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The unavoidable nature of population ageing and ageing-driven growth – an update for New Zealand

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Introduction: Despite overwhelming evidence to the contrary, many people still question the extent to which population ageing will unfold more or less as projected. Regular among comments is the expectation that the phenomenon is 'cyclical', and, like an economic cycle, the age structure will at some point return to an earlier configuration. These comments are made particularly in response to propositions that more than 30 or 40 per cent of the population will be aged 65 years or over for many subnational populations within a few decades (Statistics New Zealand 2013; Jackson, Cameron and Cochrane 2014a, 2014b; Cameron, Jackson and Cochrane 2014).

This paper revisits and updates the process of population ageing in New Zealand, not because our findings differ greatly from the many other substantive and theoretical expositions that are available from the literature (e.g. Coale 1972; Pool 2003; Pool, Baxendine, Cochrane and Lindop 2005-06; Pool, Dharmalingham and Sceats 2007; Davoudi, Wishardt and Strange 2010), but because we now have sufficient retrospective evidence for New Zealand to 'prove' that there have been no notable reversals in any trend associated with population ageing at the subnational level (Jackson 2014a); moreover, we can now more fully explain the subnational dynamics which accelerate or slow ageing, and which will ultimately bring about the permanent end of population growth/onset of depopulation in many areas.

By way of explaining the progression from overall growth to ageing-driven growth and then to depopulation, we begin with an outline of the four dimensions of population ageing (Jackson 2007). We illustrate these dimensions both retrospectively and prospectively for all of New Zealand's 67 territorial authority (TA) areas, using both our own subnational population projections for selected TAs to 2053 as well as Statistics New Zealand's 2013-base high, medium and low variant deterministic projections to 2043. Noting however that the deterministic projections provide a blunt tool for analysing the unfolding dynamics, our projections use a stochastic projection methodology (Cameron and Poot, 2010; 2011) to provide confidence intervals around the projected trends for four 'typical' TAs: two of which are still growing strongly (Tauranga City, Hamilton City) and two of which have recently experienced decline (Rotorua District, South Waikato District).[3]

We conclude our analysis with an overview of the impact of various migration scenarios on the number of migrants that would be needed to reduce structural population ageing in New Zealand at the national level, partly replicating the United Nation's (2000) seminal study on *Replacement Migration*, and studies by Kippen (1999), McDonald and Kippen (1999), and Kippen and McDonald (2000; 2004), on Australia. This analysis vividly illustrates the impossibility of preventing population ageing, even in relatively youthful New Zealand, and reinforces our central argument that the phenomenon will not 'go away' and must be taken seriously, especially at the subnational level.

Population ageing in a nutshell. The inexorable process of population ageing can readily be traced via its four main dimensions: (1) numerical ageing; (2) structural ageing; (3) natural decline; and (4) absolute decline (Jackson 2007). Numerical ageing refers to the absolute increase in the numbers of elderly people, the primary cause of which is increasing longevity. Structural ageing, on the other hand, refers

[3] These TAs represent one of each trend (growth/decline) in two regional council areas, the Bay of Plenty and Waikato. Additional detail is available in the SmartGrowth (Bay of Plenty) and FutureProof (Waikato) Reports undertaken by these authors. See Jackson, Cameron and Cochrane (2014a, 2014b), and Cameron, Jackson and Cochrane (2014).

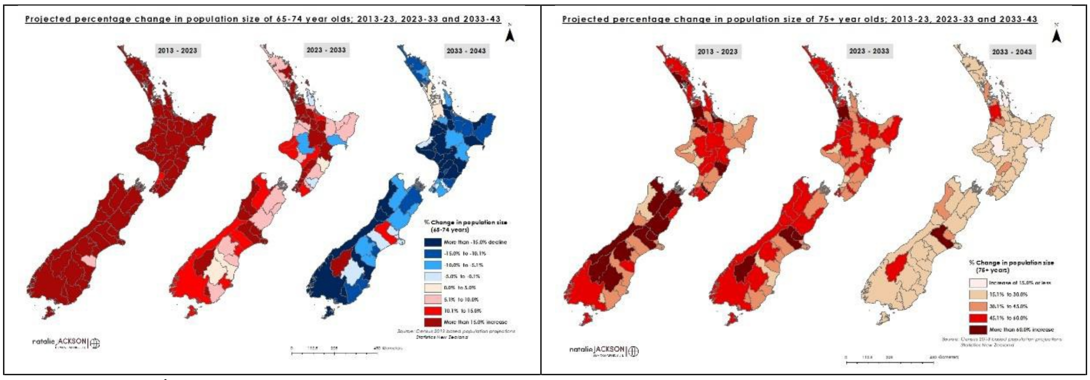
to the change in proportions by age and is primarily due to declining fertility rates, which deliver fewer babies into the base of the age structure and result in the increased numbers at older ages also becoming an increased proportion of the population. The ageing of the baby boomer cohorts born after the second world war and currently aged 51-70 years (based on the 'official' baby boom period), are now beginning to add to both numerical and structural ageing, but as indicated they are not the primary cause of either; in fact at their birth they dramatically slowed the ageing that had been unfolding in the pre-war years (Pool et al. 2007: 166-216). Numerical and structural ageing are thus clearly separated by time and cause. The increasing numbers now at older ages have of course been heading toward old age ever since their birth, but have also been gaining in number relative to previous cohorts as they fortuitously encountered new medical technology along the way and saw their life expectancy increase even further than was expected at the time of their birth. The fact that they have also been growing as a proportion of the population is due to the successively lower birth rates of their children (and now also their older grandchildren) over the past half century. That said, notable 'boomlets' of increased birth numbers around 1970, 1990, and between 2002 and 2008 have each time given rise to elated cries of new baby booms (see Statistics New Zealand 2012 for refutation). These are, however, largely 'echoes' of the baby boom, occurring first when the first of the 'boomers' started having their own children, and second and thirdly reflecting the (largely 'delayed') arrival of baby boomer grandchildren, currently to the youngest and simultaneously largest baby boom cohorts.

The next but still little acknowledged step in the structural ageing process is that once a population has more elderly than children it is a short step – a decade or two – to it having more deaths than births, and to the ending of the natural increase, which has been with us for the entire modern era and to this point has largely been taken for granted. As we will illustrate below, despite the perturbations caused by the baby boom echo-related changes in the size of younger birth cohorts, the trend is essentially inexorable. One TA after another is seeing steadily increasing numbers of elderly per child and, once above about 20 per cent aged 65 years and over, natural decline begins to set in —typically preceded by a period of incipient decline (trending between positive and negative). Finally, with few exceptions, the ending of natural increase ushers in absolute decline, sooner in subnational areas where net migration loss is an accompanying characteristic, with this last step heralding the shift to a new and essentially intractable form of decline (Bucher and Mai 2005; Matanle and Rausch 2011: 19-20, 46-47).

Numerical ageing: Under the Statistics New Zealand medium case projections, numbers aged 65 years and over are projected to be greater in 2043 than in 2013 in every New Zealand TA. Without exception this continues a trend extant as far back as similar data boundaries permit analysis (Pool et al. 2005-06). However, providing an important insight into the overall trend, Map 1 shows the projected data disaggregated for two broad age groups (65-74; and 75 years and over) over three periods (2013-23, 2023-33 and 2033-43). The disaggregation by age identifies an issue few are yet engaging with: the slowing of growth followed by widespread decline in numbers at 65-74 years in the period 2033-2043, as the youngest/largest baby boomer cohorts move out of the 'younger-old' age groups and into the oldest age group. A similar trend of decelerating growth is evidenced at 75+ years, but no territorial authority area sees decline in numbers over this projection period.

Needless to say, projections under the high variant assumptions (not shown here) evidence somewhat greater growth in the population aged 65 years and over for all TAs. They also show fewer TAs (53 compared with 60 under the medium case) experiencing decline at 65-74 years across the period 2033- 2043, but again none end the period with fewer people aged 65 years and over than in 2013. Even under the low variant assumptions there is projected growth at 65 years and over for all TAs until 2033, following which there is projected decline for 27 TAs in the period 2033-2043, and only one ends the projection period with fewer people aged 65 years and over than in 2013. There are thus no past and only one projected reversal in the trend of increasing numbers at 65 years and over across New Zealand's 67 TAs under any projection variant; however within this broad age group the force of ageing will shift upwards from the younger to the older age groups during the 2033-2043 period, leaving an 'age structural transition' decline in its wake (Pool, Wong and Vilquin 2006).

