-, and net migrants. The much slower growth in migration numbers resulting from the use of age-specific rates, as opposed to aggregate rates per unit of the total population, is a feature that would apply only to industrialized countries such as Canada which are now experiencing an aging of the population resulting from the transition from high fertility levels of the past to low current levels. The aging trend is further reinforced by the on-going increase in life expectancy resulting from the decline in age-specific mortality rates.

In the calculations for Canada, the total population had grown by about 20 percent between 1990 and 2011, while in-, out-, and net migrants experienced increases of 8.7, 6.1, and 9.9 percent respectively. For Toronto, the 1989-2011 population growth was approximately 34 percent with increases of 15.6, 18.3, and 9.3 percent for the in-, out-, and net migrants. The total annual net migration actually declined slightly during the first decade of the Toronto projection before recovering and increasing moderately during the second decade. In both Tables B8 for Canada and B9 for Toronto, there is a decline over time in the percentage of migrants in the young adult age groups and an increase in the percentage in the 40-64 and 65+ age categories. The upward shift in the age structure of the population to which this can be attributed affects all three migration components, in, out, and net. The drop in the migration proportions for the 20-29 age group all occurs during the first decade of the projection and then shifts to the 30-39 age group in the second decade.

The PHD model, as currently structured, cannot be used with age-sex specific migration rates as inputs to measure exactly how much effect the use of migration rates would have on projected population growth and housing demand. However, some approximate conclusions can be drawn from the growth in total net migration and changes in the age composition of the net migrants estimated in Tables B8 and B9. The percentage increase in total annual net migration of 9 to 10 percent for Toronto and Canada was less than the increase of almost 17 percent used in Variant 6 in the migration sensitivity analysis for Toronto, which assumed an annual net migration gain of 35,000. The growth in the annual net migration based on the migration rates was also a gradual process, as opposed to a higher level that prevailed throughout the entire projection. Thus, the impact on the growth in the number of dwelling units would be much less than what was observed in Variant 6 of the sensitivity analysis. The effect of the changes in age structure of the net migrants on the growth in dwelling units is more difficult to assess, but it would probably be relatively slight. Variant 4 in the sensitivity analysis for Toronto had a reduction in the percent of net migrants in the 20-29 age group similar to the reduction in Table B9 resulting from the use of migration rates. In Variant 4 this was associated with a below-average growth in the number of dwelling units. However, in Variant 4 it was more an increase in the percent of migrants in the child age groups, rather than in the 40-64 and 65+ age groups, that tended to constrain the growth in households and dwelling units.

Problem of Using Net Migrants as Data Inputs in the PHD Model

In a population projection model, to require data inputs in the form of in- and out-migrants distributed by one-year age-sex group would normally be extremely demanding on the user in terms of both the manual data entries and the difficulty of selecting appropriate values. In the PHD model these problems are essentially circumvented through the provision of ready-made migrant distribution files for the nation, provinces, and CMAs that apportion the user-supplied values for total in- and out-migrants amongst the age-sex groups. If net migrants were used as data inputs, presumably an attempt would be made to employ the same procedure, with the user supplying an annual net migration total and net migrant distribution files prepared by CMHC used to break the total down amongst the one-year age-sex groups.

There would be few advantages, and many problems, in shifting to a system of data inputs in the form of net migration values. The advantages could be summarized as follows:

1. There could be some minor saving in computer processing time.
2. Users, having decided on an annual net migration total, would be spared the problem of selecting the most appropriate ratio of total in-migrants to out-migrants to employ to yield the net migration total. As previously noted, the ratio selected could have unexpected, and perhaps undesired, effects on the

calculated age composition of the net migrants. This, in turn, can have more than a minor impact on the projected growth in households and associated dwelling units.

The disadvantages of using net migrants, in place of in- and out-migrants, as data inputs in the PHD projection model would appear to far outweigh the advantages. At least two major problems can be identified. The first is related to the provision of ready-made files to distribute net migrants by one-year age-sex group based on the initial net migration total supplied by the user. The second problem relates to the adjustments which have to be made to the net migration values for individual age-sex groups in response to a user-scheduled change in total net migration in those cases in which the original net migration age-sex distribution included a mixture of gains (positive values) for some age groups and losses (negative values) for others. The foregoing two problems are further clarified below:

1. <u>Distributing the initial net migration total by age-sex group</u>

The net migrant distribution files that would need to be prepared by CMHC would often contain positive proportions for some age-sex groups and negative proportions for others, with the proportions for all of the age-sex groups summing to 1.0 if the total net migration on which they had been based was positive. If the total net migration for a province or CMA had been negative, then the proportions would sum to -1.0. In distributing a user-supplied net migration total for the initial projection year with these proportions, a problem would arise if the user chose to supply a negative net migration total and the proportions in the distribution file had been derived from a positive total or, vice versa, if the net migrant distribution file was based on a negative total and the user entered a positive total. This would create some difficulties even if all of the proportions for individual age-sex groups were uniformly either positive or negative. A shift from a positive total to a negative one in the initial distribution of the net migrants would convert the age groups with the highest net gains into those with the highest net losses, which in at least some instances would be difficult to justify on logical grounds.

Even greater problems would arise if the net migrant distribution file contained a mixture of positive and negative values. These problems are related to those which would be encountered if the total annual net migration was scheduled to increase or decrease during the course of the projection, as discussed below.

