Statistics New Zealand
TATAURANGA AOTEAROA

Estimated resident population 2013: Data sources and methods

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1 Purpose and summary

Purpose

Estimated resident population 2013: Data sources and methods describes the data sources and methods used to produce the 2013 estimated resident population (ERP) following the 2013 Census of Population and Dwellings. It includes data sources and methods for estimates at both national and subnational level, as well as for estimates by major ethnic group. The report is aimed at technical users who want to gain an understanding of how we compiled the 2013 ERP.

Summary

The estimated resident population (ERP) of New Zealand is an estimate of all the people who usually live in New Zealand at a given date. It is derived using the 'census usually resident population count' adjusted for net census undercount, residents temporarily overseas, and births, deaths, and migration between census night (5 March 2013) and the 30 June 2013 reference date.

We describe the data sources and methods we used to estimate each of these adjustments, at both the national and subnational level and by the major ethnic groups.

While some of the methods and data sources remain consistent with those we used to produce the 2006 ERP, some we used for the first time while producing the 2013 ERP.

We used results from the Post-enumeration Survey (Statistics NZ, 2014c) to adjust for census coverage. We estimated the number of residents temporarily overseas using international travel data and census data. Birth and death registrations accounted for some of the population change between census night and mid-year. Internal migration was estimated using various administrative sources, and international migration was measured using information on arrivals and departures to and from New Zealand. A final adjustment was made to ensure estimates reflect vital registration data. This is known as demographic reconciliation.

All population measures, including census counts and population estimates, have some uncertainty around them. This report also describes new methods we used to measure the uncertainty around the 2013 ERP.

Links to data

See National Population Estimates: At 30 June 2014 (Statistics NZ, 2014b) for data and commentary about the 2013 ERP. (Note the 2013 ERP and 2014 National Population Estimates were released together.)

Tables available in NZ.Stat

- Estimated resident population (ERP), adjustments to derive ERP at 30 June 2013 (from census usually resident population)
- Estimated resident population (ERP), national population by ethnic group, age, and sex, 30 June 1996, 2001, 2006, and 2013
- Estimated resident population (ERP), subnational population by ethnic group, age, and sex, 30 June 1996, 2001, 2006, and 2013.

2 The estimated resident population

Here is background information about the resident population (ERP), including:

- About the ERP
- Why we produce the ERP
- How we derived the 2013 ERP
- Summary of adjustments and data sources used for 2013 ERP.

About the ERP

The estimated resident population (ERP) of New Zealand is an estimate of all people who usually live in New Zealand at a given date.

The estimated resident population of New Zealand at a given date after census night is derived by updating the census usually resident population count for estimates of:

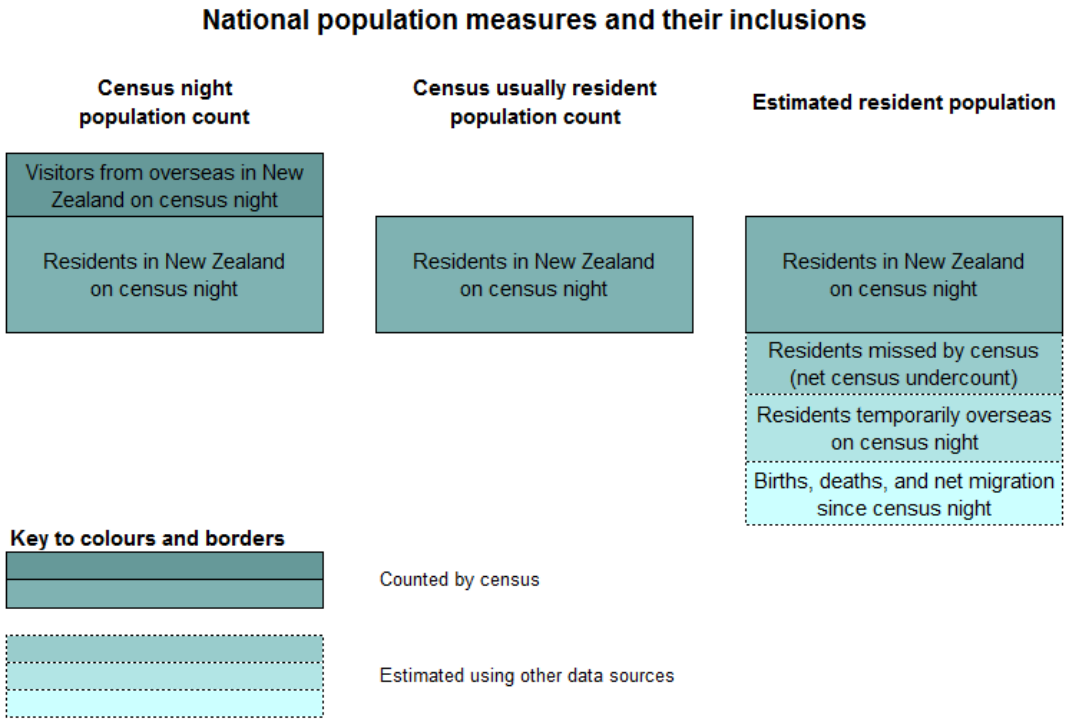
- net census undercount
- residents temporarily overseas on census night
- natural increase (births less deaths) between census night and the given date
- net migration (arrivals less departures) between census night and the given date.