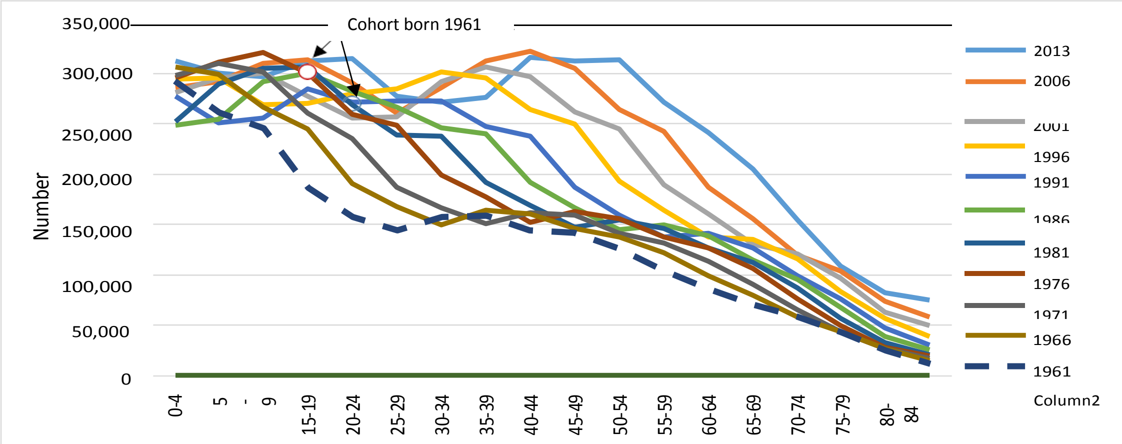
Map 1: Projected change (%) in numbers aged 65-74 and 75+ years by territorial authority area, 2013- 23, 2023-33 and 2033-43, medium case assumptions



Source: Jackson/Statistics New Zealand 2015a

Structural ageing: The combined impact of more elderly and fewer children is projected to see all TAs continue to age structurally, again without exception. We can observe the trend first retrospectively and cross-sectionally, at the national level, over the period 1961-2013. As Figure 1 shows, over the half century since 1961 there have been only small increases in numbers at 0-14 years, somewhat greater increases at 15-49 years, and substantial increases at 50+ years where the baby boomers are now situated. Migration has of course played a sizeable role; however the main picture the figure is illustrating is the passage of the boomer cohorts through each successive age group. The largest cohort, born 1961, for example, drove an increase in numbers at 15-19 years as it reached those ages between 1976 and 1980, and at 20-24 years between 1981 and 1985, etc. Only recently has a birth cohort approached those initial numbers—namely that born in 2008 which fell just 1,400 births short of the 1961 cohort—and thus we can anticipate numbers at 15-19 years again generating a short-term peak between 2023 and 2027 (see Churchill, Denny and Jackson 2014 on Australia).

Figure 1: Estimated resident population (number) by five-year age group 1961-2013, Total New Zealand

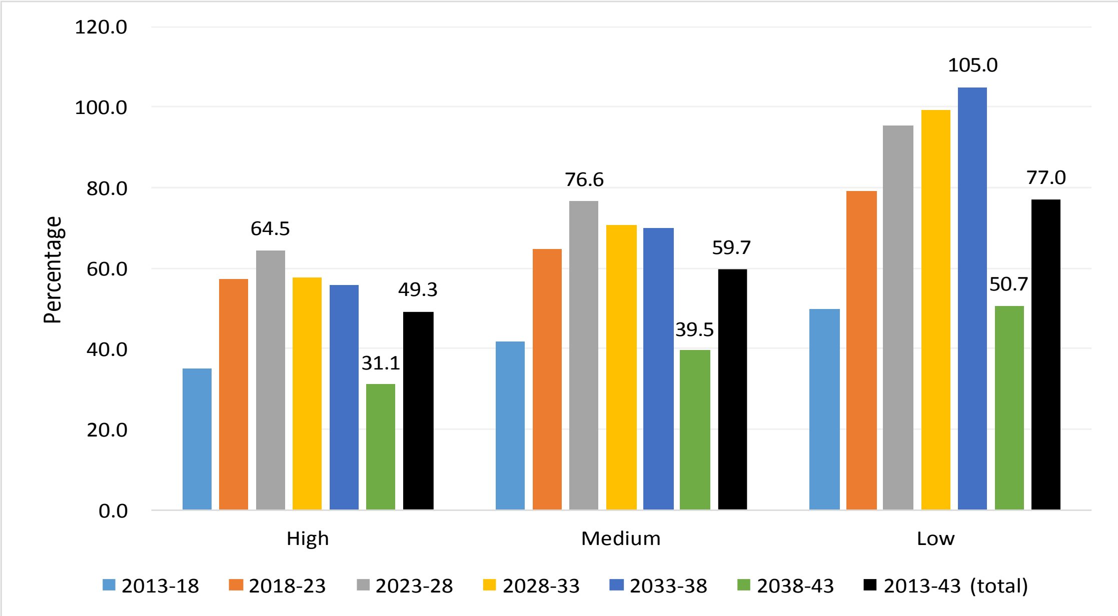


Source: Author/Statistics New Zealand various years

Given current increases in life expectancy and declines in fertility rates there is no reason to expect that this structural ageing will not continue as the boomers reach the older age groups, and indeed those are precisely the assumptions built into most projection variants, at least until 2033. The outcome under the medium case assumptions, as Figure 2 shows, is that those aged 65 years and over will account for around 60 per cent of New Zealand's population growth across the period 2013-2043. However, as indicated above this contribution will change over time, with those aged 65 years and over under the medium case assumptions accounting for 42 per cent of New Zealand's growth between 2013 and 2018, rising rapidly to a peak contribution of 77 per cent between 2023 and 2028, and falling back to 39 per cent between 2038 and 2043. The high and low variant projections both show this contribution to be conservative. Indeed it is only a little lower under the high variant projections, despite somewhat higher fertility, life expectancy and migration assumptions. The greatest contribution to overall growth under the high assumptions also occurs across the 2023-2028 period, dropping away thereafter. By contrast, should the assumptions of the low variant projections prevail, contribution to growth by those aged 65 years and over will be substantially greater, and not peak until the 2033-38 period. By 2033 it would account for all population growth, rising to 105 per cent between 2033 and 2038,[4] before falling back to just over 50 per cent of growth between 2038 and 2043.

[4] The contribution of one age group to overall population growth can exceed 100 percent, because of absolute declines in the numbers in some other age groups.

Figure 2: Projected contribution to change (%) at 65+ years, Total New Zealand, by projection variant and five year period, 2013-2043

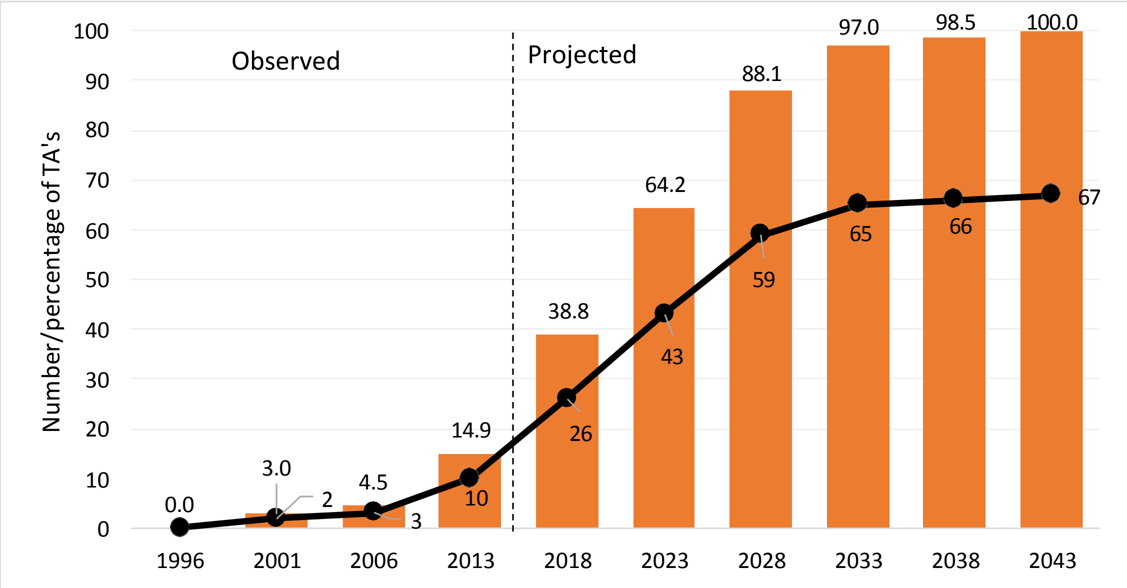


Author/Statistics New Zealand 2015a

Although the very high percentages under the low variant projections in Figure 2 look extreme, they are in fact the 'norm' under the *medium* variant projections at the TA level, especially where growth at 65 years and over offsets overall decline at other ages. However before discussing those data, we turn briefly to the ratio of elderly to children, and the related issues of natural and absolute decline.

The 'elderly-child' ratio: As recently as 1996, no TA had more elderly than children (65+ years: 0-14 years); by 2013 there were ten (15 per cent). Under the medium case assumptions (Figure 3) this number is projected to increase to 26 TAs by 2018 (39 per cent) and 43 TAs by 2023 (64 per cent). By 2028 this situation is projected to obtain for almost 90 per cent of TAs, and by 2043, for all TAs. The total New Zealand population is expected to shift to having more elderly than children between 2023 and 2028, when the sum of the subnational changes will tip the national trend.

Figure 3: Observed (1996-2013) and projected (medium case) number and percentage of territorial authority areas with more elderly (65+ years) than children (0-14 years), 1996-2043

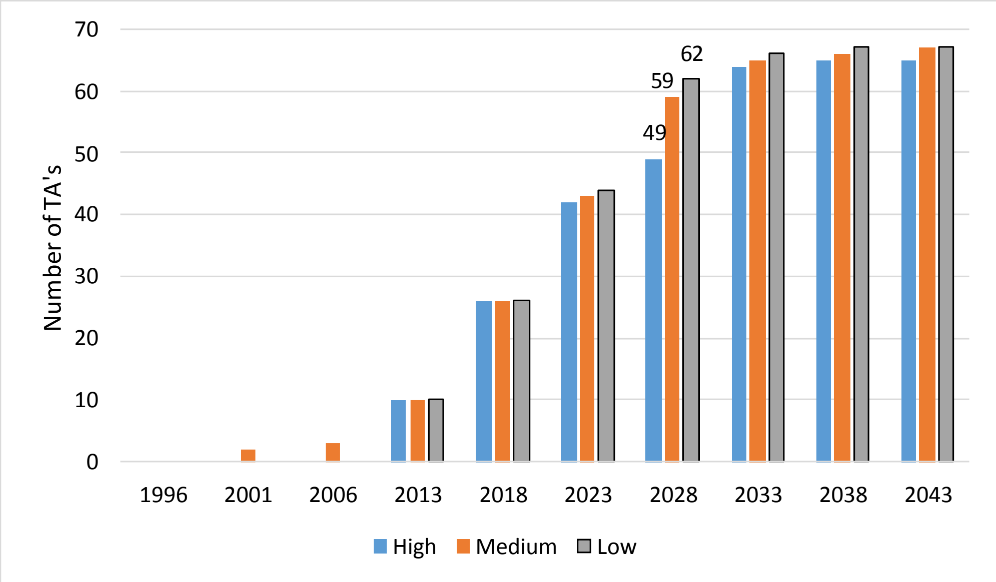


Source: Author/Statistics New Zealand, 2014 and 2015a

The high and low variant projections differ very little to the medium, with New Zealand having more elderly than children in total by 2028 under all three projections; the only difference between the three variants is the extent to which the older population is likely to outnumber children by 2028: 1.07: 1.0 under the high variant, 1.12: 1.0 under the medium variant, and 1.18: 1.0 under the low variant.

