Local area population forecast error: what can we do about it?

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Definitions

Jump-off year: the year from which the projections 'jump off' into the demographic future. It is sometimes also known as the launch year.

Population estimate: the population for a past point in time based on information available for that time.

Population projection: a calculation of population beyond the jump-off year based on selected assumptions about the future drivers of population change (commonly, fertility, mortality and migration).

Population forecast: a population projection regarded as the most likely outcome; a prediction.

Many producers of projections/forecasts emphasise that their numbers are NOT forecasts, just projections.

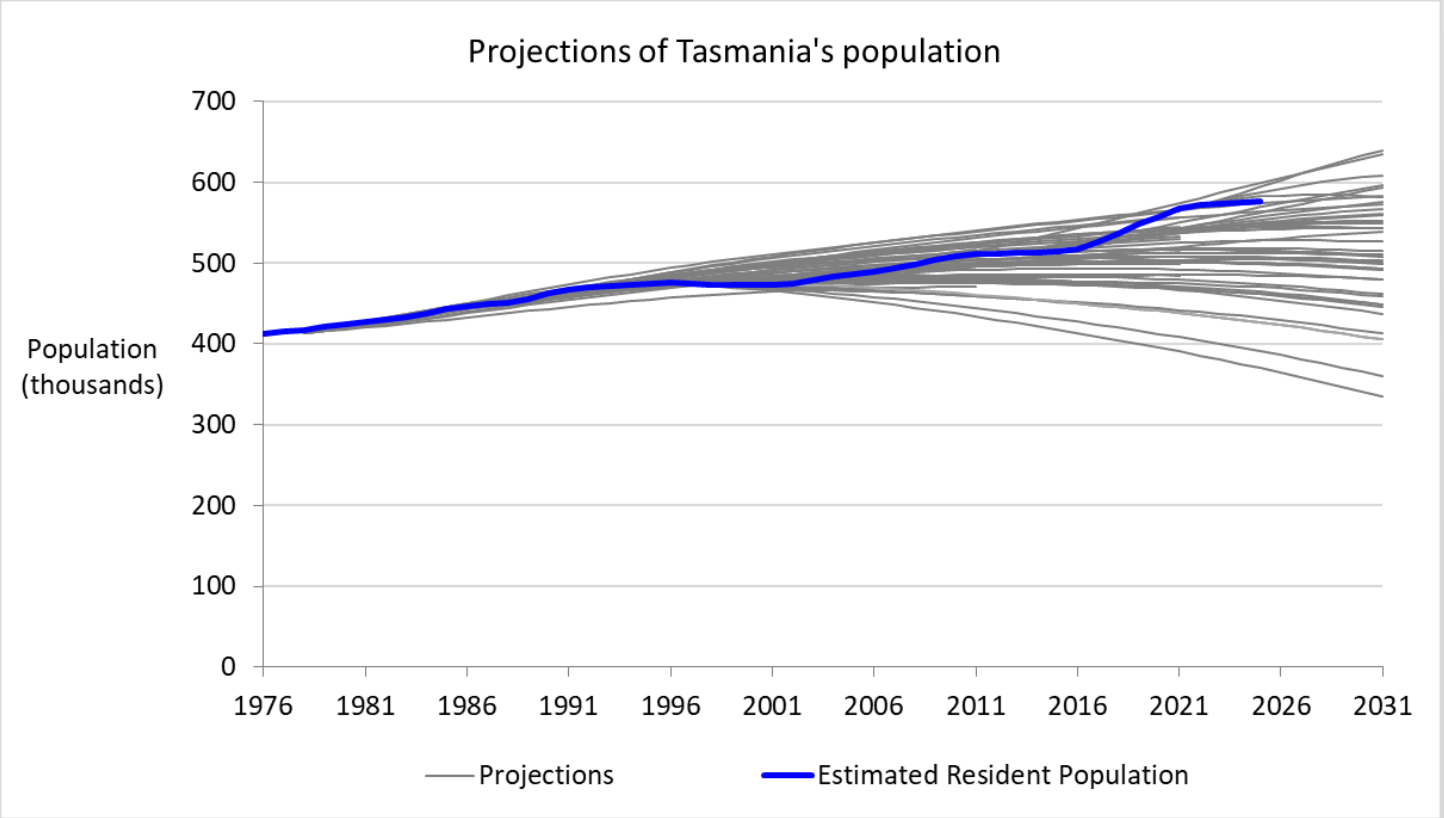
My view:

- This is a form of legal disclaimer.
- If a "projection" looks and feels like a forecast, it is effectively a forecast.

Population forecast error

All population forecasts will turn out to be wrong to some extent.