2. Redistributing net migrants by age-sex group in response to a scheduled change in total annual net migration

The main difference between the problems here and those involved in the initial distribution of net migrants relates to the type of change that one could logically expect in the age-sex composition of net migrants if the total annual net migration was scheduled to increase or decrease relative to the value set for the first year in the projection. The problem of changing the age-sex composition of net migrants arises when the file of net migrant proportions contains a mixture of positive and negative values for individual age-sex groups. If these proportions were applied as constants throughout the projection, as the in- and out-migrant proportions are in the existing PHD model, then an increase in a total annual net migration gain would result in still higher losses for those groups with negative values rather than reduced losses as might be expected. In the same fashion, a decline in a total net migration gain would result in the calculation of lower losses for the negative groups rather than higher losses as one would anticipate. Similar problems would be encountered for the age groups experiencing gains when the total annual net migration was negative and the magnitude of the overall loss was scheduled to increase or decrease.

From the foregoing discussion, it would seem inappropriate to apply a constant set of age-sex specific net migrant proportions to total annual net migration values that increase or decrease during the course of a projection in those cases in which the initial proportions contain a mixture of positive and negative values. I have been able to devise a method of apportioning a change in total net migration in a rationale manner between age-sex groups that include both gains and losses that will work whenever the total annual net migration is scheduled to remain either positive or negative throughout the entire projection. This procedure would reduce losses for age groups with negative values, while increasing the gains for the groups with positive values, if the total net migration increased, and would simultaneously ensure that the sum of all the individual age-sex groups balanced with the new total. However, I have been unable to devise an adjustment procedure to cope with those rare cases in which a user scheduled a shift part way through a projection from a total annual net migration gain to a total loss for all age groups combined. I do not think that there is any acceptable mathematical solution to this problem.

Recommendations

The existing method for handling the migration variable in the PHD model has much to commend it and I would not recommend any radical changes. What I would suggest is the following:

1. I would not try to use net migration as the basis for data inputs employing net migrant age-sex distribution files.
2. I would retain the existing procedures in their present form, but as a supplementary option would incorporate a procedure to use age-sex specific in- and out-migration rates to calculate the net migrants. A method of doing this has been described in the section on the potential use of per capita migration rates. A user could choose between either of the two methods of calculating net migrants and could compare results in two separate runs of the program. It would also be possible to offer a third option combining the two approaches. In this option the user would be responsible for scheduling the total annual number of in- and out-migrants throughout the projection, but the percentage allocation of the totals by age-sex group would be based on calculations employing age-specific per capita migration rates.
3. A summary output table should be added to display the percentage distribution of net migrants, including changes in this distribution during the course of the projection, for a set of aggregated age-sex groups. The percentage distribution of in- and out-migrants could also be included. This would help users

to assess the impacts of their total in- and out-migration entries on the calculated age-sex composition of the net migrants. Additional comments on the design of such a table are included in the final section of this report on output tables.

4. For a subprovincial areal unit, other than a CMA, it would be exceedingly tedious for a user to create manually his/her own migrant distribution file of proportions with 92 age values for each sex for both in- and out-migrants. It would be possible to build into the PHD model a procedure in which a user could supply proportions for a defined set of aggregated age groups (e.g. 10-year age groups or even broader age categories such as 40-64). These proportions could then be distributed by single years of age (and sex?} within each group using the relative distribution of values within the corresponding aggregated age groups in a selected provincial or CMA migrant distribution file.
5. For subprovincial study areas such as CMAs and smaller urban centres, more assistance could be given to users in their selection of an appropriate ratio of in-migrants to out-migrants to yield the annual net migration total. A printed tabulation of annual in-, out-, and net migration totals for Canada and the provinces for the intercensal years 1976-77 to 1989-90 is available for distribution. A similar table could be prepared for CMAs, covering at least the limited number of years on which the in- and out-migrant age-sex distribution files (e.g. MIDI69TO.CSV for Toronto) are based. Extending the historical series further back in time for CMAs might not be feasible or could prove too costly. Published census tables can be used to obtain total domestic in- and out-migrants for CMAs, as well as their in-migrants from abroad, for 5-year intercensal periods. As a service to future users, CMHC could order a custom tabulation of in-, out-, and net migrants from the 1991 Census, broken down by a set of aggregated age-sex groups, for CAs and other urban centres over some selected population-size threshold.

OUTPUT TABLES

Several additions could usefully be made to the summary output tables that can be viewed on-screen or printed when the PHD model is run. The suggestions which follow relate to the Population Projection component of the model on which this report focuses. It is recognized that some constraints must be placed on the amount of information incorporated in the summary tables. It is true, also, that most of the tabulations suggested below could be created by users on their own initiative by importing into a spreadsheet files created and saved in a projection run. The data in these files could be manipulated with spreadsheet formulas to create new summary tabulations. But the procedure would be a time-consuming one, including not only data manipulation but also the design of table layouts with appropriate row and column captions, in order to prepare the new summary tabulation for printing. This would be particularly true if a substantial number of projection variants were being run and compared. My suggested additions to the summary tables are intended for those users (hopefully the majority) who want to understand better the reasons for the results obtained with varying fertility, mortality, or migration inputs, in terms of both the population growth and the subsequent calculations involving households and dwelling units.

1. <u>Changes in the Age Structure of the Projected Population</u>

Age structure changes during the projection affect the results in a host of ways. The summary tables should include percentage distributions of the total population by age in addition to the absolute numbers. Separate percentage distributions for males and females are not needed, since age-specific propensities used in the household and demand components of the model are based on the two sexes combined.