This invariance is even more striking when the data are examined at TA level (Figure 4). In both 2013 and 2018 the number of TAs with more elderly than children is identical under all three projection variants, at 10 TAs in 2013 and 26 TAs in 2018, as indicated above in Figure 3. In 2023 the number ranges between 22 and 24 TAs (high and low variants respectively). It is only in 2028 when there is any appreciable difference by variant, with 49, 59 and 62 TAs respectively projected to have more elderly than children under the high, medium and low variants. Thereafter the gap between the variants again diminishes, with the high and low variants separated by only two TAs in both 2033 and 2038, and only one in 2043—when, it should be noted, all but one TA is projected to have more elderly than children, irrespective of variant (the exception being Hamilton City under the high variant). Indeed from 2033, over 95 per cent of the 67 TAs are projected to have more elderly than children even under the high variant assumptions. By 2043 this would be the case for all TAs in both the medium and low variants.

Figure 4: Observed (1996-2013) and projected number of territorial authority areas with more elderly (65+ years) than children (0-14 years) by projection variant, 2013-2043



Source: Author/Statistics New Zealand 2014 and 2015a

Natural decline: As noted earlier, the shift to more elderly than children foreshadows an inexorable shift from natural increase to natural decline (that is, negative natural increase, or more deaths than births). The five TAs currently with the highest elderly: child ratios (Thames-Coromandel, Kapiti Coast, Horowhenua, Waimate and Waitaki Districts), have all experienced natural decline intermittently over the past 10-15 years, with the three oldest (Thames-Coromandel, Kapiti Coast, and Horowhenua) now experiencing sustained natural decline and unlikely to return to natural growth. Waimate and Waitaki Districts are still in the incipient decline stage, wavering annually between negative and positive.

Statistics New Zealand's medium variant projections confirm that the three oldest TAs noted above are projected to experience natural decline between 2013 and 2018, along with one (Waitaki) at zero natural increase (Table 1). At this stage these TAs account for just six per cent of all TAs. The number of TAs experiencing natural decline are projected to increase slowly until around 2028 and then accelerate, accounting for around 64 per cent of TAs (N=43) by 2043.

The trend is somewhat more muted under the high variant projections, but would still see 30.0 per cent of TAs at the end of natural growth by 2043, while the low variant indicates over 80.0 per cent in that situation by 2043, passing the 30 per cent mark as soon as 2028. Thus irrespective of projection variant, the number of TAs expected to experience natural decline increases monotonically, with no anticipated reversals—albeit most will first pass through a period of incipient decline.

The underlying data indicates that TAs reaching the onset of natural decline have typically reached the 'hyper-ageing' stage of more than 20 per cent aged 65 years and over. This situation pertained to all five above-named TAs, with one having passed that point in 1996 (Kapiti Coast), one in 2001 (Thames-

Coromandel), one in 2006 (Waitaki) and two in 2013 (Horowhenua, and Waimate). However they are not the only TAs having reached the hyper-ageing stage. Of the 43 TAs projected under the medium variant to be experiencing natural decline or zero natural increase in 2043, nine already have greater than 20 per cent of the population aged 65 years and over (four in addition to the above five). This will increase to around 24 TAs by 2018, 40 by 2023, and be the experience of all 43 by 2028.

Table 1: Projected number and percentage of territorial authority areas experiencing natural decline or zero natural increase, by projection variant, 2013-2043

	Negative Natural Increase			Zero Natural Increase			Total Negative/Zero Natural Increase (%)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
2018	1	3	5	2	1	0	4.5	6.0	7.5
2023	1	3	9	1	4	4	3.0	10.4	19.4
2028	3	7	16	1	4	5	6.0	16.4	31.3
2033	6	16	32	3	2	3	13.4	26.9	52.2
2038	12	30	46	3	4	0	22.4	50.7	68.7
2043	15	37	51	5	6	3	29.9	64.2	80.6

Source: Author/Statistics New Zealand 2015b

It should be noted, however, that the strongest correlation with the loss of natural increase is the relative size of the prime reproductive age population (25-39 years) rather than either the proportion aged 65 years and over or the ratio of elderly to children (Jackson 2014; Johnson, Field and Poston 2015). It is the prime reproductive age population that by definition determines birth numbers, and is also the group that is typically most affected by net migration loss or gain. The migration assumptions underlying the projections explain why some populations are likely to remain in the incipient decline stage for a shorter or longer period and/or to experience natural decline earlier or later. Among these for example is Waimate District, which is projected to remain in the incipient decline stage for longer than Waitaki District, despite both already having entered that stage.[5]

Absolute decline: As noted above, the main cause of depopulation across New Zealand's TAs is currently net migration loss, the 'old' form of decline. However this will increasingly give way to a newer form of decline, the *combined effect* of net migration loss and natural decline (Bucher and Mai 2005). To examine this issue we turn first to the issue of ageing-driven growth and how it transforms from the old to the new form of decline, and second to a disaggregation of the projected components of change underlying the projections—for as we shall see, these deterministic projections provide a very blunt tool for analysing this profound shift.

Ageing-driven growth: As noted above, the projected contribution to growth at 65 years and over is very high (well above 100 per cent) in many TAs, particularly where it is offsetting underlying decline at

[5]Under the medium variant assumptions, Waimate District is projected to gain a net of 50 migrants per year between 2013 and 2018, then a constant 20 per year thereafter. Waitaki District is projected to gain a net 120 migrants per year between 2013 and 2018, then 40 per year thereafter.

other ages. To dampen down these percentages, contribution to overall change by those aged 65 years and over is capped on Map 2 at 100+ per cent. Map 2 shows that, under the medium case assumptions, the vast majority of TAs are projected to have all growth at 65 years and over, and that this growth will increasingly offset underlying decline in the population in other age groups. The periods 2013-2023, 2023-2033 and 2033-2043 see respectively 51, 43 and 24 TAs continue to grow (Table 2). However the first two periods will each see 30 TAs with all of that growth at 65 years and over, offsetting underlying decline at all other ages combined. In the third period (2033-2043), that number will drop to seven TAs, while the number of TAs where growth at 65 years and over will fail to offset underlying decline at all other ages will increase, from 12 TAs between 2013 and 2023, to 31 TAs for the period 2033-2043. TAs where there is likely to be zero overall growth, but with growth at 65 years and over exactly offsetting decline at 0-64 years, are projected to number two, three, then four respectively (2013-2023, 2023-2033, 2033-2043), while across the first two projection periods, no TAs are projected to see decline in both broad age groups (0-64 and 65+ years), but across the 2033-2043 period that is likely to be the case for eight TAs.

Thus in sum, the number of TAs projected to decline increases from 12 (18 per cent) between 2013 and 2023 to 39 (58 per cent) between 2033 and 20343 with another four at zero growth between 2033 and 2043, up from two 2013-2023. Of some importance is that by the 2033-2043 period the declining TAs will account for almost 22 per cent of New Zealand's projected population of 5.64 million, up from just five per cent[6] across the 2013-2023 period, with attendant implications for—among many other things—New Zealand's historical approach to funding local infrastructure from rates revenue.

[6] It should also be noted that the projection of 12 TAs declining across the 2013-2018 period represents a halving of the number which were observed to decline between 1996 and 2013, and is driven by Statistics New Zealand's very high net migration assumptions for the 2013-2018 period. Currently net international migration is around those projected levels and thus it is likely that such gains will realized, at least nationally. At subnational level, however, they are also impacted upon by the internal migration assumptions, and the international movements give no insight into the current strength or otherwise of those internal flows.