Example 1: ABS population projections for Tasmania from 1978 to 2022

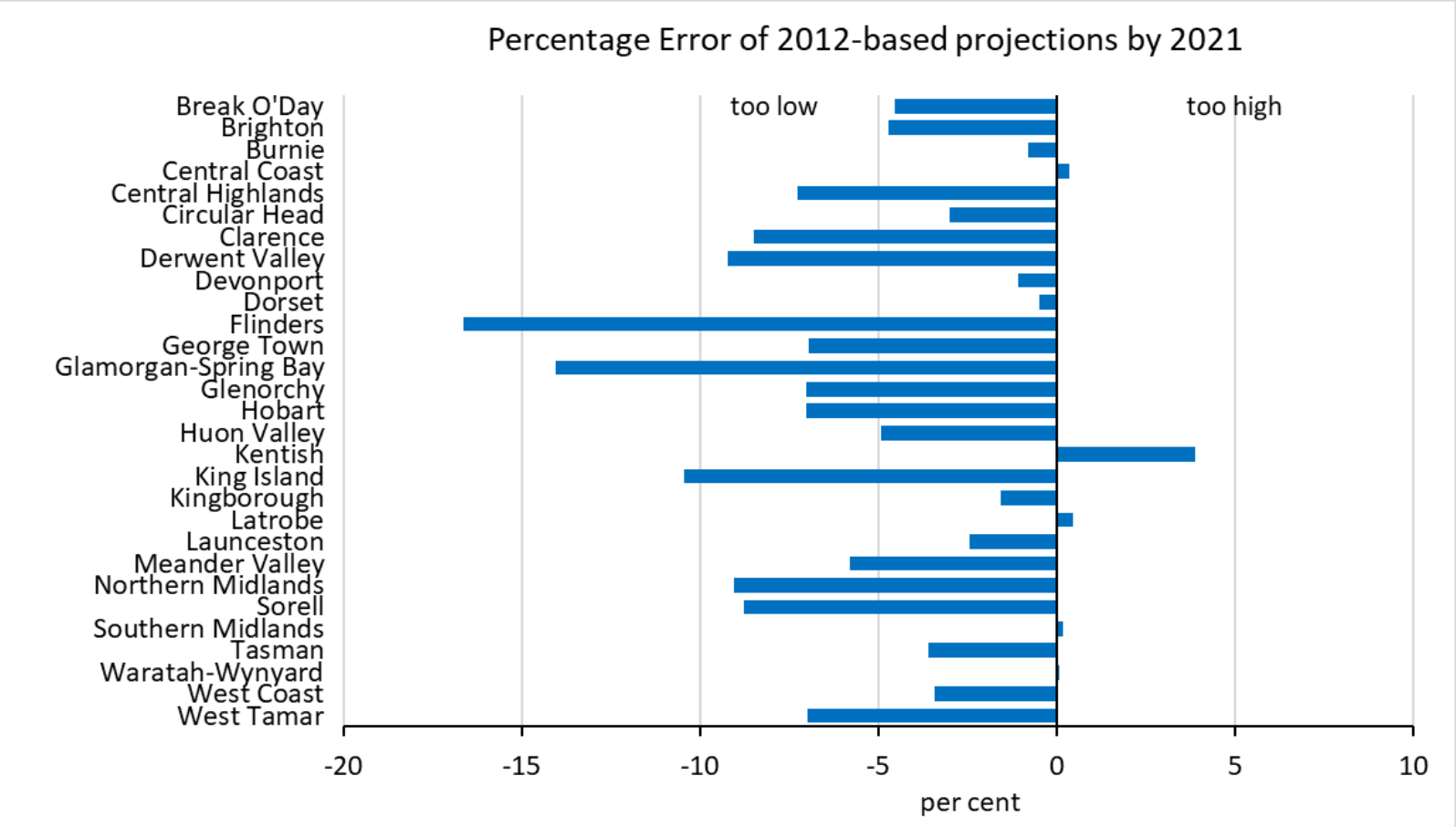


Source: ABS ERPs and population projections

Population forecast error

Example 2: Tasmanian LGA population forecasts

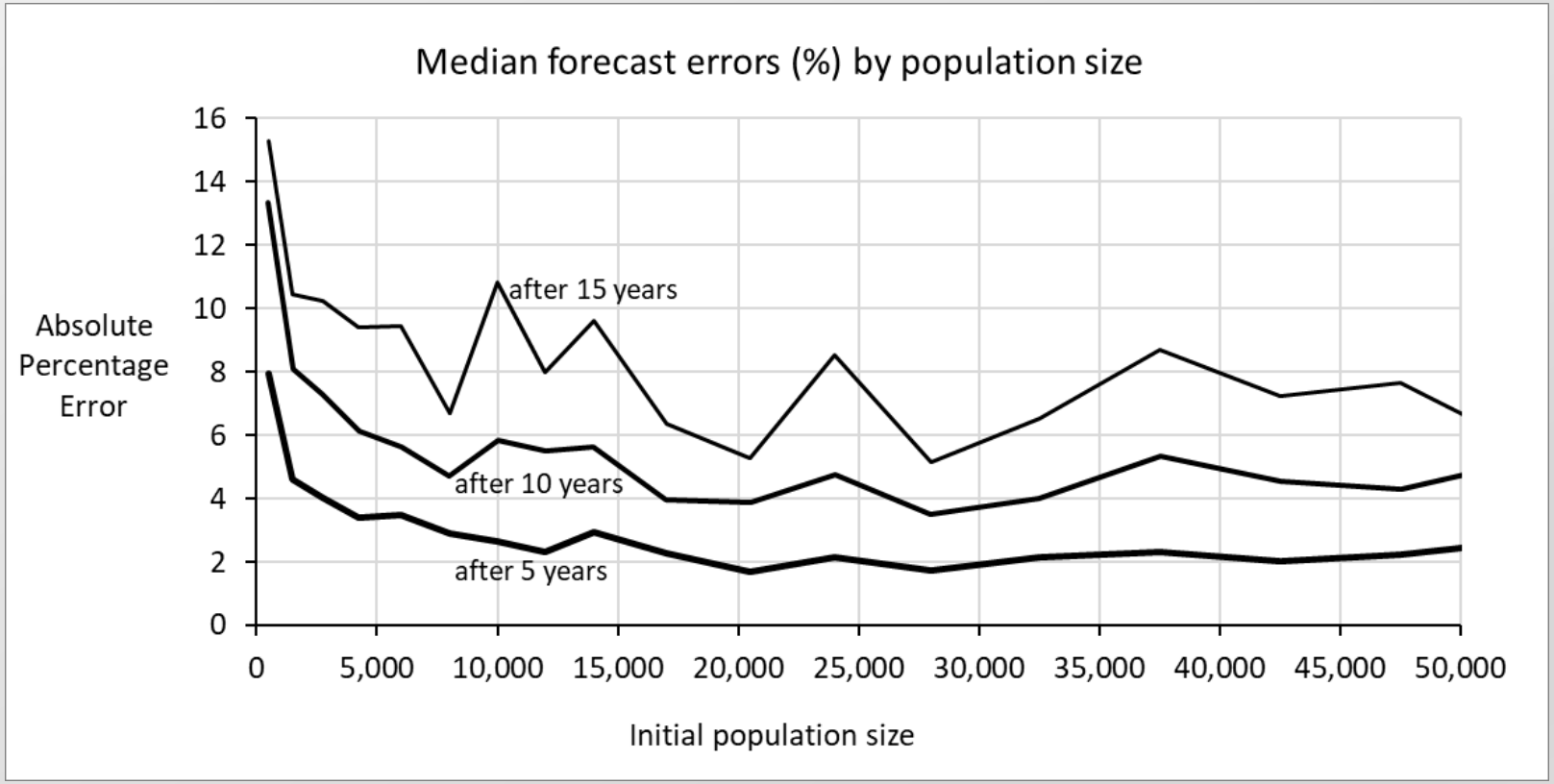
Evaluation of 2012-based LGA projections (medium series)