At the subnational level, the estimated resident population of an area in New Zealand is an estimate of all people who usually live in that area at a given date. The estimated resident population for each area at a given date after census night is derived in the same way as for the national population of New Zealand.

The estimated resident population is as at midnight of the reference date. A ‘resident’ is a person who usually lives in an area. This is a statistical, not legal, definition generally based on a person's self-identified usual address. The term 'resident' may be used differently in other contexts, such as in economic statistics or to describe immigration status. In international travel and migration statistics, a resident is a person who is living in New Zealand for 12 months or more.

The wording of the term 'estimated resident population' clarifies that it is a demographic estimate, and differentiates it from the other two main population measures: ‘census usually resident population count’ and ‘census night population count’. Figure 1 illustrates the differences between these three population measures at the national level.

Figure 1



Why we produce the ERP

We produce an ERP in addition to the population counts resulting directly from the census for several reasons:

- to represent the best possible measure of the resident population for a wide variety of customers and uses (including use in demographic projections and indices)
- to meet the need for updated population estimates beyond census date as an indication of demographic change
- to satisfy United Nations 1952 recommendations to adjust for known deficiencies in census (United Nations, 1952).

How we derived the 2013 ERP

The 2013 ERP is based on the 2013 Census count, with various adjustments. These adjustments are best described in two groups: adjustments at census date (5 March 2013) and adjustments made to account for population change between census night and 30 June 2013.

Adjustments we made at census date:

- assigned ethnic indicators and Māori descent where these are missing
- adjusted for net census undercount, as measured by the 2013 Post-enumeration Survey
- included the number of residents temporarily overseas on census night, using international travel data and census data.

Adjustments we made to account for population change between census night and 30 June 2013:

- natural increase (births less deaths), using birth and death registrations
- international migration (arrivals less departures), using passenger cards completed by international migrants
- net internal migration, using a combination of administrative data sources.

We made other adjustments, known as demographic reconciliation, to ensure the final estimates reflected vital registration data.

The methods and data sources used to determine the size and nature of each adjustment are described in this report.

Although we assigned indicators for both ethnicity and Māori descent to produce the 2013 ERP, we have only described the methods for assigning missing ethnic indicators in this report. This is because, in most cases, the methods for assigning missing Māori descent are similar to those for ethnic indicators.

We derived the 2013 ERP by age, sex, geographic location down to meshblock level, broad ethnic indicators (European, Māori, Asian, Pacific, Middle Eastern/Latin American/African (MELAA), Other), and Māori descent. This is the first time we have derived ERP at meshblock level. We derived estimates at meshblock level to provide flexibility in aggregating to all geographies needed by our diverse range of customers. Population estimates at meshblock level are not of suitable quality for publication.

Summary of data sources and adjustments for the 2013 ERP

Table 1 summarises the data sources we used to determine the size of each adjustment and the size of the adjustment made to produce the national level total 2013 ERP.

Table 1

Data sources and size of each adjustment used to derive the 2013 ERP

Adjustment	Data sources	Size
Census usually resident population count	2013 Census	4,242,000
Adjustments made at census date		
Imputation of non-response for ethnic indicators and Māori descent	2013 Census	n/a
Estimated net census undercount	Post-enumeration survey	104,200
Estimated number of residents temporarily overseas on census night	ITM statistics (1)	81,700
	2013 Census	
Adjustments made for population change between census date and 30 June 2013		
Natural increase (births less deaths)	Birth registrations	9,100
	Death registrations	
International migration (arrivals less departures)	ITM statistics (1)	200
Net internal migration	Administrative sources, incl health and tax transitions data	n/a
Total population change	n/a	9,300
Demographic reconciliation	Birth registrations	4,800
	Death registrations	
	ITM statistics(1)	
Estimated resident population	n/a	4,442,100

1. ITM: International travel and migration
n/a: not applicable

3 Adjustments made at census date

This chapter introduces the 2013 Census counts and why the adjustments to derive the ERP are necessary; and outlines three methods we used to make the necessary adjustments at census date:

- About 2013 Census counts
- Assigning ethnic indicators
- Adjusting for net census undercount
- Adjusting for residents temporarily overseas.

About 2013 Census counts

The starting population for deriving 2013 ERP was the 2013 ‘census usually resident population count’. The census usually resident population count of New Zealand is a count of all people who usually live, and are present, in New Zealand on census night. This count excludes visitors from overseas and excludes residents who are temporarily overseas on census night.

Residents were counted at the meshblock of their address. A meshblock is the smallest geographic area we use for statistical purposes – see insert Geographic areas used in population estimation. Those who were temporarily elsewhere in New Zealand on census night were included in the meshblock they usually live in. If they gave insufficient information about their usual address, we used available geographic information (eg an area unit, territorial authority, regional council or 'in New Zealand') to select (impute) (see insert What is imputation?) a meshblock within that area.

Some people who usually live, and are present, in New Zealand on census night are not counted by census. Some people, although fewer than those not counted, are also counted twice by the census. The 2013 Post-enumeration Survey (Statistics NZ, 2014c) provided a measure of the census undercount.

Also, some people were counted by census but did not respond to all questions. Therefore, some census records lacked details crucial for producing the ERP, such as ethnic indicators. Each type of non-response to census were adjusted for in the preparation of the ERP.

See the following sections for the methods and data sources we used.