In the 3-page table of <u>Aggregated Projected Population</u> (by 5-year age group 0-4 to 90+) for census years, one additional column could be added to display the percentage of the total population in each age group. A new summary tabulation should also be added to compare in one small table the change in the percentage distribution of the total population between census years for a set of the more aggregated age groups on which the propensities in subsequent parts of the model are based (10-year groups from 15-24 to 65-74 and 75+). This set of population percentages should also incorporate the 0-14 group as a category. In addition to census years it might also be useful to include the last year to which the population was updated in the base year population file (i.e. 1990 for Canada or 1989 for Toronto). A sample table layout is shown below, with the values for the census years 1991 to 2011 derived from the projection for Canada which was used to estimate the number of migrants if age-specific migration rates were employed (Table B8 in Appendix B). The table below could be inserted as a fourth page addendum to the Aggregated Projected Population table for census years by 5-year age group or it could be placed on a second page addition to the Components of Growth table.

Projected Change in the Percent of the Population by Age Group

	1986	1990	1991	1996	2001	2006	2011
0-14	21.3	20.9	20.9	20.5	19.8	18.8	17.7
15-24	16.5	14.5	14.2	13.3	13.0	13.0	13.1
25-34	17.9	17.9	17.6	15.6	13.7	13.0	12.9
35-44	14.4	15.7	15.9	16.6	16.5	14.9	13.3
45-54	10.1	10.6	10.9	12.8	14.4	15.2	15.3
55-64	9.2	8.9	8.8	8.6	9.5	11.4	12.7
65-74	6.5	6.9	6.9	7.2	7.0	7.0	7.9
75+	4.1	4.6	4.7	5.4	6.1	6.6	6.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2. Summary Migration Table

A summary table is needed to show the percentage composition of migrants by aggregated age group and any changes that occur in this distribution during the course of the projection. The age groups employed could be the same as those used above in the table for changes in the percentage age composition of the population. The absolute numbers of total in-, out-, and net migrants should be incorporated in the table as well as the absolute number of net migrants by age group. The table could be limited to values for census years, plus a set of values for the starting year in the projection calculations whenever it differs from the first census year. For example, a Toronto table would currently include annual migration values for 1990, representing the 1989-90 intercensal year, as well as for 1991, representing the 1990-91 intercensal year. For Canada and the provinces, with population estimates updated to 1990, the first set of annual migration values would be for 1991.

In the existing PHD model the percentage distribution for in- and out-migrants remains constant throughout the projection and is the same (for any given migrant distribution file) regardless of the absolute numbers for total in- and out-migrants. The percentage age composition of the <u>net</u> migrants depends on the ratio of in-migrants to out-migrants used in any given projection run. It can also change during the course of a projection if any change is scheduled in the absolute number of in- and out-migrants. For a summary table based on the present PHD model, it might be superfluous to include columns for the percent distribution of in- and out-migrants for more than the starting year since the values would never change, unless a user manually altered the age-specific migrant values with the on-screen edit option. However, if the age composition of the net migrants changed in response to scheduled changes in the total numbers of in- and out-migrants, it would be important to have included in the table at least the new total values for the in- and out-migrants.

A sample table layout that would be appropriate for the PHD model based on its current procedures for handling the migration variable is shown below. The sample table is for Saskatchewan. The first set of net migration columns reserved for the starting year have been left blank, since the 1991 census year values (representing the migration for the preceding 12-month period) are the first migration inputs that are currently used in projections for provinces. For illustrative purposes net migration values by age group have been calculated, based on hypothetical changes made by the user to the annual in- and out-migrant totals. Actual numbers, as well as percentage distributions, have been included for the net migrants by age group. Note that the percentage distribution could not be calculated if the total annual net migration is set to zero as in 1996. With two columns for the net migrants for each year, it would not be possible to print values for all of the census years across the width of a page. The table would have to be continued, with a new set of row captions for age groups, in a second part below. Even more space would be needed if each year included two additional columns for the absolute numbers of in-migrants and out-migrants by age group. The summary migration table, shown below, could be incorporated as an addendum to the Components of Growth table, printed either on a separate page or on the same page as the suggested table for Projected Change in the Percent of Population by Age Group.

Age Composition of Migrants
(In-migrant and out-migrant percentage distributions remain constant throughout the projection)

Age Group	In-mig. %	Out-mig. %	Starting Yr. Net Migrants #	Starting Yr. Net Migrants %	1991 Net Migrants #	1991 Net Migrants %	1996 Net Migrants #	1996 Net Migrants %
0-14	25.5	24.4			-3542	23.0	317	
15-24	23.4	25.9			-4379	29.2	-750	
25-34	27.7	26.6			-3770	25.1	332	
35-44	12.2	11.3			-1528	10.2	256	
45-54	4.9	4.1			-458	3.1	233	
55-64	3.1	3.6			-639	4.3	-149	
65-74	2.3	2.8			-509	3.4	-141	
75+	1.0	1.3			-266	1.8	98	
Total	100.0	100.0			-15000	100.0	0	
Tot. In					20000		30000	
Tot. Out					35000		30000	

Age Group	2001 Net Migrants #	2001 Net Migrants %	2006 Net Migrants #	2006 Net Migrants %	2011 Net Migrants #	2011 Net Migrants %
0-14	1315	32.9	2813	28.1	2813	28.1
15-24	234	5.9	1710	17.1	1710	17.1
25-34	1419	35.5	3049	30.5	3049	30.5
35-44	726	18.2	1431	14.3	1431	14.3
45-54	412	10.3	680	6.8	680	6.8
55-64	-15	-0.4	185	1.9	185	1.9
65-74	-40	-1.0	112	1.1	112	1.1
75+	-51	-1.3	19	0.2	19	0.2
Total	4000	100.0	10000		10000	
Tot. In	32000		35000		35000	
Tot. Out	28000		25000		25000	

A conceptual issue arises in displaying the net migrant percentages by age group when the total net migration value is a negative number, as it was in the sample table for the 1991 census year. The procedure employed in the table was to display the losses for individual age groups as positive percentages of the total net migration loss. Had any of the age groups experienced a net migration gain it would have been entered as a negative percent. The alternative would be to enter a -100.0% for the total and negative percents for the age groups with losses. This could be viewed as more consistent with the meaning attached to positive and negative percentages in columns with a positive net migration total.