Source: Tasmanian Government population projections

Population forecast error

A study of several thousand past local area population forecast errors produced over a 30 year period revealed these error patterns:



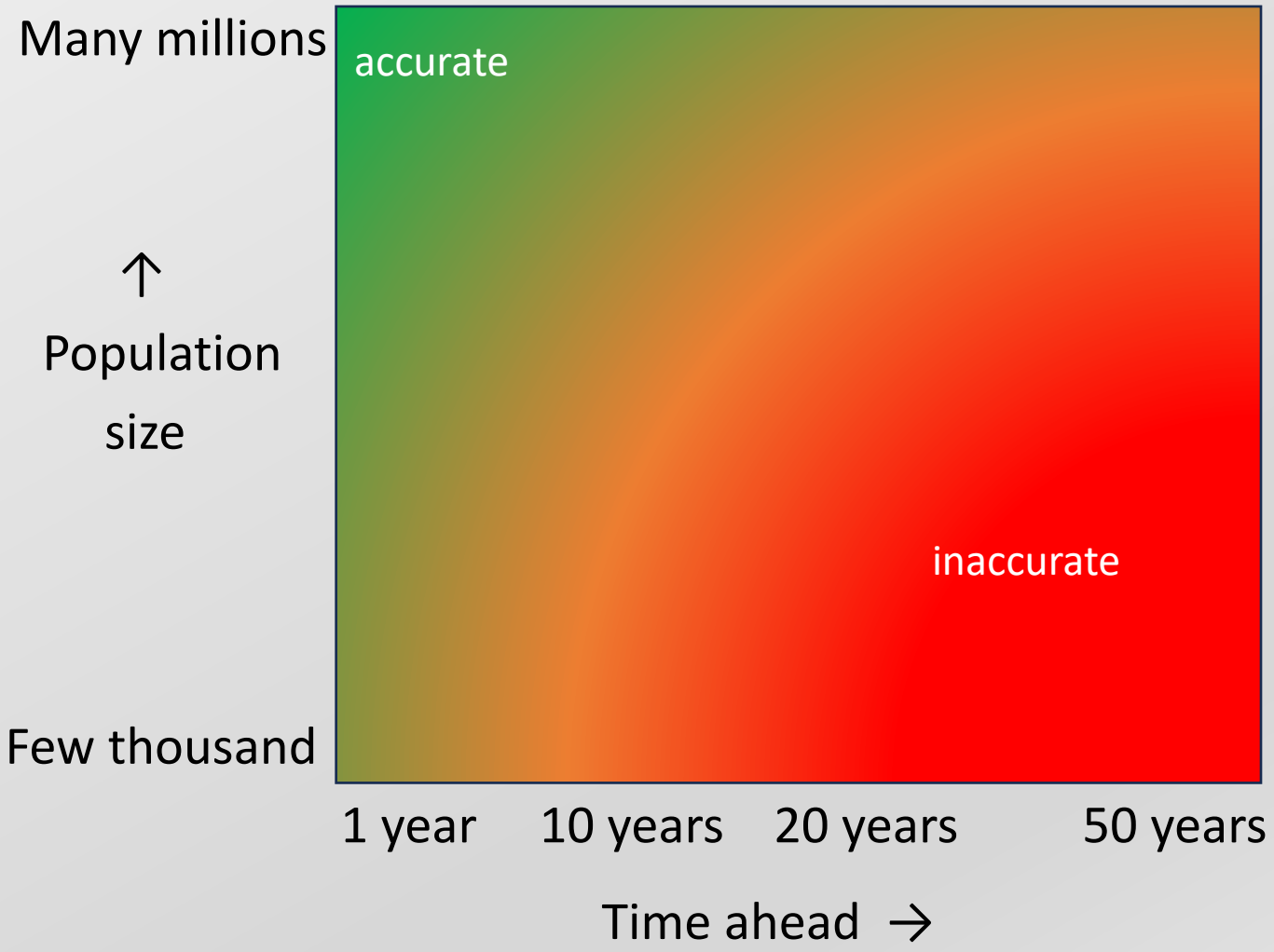
Source: Wilson et al. 2018

Population forecast error

As a general rule, population forecasts are more accurate for:

- short periods ahead
- large populations

Error is generally greater than many people expect.



What do we do about forecast error?

Surely the answer is: develop better models to produce more accurate local forecasts.

Small amount of research in this field and it has improved models to some extent.

But significant forecast errors remain, especially for small populations.

Causes of error include:

- Forecasting models
- Imperfect demographic data
- Noisy data in small populations
- Factors affecting migration, fertility, and mortality are not fully understood
- Many factors are between hard-to-predict and unpredictable (preferences relating to partnership and children; recession; pandemics; migration policy; housing market, etc.)

Scope for reducing forecast error further is probably limited.

What do we do about forecast error?

Late Professor Nathan Keyfitz's advice to demographers:

> "Demographers can no more be held responsible for inaccuracy in forecasting population 20 years ahead than geologists, meteorologists, or economists when they fail to announce earthquakes, cold winters, or depressions 20 years ahead. What we can be held responsible for is warning one another and our public what the error of our estimates is likely to be."

(Keyfitz, 1981)

What are our options?

❶ Provide summary information about past errors. But they don't convey the extent of uncertainty in current forecasts.

Table 13. DIFFERENCE (%) BETWEEN POPULATION PROJECTIONS AND OUTCOMES, AUSTRALIA, 30 JUNE

Projection	2015	2016	2017	2018	2019	2020	2021	2022	2023
Intergenerational Report, 2015	0.4	0.5	0.6	0.8	0.9	1.2	2.7	2.9	2.0
ABS projection series medium series (2017 base)	-	-	-	0.2	0.4	0.9	2.4	2.7	1.9
2019–20 MYEFO	-	-	-	-	0.2	0.6	2.2	2.6	1.8
Population Statement 2020	-	-	-	-	-	0.0	0.1	-0.8	-2.3
Intergenerational Report, 2021	-	-	-	-	-	-	0.2	-0.9	-2.5
Population Statement 2021	-	-	-	-	-	-	0.2	-0.8	-2.0
Population Statement 2022	-	-	-	-	-	-	-	-0.2	-1.3
Intergenerational Report, 2023	-	-	-	-	-	-	-	-	-0.5
ABS projection series medium series (2022 base)	-	-	-	-	-	-	-	-	-0.4
Population Statement 2023	-	-	-	-	-	-	-	-	0.0

