Population Ageing
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The Unavoidable Nature of Population Ageing and the Ageing-Driven End of Growth – an Update for New Zealand

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Abstract Despite overwhelming evidence to the contrary, many people still question the extent to which population ageing and the ageing-driven ending of growth will unfold more or less as projected. This is particularly so in New Zealand, where the population is still relatively youthful due to near-replacement fertility and many years of high per capita net migration gains. As elsewhere, however, the picture differs markedly at subnational level, with the populations of one-quarter of the nation's 67 territorial authority areas (TAs) already (in 2017) having more than 20% aged 65+ years. Accompanying this trend, one-third of the nation's TAs declined in population between 1996 and 2013, primarily because of net migration loss at young adult ages, but in the process accelerating their structural ageing. Taking a subnational approach, this paper explores the dynamics of population ageing across New Zealand's TAs. We demonstrate that structural ageing is accelerating and that even excessively high levels of net international migration gain cannot be expected to appreciably reduce future structural ageing. We also show that over the period 2013–43 the majority of declining TAs will move from the old form of decline, caused by net migration loss exceeding natural increase, to a new form caused by the combined effects of net migration loss and natural decrease. The findings reinforce our central argument that the phenomenon of population ageing and the ageing-

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driven end of growth will not 'go away' and has urgent implications for matters such as rate-based local government infrastructure funding.

Keywords Population ageing · Subnational ageing · Ageing-driven growth · Natural decrease · Depopulation

Introduction

As elsewhere in OECD countries, population ageing and the ageing-driven ending of population growth is unfolding at markedly different rates across subnational New Zealand. At national level, those aged 65+ years presently account for around 15% of the New Zealand population. At subnational level, 13% of the nation's 67 territorial authority areas (defined further below) were already experiencing 'hyper-ageing' in 2013, that is, having more than 20% aged 65+ years. Medium variant projections expect this proportion to be above one-third of TAs in 2018 and two-thirds as soon as 2023 (Statistics New Zealand 2015a).

Accompanying this trend, one-third of New Zealand's territorial authority areas declined in size between 1996 and 2013, primarily because net migration loss was greater than natural increase (where births exceed deaths)—referred to by Bucher and Mai (2005) as the 'old' form of population decline (cited in Matanle et al. 2011: 19–20 and 46–47) (Jackson 2014, 2016). However the decline affected only 14% of the New Zealand population, and the trends were not monotonic.

Looking ahead we see natural decrease (where deaths exceed births) or zero natural increase emerging and becoming sustained in an increasing proportion of New Zealand's territorial authority areas, by 2043 affecting almost two-thirds of territorial authority areas and 24% of the projected population (Jackson et al. forthcoming). In a minority of cases, net migration gain will offset natural decrease to prevent population decline, but where natural decrease is accompanied by net migration loss, a 'new' and increasingly intractable form of subnational depopulation is foreshadowed (Bucher and Mai 2005).

While national level depopulation is therefore 'over the horizon' in this timeframe, the subnational trends take on an increasingly monotonic nature and place New Zealand right alongside its ageing counterparts. There are, however, important differences in the underlying drivers of natural decrease. In New Zealand's case, as is the case for the counties of the USA, natural decrease is emerging primarily because of age-selective migration, rather than low fertility per se, the cause across much of Europe (see Johnson et al. 2015).

Timely awareness of and engagement with the shift and subtle differences in these drivers is imperative, because the new forms of depopulation are potentially self-reinforcing and their implications wide-reaching. The end of global population growth, plausibly around the end of the present century (Lutz et al. 2001, 2004) is an increasingly accepted proposition that is likely to bring about positive benefits, both globally and nationally (Demeny 2009). However insights into its negative subnational implications are beginning to emerge, among them: '… reduced local tax revenues and reductions in redistributed income from urban regions; obsolete public infrastructure and reduced investment in the rural economy; … abandonment of residential and business properties; decline in the quality of the built environment; and severe damage to the natural environment' (Matanle et al. 2011: 37–38; see also Haartsen and Venhorst 2009: 218–227).

At subnational level, reduced local rate revenue *vis-à-vis* increased demand from locally ageing and/or declining populations would render many local governments incapable of providing necessary physical and social services (Office of the Auditor General 2014; Local Government New Zealand 2015). There is no compensatory fund to appeal to when a population is somewhat older or declining faster than the average, such as exists in Australia[1] (DOTARS 2003; Jackson 2004).

Such insights and emerging policy responses to subnational ageing and depopulation across OECD countries (Haartsen and Venhorst 2009; McMillan 2016), fundamentally contradict an assertion by two leading population analysts, that the rise of subnational population decline is devoid of strategic or political importance unless accompanied by decline at the national level (Coleman and Rowthorn 2011: 219). By contrast, we argue that population ageing is played out at the local level, where people live and where goods and services must be provided and resourced. Failing to provide acutely needed services and facilities has political implications, and these are experienced by both local and national governments.

Given that the discourse of population ageing and most related planning in New Zealand remains centred around national level averages, and there is ministerial resistance to seemingly important policy revision (Hartevelt 2012; Johnson 2015), we hold concerns for the timely development of sub-nationally-appropriate policy. In New Zealand, the major policy directions for the past two decades have been centralization and mainstreaming ('one-size-fits-all' policy), by both public and private sectors. Globalisation and agglomeration have both fueled and reinforced this situation, with jobs and capital increasingly concentrated in the major urban centres (Pool et al. 2005–06; Cochrane et al. 2010; Eaqub 2014; Grimes et al. 2016; Alimi et al. 2016), particularly Auckland and Wellington—although many other factors are involved. Little central government attention is yet being paid to the possibilities of ageing-related decentralization and sub-national development as is now occurring across many of New Zealand's older counterpart countries, with the express objectives of slowing ageing-driven population decline and reviving declining townships and communities (Martinez-Fernandez et al. 2012; McMillan 2016).

We argue that this slow engagement with subnational ageing and its implications by central government (Eaqub 2014; Johnson 2015; Spoonley 2016) reflects the often-repeated mantra that the New Zealand population is relatively youthful (for example by comparison with Europe and Japan), the historical product of relatively high fertility rates and per capita net international migration gains. We also argue that while low fertility rates are conventionally seen as the primary driver of escalating structural ageing, they are not yet particularly low in New Zealand. Rather, as shown elsewhere (Jackson et al. 2016), New Zealand's subnational ageing is being driven by a quite different set of circumstances, namely age-selective migration. This age-selective

[1] In Australia, local governments facing disproportionate ageing, depopulation etc., can appeal through their state government apparatus for 'disability' (relativity) funding to enable them to provide 'equivalent services, irrespective of their ability to do so'. This is enshrined in the Local Government [Financial Assistance] Act 1995 (Department of Infrastructure and Regional Development 2016).

migration on the one hand removes young people, especially people of reproductive age, from the majority of TA and township populations, and on the other, adds older, retiree-age migrants, who augment both numbers and proportions at older ages. The impact of either can accelerate structural ageing as rapidly as low fertility, while both in combination ensure the rapid end of population growth (see Johnson et al. 2015 on the United States and Europe).