Geographic areas used in population estimation

Estimates of the resident population are required at various geographic levels, both national and subnational. Certain data sources used in population estimation are only available, or accurate, at higher geographical areas so further estimation techniques are used to derive the data at lower levels. The key geographical levels used in population estimation are grouped below by national and subnational level.

National level

New Zealand. For statistical purposes, the term ‘New Zealand’ refers to ‘geographic New Zealand’. This includes offshore islands, but does not include the Cook Islands, Niue, or the Tokelau Islands.

Subnational level

Regional council areas (regions). The boundary of each regional council conforms as far as possible to one or more water catchment, and also takes into account factors such as natural resource management, land use planning, and environmental matters. Generally, regional council areas contain complete territorial authorities. Where territorial authorities straddle regional council boundaries, the affected area has been statistically defined in complete area units.

Territorial authority areas. A territorial authority is a city council or district council. There are 67 territorial authorities comprising 12 cities, 53 districts, Auckland, and Chatham Islands territory. ‘Community of interest’ was a key factor in determining the extent of territorial authority areas.

Auckland local board areas. Local boards were introduced as part of the new local government arrangements for Auckland in 2010. Statistics at the local board level are often presented alongside territorial authority level statistics to provide greater detail for Auckland.

Area unit. Area units are non-administrative geographic areas that are in between meshblocks and territorial authority areas in size. Area units must either define, or aggregate to define, regional council, territorial authority, and urban areas. They are aggregations of meshblocks. Area units within urban areas normally contain a population of 3,000–5,000 people. The median population of area units is about 2,200 people. At the time of the 2013 Census, there were 2,020 area units in New Zealand.

Meshblock. A meshblock is the smallest geographic unit for which we collect statistical data. Meshblocks vary in size, from part of a city block to large areas of rural land. Each meshblock borders on another to cover all of New Zealand, extending out to the 200-mile economic zone (approximately 320 kilometres). Meshblocks are aggregated to build larger geographic areas, such as area units and territorial authority and regional council areas. At the time of the 2013 Census, there were 46,637 meshblocks in New Zealand.

Assigning ethnic indicators

To produce an ERP by ethnic group, individuals who have not responded to the census ethnicity question are an assigned an ethnic indicator.

The 2013 Census Individual Form asks "Which ethnic group do you belong to?" with the secondary instruction "Mark the space or spaces which apply to you".

The six level 1 ethnic groups are European, Māori, Pacific, Asian, Middle Eastern/Latin American/African (MELAA), and Other. There were 230,600 individuals in the census usually resident population count who either did not respond to this question, or whose response was not coded to a major (level 1) ethnic group.

For population estimation purposes, we assigned either a ‘yes’ or ‘no’ to the major ethnic group indicators for these 230,600 individuals. The statistical technique for assigning missing values is called imputation (see insert What is imputation?). The imputation of ethnic indicators in this case was based on characteristics known to be associated with ethnic group, known as predictor variables. The predictor variables used, in order of priority, were: age group (10-year), Māori descent ('Yes'/'No' indicator), area unit, and sex.

What is imputation?

The data sources used to derive the ERP often have missing values. A variety of techniques are used to assign, or impute, plausible values where they are missing, in order to produce complete datasets. The technique used depends on the data available and the proportion of values that are missing.

Sometimes values are missing from the raw data source, and sometimes the data source was not designed to collect data at a particular level (eg raw data on residents temporarily overseas are not available at meshblock level). In both cases, imputation is used.

We assigned each individual with no response for ethnicity a combination of ethnic indicators based on the probability of that combination of indicators in the non-missing sector of the population of that age group, Māori descent, area unit, and sex.

This method allowed us to impute any combination of the six ethnic group indicators, provided at least one of those indicators was imputed to 'Yes'. The imputation drew on the known distribution of ethnic responses from census respondents. We created a probability distribution using the population not requiring imputation. We selected a random point on this distribution to determine the combination of ethnic indicators that are imputed to ‘Yes’.

This method is similar to that used in previous census years. In 2013, however, for the first time, we repeated the imputation process 1,000 times. This gave us a spectrum of results that provide a measure of uncertainty for the 2013 ERP.

See Measuring uncertainty in the ERP for more details.

The imputation resulted in all individuals having an indicator for each ethnic group, and affected the number and age-sex composition of each ethnic population at the national (New Zealand) and subnational levels. The imputation did not, however, affect the total number of people in New Zealand or in any subnational area; nor did it affect the age-sex composition of the total population in any area.

Table 2 shows the size of the ethnic groups before and after imputation. The number of people with a Pacific ethnic indicator increased by 8.2 percent as a result of the imputation, whilst the increase for those with a European ethnic indicator was smaller at 5.4 percent. This difference reflects the fact that non-response is higher in areas with more people with Pacific ethnic indicators.

Table 2

Census usually resident population count by ethnic group, before and after imputation

	2013 Census usually resident counts, before imputation	Estimate, after imputation	Difference	
			Number	Percent
Total population	4,242,000	4,242,000	0	0
European	2,969,000	3,129,000	160,000	5.4
Māori	599,000	641,000	42,000	7.1
Pacific	296,000	320,000	24,000	8.2
Asian	472,000	500,000	28,000	6.0
MELAA[(1)]	47,000	50,000	3,000	6.2
Other	68,000	71,000	4,000	5.5

1 Middle Eastern/ Middle Eastern/Latin American/African

Note: People who reported more than one ethnic group are counted once in each group reported. This means that the total number of responses for all ethnic groups can be greater than the total number of people who stated their ethnicities.