Map 2: Projected contribution to change (%) at 65+ years by territorial authority area, 2013-2023, 2023-2033 and 2033-2043, medium case assumptions

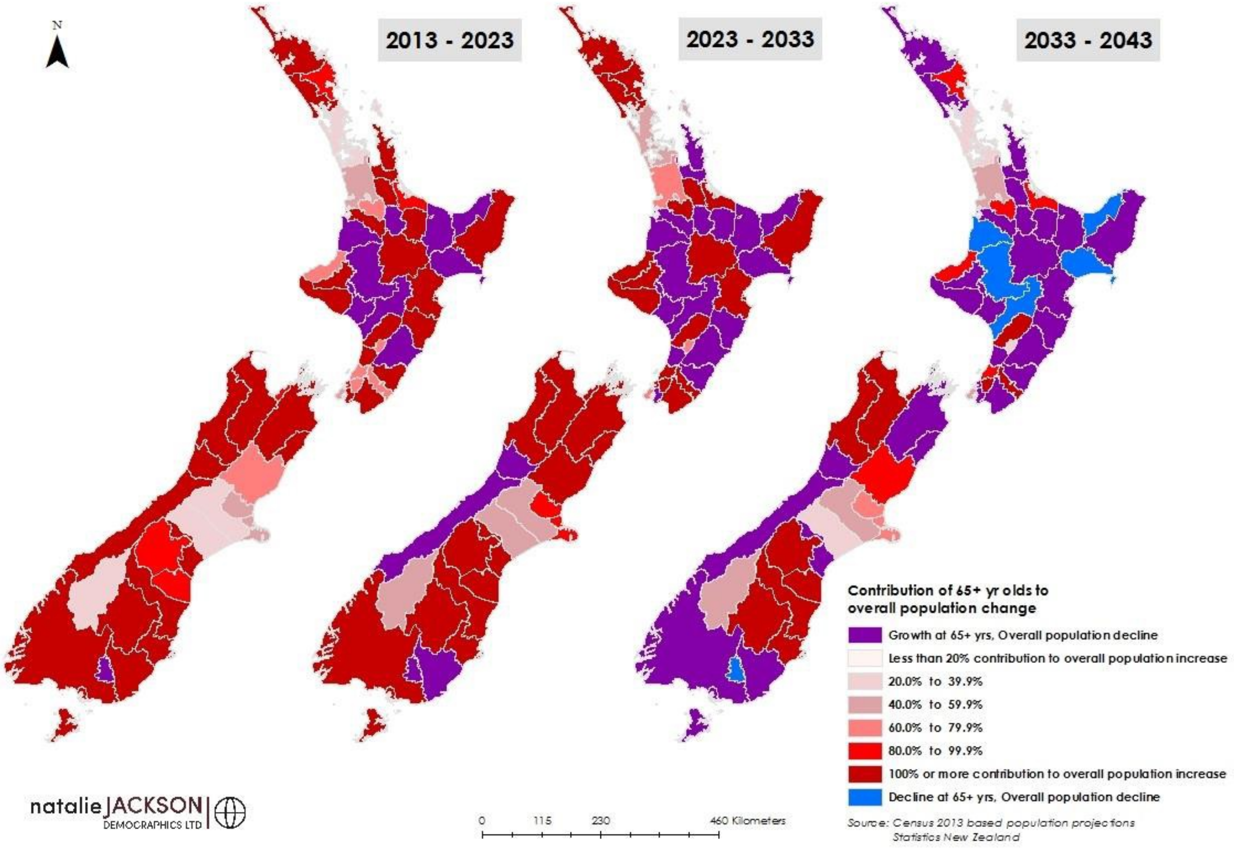


Table 2: Projected contribution to change by broad age group at territorial authority area level, 2013-2023, 2023-2033 and 2033-2043, medium case assumptions

	2013-2023	2023-2033	2033-2043	2013-2023	2023-2033	2033-2043
	Number of TAs			Percentage of TAs		
Growth at both 0-64 and 65+ years	23	11	17	34.3	16.4	25.4
Growth at 65+ years more than offsets decline at 0-64 years	30	30	7	44.8	44.8	10.4
Zero growth (growth at 65+ years exactly offsets decline at 0-64 years)	2	3	4	3.0	4.5	6.0
Growth at 65+ years which fails to offset decline at 0-64 years	12	23	31	17.9	34.3	46.3
Decline at both 0-64 and 65+ years	0	0	8	0.0	0.0	11.9
	67	67	67	100.0	100.0	100.0
Summary						
Overall Growth	53	41	24	79.1	61.2	35.8
Zero Growth	2	3	4	3.0	4.5	6.0
Overall Decline	12	23	39	17.9	34.3	58.2
	67	67	67	100.0	100.0	100.0
Percentage of New Zealand population experiencing zero growth or decline				**4.8**	**10.8**	**21.9**

Source: Author/Statistics New Zealand 2015a

From the old to the new form of depopulation: Finally for this section, Table 3 disaggregates the underlying assumptions into their natural increase and net migration components (for the medium case only). These show that the number of TAs likely to experience the new, combined form of depopulation will remain low until 2033, following which it will almost certainly escalate. The data indicate that of the above 43 TAs projected to either decline in size or experience zero growth between 2033 and 2043 (Table 2), the majority (25 TAs) are likely to be experiencing the new form of depopulation by 2043. By then these TAs will account for around 37 per cent of all TAs, and 10 per cent of the New Zealand population.

That said, Table 3 also identifies one very important element of this story, and that is that for 39 TAs, the zero/negative migration assumptions underlying the Statistics New Zealand projections are unchanging across the period 2023-2043. This is true both in terms of the number of TAs so-affected, and numerically in terms of the level of the net migration loss, which differs by TA but remains constant for each. Accordingly, we now turn to a brief analysis of a set of stochastic population projections, which allow for a more nuanced analysis of projected ageing.

Table 3: Projected number and percentage of territorial authority areas experiencing natural decline/zero natural increase and/or negative/zero net migration, medium variant, 2013-2043

	Negative/ Zero Natural Increase	Negative/ Zero Net Migration	Both	Negative/ Zero Natural Increase	Negative/ Zero Net Migration	Both
	Number of TAs			Percentage of TAs		
2018	4	25	0	6.0	37.3	0.0
2023	7	39	1	10.4	58.2	1.5
2028	11	39	3	16.4	58.2	4.5
2033	18	39	6	26.9	58.2	9.0
2038	34	39	19	50.7	58.2	28.4
2043	43	39	25	64.2	58.2	37.3

Source: Author/Statistics New Zealand 2015b

Stochastic Projections: The following section utilises a somewhat different projection methodology to that employed by Statistics New Zealand with regards to the application of the migration assumptions. Both use essentially the same cohort component method of projecting, that is, the fertility, mortality and migration assumptions are applied stepwise to the baseline populations by age and sex, with each step ageing the population by one or five years (depending on the width of the age groups used) and repeating the process. However, rather than estimating a pre-determined and constant net migration number and applying that number to a net migration age-sex profile for each territorial authority as does Statistics New Zealand, we follow Cameron and Poot (2010; 2011) and estimate age- and sex-specific net migration *rates* and then apply them directly to the age-sex profile of each population. These rates can be either positive or negative for different age-sex groups, irrespective of whether overall (total) migration is positive or negative. Where populations increase or decrease over time, the Statistics New Zealand approach results in the number of migrants becoming respectively smaller or larger as a proportion of the changing population. By instead applying age-specific migration rates to each successively survived population number by age and sex, the number of migrants is more closely proportional to population size, which we believe is a more realistic assumption.

Moreover, to demonstrate the uncertainty in the population projections for each TA, we adopt a stochastic population projection approach (Bryant, 2005). The specific methodology we employ is outlined in Cameron and Poot (2010; 2011), as well as Jackson, Cameron and Cochrane (2014a, 2014b), and Cameron, Jackson and Cochrane (2014).[7] Essentially, we run the projection model 10,000 times for each TA, randomly drawing a new set of fertility, mortality, and net migration rate assumptions from each of their distributions. This allows the variability in the projected population to be explicitly modelled. The median projection is the projected population that lies above 50 percent of the 10,000 scenarios and below the other 50 percent of scenarios. Similarly, the 90 per cent projection interval indicates the range where only 5 per cent of the 10,000 projection scenarios are above the upper bound, and 5 percent below the lower bound. Conventionally, these projection intervals are interpreted probabilistically, i.e. that there is a 90 per cent chance that the future population will fall within the 90 percent projection interval. By contrast, Statistics New Zealand's deterministic high, medium and low projections give only an upper, medium and lower estimate of future population size and composition and, as illustrated above, the use of constant migration assumptions compromises detailed investigation of the unfolding dynamics.

Here we present the resulting projections for two TAs from each of two regional council areas: Tauranga City and Rotorua District from the Bay of Plenty Region, and Hamilton City and South Waikato District from the Waikato Region. Specifically, we present four outputs from the projections:

(1) the population pyramids and associated summary statistics for each TA for 2013, 2033, and 2053;

(2) the median proportion of the population aged 65 years or older for each year from 2013 to 2053;

(3) the proportion of the 10,000 scenarios that show annual population decline for each year from 2014 to 2053; and

(4) the median number of people aged under 65 years that would need to be added to the population in order to reduce the proportion aged over 65 years by one percentage point.

The last of these outputs is similar to McDonald and Kippen's (1999, page 14) 'index of efficiency', although here it is calculated for a single year, rather than as an annual migration change over an extended period.[8]

[7] We note that Statistics New Zealand produces sub-national stochastic population projections. However, we use our own projections here because the Statistics New Zealand stochastic projections, like their deterministic projections discussed earlier in the paper, rely on migration assumptions that are invariant over time in each projection run (see Dunstan, 2011).

[8] Specifically, we calculate the index here as:

Figure 5 presents the population pyramids for Hamilton City for 2013, 2033, and 2053. The corresponding pyramids for Tauranga City, Rotorua District, and South Waikato District are shown in Figures 6, 7 and 8 respectively. The stochastic nature of the projections in 2033 and 2053 is represented in each population pyramid by 'error bars' that contain the 90 percent projection interval for each age- sex group. The corresponding summary statistics for Hamilton City, Tauranga City, Rotorua District, and South Waikato District are included in Tables 4, 5, 6 and 7 respectively.

In all cases, the unavoidable nature of population ageing is clear, even when the uncertainty of the population projections is considered. This uncertainty (or rather, the certainty of ageing) is demonstrated by the 90 per cent projection intervals. The older population age groups increase in size relative to the younger population groups, and this change is particularly acute for Tauranga City, Rotorua District, and South Waikato District.