Accordingly, this paper revisits and updates the progress of population ageing in New Zealand. We do this 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 et al. 2005–06; Pool et al. 2007; Davoudi et al. 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 2014; Jackson et al. 2016); 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.

Methodological Notes The units of analysis for this paper are territorial authority areas (hereafter TAs), which are also local government administrative areas with legal status. Each TA/local government area is led by an elected mayor and council, and is accountable to both the local electorate and the New Zealand Government. The 67 TAs comprise 12 cities, 53 districts, Auckland Council and Chatham Islands territory, and are subsumed under 16 Regional Council Areas. TAs (and the Regional Councils to which they belong) vary widely in size, with the largest, Auckland, accounting for one-third of the New Zealand population. Relatedly, each TA commands a very different share of resources and capital, especially revenue gathered from rates on dwellings, and on which they are heavily dependent for the provision of local services and infrastructure, community facilities and 'attractiveness' of place.

As noted, regional New Zealand and its respective TAs already differ greatly in economic terms. Globalisation, agglomeration and centralization have favoured Auckland and Wellington and a few major urban areas. Some rural areas saw a small improvement in their economic standing between 2001 and 2013, due to the conversion of many sheep and beef farms, and some forestry areas, to dairying; however, this one-off stimulation to local economies is now being impacted upon by very low terms of trade for agricultural products. What Pool et al. (2005–06) referred to as 'trichotomisation' – some regions doing very well, some doing very poorly, and the rest falling in between – has not changed.

We argue that population ageing and the ageing-driven end of growth will continue this divergent process, and that local governments, as stewards of their respective TAs, will be diversely and in many cases negatively affected—unless the changes are positively and proactively engaged with. Accordingly, in this paper we are primarily interested in the number and proportion of TAs affected by extreme levels of ageing, than in the proportion of the overall New Zealand population so affected—although we do give the latter where relevant. Because of this focus we do not apply population weights to our diversely sized TAs, but treat them as equal.

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 to 1996, and prospectively for New Zealand's TAs using Statistics New Zealand's 2013-base medium variant deterministic projections to 2043 (Statistics New Zealand 2015a).[2] Noting however that deterministic projections provide a blunt tool for analysing the unfolding dynamics, we also use a stochastic projection methodology (Cameron and Poot 2010, 2011) to provide projection intervals around the median trend for four 'typical' TAs: two of which are still growing strongly (Tauranga City, Hamilton City) and two of which are relatively large but have recently experienced decline (Rotorua District, South Waikato District).[3]

We conclude our analysis with a brief 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 at the national level, let alone the subnational level, even in relatively youthful New Zealand. It reinforces our central argument that population ageing requires timely, strategic responses directed at the subnational level. Among such policy changes might be decentralization incentives for the relocation of head offices and emerging industries to slower growing or depopulating areas, and an investigation into other mechanisms for local government funding (such as those being explored by Local Government New Zealand 2015).

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. Birth rates and cohort size at birth are of course contributing factors. The current elderly belong to relatively small cohorts born between the two world wars, while the ageing of the 'Baby Boomer' cohorts born in all Western countries after the Second World War is now beginning to add to these numbers.

Structural ageing, on the other hand, refers 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. As the Boomers age they will

[2] Statistics New Zealand has recently released updated subnational population projections. We use instead the earlier set of projections, which are comparable with the stochastic population projections we present later in the paper.

[3] These territorial authority areas represent one of each trend (growth/decline) in two contiguous, strongly growing Regional Council areas: the Bay of Plenty, and Waikato. Additional detail is available in the SmartGrowth (Bay of Plenty) and FutureProof (Waikato) Reports. See Jackson et al. (2014a, b), and Cameron et al. (2014). While we would have preferred to use stochastic projections for the entire analysis, we note that these are not yet available. Stochastic subnational population projections are being developed by Statistics New Zealand, but until they are available we are dependent on those we have developed ourselves for other purposes. Unfortunately, these can provide only a limited insight into the situation because we have not yet developed a full set that constrains to the national level.

add to this structural ageing, but as indicated they are not its primary cause; that cause being the low fertility rates of their children and grandchildren. Importantly, the process is not monotonic, with 'age structural transitions' accompanying the overall trend (Pool et al. 2006). These transitions see waves of variously sized cohorts born and ripple through the age structure. In New Zealand particularly, large cohorts have generated relatively large numbers of children (even as birth rates per woman have fallen), and vice-versa[4] (Pool et al. 2007:220). Consequently, large cohorts often replace small cohorts, causing growth where there had been decline, and vice-versa. These waves, variously referred to as 'echoes', 'boomlets', 'blips' and 'new baby booms', have major implications for planners, who one minute are faced with diminishing demand (or supply, for example of labour), and the next, increasing demand/supply.

The next but still little acknowledged step in the structural ageing process is that once a population has more elderly than children it is typically a short step—a decade or two—to it having more deaths than births. This situation foreshadows the ending of the natural increase which has been with us for the entire modern era, and which to this point has largely been taken for granted. As we will illustrate below, despite the perturbations caused by the changing size of birth cohorts, the trend is essentially inexorable. In New Zealand, one TA after another is seeing steadily increasing numbers of elderly per child and, once above 20% aged 65 years and over, natural decline begins to set in—intermittently at first, representing the incipient decline stage of the demographic transition.

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 the new and essentially intractable form of depopulation (Bucher and Mai 2005, cited in Matanle et al. 2011: 19–20, 46–47).

Numerical Ageing

Under the Statistics New Zealand medium variant projections (2015a), 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 spatial data boundaries permit time-series analysis (Pool et al. 2005–06). However, providing an important insight into the overall trend, Fig. 1 shows the projected data disaggregated for two broad age groups (65–74 years, 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.

[4] This is different to Richard Easterlin's (1987) argument which pertains to America's experience of the Baby Boom and differs from that of New Zealand (Pool 2007). High/low birth rates alone do not necessarily deliver large/small cohorts, as this outcome also depends on the number of people at reproductive age.