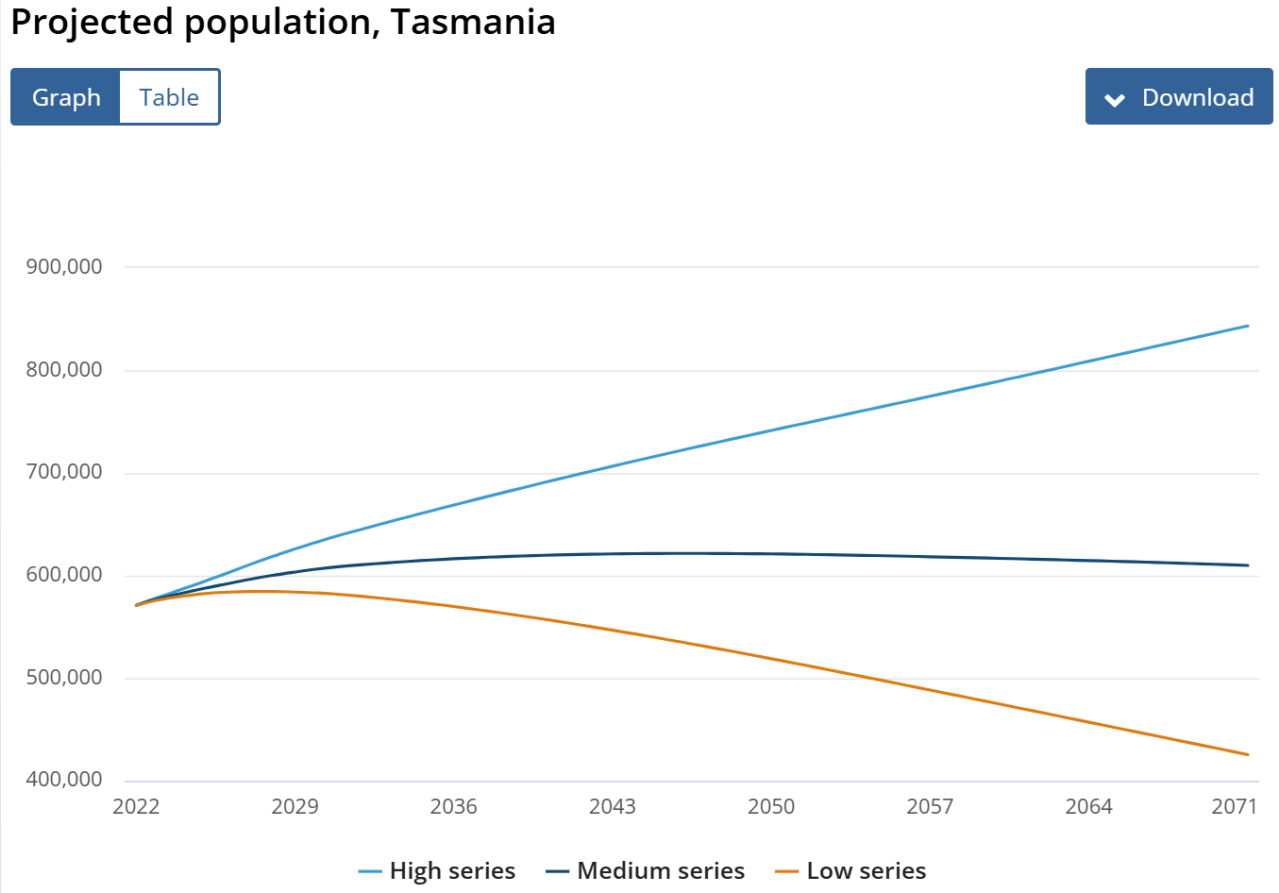
Note: Positive numbers indicate an overestimation while negative numbers indicate an underestimation.

Source: ABS, *National, state and territory population, March 2024*; ABS, *Population Projections 2017 (base) – 2066*; ABS, *Population projections, 2022 (base) – 2071*; Commonwealth of Australia, *2015, 2021, 2023 Intergenerational Report;* Commonwealth of Australia, *MYEFO 2019–20;* and Centre for Population.

Source: Centre for Population

What are our options?

❷ Use high and low series projections. Might seem reasonable, but unfortunately, these are highly unreliable measures of uncertainty.