Of the four TAs, Hamilton City has the youngest age profile in 2013, with a median age of 30.3 years and 11.3 percent of the population aged 65 years and over. Tauranga City has the oldest age profile in 2013, with a median age of 40.1 years and 19.5 percent of the population aged 65 years and over. However, in both cases the median age increases to over 50 years by 2053, with Hamilton City having a median age of 51.3 years and Tauranga City a median age of 55.4. Of the four TAs, Rotorua District experiences the most rapid ageing, with the proportion aged 65 years and over increasing from 13.4 per cent in 2013 to
31.2 per cent in 2053, an increase of 17.8 percentage points (compared with 16.9 percentage points for Tauranga City, 16.3 for Hamilton City, and 11.6 for South Waikato District). However, at the oldest age group (85 years and over) it is Tauranga City that exhibits the largest increase, with the proportion aged 85 years and over increasing 2.4 percentage points from 2.9 per cent in 2013 to 5.3 per cent in 2053 (compared with 2.3 percentage points for South Waikato District, 2.2 for Rotorua District, and 1.7 for Hamilton City). In part, this reflects the older initial age profile of Tauranga City compared with the other TAs, and in part the age profile of its migrants, discussed further below.

$$E = (P+S)^2/(99S - P)$$

Where *E* is the Index of Efficiency, *P* is the population aged under 65 years, and *S* is the population aged 65 years or older.

Figure 5: Population Pyramids for Hamilton City, 2013, 2033, and 2053

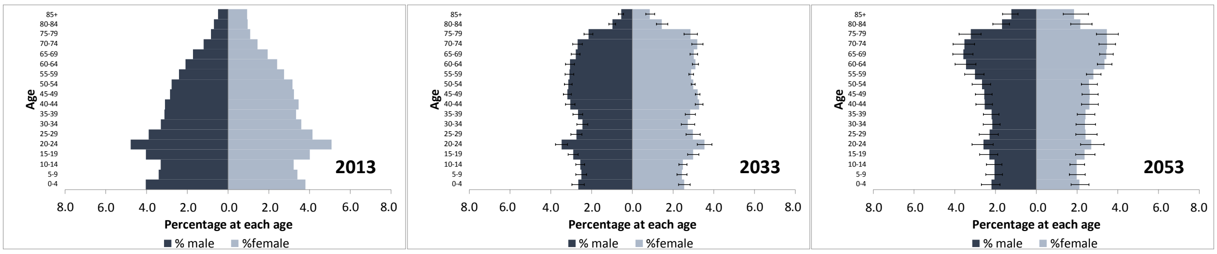


Table 4: Projected Summary Statistics for Hamilton City, 2013, 2033, and 2053

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 16,670	65+ years (N): 40,753 (36,507 – 45,419)	65+ years (N): 65,078 (54,735 – 77,216)
(%): 11.3	(%): 20.5% (18.4% - 22.9%)	(%): 27.6% (23.2% - 32.7%)
85+ years (N): 2,106	85+ years (N): 2,788 (2,172 – 3,539)	85+ years (N): 7,258 (5,229 – 9,941)
(%): 1.4	(%): 1.4% (1.1% - 1.8%)	(%): 3.1% (2.2% - 4.2%)
Median Age: 30.3 years	Med. age: 40.3 years (40.3 – 40.4 years)	Med. Age: 51.3 years (50.5 – 52.2 years)

Figure 6: Population Pyramids for Tauranga City, 2013, 2033, and 2053

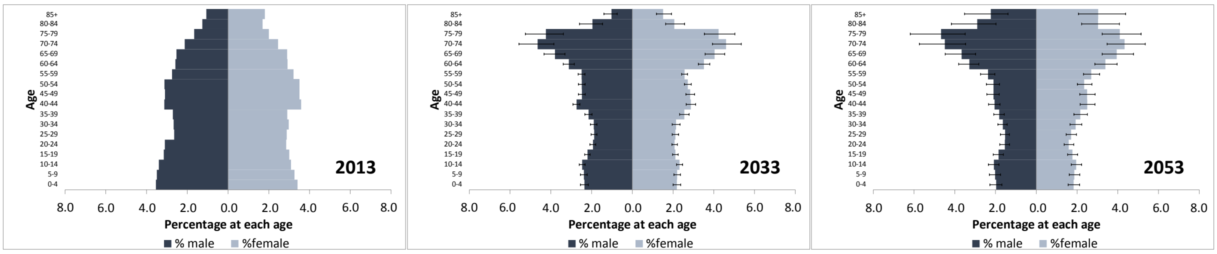


Table 5: Projected Summary Statistics for Tauranga City, 2013, 2033, and 2053

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 22,880	65+ years (N): 54,675 (45,314 – 65,597)	65+ years (N): 75,235 (56,913 – 98,803)
(%): 19.5	(%): 32.1% (26.6% - 38.5%)	(%): 36.4% (27.5% - 47.8%)
85+ years (N): 3,370	85+ years (N): 4,322 (3,272 – 5,647)	85+ years (N): 10,886 (7,136 – 16,338
(%): 2.9	(%): 2.5% (1.9% - 3.3%)	(%): 5.3% (3.5% - 7.9%)
Median Age: 40.1 years	Med. age: 51.5 years (45.6 – 53.3 years)	Med. Age: 55.4 years (55.1 – 60.2 years)

Figure 7: Population Pyramids for Rotorua District, 2013, 2033, and 2053

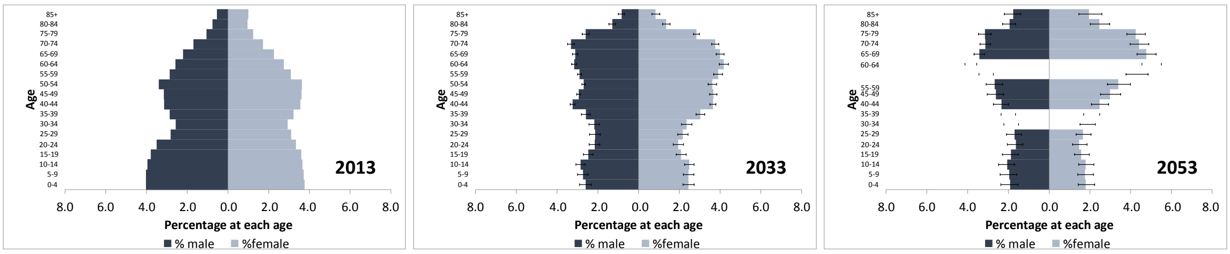


Table 6: Projected Summary Statistics for Rotorua District, 2013, 2033, and 2053

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 9,210	65+ years (N): 17,129 (15,964 – 18,368)	65+ years (N): 20,062 (17,664 – 22,760)
(%): 13.4	(%): 23.9% (22.3% - 25.6%)	(%): 31.2% (27.5% - 35.4%)
85+ years (N): 1,060	85+ years (N): 1,189 (961 – 1,456)	85+ years (N): 2,386 (1,830 – 3,074)
(%): 1.5	(%): 1.7% (1.3% - 2.0%)	(%): 3.7% (2.8% - 4.8%)
Median Age: 35.1 years	Med. Age: 45.3 years (45.2 – 45.4 years)	Med. Age: 55.4 years (55.2 – 55.6 years)

Figure 8: Population Pyramids for South Waikato District, 2013, 2033, and 2053

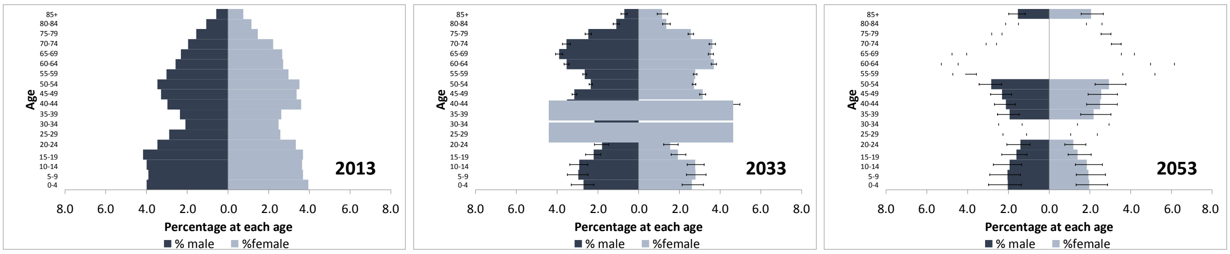


Table 7: Projected Summary Statistics for South Waikato District, 2013, 2033, and 2053

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 3,540	65+ years (N): 4,813 (4,484 – 5,164)	65+ years (N): 4,233 (3,749 – 4,777)
(%): 15.7	(%):23.9% (22.3% - 25.7%)	(%): 27.3% (24.2% - 30.8%)
85+ years (N): 300	85+ years (N): 372 (297 – 460)	85+ years (N): 557 (425 – 720)
(%): 1.3	(%): 1.8% (1.5% - 2.3%)	(%): 3.6% (2.7% - 4.6%)
Median Age: 35.2 years	Med. Age: 45.0 years (40.6 – 45.3) years	Med. Age: 55.4 years (54.3 – 60.3) years

Figure 9 shows how the median proportion aged 65 years and over increases over the course of the projections for each of the four TAs. Again, the inexorable advance of population ageing is apparent, with the proportion increasing consistently for all four TAs. Tauranga City is projected to have the highest proportion aged 65 years and over for the entire period to 2053, with Hamilton City having the lowest. The certainty of rapid ageing is demonstrated in Figure 10, which shows the ratio of the 95th to the 5th percentile in the stochastic projections, in terms of proportions of the population aged 65 years and over – this ratio is a measure of how wide the projection interval is, relative to the projected proportions. By this measure, the uncertainty in the projected proportion of the population aged 65 years and over is lowest for Hamilton City and Rotorua District, and somewhat higher for Tauranga City and South Waikato District – however, in all cases except South Waikato District the ratio of the 95th to the 5th percentile remains relatively low and stable over the entire projection period to 2053. For South Waikato District the uncertainty increases steadily after about 2025, but is still relatively low in 2053.