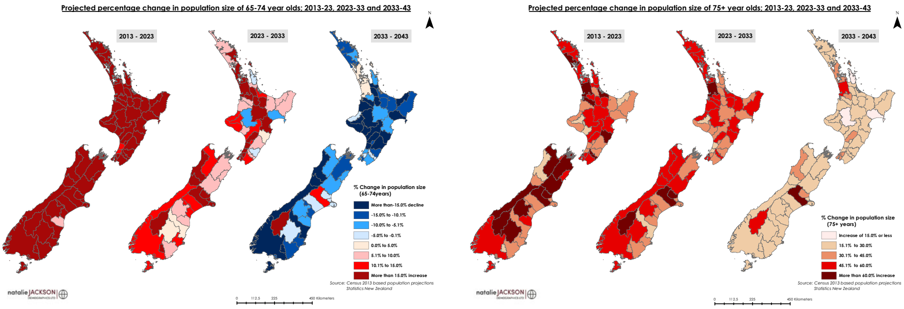

Fig. 1 Projected change (%) in numbers aged 65–74 and 75+ years by territorial authority area, 2013–23, 2023–33 and 2033–43. Source: Author/Statistics New Zealand 2015a. Created in ArcGIS

There are thus no past or projected reversals in the trend of increasing numbers at 65 years and over across New Zealand's 67 TAs; 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 et al. 2006).

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 Fig. 2 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 located. Migration has of course played a sizeable role, while different population measures used over the period may have slightly distorted the trends (see footnote to Fig. 2); however, the main picture Fig. 2 is illustrating is the passage of the boomer cohorts through each successive age group. The largest cohort at its birth, born 1957–61, for example, drove an increase in numbers at 15–19 years in 1971, compared with its predecessor cohort born 1952–56. Only recently has a birth cohort approached those initial numbers—namely that born in 2008 which fell just 1400 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 et al. 2014 on Australia).

Given current increases in life expectancy and declines in fertility rates, there is reason to expect that this structural ageing will continue as the boomers reach the older age groups. Indeed, those are precisely the assumptions built into most projection variants. The outcome, as Fig. 3 indicates, is that those aged 65 years and over are projected to account for around 60% of New Zealand's population growth across the period 2013–2043 (medium variant). However, as indicated above, this contribution will change over time, with those aged 65 years and over accounting for around 43% of New Zealand's growth between 2013 and 2018, rising rapidly to a peak contribution of 77% between 2023 and 2028, and falling back to just on 40% between 2038 and 2043.

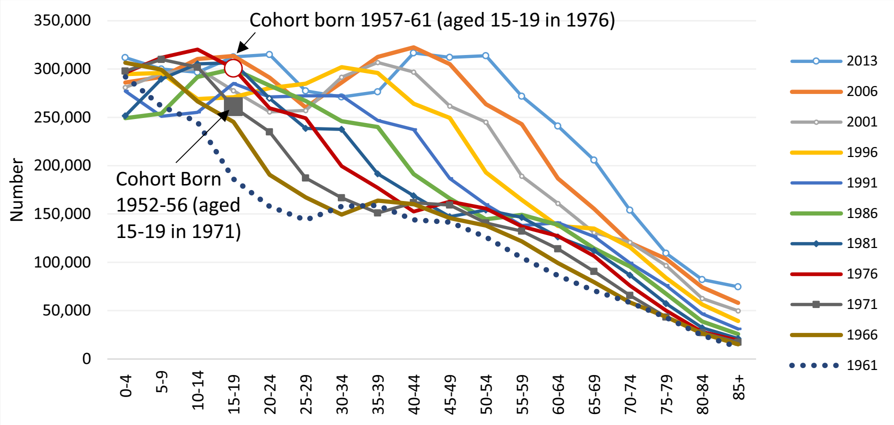

Fig. 2 Population (number) by five-year age group 1961–2013, Total New Zealand. Source: Author/Statistics New Zealand. Notes: For the period 1961–1991, numbers refer to Census Counts (de facto population); from 1996 inclusive numbers refer to Estimated Resident Population

The 'Elderly-Child' Ratio

Another useful index of structural ageing is the 'elderly-child' ratio, measured here as those aged 65+ years to those aged 0–14 years. As recently as 1996, no TA had more elderly than children; by 2013 there were ten (15%). As shown in Fig. 4, this number is projected to increase to 26 TAs by 2018 (39%) and 43 TAs by 2023 (64%). By 2028 this situation is projected to pertain for almost 90% 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.

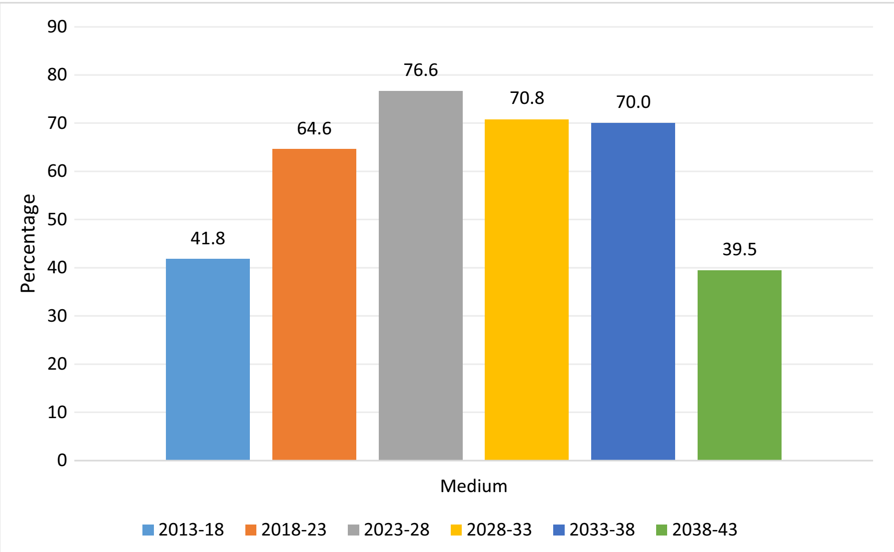

Fig. 3 Projected contribution to change (%) at 65+ years, Total New Zealand, by five year period, 2013–2043. Source: Author/Statistics New Zealand 2015a