Adjusting for net census undercount

It is inevitable that some people will be missed by the census, and some people will be counted more than once. This reflects the large and complex undertaking of a census, the increasingly difficult environment for encouraging participation in the census and collecting data, and the growing diversity of the New Zealand population in terms of ethnicity, living arrangements, and lifestyles.

For the purposes of estimating the resident population, it is important to make allowance for differential census coverage. Typically in New Zealand, more people are missed by the census than are counted twice, so the adjustment is referred to as net census undercount (NCU). NCU is the difference between census undercount (people missed by the census who were meant to be counted) and census overcount (people counted by the census who should not have been counted or who were counted more than once).

Significantly, the New Zealand and international experience also suggests ‘differential’ undercount. That is, census undercount patterns typically vary by age, sex, ethnic group, and geographic area (of usual residence). Consequently, any adjustment for undercount must attempt to adequately reflect these demographic differentials, which are often inter-related.

We based the adjustment for NCU on the results of the Post-enumeration Survey (PES): 2013 (Statistics NZ, 2014c).

The PES measures the level of coverage (undercount and overcount) in the census. The 2013 PES was carried out in April–May 2013, following the census on 5 March 2013. It is an interviewer-administered survey with a paper questionnaire that can be easily administered on the doorstep. All usual residents in a selected dwelling were asked for basic demographic information and to provide any addresses where (s)he might have filled in a census form, or had one filled in for them.

The 2013 PES sample consisted of approximately 15,000 private dwellings selected using a two-stage stratified cluster design. With the results from both the 2013 Census and the 2013 PES, we applied the statistical methodology called Dual System Estimation (DSE), also known as capture-recapture estimation, to estimate the NCU.

More detail is available in *Coverage in the 2013 Census based on the 2013 Post-enumeration Survey (*Statistics NZ, 2014a)

The size of the PES sample limits the availability of direct survey estimates of NCU. To derive the ERP, we needed estimates of NCU by single year of age, sex, and at lower geographic levels. Therefore we had to apply additional statistical modelling techniques.

We modelled net undercount by age, sex, ethnic grouping, and regional grouping using a hierarchical Bayesian approach (Gelman, Carlin, Stern, and Rubin, 2004; and You and Dick, 2004). This was the first time Statistics NZ used this approach to model NCU.

In contrast to estimates for broadly defined groups and regions obtained directly from the PES data, the Bayesian approach models data for all groups simultaneously. This permits the overall pattern of undercount, by region, ethnic group, sex, and age to inform estimates for specific cells defined by these characteristics. This process helps stabilise estimates for cells with limited PES data.

However, the modelled point estimates sometimes differ slightly from published PES results for broad groups because the Bayesian modelling approach implicitly accounts for sampling errors in the estimation process, in such a way that unstable estimates can move towards values that are more consistent with the overall pattern of variation in census undercount.

The Bayesian model allows the age-profile of census undercount to vary by ethnicity. Geographies smaller than a region are assumed to have uniform undercount in line with their regional grouping.

Further details of this method, including its development and comparisons with the method used for the 2006 ERP are planned for publication as a Statistics New Zealand Working Paper.

The overall modelled net census undercount was 104,200 (2.4 percent). Nearly all the modelled adjustments fall within the 95 percent sample error bounds of the published PES results. Any NCU adjustments outside the range indicated by PES results (eg the lower North Island), are only slightly outside the range, but supported by the overall pattern of NCU observed in the PES results.

The modelled NCU varied by age, sex, ethnic group, and region. Some of the key variations were:

- Males (2.7 percent) had a higher percentage undercount than females (2.1 percent).
- Younger adults aged 15–24 years (4.4 percent) had a higher percentage undercount than other age groups.
- People aged 65 years and over had the lowest percentage undercount by age group, at 0.4 percent.
- The percentage undercount for Māori (5.4 percent) and Pacific peoples (4.3 percent), with young age structures, was higher than for Asian (2.5 percent), MELAA (2.1 percent) and European (2.0 percent).
- Northland regional council area had the highest modelled undercount (6.2 percent) compared with 1.3 percent for the Wellington region, which is the lowest modelled undercount.

See table 3 for a summary of the modelled undercount adjustments by ethnic group.

Table 3

Net census undercount adjustments by ethnic group, 2013

Ethnic group	Net census undercount	Percentage of total NCU
Total population	104,200	100
European	64,000	61
Māori	36,900	35
Pacific	14,200	14
Asian	12,700	12
MELAA[1]	1,100	1
Other	1,300	1

1. Middle Eastern/Latin American/African

Note: People who reported more than one ethnic group are counted once in each group reported. This means that the total number of responses for all ethnic groups can be greater than the total number of people who stated their ethnicities.

See the following table in NZ.Stat for a full breakdown by ethnic group, sex and, geography:

- Estimated resident population (ERP), adjustments to derive ERP at 30 June 2013 (from census usually resident population)

As with other adjustments, the data sources we used were incomplete, so there is some uncertainty around the results. The methods we used to derive undercount estimates also produced associated measures of uncertainty.

See Measuring uncertainty in the ERP for more details.

Adjusting for residents temporarily overseas

The census usually resident population count does not include residents who are temporarily overseas on census night. The definition of the ERP does include such individuals; therefore we made an adjustment to include residents temporarily overseas (RTOs) as part of the ERP.