Figure 9: Median proportion of the population aged 65 years and over, 2013-2053

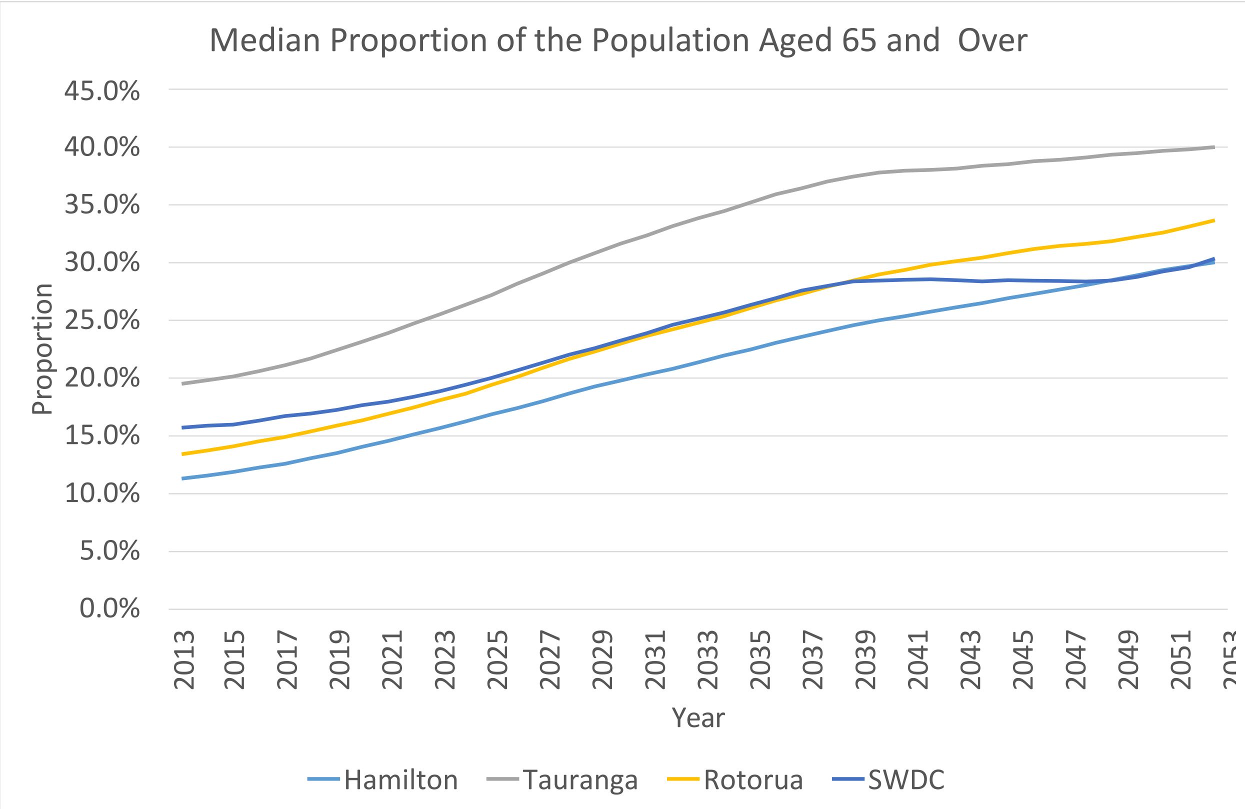


Figure 10: Ratio of 95th to 5th percentile in the proportion of the population aged 65 years and over, 2013-2053

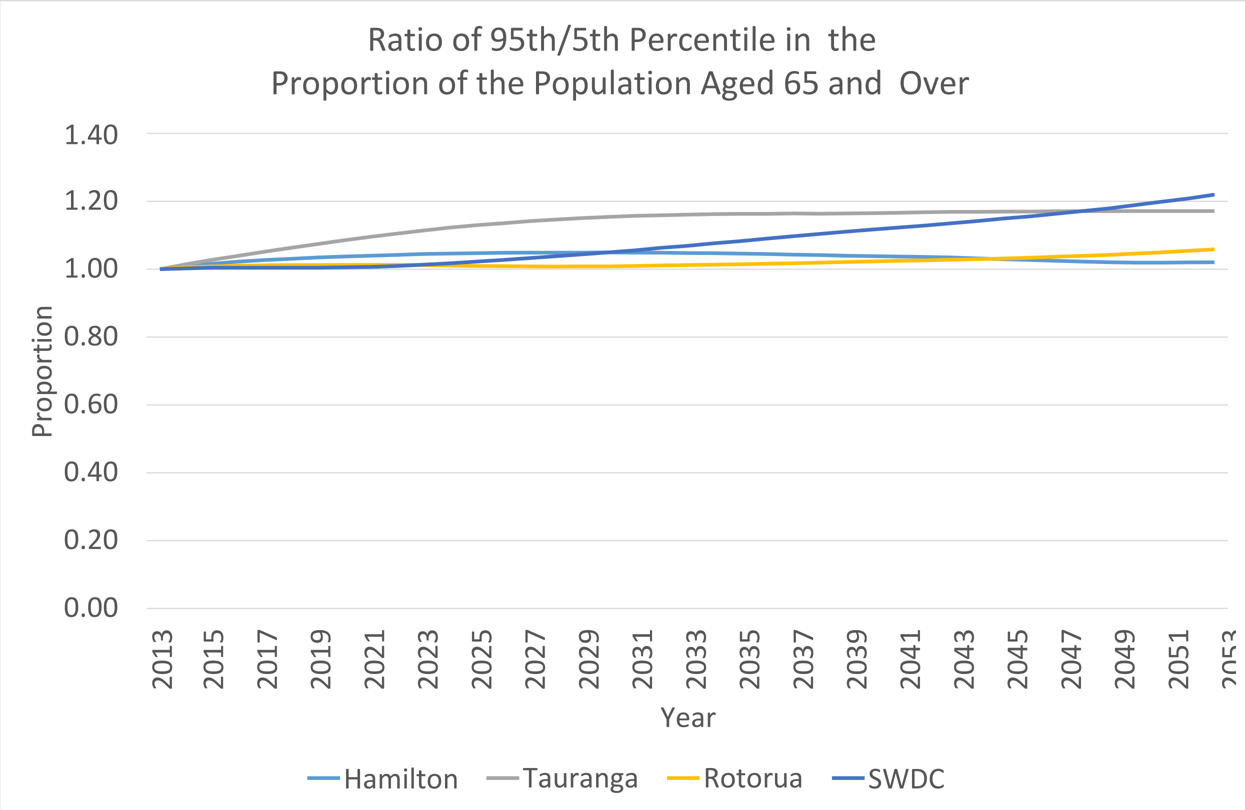


Figure 11 shows the proportion of the 10,000 scenarios that exhibit population decline for each of the four TAs, over the period 2014-2053. South Waikato faces almost certain population decline over the entire projection period. The probability of population decline increases from a moderate base for Rotorua District, becoming almost certain by 2040, while the probability that either Hamilton City or Tauranga City will experience population decline increases appreciably only towards the end of the projection period. The probability of population decline increases more rapidly for Hamilton City than for Tauranga City, which reflects the underlying migration assumptions by age and sex. Hamilton City typically experiences net gains at 15-19 and 20-24 years but these are followed by a net loss at 25-29 years, while thereafter net change by age is almost flat with net losses at several ages (see Appendix A). By contrast, Tauranga City typically experiences net loss at 20-24 years but net gain at all other ages up to age 80. The outcome is that Hamilton City gains relatively few people of reproductive age, while Tauranga City makes the majority of its migration gain at those ages—at the same time as it takes in a sizeable number of older people. Over time these differences deliver considerably more births *vis-à-vis* population size to Tauranga City, despite its greater number of older migrants, with the end result that it has a lower probability of population decline for longer than Hamilton City.