Low series, 2025
582,400

ERP, 2025
575,960

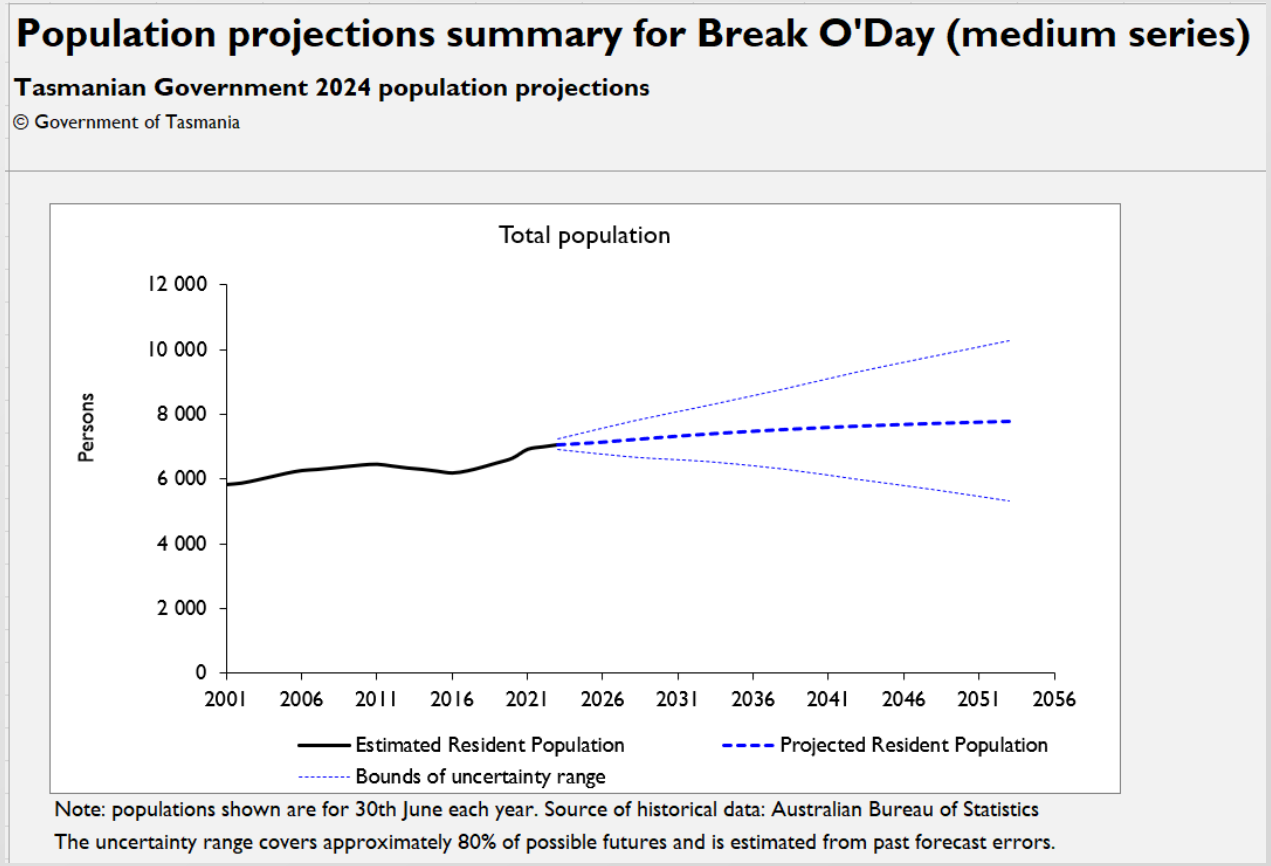
Source: ABS population projections

What is wrong with high-low series?

- High and low series are usually created by adjusting the projection assumptions from the main forecast by arbitrary amounts, such as 10%. It is almost impossible to judge how likely these series are, or even what they actually mean.
- The series often involve higher and lower fertility and migration assumptions, but not always variations in mortality. Whenever this is the case, future numbers of deaths, and the forecast size of the elderly population, don't vary much between series.
- High and low series for internal migration are problematic because net internal migration must sum across areas to 0. If some areas have higher net internal migration than the main forecast, then other areas must have lower net internal migration.
- When compared to real forecast errors, the high-low range varies hugely over time and between variables in how much of the error distribution it covers. e.g. it might cover 30% of the error distribution 5 years out, but 90% 30 years out.

What are our options?

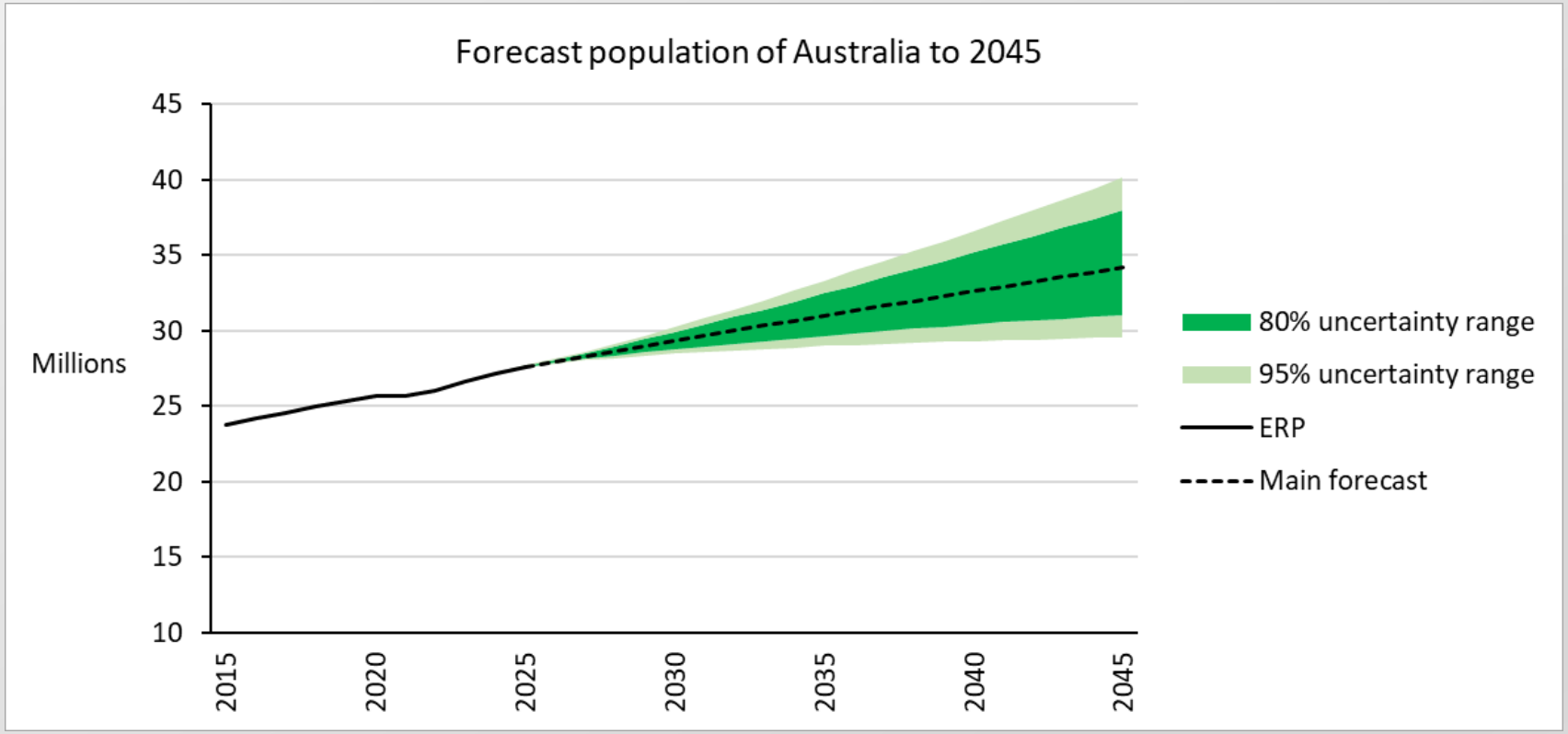
❸ Add empirical prediction intervals to population forecasts. These are based on errors calculated from the errors of many past forecasts of total population



Source: Tasmanian Government population projections

What are our options?