Some information about RTOs is available from the census absentee overseas data from the 2013 Census. A census absentee overseas is identified on the census dwelling form as usually living in a New Zealand dwelling but is missing from the census individual form at that dwelling because they were overseas at the time of the census. However, only 27 percent of RTOs were identified on census night.

There are two types of RTOs: civilian and military. The estimated number of RTOs (both civilian and military) at the time of the 2013 Census was 81,700. This included 81,300 civilian and 500 military RTOs.

At the national level, we estimated the number of civilian RTOs by age and sex using international travel and migration data. For census night 2013, we calculated the number of RTOs by age and sex by matching New Zealand-resident traveller arrivals to (earlier) departures, to determine those out of the country at midnight 5 March 2013.

For population estimation, we required an estimate of the number of RTOs by age, sex, and ethnic group down to meshblock level.

In three separate stages (described below) we assigned each RTO with:

1. a combination of ethnic indicators (plus the Māori descent indicator)
2. a TA of usual residence
3. a meshblock of usual residence.

1. Ethnic indicators assigned using country of birth and citizenship information

Ethnicity is not collected in international travel and migration statistics. So, for RTOs, we imputed ethnic indicators based on a combination of country of birth and ethnicity information from the 2013 Census, and citizenship and country of birth from international travel data. We only collected country of birth from a small sample of travellers.

For those RTOs not included in the sample, we assigned a country of birth based on their continent of citizenship in line with the relationship between citizenship and country of birth seen in the sample. Then, we assigned ethnic indicators to all RTOs based on the relationship between country of birth and ethnicity seen at national-level in the 2013 Census.

2. Territorial authority area of usual residence assigned using citizenship information

For a five percent sample of RTOs, we recorded TA of usual residence from the international travel data. For the remaining RTOs, for which no TA was available from the raw data source, we randomly assigned a TA based on citizenship. We imputed the TA for RTOs with Oceania as their region of citizenship based on ethnic group.

3. RTOs distributed to meshblock of usual residence using a statistical model

International travel statistics only have data at TA level. We used a statistical model to distribute RTOs to meshblock level within the TAs assigned in the previous step. The model used the meshblock level distribution of census absentees overseas and borrowed strength from other factors that correlate with being a census absentee (called predictor variables) in order to build a more comprehensive meshblock level distribution against which RTOs within each TA was distributed. Predictor variables used in the model included family median income, age group, occupation, ethnic group, Māori descent, overseas five years ago, and regional area of residence.

Because international travel and migration data does not include movements of military personnel, we determined the number and distribution of military RTOs using information supplied by the New Zealand Defence Force.

Table 4 shows the distribution of RTOs by sex and ethnic group at the national level. Almost half of RTOs (44 percent) are estimated to be usually resident in Auckland, with the next largest allocation (7 percent) being to Christchurch City.

Table 4

Estimated number and percentage of residents temporarily overseas, by population group

Census night 2013

	Residents temporarily overseas	
	Number	**Percent**
Total	81,700	100
Sex		
Male	43,100	53
Female	38,600	47
Ethnic groups		
European	49,000	60
Māori	9,000	11
Pacific	6,900	8
Asian	21,500	26
MELAA[1]	1,100	1
Other	1,100	1

1. Middle Eastern/Latin American/African

Note: People who reported more than one ethnic group are counted once in each group reported. This means that the total number of responses for all ethnic groups can be greater than the total number of people who stated their ethnicities.

As with other adjustments, the data sources we used were incomplete, therefore there is some uncertainty around the resulting RTO distributions. The methods we used to estimate the number of RTOs allow uncertainty to be measured for the first time in 2013.

See Measuring uncertainty in the ERP for more details.

4 Adjustments made for population change between census night and 30 June

Between census date (5 March 2013) and the ERP reference date of 30 June 2013, the population changed. This was due to both natural increase (the difference between births and deaths) and net migration (the difference between those leaving an area and those arriving). To ensure the ERP represents the most accurate population at 30 June, we had to account for these changes.

See the following sections for the data sources and methods we used to estimate population change between census night and mid-year:

- Births and deaths
    - Adjustments to account for late or delayed registrations
    - Imputation of missing ethnic indicators and location of usual residence
- Net migration
    - International migration
    - Net internal migration.

Births and deaths

The number of births and deaths occurring in the period between census night and mid-year is recorded through the national registration system, administered by the Registrar-General under the auspices of the Department of Internal Affairs. As birth and death registrations are required by law, these data are considered to be of high quality.

To ensure the births and deaths data were as complete as required for the compilation of the ERP, we made the following adjustments to the data where necessary.

Adjustments to account for late or delayed registrations

By law, both parents of a child born in New Zealand must jointly notify Births, Deaths and Marriages as soon as is reasonably practicable after the birth (deemed by the Registrar-General as generally being within two months of the birth).

However, not all births that occurred between census night and mid-year 2013 were registered at the time of the ERP compilation. Therefore, we had to make an allowance for the expected number of births that would have occurred during this period that had not yet been registered at the time of ERP compilation.

We based the size of this allowance on actual birth registrations for previous years, and calculated it separately for each ethnic group, as the proportion of births registered too late for inclusion in the ERP is not uniform across ethnicities.

We made an adjustment of around 500 births to the estimate of births between census night and 30 June 2013 to account for delayed and late registrations.