Figure 11: Proportion of scenarios exhibiting population decline, 2014-2053

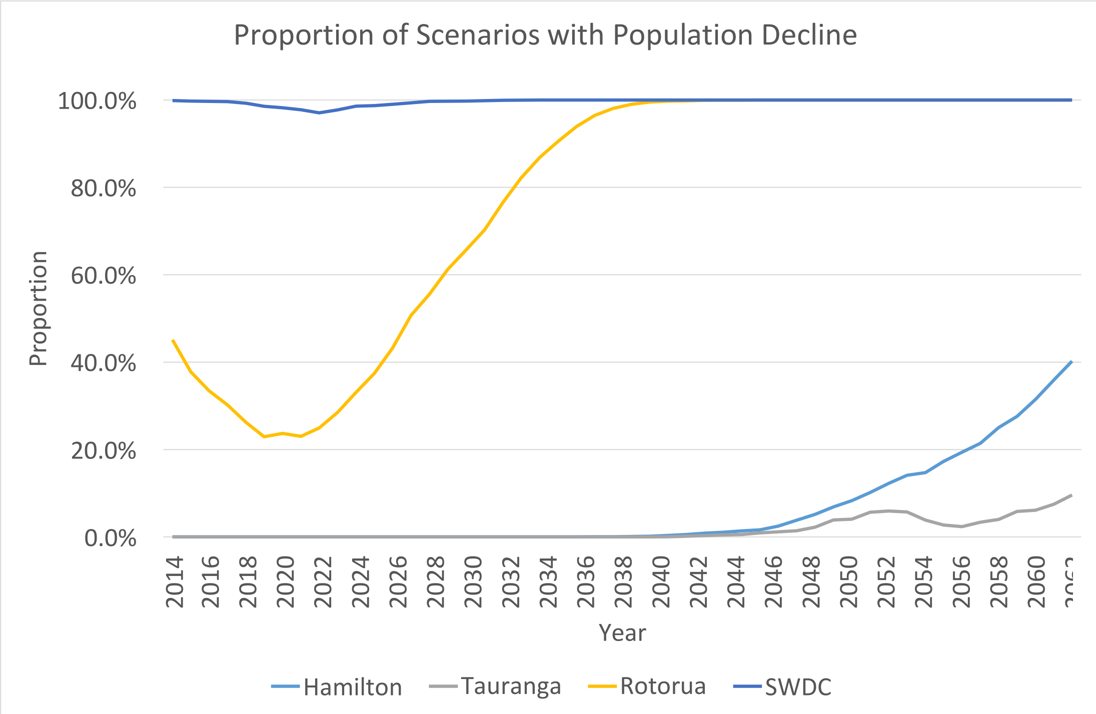
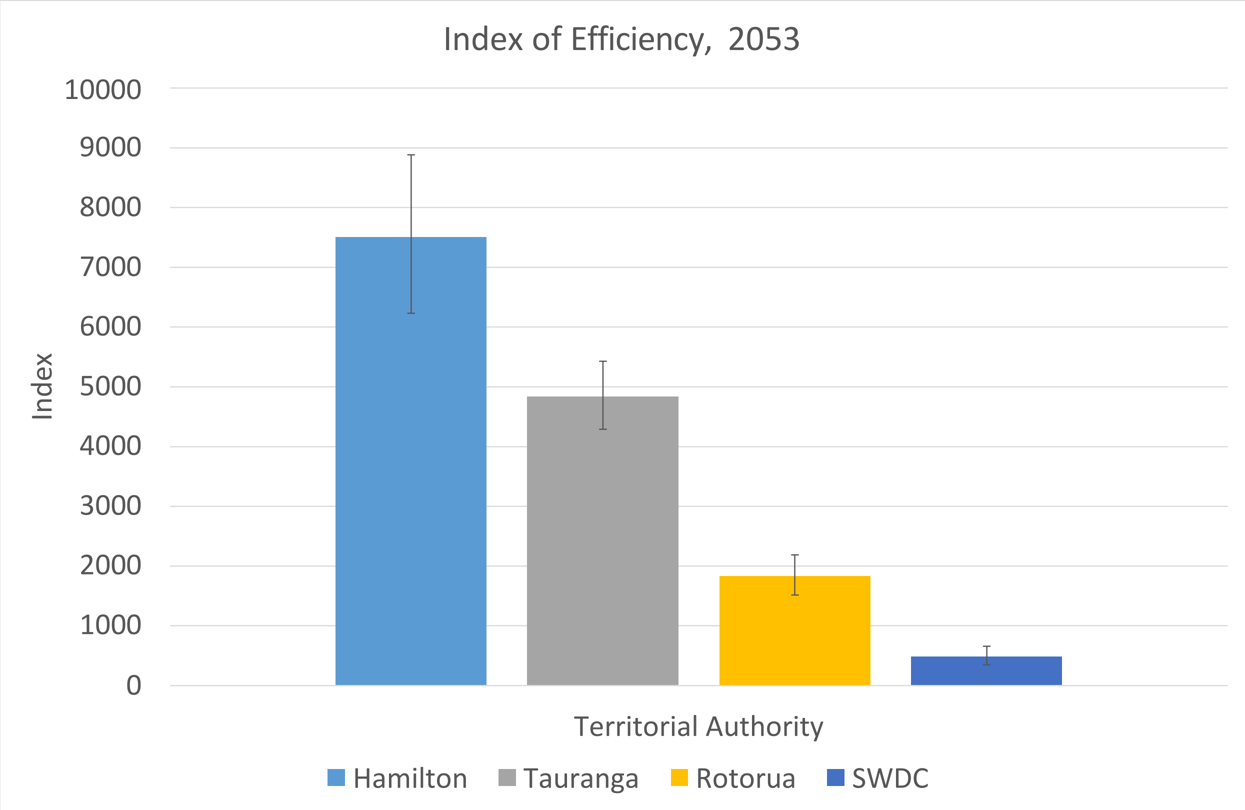


Figure 12 shows the (revised[9]) index of efficiency for 2053 for each of the four TAs, along with the 90 percent projection interval for each estimate. This index represents the number of migrants aged under 65 years that would be need to be added to the population in that year in order to reduce the proportion aged 65 years and over by one percentage point. There are two aspects to this index: (1) larger populations (e.g. Hamilton and Tauranga Cities) require a larger number of migrants to offset population ageing; and (2) populations with a higher proportion of older people (e.g. Tauranga City) require a smaller number of migrants to offset population ageing.[10] Thus, combining these two effects Hamilton City has the highest index of efficiency (large population and small proportion of older people), while South Waikato has the lowest index of efficiency (small population and small proportion of older people). The index numbers are very large. For instance, adding 7,000 migrants to Hamilton City in 2053 represents additional migration equal to 3.2 percent of the median projected population in that year – a massive increase in population in order to decrease the proportion of the population aged 65 years and over by a single percentage point.

[9] Revised McDonald and Kippen 1999, p. 14.
[10] Consider the formula for the Index of Efficiency in footnote 8. As the proportion of the population aged 65 years and over increases (holding total population constant), the denominator (*99S – P*) gets larger leading to a smaller value for the index.

Figure 12: Number of people aged less than 65 years needed to reduce the proportion of the population aged 65+ years in 2053 by one percentage point



The preceding analysis demonstrates that structural ageing cannot be easily mitigated at the subnational level by increases in migration. However, does that extend to New Zealand as a whole? In other words, how many migrants would New Zealand need in total to 'resolve' its structural ageing? Here we return to the use of deterministic projection modelling, as the objective is simply to identify the reduction in the percentage aged 65 years and over that would be achieved under varying net migration scenarios, ranging here from zero to 150,000 per year.[11] Holding the fertility and mortality assumptions constant at similar rates to those used by Statistics New Zealand, and using the international migration age profile observed over the past decade, Figure 13 shows that even extremely high migration levels would have only minimal impact on the proportion of the population aged 65 years and over. Zero net migration (Scenario 8) would see around 28.1 per cent aged 65 years and over in 2068, while net migration of 150,000 per year would reduce that to 23.6 per cent (Scenario 1, see also Table 8). The resulting populations would number around 5 million and 16.3 million respectively (Table 9), thus the reduction of 4.6 percentage points in ageing would come at a 'cost' of 11 million additional people.

[11] The stochastic population projections model does not allow for the addition of absolute net migration, as the model is based on net migration rates, rather than numbers (Cameron and Poot, 2010).

The greatest *incremental* reduction, of 3.9 per cent in 2063, would come with a net migration gain of 50,000 per year (Table 10); however this reduction would be somewhat greater around 2043, when the majority of the baby boomers will be at the oldest ages. That is, as found by Kippen and McDonald (1999) for Australia, 'moderately high' levels of migration will reduce structural ageing by a few percentage points, but cannot resolve the situation over the longer term because migrants themselves also age, adding to both the increased numbers and percentages at older ages. Unless they come from very high fertility populations, they are also less likely to replace themselves through births, adding further to structural ageing; New Zealand's dominance of Asian migrants for example have a fertility rate somewhat below that of all other major ethnic groups (in 2013, a TFR of 1.69, compared with 2.02 for European, 2.49 for Māori, and 2.73 for Pacific Peoples – Statistics New Zealand 2015c). Thus migration in and of itself is of limited utility in addressing structural ageing; more important is who those migrants are.

Figure 13: Projected percentage of the New Zealand population aged 65+ years under different migration scenarios (with medium fertility and life expectancy assumptions).

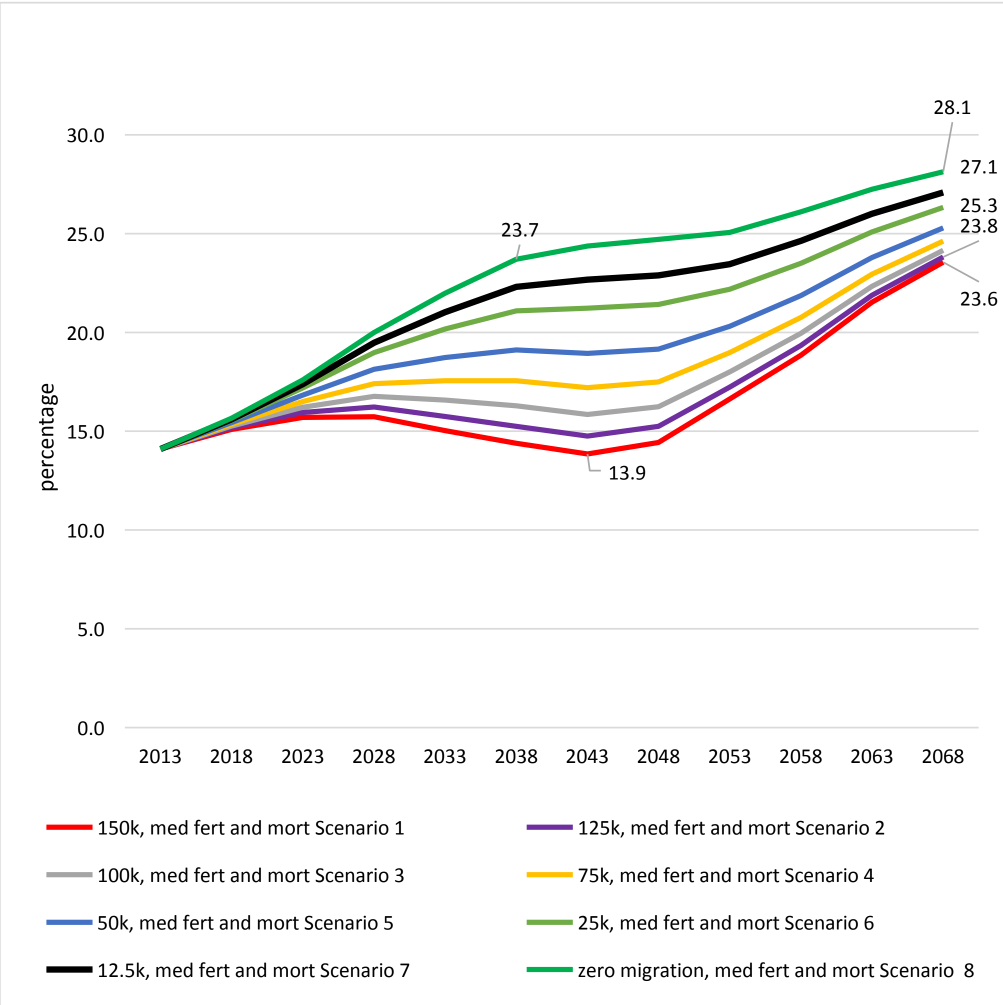


Table 8: Projected percentage aged 65+ years under different net migration scenarios, Total New Zealand