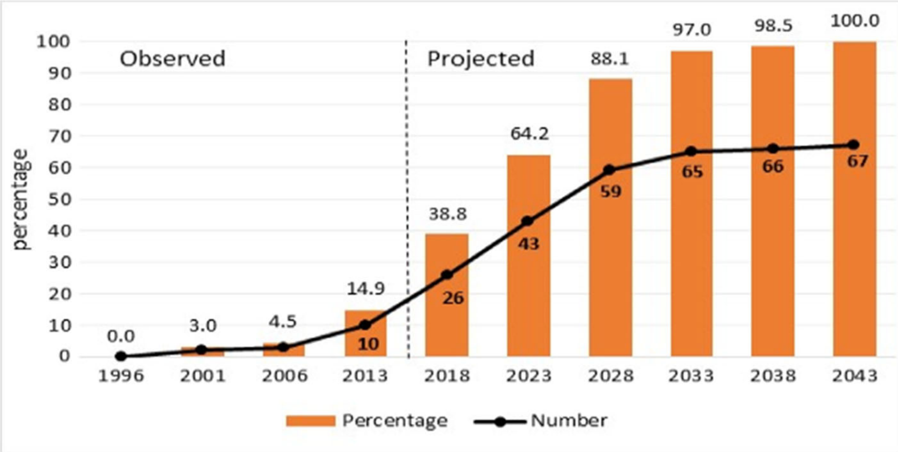

Fig. 4 Observed (1996–2013) and projected number and percentage of territorial authority areas with more elderly (65+ years) than children (0–14 years), 1996–2043. Source: Author/Statistics New Zealand 2014 and 2015a. Note: The periodicity on the horizontal axis is irregular, with a 7 year gap between 2006 and 2013 due to the delayed 2011 Census

Natural Decrease

As noted earlier, the shift to more elderly than children foreshadows an inexorable shift from natural increase to natural decrease (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 decrease intermittently over the past 10–15 years, with the three oldest (Thames-Coromandel, Kapiti Coast, and Horowhenua) now experiencing sustained natural decrease and unlikely to return to natural growth in the near future. Waimate and Waitaki Districts are still in the incipient decline stage, wavering annually between negative and positive.

Statistics New Zealand's projections confirm that the three oldest TAs noted above are expected to continue to experience natural decrease between 2013 and 2018, along with one (Waitaki) at zero natural increase (Table 1). At this stage these TAs account for just 6 % of all TAs. The number of TAs experiencing natural decrease or zero natural increase is projected to increase slowly until around 2028, when it will pertain to 11 TAs (16.4%) and then accelerate to around 64% of TAs ($N = 43$) by 2043.

The underlying data indicate that TAs reaching the onset of natural decrease have typically reached the 'hyper-ageing' stage of more than 20% 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 to have reached the hyper-ageing stage. Of the 43 TAs projected to be experiencing either natural decrease or zero natural increase in 2043, 16 (24%) already had greater than 20% aged 65 years and over at the time of writing (2016). This is projected to increase to around 24 TAs by 2018, 40 by 2023, and be the experience of all 43 by 2028.

It should be noted, however, that the loss of natural increase is almost as strongly correlated with the relative size of the prime reproductive age population (women aged

Table 1 Number and percentage of territorial authority areas projected to experience either natural decrease or zero natural increase, 2013–2043, medium variant

	Natural Decrease (Number of TAs)	Zero Natural Increase (Number of TAs)	Total Natural Decrease/Zero Natural Increase	
			Number of TAs	% TAs
2013–18	3	1	4	6.0
2018–23	3	4	7	10.4
2023–28	7	4	11	16.4
2028–33	16	2	18	26.9
2033–38	30	4	34	50.7
2038–43	37	6	43	64.2

Author/Statistics New Zealand 2015b

15–44 years) as it is with the proportion of the total population aged 65 years and over (Jackson 2014; Johnson, Field and Poston 2015). Jackson et al. (forthcoming) find the Pearson Correlation Coefficient (R) between natural increase and the proportion of women aged 15–44 years in each TA to be strongly positively correlated, increasing from 0.785 in 2013 to 0.872 in 2043 (medium variant projection), and indicating that the higher the proportion of reproductive age women, the higher the natural increase—and vice-versa. That is, the loss of reproductive age population due to net migration loss has a strong negative effect on natural increase.[5]

Conversely, the Total Fertility Rate (TFR) in each TA is only weakly correlated with natural increase (Jackson et al. forthcoming). Indeed, although the TFR in 2013 was below the intergenerational replacement level of 2.1 births per women in 18 TAs (28%), none of them were experiencing sustained natural decrease. As above, it is the relative size of the prime reproductive age population *in combination* with the TFR that determines birth numbers and largely determines natural increase, and it is the reproductive age population that is often most affected by net migration movements. Because of these interactions, Waimate District is projected to remain in the incipient decline stage for longer than Waitaki District, despite both having already entered that stage.[6]

Absolute Decline

As noted above, the main cause of depopulation across New Zealand's TAs is currently net migration loss which is greater than natural increase, the 'old' form of population decline. However, this will increasingly give way to a newer form of decline, the *combined* effect of net migration loss and natural decrease (Bucher and Mai 2005). To examine this issue we turn first to the issue of ageing-driven growth and how it

[5] Strengthening from −0.840 to −0.973 between 2013 and 2043, the correlation between natural increase and the proportion aged 65+ years in each TA is, as might be expected, strongly negative (the higher the proportion aged 65+ years, the lower the natural increase).

[6] Waimate District is projected to have a slightly higher per capita net migration gain per year and a slightly higher TFR than Waitaki District (Statistics New Zealand 2015b, 2015d).

transforms from the old to the new form of decline, and second to a disaggregation of the projected components of change underlying the projections.

Ageing-Driven Growth

The projected contribution to growth at 65 years and over in many TAs is very high (well above 100%), particularly where it is offsetting underlying decline at other ages. To dampen down these percentages for mapping purposes, contribution to overall change by those aged 65 years and over is capped on Fig. 5 at 100+ per cent. Figure 5 shows that 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—although only for so long. The periods 2013–2023, 2023–2033 and 2033–2043 see respectively 51, 43 and 24 TAs continue to grow (Table 2). 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), the number so-affected 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 (46%) 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.

While Table 2 clearly illustrates the progressive nature of projected depopulation and some of its ageing-related drivers, its periodicity can also make it difficult to conceptualise the overall impact or magnitude of change. In sum, 26 TAs (39%) are projected to be smaller in 2043 than in 2013, while the total New Zealand population is projected to be around 27% larger (Statistics New Zealand 2015a medium variant). Two TAs are projected to decline by between 30 and 40%, three by between 20 and 30%, six by between 10 and 20%, six by between five and 10 %, and nine by less than 5 %. In 2043 these 26 TAs will account for a little over 9 % (9.2%) of New Zealand's projected population of 5.64 million. However, the progressive nature of the trends means that between 2038 and 2043, declining TAs will number around 46 and will account for approximately one-quarter of the New Zealand population, up from just 5 % across the 2013–2023 period,[7] with attendant implications for—among many other things—New Zealand's historical approach to funding local infrastructure from rates revenue.