If the PHD model was revised to incorporate an optional procedure to calculate migrants using age-sex specific migration rates, then the required content for an associated summary migration table would differ in some respects from the one suggested for use with the present model. Two slightly different types of tables would have to be available for use, depending on which procedure had been selected by the user for the migration calculations. The same set of aggregated age groups would be used in each case. In the Migration section of this report it was noted that the use of age-specific migration rates would result in changes over time in the percentage age composition not only of the net migrants but also of the in- and out-migrants. It would be important therefore to include columns for the in- and out-migrants, as well as the net migrants, for each census year if age-sex specific migration rates had been employed. Since only the net migrants are used in the projection calculations, it might be sufficient to incorporate in the table only the absolute numbers for in- and out-migrants and to omit their percentage distributions if the latter made the table too voluminous. The first two (or four) columns of figures in the table would show the calculated age-specific in- and out-migration rates instead of the percentage distribution of the in- and out-migrants by age. If only two columns were used, the rates displayed would have to be weighted rates for males and females combined, although separate rates for each sex would be employed in the migration calculations. A minor conceptual issue arises here, since it is the male and female age-specific migration rates that independently remain constant throughout the projection (unless an adjustment coefficient is entered by the user to schedule an across-the-board increase in the rates for all age-sex groups). If weighted age-specific rates for males and females combined were displayed in the table for the initial year, the combined rates could not be described as perfect constants for all years in the projection since the relative weighting of males to females in each age category could change, albeit very slightly, over a period of 20-25 years.

3. Components of Growth Table

A small table could be added on the same printed output page as the Components of Growth table showing, for census years only, the growth components as rates per 1000 population. This would provide additional perspective in assessing demographic trends. The following measures should be included: population growth rate, crude birth rate (CBR), crude death rate (CDR), natural increase rate (NIR), in-migration rate, out-migration rate, and net migration rate. In additional columns I would also include the male and female life expectancy, as well as the total fertility rate (TFR) if the model is revised to permit user-scheduled changes in fertility during the 25-year projection period.

4. Addition of Percentage Distributions in Tables Produced in the Household and Demand Segments of the Model

Although the focus in this evaluation of the PHD model has been on the Population Projection component, one general comment could be made on the output tables in the Household and Demand segments. The identification of trends in the composition of households and dwelling units would be facilitated if at least a few percentage distributions were added to the absolute values contained in the current set of output tables. In some cases the percentage values would apply to the distribution in a given year, while in other cases the percentages would represent shares of the total growth during a 5-year period (or, alternatively, percentage growth rates for the various types of households or types of dwelling units). Percentage distributions could be added to the existing tables for selected rows of the more important values or new summary tables of percentage distributions could be designed. The most extreme solution would be to produce a supplementary set of duplicate tables in which all of the values in the current tables were converted to percentage distributions.

APPENDIX A

FERTILITY DATA

PHD MODEL SENSITIVITY ANALYSIS: FERTILITY VARIABLE

STUDY AREA: TORONTO

FACTORS HELD CONSTANT IN ALL VARIANTS:

1. All variants use Ontario survival ratios (SURVON.CSV), an annual net migration of 30,000 (100,000 in-migrants and 70,000 out-migrants), and a migrant age distribution based on the Toronto file MIDI69TO.CSV.

2. All variants use constant base year (1986) rates for headship (HIHRTRNT.CSV), family proportions (HIFPTRNT.CSV), ownership (HIOPTRNT.CSV), and dwelling choice (HIDPTRNT.CSV).

3. The five projection variants employ different Total Fertility Rates (TFR), but retain the same distribution of fertility rates between age groups. The age-specific fertility rates (ASFR) in the Toronto file (FERT88TO.CSV), representing a TFR of 1638 (per 1000 females), are scaled up or down by multiplying each of the seven ASFR by the TFR for the projection variant divided by 1638.

PROJECTION VARIANTS:

VARIANT 1:	TFR = 1638	(uses the FERT88TO.CSV ASFR). This variant is identical to Variant 1 in the migration sensitivity analysis).
VARIANT 2:	TFR = 1600	
VARIANT 3:	TFR = 1800	
VARIANT 4:	TFR = 2000	
VARIANT 5:	TFR = 2200	

FERTILITY SENSITIVITY ANALYSIS FOR TORONTO: COMPARISON OF PROJECTION RESULTS

TABLE A1: POPULATION CHANGE

VARIANT	POP. 2011 ('000)	POPULATION GROWTH 1989-2011 ('000)	%	POPULATION BY AGE GROUP IN 2011 ('000) 0-14	15-24	25+	PERCENT OF POPULATION BY AGE GROUP IN 2011 0-14	15-24	25-34	35-64	65+
1	4921.4	1254.7	34.2	820.6	606.0	3494.9	16.7	12.3	13.5	44.1	13.4
2	4892.6	1225.9	33.4	801.2	596.6	3494.9	16.4	12.2	13.6	44.4	13.4
3	5043.0	1376.3	37.5	902.6	645.5	3494.9	17.9	12.8	13.2	43.0	13.0
4	5193.0	1526.3	41.6	1003.9	694.2	3494.9	19.3	13.4	12.8	41.8	12.7
5	5343.7	1677.0	45.7	1105.8	743.0	3494.9	20.7	13.9	12.5	40.6	12.3
1989 BASE YEAR	3666.7						19.3	15.7	19.7	35.6	9.7