		2013	2018	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068
150k, med fert and mort	Scenario 1	14.1	15.1	15.7	15.7	15.0	14.4	13.9	14.4	16.6	18.9	21.5	23.6
125k, med fert and mort	Scenario 2	14.1	15.2	15.9	16.2	15.7	15.3	14.8	15.2	17.2	19.3	21.9	23.8
100k, med fert and mort	Scenario 3	14.1	15.3	16.2	16.8	16.6	16.3	15.8	16.2	18.0	20.0	22.3	24.2
75k, med fert and mort	Scenario 4	14.1	15.3	16.5	17.4	17.6	17.5	17.2	17.5	19.0	20.8	22.9	24.6
50k, med fert and mort	**Scenario 5**	**14.1**	**15.4**	**16.8**	**18.1**	**18.7**	**19.1**	**18.9**	**19.2**	**20.3**	**21.9**	**23.8**	**25.3**
25k, med fert and mort	Scenario 6	14.1	15.5	17.2	19.0	20.2	21.1	21.2	21.4	22.2	23.5	25.1	26.3
12.5k, med fert and mort	Scenario 7	14.1	15.6	17.4	19.5	21.0	22.3	22.7	22.9	23.5	24.6	26.0	27.1
zero migration, med fert and mort	Scenario 8	14.1	15.7	17.6	20.0	22.0	23.7	24.4	24.7	25.1	26.1	27.2	28.1
12k, med fert, med mort	SNZ MED	14.4	15.8	17.9	20.2	22.0	23.4	23.8	24.0	24.4	25.6	26.7	27.5

Table 9: Projected population size under different migration scenarios, Total New Zealand

		2013	2018	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068
150k, med fert and mort	Scenario 1	4442080	5368926	6396293	7464493	8531856	9589209	10650268	11738401	12873368	14044198	15227900	16377185
125k, med fert and mort	Scenario 2	4442080	5233432	6108688	7016214	7919731	8811381	9702777	10613163	11560507	12536611	13524324	14483557
100k, med fert and mort	Scenario 3	4442080	5097938	5821084	6567934	7307606	8033553	8755287	9487924	10247647	11029024	11820747	12589929
75k, med fert and mort	Scenario 4	4442080	4962444	5533479	6119654	6695481	7255724	7807797	8362685	8934787	9521437	10117171	10696301
50k, med fert and mort	Scenario 5	4442080	4826951	5245875	5671374	6083355	6477896	6860307	7237446	7621926	8013850	8413595	8802673
25k, med fert and mort	Scenario 6	4442080	4691457	4958271	5223095	5471230	5700068	5912817	6112207	6309066	6506263	6710019	6909045
12.5k, med fert and mort	Scenario 7	4442080	4623710	4814469	4998955	5165168	5311154	5439071	5549588	5652636	5752470	5858231	5962231
zero migration, med fert and mort	Scenario 8	4442080	4555963	4670666	4774815	4859105	4922240	4965326	4986968	4996206	4998676	5006443	5015417
12k, med fert, med mort	SNZ MED	4509700	4738400	4948800	5152900	5338300	5499100	5639000	5761100	5868700	5969500	6070500	6174600

Table 10: Projected % reduction in proportion aged 65+ years for each increase in net migration under different migration scenarios, Total New Zealand

		2013	2018	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068
150k, med fert and mort	Scenario 1	0.0	-0.5	-1.5	-3.0	-4.5	-5.7	**-6.1**	-5.3	-3.5	-2.5	-1.6	-1.1
125k, med fert and mort	Scenario 2	0.0	-0.6	-1.6	-3.3	-5.0	-6.4	**-6.9**	-6.1	-4.2	-3.1	-2.0	-1.4
100k, med fert and mort	Scenario 3	0.0	-0.6	-1.8	-3.6	-5.6	-7.2	**-7.9**	-7.2	-5.2	-3.9	-2.6	-1.9
75k, med fert and mort	Scenario 4	0.0	-0.6	-1.9	-4.0	-6.3	-8.2	**-9.1**	-8.6	-6.5	-5.1	-3.6	-2.6
50k, med fert and mort	**Scenario 5**	**0.0**	**-0.6**	**-2.1**	**-4.5**	**-7.1**	**-9.4**	**-10.8**	**-10.6**	**-8.5**	**-6.9**	**-5.1**	**-3.9**
25k, med fert and mort	Scenario 6	0.0	-0.3	-1.1	-2.5	-4.0	-5.4	**-6.4**	**-6.4**	-5.4	-4.6	-3.5	-2.8
12.5k, med fert and mort	Scenario 7	0.0	-0.3	-1.2	-2.7	-4.3	-5.9	-7.0	**-7.3**	-6.4	-5.7	-4.5	-3.7
zero migration, med fert and mort	Scenario 8	…	…	…	…	…	…	…	…	…	…	…	…

Conclusion: In this paper we have demonstrated the inexorability of population ageing for New Zealand, both for the country as a whole and importantly, for subnational areas. The process of population ageing moves through four dimensions: (1) numerical ageing; (2) structural ageing; (3) natural decline; and (4) absolute decline. Despite being much younger than its European counterparts, the momentum of population ageing in New Zealand, both nationally and subnationally, is profound – all TAs will experience population ageing, and many TAs are already, or will soon, experience population decline as a result of this ageing. This is because the trend is moving from the 'old' form of decline, caused by net migration loss, to a new form, the combined effect of net migration loss and natural decline. Migration is not a panacea – the amount of migration required to offset population ageing is unrealistic, and migrants themselves age as well, initially subtracting from structural ageing but eventually adding to it. Fertility rates for migrants are also variable, with the numerically dominant group, those of Asian origin, having particularly low birth rates and further contributing to structural ageing. Local authorities and policy-makers (both local and national) must recognise that an ageing population is a reality and that subnational (and eventually national) population decline is a very real future (Lutz, Sanderson and Sherbov 2001, 2004; Rostow 1998), with important implications for planning and policy. As advised in the seminal United Nations (2000: 4) Replacement Migration study, it is essential that policies developed at a time when populations were youthful and growing are urgently revisited and revised, along with the principles on which they are based:

> *"The new challenges being brought about by declining and ageing populations will require objective, thorough and comprehensive reassessments of many established economic, social and political policies and programmes. Such reassessments will need to incorporate a long-term perspective."*

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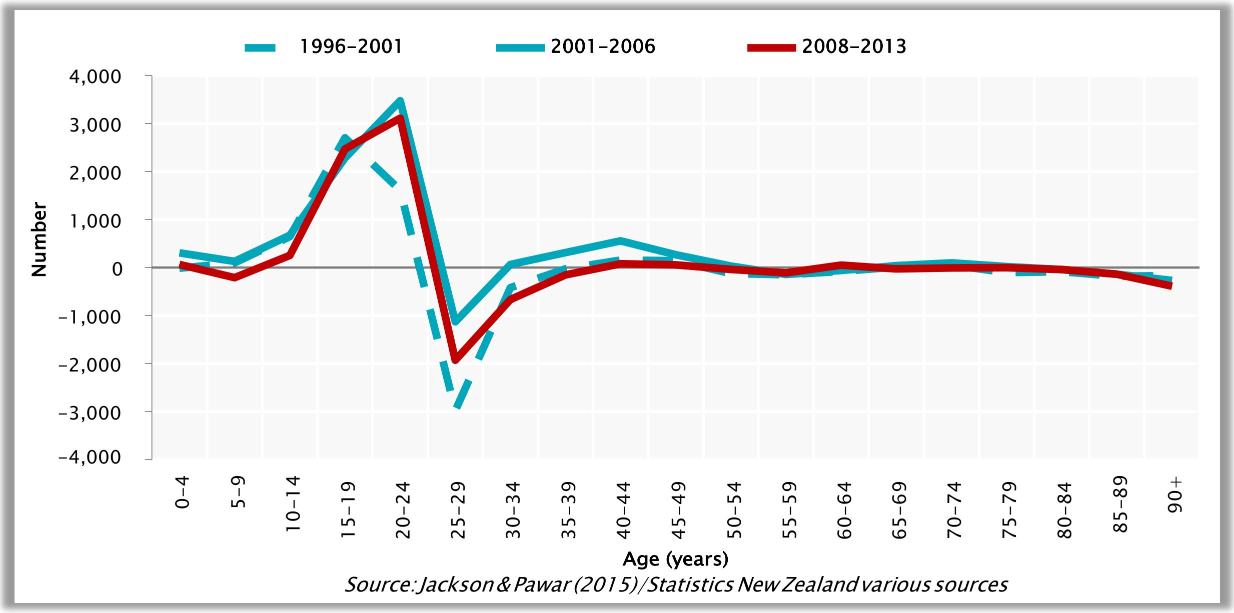
Appendix A: Age Profile of Estimated Net Migration, Hamilton City and Tauranga City

Hamilton City



Tauranga City