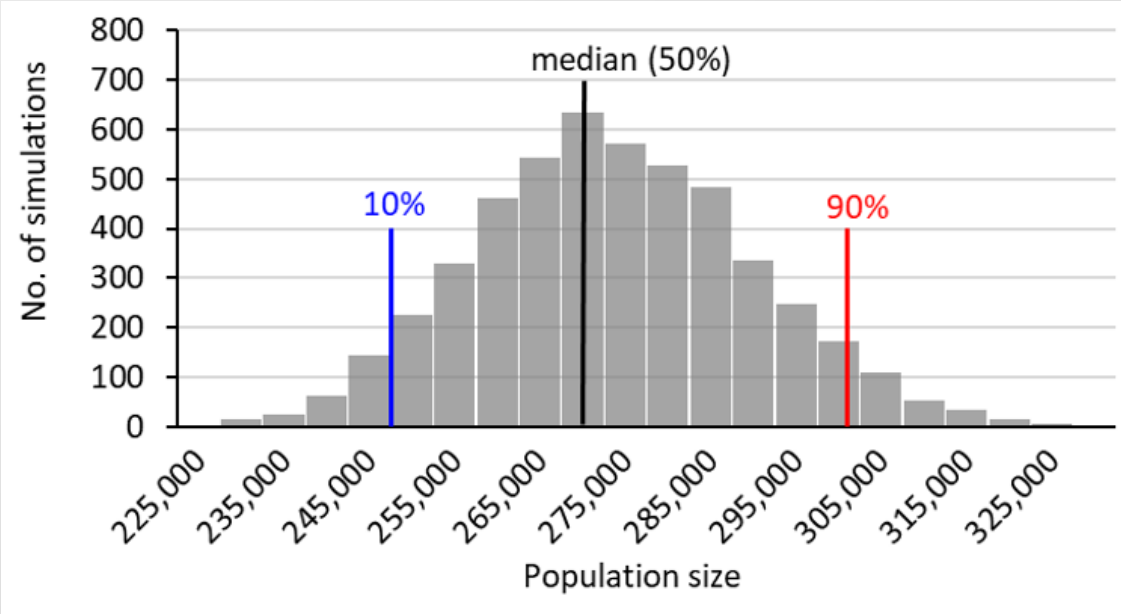
❹ Create probabilistic population forecasts. Provide the most detailed information about uncertainty, and regarded as the best option in the academic literature.



What is a probabilistic population forecast?

A **probabilistic population forecast** consists of a distribution of possible future populations. It is created from thousands of forecasts with randomly varying fertility, mortality and migration rates. The resulting population forecasts are then sorted in size order to give a distribution of possible future populations.

Example forecast distribution for a year in the future:



Why are probabilistic forecasts useful?

Probabilistic forecasts

- emphasise that population forecasts are likely to have errors.
- provide estimates of the extent of forecast uncertainty.
- include models which mimic the actual errors in fertility, mortality and migration forecasts, and therefore produce realistic uncertainty distributions for population forecasts by age and sex.
- provide users with information about uncertainty which they can factor into decision-making.

How do users apply probabilistic forecasts?

In using probabilistic forecasts, it is recommended that users first take the principal (middle) forecast and apply this in analysis, discussions, and modelling, etc.

Then apply populations at 10% and 90% of the population distribution to see if decisions would change. This covers the middle 80% of possible population futures.

If you think decisions might change, then:

- maybe delay the decision; or
- make a decision which relates to the less uncertain period over the immediate future; or
- make a decision that allows flexibility to respond to a range of population sizes later on.

The SAPPFORM model

Most applications of probabilistic forecasts in the academic literature are:

- for national populations only
- created only as probabilistic forecasts (not via regular forecasts)
- very complicated and data-hungry.

SAPPFORM (Spatially Adaptable Probabilistic Population Forecasting Model) is a new probabilistic forecasting model. It:

- takes an existing cohort-component forecast and ‘adds on’ the uncertainty
- can be applied to a wide variety of population sizes (minimum about 5,000 people)
- consists of a single year of age cohort-component model with fertility, mortality, inward migration, and outward migration
- is much less data-hungry than existing probabilistic models.

Probabilistic summary indicators

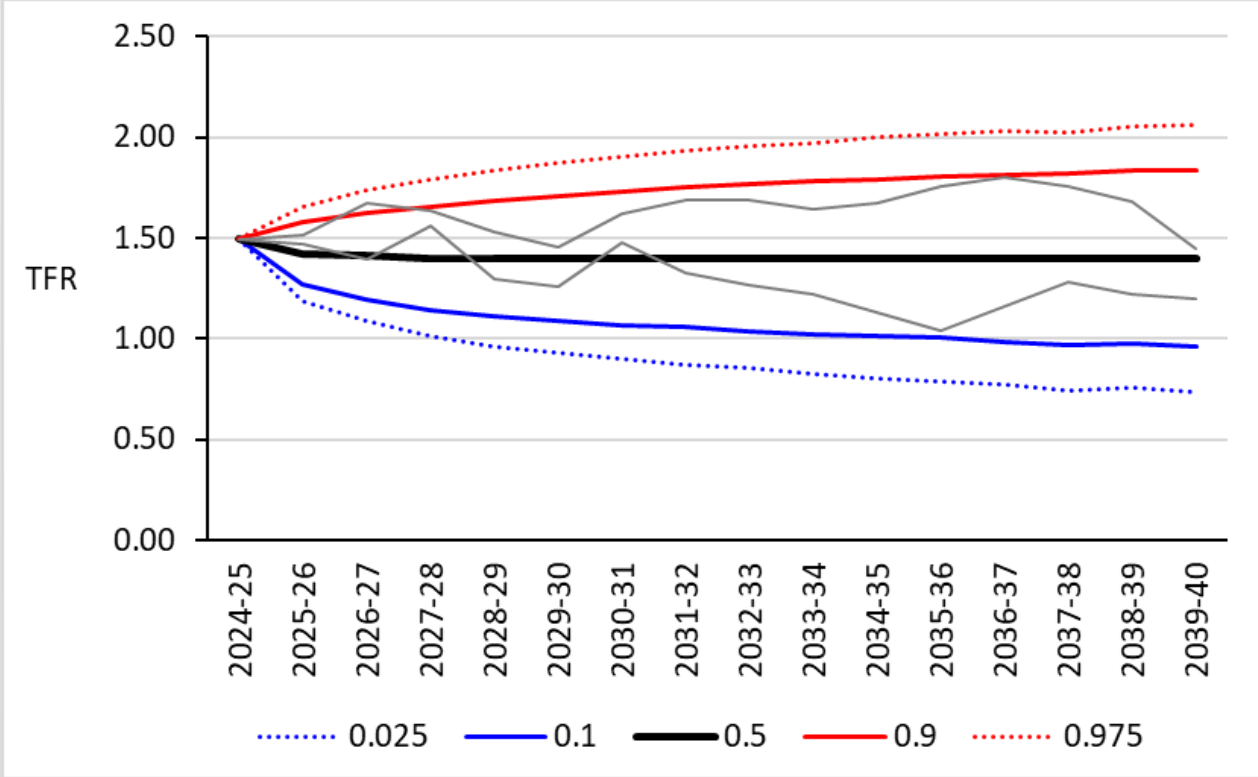
In SAPPFORM, probabilistic forecasts are created via summary indicators:

- total fertility rate (TFR);
- life expectancy at birth (e_0);
- summary migration rates

Forecast with time series models

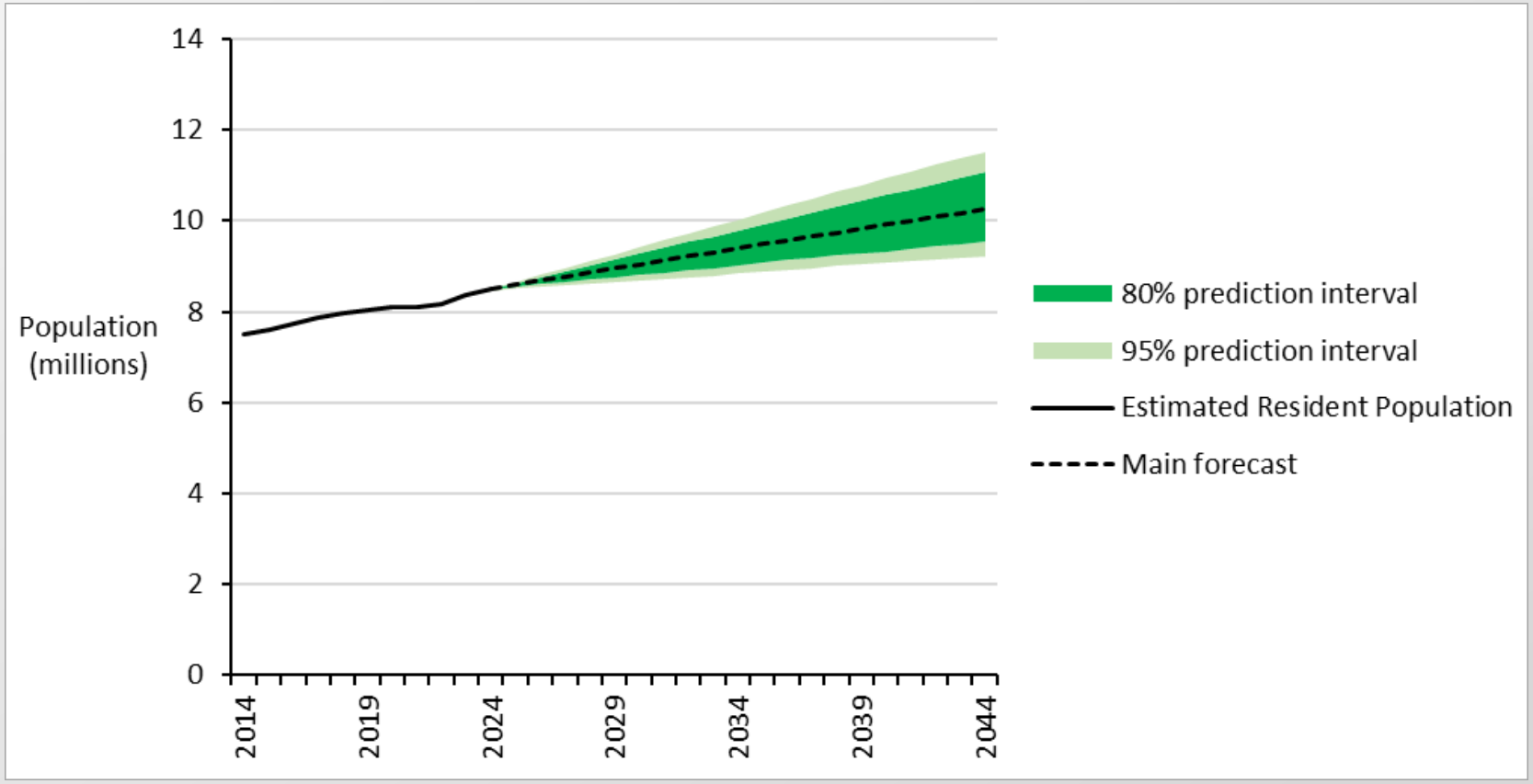
Coloured lines are prediction intervals (uncertainty ranges)