[7] It should also be noted that between 2013 and 2018 the number of TAs projected to decline, 12, 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 2014–2018 period. Net international migration as indicated by Permanent and Long Term (PLT) migration for the period 2013–15 exceeds the projection assumption and thus it is indeed likely that such gains will be realized, at least nationally. At subnational level, however, they are also impacted upon by internal migration, and the international PLT movements give no insight into the current strength or otherwise of those internal flows.

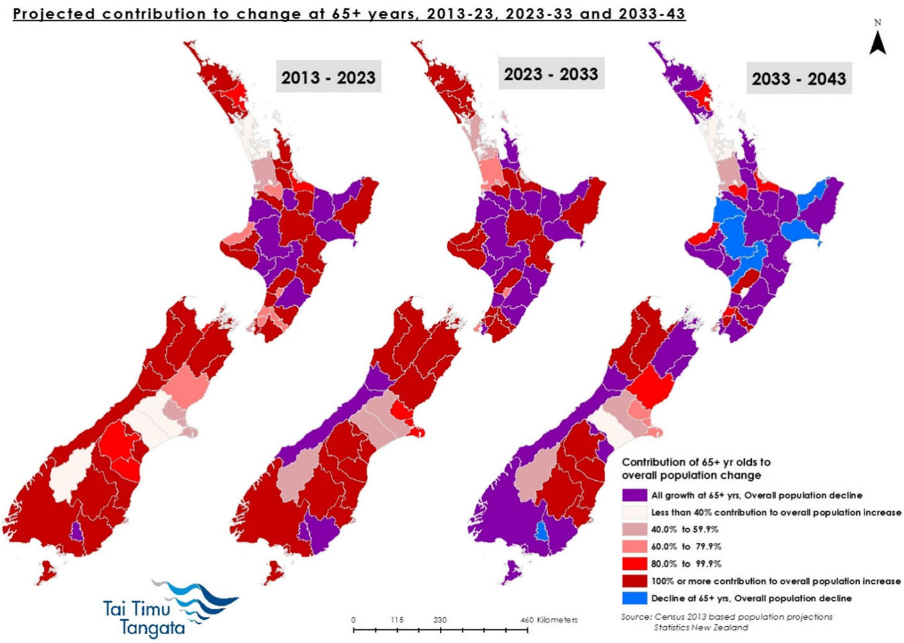

Fig. 5 Projected contribution to change (%) at 65+ years by territorial authority area, 2013–2023, 2023–2033 and 2033–2043, medium variant. Source: Author/Statistics New Zealand 2015a. Created in ArcGIS

From the Old to the New Form of Depopulation

Finally for this section, Table 3 disaggregates the SNZ population projections into their natural increase and net migration components, for five-yearly intervals. 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 (N = 39) or experience zero growth (N = 4) across the final projection period (2033–2043) (Table 2), the majority are by then likely to be experiencing the new form of depopulation. Table 3 shows that between 2038 and 2043, the combined effect of natural decrease/zero natural increase and negative/zero net migration will pertain to 25 TAs (37% of all TAs). Underlying population data indicate that this will affect approximately 10% of the projected New Zealand population. In a further eight TAs (12%), net migration gain will fail to offset natural decrease, affecting a further 6.3% of the projected 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 allows for a more nuanced analysis of projected ageing.

Table 2 Projected contribution to change by broad age group at territorial authority area level, 2013–2023, 2023–2033 and 2033–2043, medium variant

	2013–2023 Number of TAs	2023–2033	2033–2043	2013–2023 Percentage of TAs	2023–2033	2033–2043
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
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
Total (N/Per Cent)	67	67	67	100.0	100.0	100.0
Percentage of total New Zealand population living in a TA experiencing zero growth or decline				4.8	10.8	21.9

Author/Statistics New Zealand 2015a

Table 3 Projected number and percentage of territorial authority areas experiencing natural decrease/zero natural increase and negative/zero net migration, 2013–2043, medium variant

	Negative/Zero Natural Increase Number of TAs	Negative/Zero Net Migration	Both	Negative/Zero Natural Increase Percentage of TAs	Negative/Zero Net Migration	Both
2013–18	4	25	0	6.0	37.3	0.0
2018–23	7	39	1	10.4	58.2	1.5
2023–28	11	39	3	16.4	58.2	4.5
2028–33	18	39	6	26.9	58.2	9.0
2033–38	34	39	19	50.7	58.2	28.4
2038–43	43	39	25	64.2	58.2	37.3

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 remains 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 et al. (2014a), and Cameron et al. (2014). 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% of the 10,000 scenarios and below the other 50% of scenarios. The 90% projection interval indicates the range within which 90% of 10,000 scenarios lie, i.e. 5% of the scenarios are above this range, and 5% below this range. Conventionally, these projection intervals are interpreted probabilistically, i.e. that there is a 90% chance that the future population will fall within the 90% projection interval.

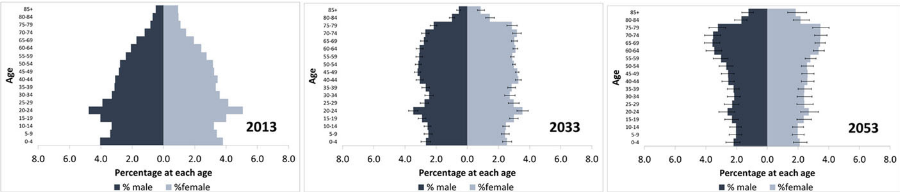

Fig. 6 Population Pyramids for Hamilton City, 2013, 2033, and 2053

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 proportions of the population aged 65 years or older and 85 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]

Figure 6 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 Figs. 7, 8, and 9 respectively. The stochastic nature of the projections in 2033 and 2053 is represented in each population pyramid by ‘error bars’ that contain the 90% 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% 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 32.1 years and 11.3% of the population aged 65 years and over. Tauranga City has the oldest age profile in 2013, with a median age of 40.7 years and 19.5% of the

[8] Specifically, we calculate the index here as:
$E = (P + S)^2/(99S - P)$
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.