TABLE A2: PROJECTED HOUSEHOLDS (HH) AND HOUSING DEMAND

VARIANT	# of HH 2011 ('000)	GROWTH IN HH 1989-2011 ('000)	%	PROJECTED VALUES IN 2011 AVG.SIZE OF HH	FAMILY % of HH	CC % OF FAMILIES	2011 % OF DWELLINGS SINGLE	APT.	OTHER MULT.
1	1929.9	631.7	48.7	2.55	73.4	54.2	45.3	36.8	17.9
2	1929.4	631.2	48.6	2.54	73.4	54.2	45.3	36.8	17.9
3	1932.1	633.9	48.8	2.61	73.4	54.2	45.2	36.8	17.9
4	1934.8	636.6	49.0	2.68	73.4	54.1	45.2	36.9	17.9
5	1937.5	639.3	49.2	2.76	73.4	54.1	45.2	36.9	17.9
1989 BASE YEAR	1298.2			2.82	73.2	54.7	43.1	38.9	18.1

CC - Couples with children

TABLE A3: SAMPLE CALCULATION OF ASFR (AGE-SPECIFIC FERTILITY RATES) FOR A PROJECTED TFR (TOTAL FERTILITY RATE)

TORONTO FILE (FERT88TO.CSV)	1988 ASFR	ASFR FOR A PROJECTED TFR OF 2100 1988 ASFR X 2100 / 1638 (1.2820513)
15-19	0.0158	0.020256
20-24	0.0589	0.075513
25-29	0.1100	0.141026
30-34	0.0985	0.126282
35-39	0.0386	0.049487
40-44	0.0056	0.007179
45-49	0.0002	0.000256
SUM	0.3276	0.420000
TFR	1638.0	2100:000

1988 TFR = SUM OF ASFR X 5 X 1000
= 0.3276 X 5 X 1000 = 1638

ASFR ADJUSTMENT FACTOR FOR A PROJECTED TFR OF 2100 = 2100 / 1638 = 1.2820513

TABLE A4: PERCENTAGE DISTRIBUTION OF ASFR 1986-90 (CANADA AND QUEBEC)

AGE GROUP	CANADA ASFR 1986	1987	1988	1989	1990	PERCENT OF ASFR SUM 1986	1987	1988	1989	1990
15-19	0.0256	0.0235	0.0232	0.0235	0.0266	7.24	6.95	7.00	7.03	7.28
20-24	0.0847	0.0818	0.0815	0.0848	0.0855	23.95	24.18	24.60	25.36	23.41
25-29	0.1288	0.1250	0.1230	0.1246	0.1322	36.42	36.95	37.13	37.26	36.19
30-34	0.0837	0.0787	0.0763	0.0756	0.0881	23.66	23.26	23.03	22.61	24.12
35-39	0.0270	0.0254	0.0237	0.0226	0.0288	7.63	7.51	7.15	6.76	7.88
40-44	0.0038	0.0037	0.0034	0.0032	0.0040	1.07	1.09	1.03	0.96	1.09
45-49	0.0001	0.0002	0.0002	0.0001	0.0001	0.03	0.06	0.06	0.03	0.03
ASFR SUM	0.3537	0.3383	0.3313	0.3344	0.3653	100.0	100.0	100.0	100.0	100.0
TFR	1768.5	1691.5	1656.5	1672.0	1826.5					

AGE GROUP	QUEBEC ASFR 1986	1987	1988	1989	1990	PERCENT OF ASFR SUM 1986	1987	1988	1989	1990
15-19	0.0151	0.0158	0.0163	0.0178	0.0190	5.27	5.54	5.48	5.55	5.53
20-24	0.0736	0.0723	0.0754	0.0805	0.0847	25.67	25.33	25.34	25.08	24.67
25-29	0.1164	0.1146	0.1188	0.1273	0.1349	40.60	40.15	39.92	39.66	39.28
30-34	0.0616	0.0627	0.0652	0.0720	0.0786	21.49	21.97	21.91	22.43	22.89
35-39	0.0174	0.0173	0.0189	0.0205	0.0231	6.07	6.06	6.35	6.39	6.73
40-44	0.0025	0.0026	0.0029	0.0028	0.0030	0.87	0.91	0.97	0.87	0.87
45-49	0.0001	0.0001	0.0001	0.0001	0.0001	0.03	0.04	0.03	0.03	0.03
ASFR SUM	0.2867	0.2854	0.2976	0.3210	0.3434	100.0	100.0	100.0	100.0	100.0
TFR	1433.5	1427.0	1488.0	1605.0	1717.0					

APPENDIX B

MIGRATION DATA

TABLE B1: COMPARISON OF CMHC MIGRANT AGE DISTRIBUTION FILES (BOTH SEXES COMBINED) FOR AGGREGATED AGE GROUPS

	PERCENT OF IN-MIGRANTS BY AGE GROUP						
	-1-9	10-19	20-29	30-39	40-64	65+	TOTAL
CANADA	15.0	16.4	27.5	20.4	16.4	4.3	100.0
NEWFOUNDLAND	17.5	15.4	35.1	19.6	11.4	1.1	100.0
P.E.I.	16.6	14.5	31.8	19.9	14.1	3.2	100.0
NOVA SCOTIA	15.8	15.3	33.1	20.2	12.8	2.9	100.0
NEW BRUNSWICK	16.4	15.1	32.3	19.9	13.1	3.1	100.0
QUEBEC	15.5	14.9	30.9	20.9	14.4	3.4	100.0
ONTARIO	15.4	15.4	30.9	20.8	14.1	3.4	100.0
MANITOBA	17.3	15.4	31.7	19.5	12.7	3.3	100.0
SASKATCHEWAN	19.0	14.8	31.1	19.3	12.5	3.3	100.0
ALBERTA	15.4	17.2	32.1	18.7	12.9	3.7	100.0
B.C.	14.4	14.3	27.6	19.1	18.4	6.1	100.0
NWT	17.6	14.5	33.3	21.9	12.4	0.3	100.0
YUKON	17.8	14.0	31.2	21.8	14.4	0.7	100.0
TORONTO	15.2	11.5	36.6	19.4	14.0	3.3	100.0