Deaths are required to be registered within three working days after disposal of the body concerned. Historical data indicates there is likely to be no more than 10 deaths occurring during the period 6 March to 30 June 2013 registered too late (that is, after 28 February 2014) for inclusion in the 2013 ERP. This number was considered too small to take into account.

Imputation of missing ethnic indicators and location of usual residence

A small number of birth and death registrations had missing ethnicity or residence information. We imputed ethnic indicators and residence where missing, based on the distribution of the missing characteristic in the population for which it was not missing. We placed some restrictions on the values that could be assigned, in order to maintain realistic population distributions. For example, allocation of usual residence area was limited only to areas coded by the existing population.

Some uncertainty is inherent in the registration data given the small amount of missing information. The methods used to account for delayed and late registrations as well as those used to impute missing ethnic indicators and usual residence allowed a measure of the amount of uncertainty to be obtained.

See Measuring uncertainty in the ERP for more detail.

Net migration

Net migration is the difference between the number of people who arrive in an area and the number of people who depart from the same area. It is the combined inflow of both internal and international migrants minus the combined outflow of internal and international migrants.

Arrivals from, or departures to, overseas locations are classified as international migration while movements between one area of New Zealand and another are known as internal migration.

The data sources available for estimating internal and international migration are different, and therefore we used different methods. We estimated both internal and international migration for the period between census night and mid-year for the purposes of the ERP. In the derivations of the 1996, 2001, and 2006 ERPs, internal migration was assumed to be zero.

As with other adjustments, the data sources used were incomplete and there will be some uncertainty around the estimates of migration. However, unlike for other adjustments, the methods we used to derive the migration adjustment of the 2013 ERP do not currently allow measurement of uncertainty.

International migration

Electronic passport and flight records, along with details from arrival and departure cards for every passenger collected by the New Zealand Customs Service, formed the basis for our estimates of international migration in the ERP. We only considered permanent and long-term (PLT) migration, that is migration for a period of 12 months or more, for the purposes of population estimation. The number of PLT departures and arrivals was available by variables such as age, sex, TA, citizenship, and country of birth. However, we also had to estimate ethnic indicators and a more detailed geographic breakdown for the ERP.

PLT movements are generally a good indicator of the contribution to population change at the national level, but some quality issues are inherent below national level. This is partly because some of the information is intention-based and an individual’s locality within New Zealand and length of stay (or absence) may change from initial plans. Therefore, we only coded New Zealand address information given on arrival and departure cards to TA level.

For the 2013 ERP, we had to distribute PLT arrivals and departures to meshblock level, and by ethnic group.

The following paragraphs describe the different distribution methods we applied for both arrivals and departures, as well as for New Zealand and overseas citizens.

New Zealand citizens (arrivals and departures)

For New Zealand citizens, a TA of origin or destination is available from the arrival or departure card information in the majority of cases. Where TA was missing, we allocated it based on the distribution of those who did respond, separately for arrivals and departures.

We applied ethnic indicators for arrivals by TA and age, based on an estimate of expected arrivals by ethnicity sourced from the 2013 Census for New Zealand citizens living overseas five years ago and aged accordingly. The propensity to be overseas five years prior to a census peaks at about age 30 years and international migration data shows New Zealand citizen PLT arrivals peak at about age 26 years, therefore the age distribution of the 2013 Census ethnicity information was brought forward by four years.

There is no source of ethnicity information for those who have left New Zealand, so ethnic group was applied in the same way as for arrivals of New Zealand citizens, except the propensities used were moved a further two years younger by age. This was based on the assumption that a New Zealand citizen who migrates will have been overseas on average for two years before they return.

Overseas citizens (arrivals and departures)

Overseas citizens have higher rates of non-response to the New Zealand address question on arrival and departure cards, are more concentrated in their geographical distribution across New Zealand, and are often more easily assigned to an ethnic group based on their country of birth than New Zealand citizens. Therefore the methods to estimate the overseas citizens were different from those for New Zealand citizens.

The overseas citizen PLT movements required both a TA and an ethnic group. We derived the ethnic group first.

The 2013 Census provided information on recent immigrants by country of birth and ethnicity. For each country of birth, we calculated an ethnicity distribution and then applied it to the arrivals and departures information for overseas citizens based on country of birth. For most countries of birth, just one ethnic indicator was applied. For example, all those born in Taiwan were given only the Asian ethnic indicator.

A TA of origin or destination is available from the arrival or departure card information in the majority of cases. For instance, where the TA was missing, we used the distribution of the non-missing arrival and departure card information for overseas citizens by ethnicity and TA to determine the allocation of a TA.

Using previously assigned ethnic group in this way helped to ensure, for example, that an arrival with an Asian ethnic indicator had a higher probability of being assigned to Auckland over an area with a low proportion of this ethnic group. We made further adjustments to the TA distribution to account for arrivals stating their destination TA as a main city, but in fact settling in a nearby area. For example, some people who recorded Wellington on their arrival card would in fact be living in the cities of Lower Hutt, Upper Hutt, or Porirua, which are part of greater Wellington.

Meshblock breakdown

Estimates of net PLT migration are required at the meshblock level for the ERP. The breakdown by meshblock was calculated for all arrivals together (both New Zealand and overseas citizens). We determined a meshblock distribution by ethnic group using a preliminary ERP (consisting of 2013 Census usually resident population counts, RTOs, NCU, births, and deaths). We used this distribution to allocate all arrivals within a TA to meshblock level. For example, if a meshblock in Awanui area unit accounted for one

percent of people of Māori ethnicity living in Far North District, then one percent of Māori arriving into the Far North were allocated to that meshblock in Awanui.