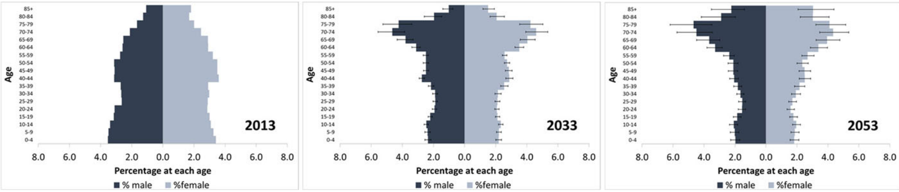

Fig. 7 Population Pyramids for Tauranga City, 2013, 2033, and 2053

population aged 65 years and over. However, in both cases the median age increases to around 50 years or more by 2053, with Hamilton City having a median age of 49.5 years and Tauranga City a median age of 57.6. Of the four TAs, Rotorua District experiences the most rapid ageing, with the proportion aged 65 years and over increasing from 13.4% in 2013 to 31.2% 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% in 2013 to 5.3% 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 the population of Tauranga City compared with the other TAs, and in part the age profile of its migrants.

Figure 10 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 Fig. 11, 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 12 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

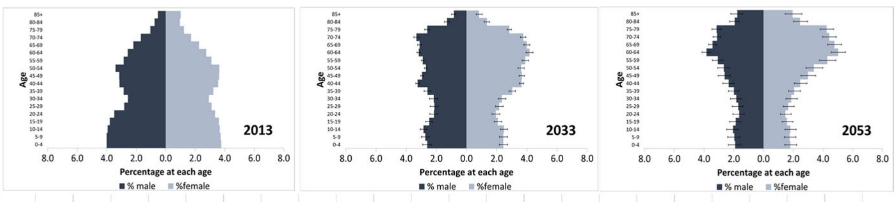

Fig. 8 Population Pyramids for Rotorua District, 2013, 2033, and 2053

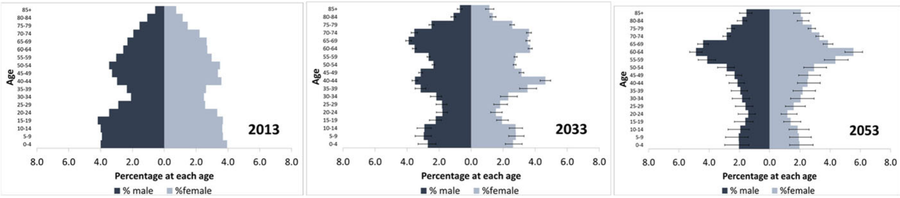

Fig. 9 Population Pyramids for South Waikato District, 2013, 2033, and 2053

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, reflecting the underlying migration assumptions by age and sex.

Following McDonald and Kippen (1999), Fig. 13 shows the (revised[9]) 'index of efficiency' for 2053 for each of the four TAs, along with the 90% 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 reduce the proportion aged 65+ years by one percentage point; and (2) populations with a higher proportion of older people (e.g. Tauranga City) require a smaller number of migrants to reduce the proportion aged 65+ years by one percentage point.[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 7000 migrants to Hamilton City in 2053 represents additional migration equal to 3.2% 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.

To What Extent Can New Zealand's Structural Ageing Be Reduced? 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 briefly 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

[9] Revised McDonald and Kippen 1999, p. 14.

[10] Consider the formula for the Index of Efficiency in footnote 9. 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.

[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).

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): 2106	85+ years (N): 2788 (2172–3539)	85+ years (N): 7258 (5229–9941)
(%): 1.4	(%): 1.4 (1.1–1.8)	(%): 3.1 (2.2–4.2)
Median Age: 32.1 years	Med. age: 42.8 years (42.4–43.2 years)	Med. Age: 49.5 years (48.8–53.3 years)

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, Fig. 14 shows that even extremely high migration levels would have only minimal impact on the proportion of the population aged 65 years and over in 2068. Zero net migration (Scenario 8) would see around 28.1% aged 65 years and over in 2068, while net migration of 150,000 per year would reduce that to 23.6% (Scenario 1). The resulting populations would number around 5 million and 16.3 million respectively. Thus, the reduction of 4.6 percentage points in ageing (by comparison with the zero migration scenario) would come at a 'cost' of 11 million additional people. Similarly, the addition of 10.4 million migrants over the period 2013–2068 would reduce the proportion under the equivalent of Statistics New Zealand's medium variant projection (Scenario 7) in 2068 by just 3.5 percentage points.

In 2068 the greatest reduction between each *successive* (i.e. incremental) net migration assumption, 3.9%, would come with a net migration gain of 50,000 per year; 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 was found by McDonald and Kippen (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: 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 1.92 for European/Other, 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; it is more important who those migrants are, and what their fertility rates are.

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): 3370	85+ years (N): 4322 (3272–5647)	85+ years (N): 10,886 (7136–16,338)
(%): 2.9	(%): 2.5 (1.9–3.3)	(%): 5.3 (3.5–7.9)
Median Age: 40.7 years	Med. age: 51.5 years (49.9–53.3 years)	Med. Age: 57.6 years (55.3–60.2 years)

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

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 9210	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): 1060	85+ years (N): 1189 (961–1456)	85+ years (N): 2386 (1830–3074)
(%): 1.5	(%): 1.7 (1.3–2.0)	(%): 3.7 (2.8–4.8)
Median Age: 36.0 years	Med. Age: 47.1 years (46.5–47.7 years)	Med. Age: 55.7 years (54.5–56.9 years)

Discussion

In this paper we have demonstrated the inexorability of population ageing for New Zealand, both for the country as a whole and for its 67 subnational territorial authority areas (TAs).

The process of population ageing moves through four dimensions: (1) numerical ageing (an absolute increase in the number of elderly); (2) structural ageing (where the increased numbers at older ages also increase as a proportion of the population, conventionally due to declining fertility rates); (3) natural decrease (where deaths come to exceed births); and (4) absolute decline (depopulation). However these 'stages' are not always consecutive. For example, where the primary driver of population change is net migration loss, absolute decline may precede natural decrease, while if the net migration loss is primarily at young adult ages (and/or there is notable net migration gain at older ages), structural ageing and the shift to natural decrease may be accelerated, even when fertility rates are relatively high.

The latter is particularly the case in subnational New Zealand. While natural decrease has only recently emerged at subnational level, in most cases driven by age-selective migration, it is projected to become significant from the late-2020s as conventional structural ageing takes hold. The resulting momentum of population ageing at subnational level is profound. While all TAs are experiencing conventional population ageing driven by declining fertility rates, many will soon experience depopulation as a result of migration-accelerated ageing.