	PERCENT OF OUT-MIGRANTS BY AGE GROUP						
	-1-9	10-19	20-29	30-39	40-64	65+	TOTAL
CANADA	15.2	14.9	25.2	24.3	17.7	2.7	100.0
NEWFOUNDLAND	11.7	23.7	36.2	16.8	9.8	1.9	100.0
P.E.I.	12.3	18.3	36.1	17.0	12.7	3.6	100.0
NOVA SCOTIA	14.5	16.1	35.8	19.6	11.3	2.6	100.0
NEW BRUNSWICK	14.6	18.0	35.1	18.2	11.6	2.5	100.0
QUEBEC	12.7	14.5	30.9	20.8	15.8	5.2	100.0
ONTARIO	14.9	14.0	30.2	21.2	15.7	4.0	100.0
MANITOBA	16.7	15.2	29.4	19.8	14.7	4.2	100.0
SASKATCHEWAN	17.8	16.8	31.1	18.3	11.9	4.1	100.0
ALBERTA	18.7	12.6	31.9	20.7	13.8	2.3	100.0
B.C.	15.5	15.5	31.0	20.9	13.7	3.5	100.0
NWT	21.2	13.5	26.4	23.2	14.4	1.3	100.0
YUKON	19.0	13.2	25.5	23.9	16.3	2.2	100.0
TORONTO	21.0	11.7	25.6	22.2	15.4	4.1	100.0

TABLE B2: COMPARISON OF CMHC MIGRANT AGE DISTRIBUTION FILES (BOTH SEXES COMBINED) FOR AGGREGATED AGE GROUPS WITH 1981 CENSUS MIGRATION VALUES FOR THE 1976-81 PERIOD (USING CENSUS AGE CATEGORIES FOR MIGRANTS AGE 5 YEARS AND OVER)

IN-MIGRANTS: PERCENT BY AGE GROUP (Domestic, Foreign, and Total for Census data)

	5-14	15-19	20-24	25-29	30-34	35-44	45-54	55-64	65+	TOTAL
ONTARIO:										
CENSUS: Dom.	16.8	9.0	13.3	15.7	13.4	14.7	7.6	4.7	4.8	100.0
For.	16.5	9.4	13.4	14.8	13.0	13.7	7.1	6.4	5.6	100.0
Tot.	16.6	9.2	13.4	15.2	13.2	14.2	7.3	5.5	5.2	100.0
CMHC FILE	15.4	9.7	15.7	17.7	13.5	14.3	5.5	4.4	3.7	100.0
B.C.:										
CENSUS: Dom.	15.5	8.0	14.4	17.3	12.9	13.0	7.2	6.3	5.4	100.0
For.	15.2	8.7	12.6	14.7	12.5	13.3	7.7	8.1	7.1	100.0
Tot.	15.5	8.2	13.9	16.6	12.8	13.1	7.4	6.8	5.9	100.0
CMHC FILE	14.4	8.8	14.2	15.6	12.0	14.0	7.1	7.5	6.6	100.0
TORONTO:										
CENSUS: Dom.	13.2	7.8	19.0	19.1	13.1	12.8	6.7	4.0	4.1	100.0
For.	15.0	9.6	14.0	15.4	13.0	13.1	7.2	7.0	5.6	100.0
Tot.	14.0	8.5	17.0	17.7	13.1	12.9	6.9	5.2	4.7	100.0
CMHC FILE	13.0	6.8	20.4	19.6	12.4	14.2	6.1	3.7	3.6	100.0

OUT-MIGRANTS: PERCENT BY AGE GROUP (Census data are for domestic migrants only)

	5-14	15-19	20-24	25-29	30-34	35-44	45-54	55-64	65+	TOTAL
ONTARIO:										
CENSUS	16.0	8.3	18.3	19.2	13.7	13.0	5.7	3.3	2.4	100.0
CMHC FILE	14.6	8.6	15.3	17.4	13.1	16.0	6.2	4.5	4.4	100.0
B.C.:										
CENSUS	16.9	8.8	16.5	17.5	14.0	13.5	5.9	3.3	3.5	100.0
CMHC FILE	14.7	10.3	16.1	17.5	13.5	14.9	5.8	3.4	3.8	100.0
TORONTO:										
CENSUS	16.3	6.4	11.3	18.2	15.0	14.1	7.1	6.4	5.2	100.0
CMHC FILE	16.8	6.2	11.6	17.8	14.7	17.0	5.4	5.9	4.7	100.0

PHD MODEL SENSITIVITY ANALYSIS: MIGRATION VARIABLE

STUDY AREA: TORONTO

FACTORS HELD CONSTANT IN ALL VARIANTS:

1. All variants use Ontario survival ratios (SURVON.CSV) and Toronto fertility rates (FERT88TO.CSV).

2. All variants use constant base year (1986) rates for headship (HIHRTRNT.CSV), family proportions (HIFPTRNT.CSV), ownership (HIOPTRNT.CSV), and dwelling choice (HIDPTRNT.CSV).