Age was considered to have little effect on the meshblock distribution.

The breakdown by meshblock was also calculated for all departures together (both New Zealand and overseas citizens). The breakdown was based on the meshblock distribution from the preliminary ERP within each TA for each ethnic group, year, and quarter of birth and sex combination. This ensured that movements of migrants out of New Zealand were in line with the population present and therefore able to leave an area; it avoided more people being moved out of an area than were present.

Net internal migration

We had already produced estimates of net internal migration between 1 July 2012 and 30 June 2013 for the intercensal (2006-based) subnational population estimates for June 2013 (Statistics NZ, 2013). We derived estimates for the period between census night and mid-year, using a proportion of these annual estimates.

The annual estimates were produced at the TA level, based on information from administrative sources, including tax and health data, in combination with expert judgement. By making the assumption that movements of migrants within New Zealand are uniform throughout the year, we derived an initial estimate of net internal migration between census night and 30 June 2013.

This assumption was invalid for tertiary students. The vast majority of student moves occurred at the start of the year prior to census night and minimal moves occurred between census night and mid-year. Therefore, the initial estimates of net migration were further adjusted to reduce the number of moves for student ages in the seven TAs with universities during this census night to mid-year period. We also made opposing adjustments to all TAs (based on population size) to ensure net internal migration by age and sex for the whole country balanced correctly.

We distributed the net internal migration by TA to meshblocks by sex and year and quarter of birth and ethnic group combinations based on a preliminary 2013 ERP (consisting of 2013 census usually resident population counts, RTOs, NCU, births, and deaths). As for international migration, this ensured movements of migrants within New Zealand were in line with the population present and therefore able to leave an area; it avoided more people being moved out of an area than were present.

Table 5 summarises the population changes due to natural increase and net migration between census date (5 March 2013) and the ERP reference date of 30 June 2013.

Table 5

Estimated population change between census night (5 March 2013) and 30 June 2013, by ethnic group

Ethnic group	Natural increase	Net migration	Total population change
Total population	9,100	200	9,300
European	4,800	-4,200	500
Māori	4,200	-100	4,100
Pacific	2,600	-200	2,300
Asian	2,600	4,100	6,700
MELAA[1]	400	600	1,000
Other	30	30	60

1. Middle Eastern/Latin American/African.

Note: People who reported more than one ethnic group are counted once in each group reported. This means that the total number of responses for all ethnic groups can be greater than the total number of people who stated their ethnicities.

See the following table in NZ.Stat for a full breakdown of total net migration by TA, sex, and ethnic group.

- Estimated resident population (ERP), adjustments to derive ERP at 30 June 2013 (from census usually resident population).

5 Compiling the official estimated resident population

This chapter describes three important aspects of compiling the official ERP and provides a table about the size of each adjustment over time:

- Deriving the initial ERP
- Demographic reconciliation
- Measuring uncertainty in the ERP
- Historical changes in size of each adjustment.

Deriving initial ERP

Once estimates for each of the components of the ERP were finalised according to the methods described, we compiled an initial total ERP.

We added the adjustments for the net census undercount and residents temporarily overseas to the census usually resident population count with ethnic indicators and Māori descent imputed; then added the estimates of births and net migration; and subtracted the estimates of deaths.

We compiled multiple simulations of the ERP from the multiple simulations for each adjustment.

Where it was not possible to produce multiple simulations for adjustments, we used the same sized adjustment in each ERP compilation. For the 2013 ERP, we completed one thousand simulations, resulting in one thousand different estimates of the ERP.

We used the distribution of the multiple simulations to understand more about uncertainty in the estimates (see Measuring uncertainty in the ERP).

We derived an initial ERP by taking the mean of the one thousand simulations for each meshblock, sex, year, and quarter of birth, ethnic group, and Māori descent combination. We used this initial estimate to determine the extent of demographic reconciliation.