The implications of migration-driven natural decrease, rather than natural decrease caused by low fertility per se, have not been widely explored or appreciated. Uppermost among them is that it can quickly become self-reinforcing, resulting in extremely rapid ageing and faster onset of intractable depopulation. This is because advanced structural ageing is accompanied by a

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

2013	2033 (90% PI)	2053 (90% PI)
65+ years (N): 3540	65+ years (N): 4813 (4484–5164)	65+ years (N): 4233 (3749–4777)
(%): 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: 37.2 years	Med. Age: 45.3 years (43.7–47.1) years	Med. Age: 55.7 years (52.2–58.2) years

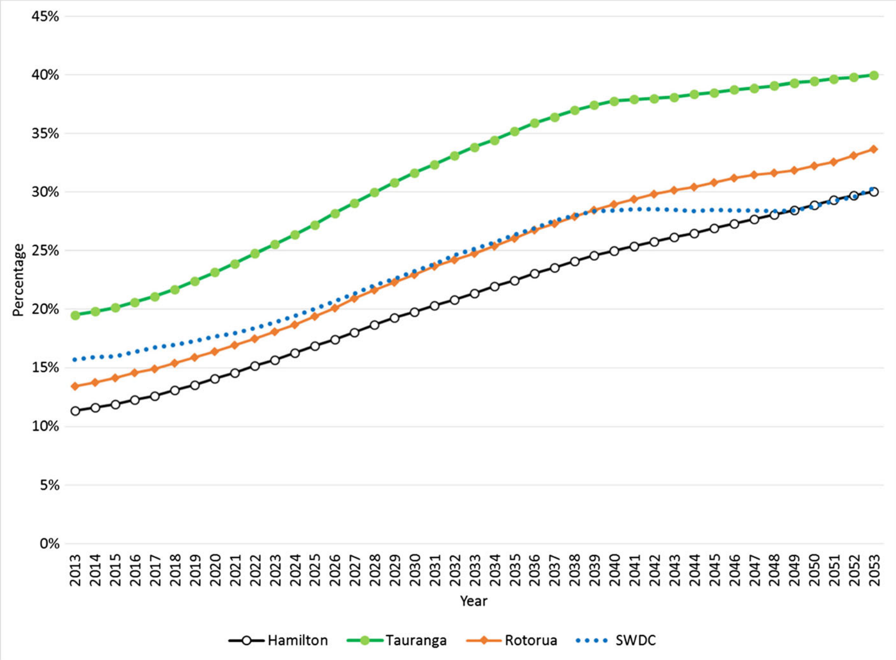

Fig. 10 Median proportion of the population aged 65 years and over, selected TAs, 2013–2053

shift from the 'old' form of depopulation, caused by natural increase failing to offset net migration loss, to a new form, the combined effect of net migration loss and natural decrease. Between 2038 and 2043 depopulation caused by the combined effects of negative or zero natural increase and negative or zero net migration will affect around 25 TAs (37%). Although this dual form of depopulation will affect barely 10% of the projected New Zealand population, net migration gain will fail to offset natural decrease in a further 12% of TAs, affecting a further 6% of the New Zealand population. Eleven additional TAs (16%, affecting 8% of the population) are also projected to decline in size because natural increase will fail to offset net migration loss (the old form of depopulation). This will bring the total number of TAs experiencing depopulation between 2038 and 2043 to around 46 (68% of TAs) and affect around one-quarter of the New Zealand population—or in other words, just 21 TAs will still be growing, although they will be home to three-quarters of the population.

Although the deterministic data we have to conceptualise this disparate future with are not perfect, the likely magnitude of the declines are also noteworthy. In 2043, 26 TAs (39%) are projected to be smaller than in 2013, while the total New Zealand population is projected to be around 27% larger. Two TAs are projected to decline by between 30 and 40%, three by between 20 and 30%, six by between 10 and 20%, six by between five and 10 %, and nine by between 0.2 and 5 %. However comparing population sizes in 2013 and 2043 misses the most important point, and that is the progressive nature of the trends, which see an increasing number of TAs and population affected as time advances.

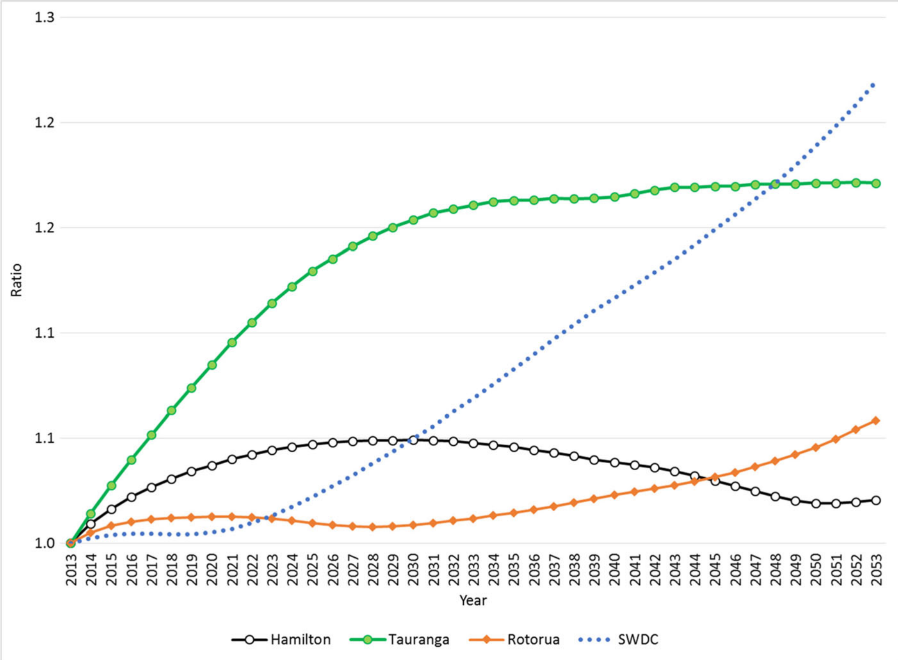

Fig. 11 Ratio of 95th to 5th percentile in the proportion of the population aged 65 years and over, selected TAs, 2013–2053