PROJECTION VARIANTS:

1. Variants 1, 2 and 3 assess the impact of using different migrant age distributions (Toronto, Ontario, and Canada), while holding total net migration and the ratio of out-migrants to in-migrants constant.

2. Variants 4 and 5 examine the impact of using a different ratio of out-migrants to in-migrants, while holding total net migration and the age distribution of migrants the same as in Variant 1.

3. Variants 6 and 7 employ somewhat higher and lower values for total net migration, with the same migrant age distribution and approximately the same ratio of out-migrants to in-migrants as in Variant 1.

TABLE B3: MIGRATION SPECIFICATIONS FOR THE PROJECTION VARIANTS

VARIANT	ANNUAL NET MIG.	IN-MIG.	OUT-MIG.	OUT-MIG. AS A % OF IN-MIG.	MIGRANT AGE FILE (*.CSV)
1	30000	100000	70000	70.0	MIDI69TO
2	30000	100000	70000	70.0	MIDI50ON
3	30000	100000	70000	70.0	MIDI50CA
4	30000	60000	30000	50.0	MIDI69TO
5	30000	200000	170000	85.0	MIDI69TO
6	35000	117000	82000	70.1	MIDI69TO
7	25000	83000	58000	69.9	MIDI69TO

TABLE B4: COMPARATIVE AGE DISTRIBUTION OF MIGRANTS (BOTH SEXES COMBINED)

AGE GROUP	IN-MIGRANTS (%)			OUT-MIGRANTS (%)			NET MIGRANTS				
	TORONTO	ONTARIO	CANADA	TORONTO	ONTARIO	CANADA	PROJECTION VARIANTS				
	MIDI69TO	MIDI50ON	MIDI50CA	MIDI69TO	MIDI50ON	MIDI50CA	#1	#2	#3	#4	#5
0-19	26.6	30.8	31.4	32.7	28.8	30.1	3764	10605	10319	6180	-2281
20-29	36.6	30.8	27.4	25.6	30.3	25.1	18658	9705	9870	14272	29625
30-39	19.4	20.8	20.4	22.2	21.2	24.3	3853	5973	3420	4975	1056
40-64	14.1	14.1	16.4	15.4	15.6	17.6	3235	3119	4009	3795	1838
65+	3.3	3.4	4.3	4.1	4.0	2.8	490	598	2382	778	-238
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	30000	30000	30000	30000	30000

MIGRATION SENSITIVITY ANALYSIS FOR TORONTO: COMPARISON OF PROJECTION RESULTS

TABLE B5: POPULATION CHANGE

VARIANT	POP. 2011 ('000)	POPULATION GROWTH 1989-2011 ('000)	%	PERCENT OF POPULATION BY AGE GROUP IN 2011 0-14	15-24	25-34	35-64	65+
1	4921.4	1254.7	34.2	16.7	12.3	13.5	44.1	13.4
2	4863.5	1196.8	32.6	16.9	13.4	12.7	43.2	13.9
3	4837.0	1170.3	31.9	16.9	13.4	12.8	41.8	15.2
4	4882.7	1216.0	33.2	16.7	12.7	12.9	43.9	13.7
5	5018.2	1351.5	36.9	16.6	11.4	15.1	44.5	12.4
6	5062.2	1395.5	38.1	16.8	12.2	13.9	44.1	13.0
7	4780.5	1113.8	30.4	16.5	12.4	13.2	44.1	13.7
1989 BASE YEAR	3666.7			19.3	15.7	19.7	35.6	9.7

TABLE B6: HOUSEHOLD (HH) CHANGE

VARIANT	# of HH 2011 ('000)	GROWTH IN HH 1989-2011 ('000)	%	2011 FAMILY % of HH	2011 PERCENT OF FAMILY HH* C	CC	LP	MF
1	1929.9	631.7	48.7	73.4	30.7	54.2	11.9	3.2
2	1882.4	584.2	45.0	73.1	31.2	53.7	11.9	3.2
3	1873.3	575.1	44.3	72.3	32.1	52.9	11.8	3.2
4	1908.7	610.5	47.0	73.2	31.0	53.9	11.9	3.2
5	1983.0	684.8	52.7	73.8	30.0	54.9	11.9	3.2
6	1982.0	683.8	52.7	73.6	30.4	54.4	11.9	3.2
7	1877.8	579.6	44.6	73.3	30.9	53.9	11.9	3.2
1989 BASE YEAR	1298.2			73.2	30.3	54.7	11.9	3.1

* C - Couples without children
CC - Couples with children
LP - Lone parents
MF - Multiple-family households

MIGRATION SENSITIVITY ANALYSIS FOR TORONTO: COMPARISON OF PROJECTION RESULTS

TABLE B7: PROJECTED HOUSING DEMAND

VARIANT	GROWTH IN DWELLINGS 1989-2011 ('000) TOTAL	OWNERS	RENTERS	% OF GROWTH IN # OF DWELLINGS 1989-2011 OWNERS	RENTERS	SINGLE	APT.	OTHER MULT.
1	631.7	431.7	200.0	68.3	31.7	49.8	32.5	17.7
2	584.2	403.3	180.9	69.0	31.0	50.3	32.4	17.3
3	575.1	391.6	183.5	68.1	31.9	49.5	33.8	16.7
4	610.5	421.1	189.3	69.0	31.0	50.2	32.3	17.5
5	684.8	458.2	222.6	66.9	33.1	48.9	33.0	18.1
6	683.8	462.1	221.7	67.6	32.4	49.4	32.8	17.8
7	579.6	401.2	178.3	69.2	30.8	50.4	32.1	17.5
1989 % OF TOTAL	100.0			58.1	41.9	43.1	38.9	18.1