Demographic reconciliation

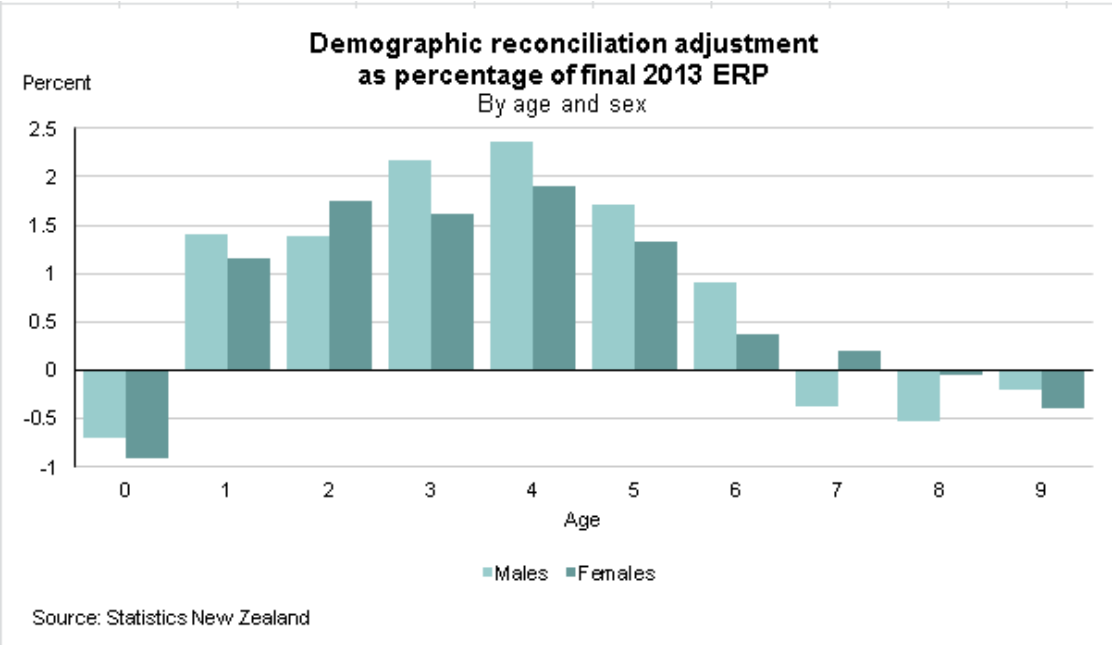
Information provided by administrative data sources (birth and death registrations, and arrival and departure cards), was used to improve the quality of initial estimates of the resident population at the youngest ages. We applied an adjustment to those aged 0 to 9 years at the national level, to align the initial estimates of these ages with demographic estimates derived from administrative data.

At these ages, the demographic estimates are high quality. This reflects the very high coverage of birth and death registrations in New Zealand. Although the quality of international migration data is also high, international migration has a relatively small cumulative impact on the population at the youngest ages. In contrast, at increasingly older ages the uncertainty of international migration flows makes the demographic estimates increasingly uncertain.

The demographic reconciliation adjustment increased the estimated resident population, for 0–9 year olds, by 4,800 (an increase of 2,700 males and 2,200 females). Figure 2 summarises the adjustment, as a percentage of final 2013 ERP by single year of age and sex. The adjustment was larger for males than females at most ages and better aligned the sex ratio to that observed from demographic estimates.

The adjustment was made at the national level and was apportioned subnationally and by ethnic group in proportion to the size of the initial ERP.

Figure 2



Measuring uncertainty in the ERP

The ERP is an estimate, and it is important to recognise that estimates by their nature have some uncertainty. The derivation of the ERP at June 2013 used data from a wide range of sources, including administrative data collected by organisations other than Statistics NZ. These data were not solely collected for statistical analysis; they might not have been subject to the same rigorous quality checks as Statistics NZ data, and may have been subject to a degree of error depending on the coverage and quality of the information collected.

Most data sources are incomplete in some way. Some source data have missing information, and others are collected from sample surveys so are also subject to sample error. Using particular methods to account for incomplete data can help us measure the uncertainty present in the ERP.

This is the first time that Statistics NZ has attempted to produce measures of uncertainty alongside the ERP, although uncertainty in the base ERP was recognised as part of the stochastic approach used for the 2011-base national population projections (Dunstan, 2011).

The adjustments for imputing ethnic indicators and estimating NCU, RTOs, and natural increase (births less deaths) have been derived using methods that allow multiple (eg 1,000) simulations of their results. The uncertainty in each of these adjustments can therefore be summarised by the spread of the results from the multiple simulations around the mean of all the simulations. Furthermore, multiple simulations of the ERP itself can be compiled from the multiple simulations for each of the adjustments. Therefore some of the uncertainty in the 2013 ERP can also be summarised by the spread of the results around the mean of all the simulations.

It is not currently possible to measure uncertainty for all the components of the 2013 ERP using empirical methods. For example, no attempt has been made here to measure uncertainty in the census counts arising from census enumeration and processing errors (eg misrecognition during scanning; uncertainty from age-sex imputation), other than the estimated uncertainty in census coverage.

Also, no attempt has yet been made to measure uncertainty in the migration estimates contributing to population change between census night and 30 June. This means that the measures of uncertainty for the 2013 ERP do not fully represent the extent of uncertainty within the estimates.

The results from the multiple simulations of 2013 ERP are being analysed and work to measure the uncertainty around population estimates is ongoing.

Statistics NZ is currently considering how best to present and publish the methods and results from this work. The work builds on the estimates of uncertainty in the national-level ERP used for the 2011-base national population projections.

If you are interested in further information about the measures of uncertainty around the 2013 ERP, please contact demography@stats.govt.nz

Historical changes in size of each adjustment

For those interested in a historical comparison, we present a summary in table 6.

Table 6

Size of ERP adjustments, 1996, 2001, 2006, 2013

Adjustment	1996	2001	2006	2013
Census usually resident population count	3,618,300	3,737,300	4,027,900	4,242,000
Adjustments made at census date				
Estimated net census undercount	58,900	80,900	80,100	104,200
Estimated number of residents temporarily overseas on census night	39,800	54,500	64,500	81,700
Adjustments made for population change between census date and 30 June 2013				
Natural increase (births less deaths)	8,600	8,600	10,000	9,100
International migration (arrivals less departures)	2,500	-4,500	-1,300	200
Total population change	11,100	4,100	8,700	9,300
Demographic reconciliation	3,900	3,700	3,400	4,800
Estimated resident population	3,732,000	3,880,500	4,184,600	4,442,100

References and further reading

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