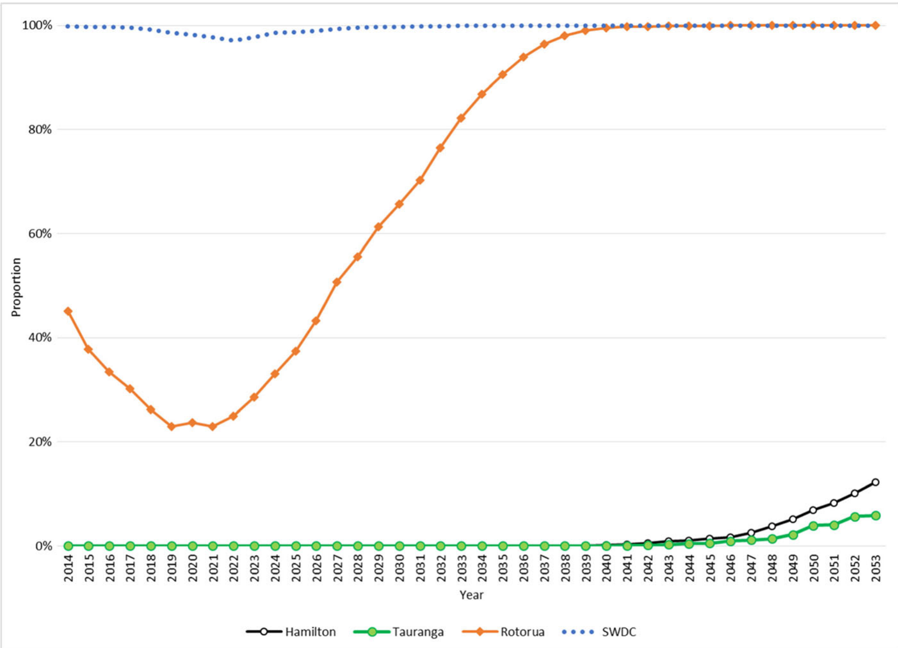

Fig. 12 Proportion of scenarios exhibiting population decline, selected TAs, 2014–2053

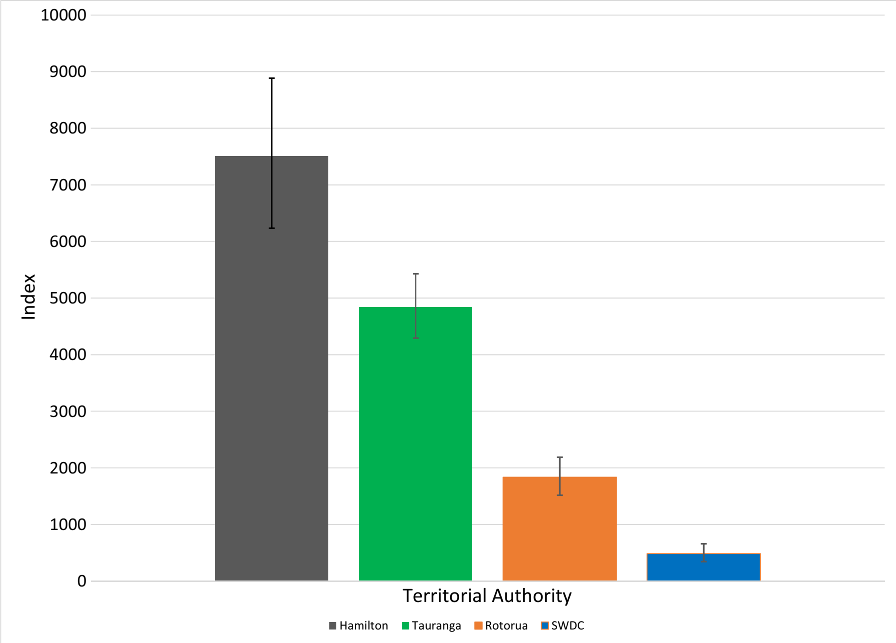

Fig. 13 Number of people aged less than 65 years needed to reduce the proportion of the population aged 65+ years in 2053 by one percentage point, selected TAs

This analysis has also highlighted an issue that few are yet engaging with: the slowing of growth in numbers and proportions aged 65–74 years followed by widespread decline at these ages across the period 2033–2043, as the youngest/largest baby

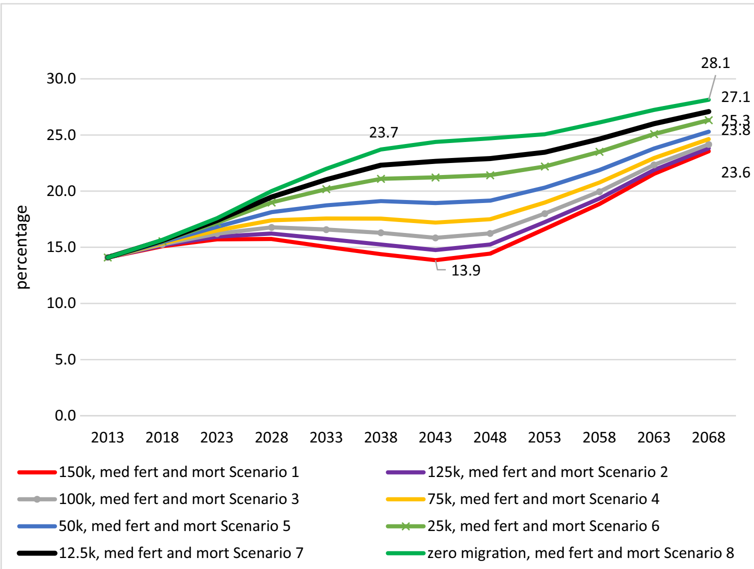

Fig. 14 Projected percentage of the New Zealand population aged 65+ years under different migration scenarios (with medium fertility and life expectancy assumptions)

boomer cohorts move out of the 'younger-old' age groups and into the oldest age groups. It is this compositional change in the older population that will see deaths and—assuming continued low fertility—natural decrease, escalate across the final years of the projection period. To some extent this shift provides the analysis with a high degree of confidence, at least conceptually.

This finding is reinforced by the stochastic projections, which demonstrate the relative certainty of both the ageing of the population and population decline in rural and peripheral areas. Our case studies also show an increasing likelihood of population decline even in areas that are younger and currently growing, albeit not for thirty or more years.

International migration is not a panacea—the amount of migration required to offset population ageing at national level 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 New Zealand's numerically dominant migrant 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 accept that an ageing population is a reality for New Zealand and that widespread subnational depopulation is a very real future, with important short, medium and long-term implications for planning and policy—for both declining and growing areas. The realities of depopulation will be particularly felt by local governments, who are the legally appointed stewards of TAs, and who rely heavily on locally-generated rate revenue to deliver community infrastructure and services. Historically, most have planned for growth, and have been able to spread the costs over future generations. This will no longer be possible for TAs that have relatively few people of working age and many at old age. It will also become increasingly difficult to raise those rates, even in growing areas, when large proportions of local populations are retired and on fixed incomes—an indisputable point on which central government must urgently support local government efforts (Local Government New Zealand 2015). An upward shift in the proportion of the older population to the oldest-old ages from 2030 will further exacerbate these difficulties. As advised in the seminal United Nations Replacement Migration study (2000):4), now almost two decades old, 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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