TABLE B8: CANADA: ESTIMATE OF PROJECTED MIGRATION VALUES BASED ON MIGRATION RATES PER CAPITA FOR MALES AND FEMALES

AGE	1990 MIGRATION			PERCENT OF TOTAL		
	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	22470	7594	14876	15.0	15.2	14.9
10-19	24592	7449	17143	16.4	14.9	17.1
20-29	41207	12573	28634	27.5	25.1	28.6
30-39	30623	12142	18481	20.4	24.3	18.5
40-64	24643	8871	15772	16.4	17.7	15.8
65+	6465	1371	5094	4.3	2.7	5.1
TOTAL	150000	50000	100000	100.0	100.0	100.0

AGE	2001 MIGRATION			PERCENT OF TOTAL		
	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	23495	7985	15510	15.0	15.2	14.9
10-19	26020	7913	18107	16.6	15.1	17.4
20-29	36529	11035	25494	23.4	21.0	24.5
30-39	29879	12006	17873	19.1	22.9	17.2
40-64	32650	11839	20811	20.9	22.6	20.0
65+	7789	1649	6140	5.0	3.1	5.9
TOTAL	156362	52427	103935	100.0	100.0	100.0

AGE	2011 MIGRATION			PERCENT OF TOTAL		
	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	22186	7512	14674	13.6	14.2	13.3
10-19	26892	8127	18765	16.5	15.3	17.1
20-29	38816	11706	27111	23.8	22.1	24.7
30-39	27427	10941	16486	16.8	20.6	15.0
40-64	38318	12742	25575	23.5	24.0	23.3
65+	9349	2012	7337	5.7	3.8	6.7
TOTAL	162987	53040	109947	100.0	100.0	100.0

PROJECTED POPULATION: BASED ON AN ANNUAL NET MIGRATION OF 100,000 (IN-MIG. = 150,000; OUT-MIG. = 50,000)
PROJECTION USES BPOP90CA.CSV, SURVCA.CSV, FERT90CA.CSV, AND MIDI50CA.CSV

MIGRATION RATES: BASED ON 1990 IN- AND OUT-MIGRATION VALUES FOR SINGLE YEAR MALE AND FEMALE AGE GROUPS PER CAPITA OF THE 1990 POPULATION. FOR THE -1 AGE CATEGORY, THE MIGRATION RATE HAS BEEN CALCULATED BY EXPRESSING MIGRANTS AGE -1 AS A PERCENT OF THE MIGRANTS AGE 0-4.

MIGRATION ESTIMATES FOR 2001 AND 2011: THE PROJECTED POPULATION FOR SINGLE YEAR AGE-SEX GROUPS HAS BEEN MULTIPLIED BY THE 1990 PER CAPITA MIGRATION RATES.

TABLE B9: TORONTO: ESTIMATE OF PROJECTED MIGRATION VALUES BASED ON MIGRATION RATES PER CAPITA FOR MALES AND FEMALES

	1989 MIGRATION			PERCENT OF TOTAL		
AGE	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	15189	14678	511	15.2	21.0	1.7
10-19	11454	8201	3253	11.5	11.7	10.8
20-29	36611	17953	18658	36.6	25.6	62.2
30-39	19374	15521	3853	19.4	22.2	12.8
40-64	14036	10801	3235	14.0	15.4	10.8
65+	3336	2846	490	3.3	4.1	1.6
TOTAL	100000	70000	30000	100.0	100.0	100.0

	2001 MIGRATION			PERCENT OF TOTAL		
AGE	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	17818	17052	766	16.3	21.5	2.6
10-19	12521	9177	3344	11.5	11.6	11.3
20-29	29915	14852	15063	27.4	18.7	50.7
30-39	24060	19350	4710	22.1	24.4	15.9
40-64	19941	14956	4985	18.3	18.8	16.8
65+	4790	3963	828	4.4	5.0	2.8
TOTAL	109046	79350	29696	100.0	100.0	100.0

	2011 MIGRATION			PERCENT OF TOTAL		
AGE	IN-MIG.	OUT-MIG.	NET MIG.	IN-MIG.	OUT-MIG.	NET MIG.
-1-9	16705	16001	704	14.4	19.3	2.1
10-19	14102	10179	3923	12.2	12.3	12.0
20-29	33017	16053	16964	28.6	19.4	51.7
30-39	20736	16641	4095	17.9	20.1	12.5
40-64	24939	18893	6046	21.6	22.8	18.4
65+	6110	5046	1064	5.3	6.1	3.2
TOTAL	115609	82812	32796	100.0	100.0	100.0

PROJECTED POPULATION: BASED ON AN ANNUAL NET MIGRATION OF 30,000 (IN-MIG. = 100,000; OUT-MIG. = 70,000) PROJECTION USES BPOPTRNT.CSV (1989 Base Pop.), SURVON.CSV, FERT88TO.CSV, AND MIDI69TO.CSV

MIGRATION RATES: BASED ON 1989 IN- AND OUT-MIGRATION VALUES FOR SINGLE YEAR MALE AND FEMALE AGE GROUPS PER CAPITA OF THE 1989 POPULATION.

MIGRATION ESTIMATES FOR 2001 AND 2011: THE PROJECTED POPULATION FOR SINGLE YEAR AGE-SEX GROUPS HAS BEEN MULTIPLIED BY THE 1989 PER CAPITA MIGRATION RATES.