Grey lines are example simulations



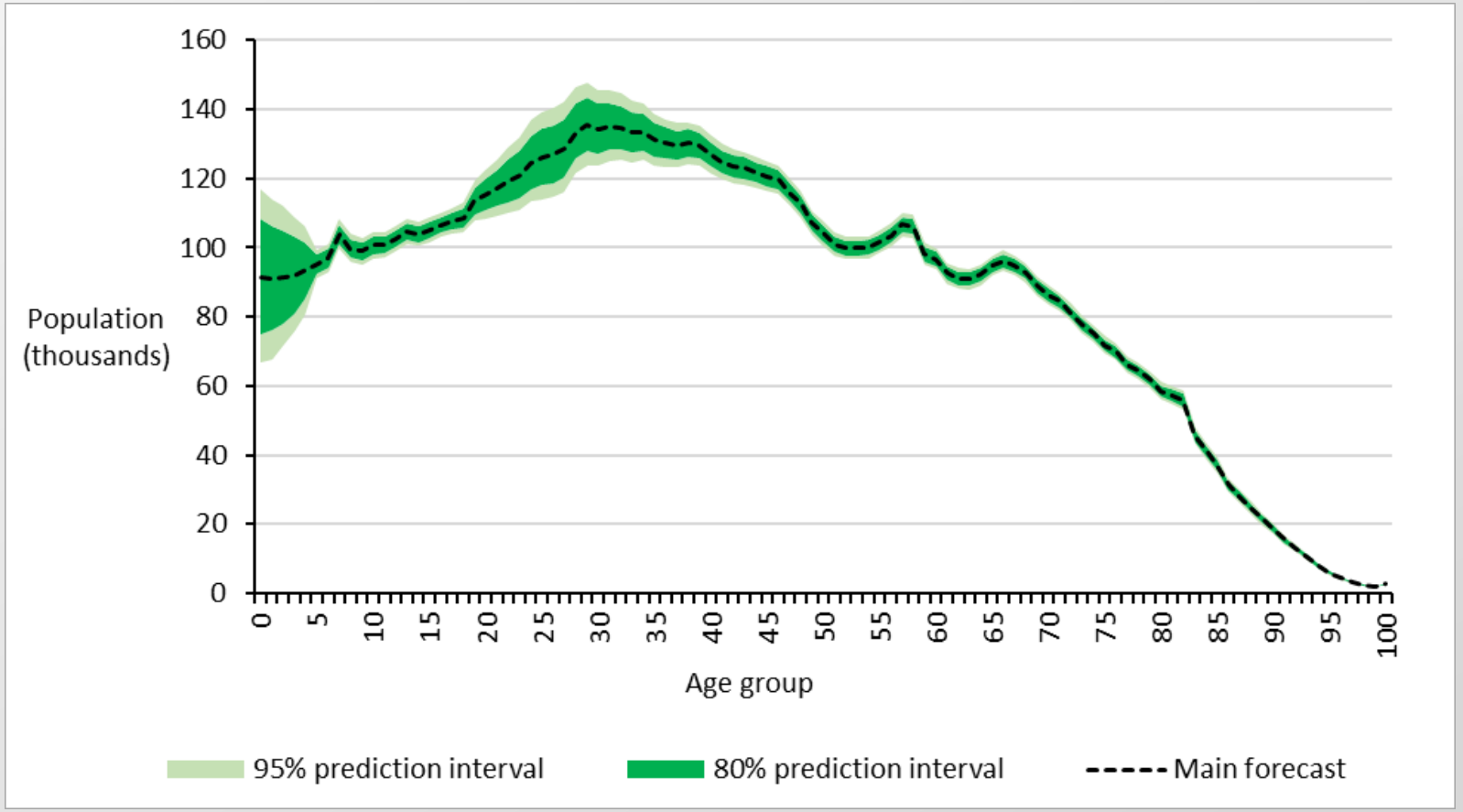
Example 1: NSW

Total population of NSW



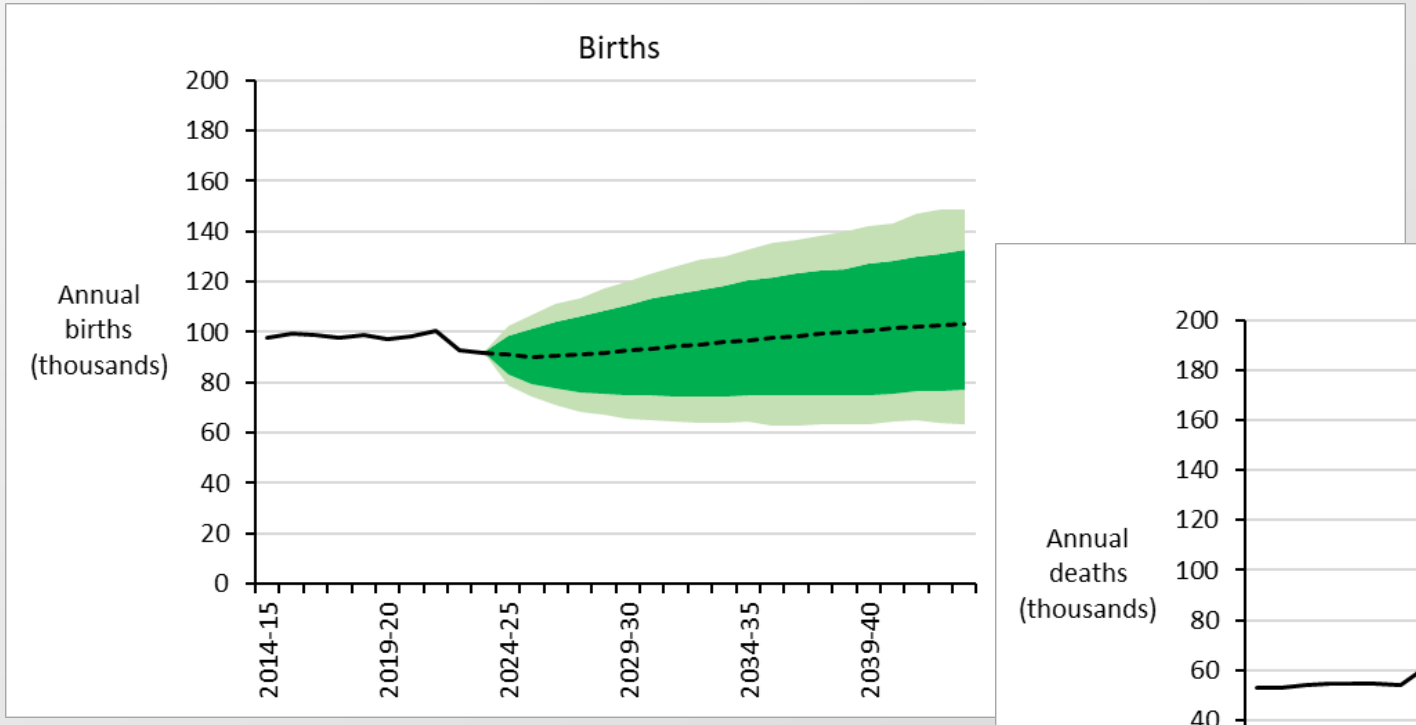
Example 1: NSW

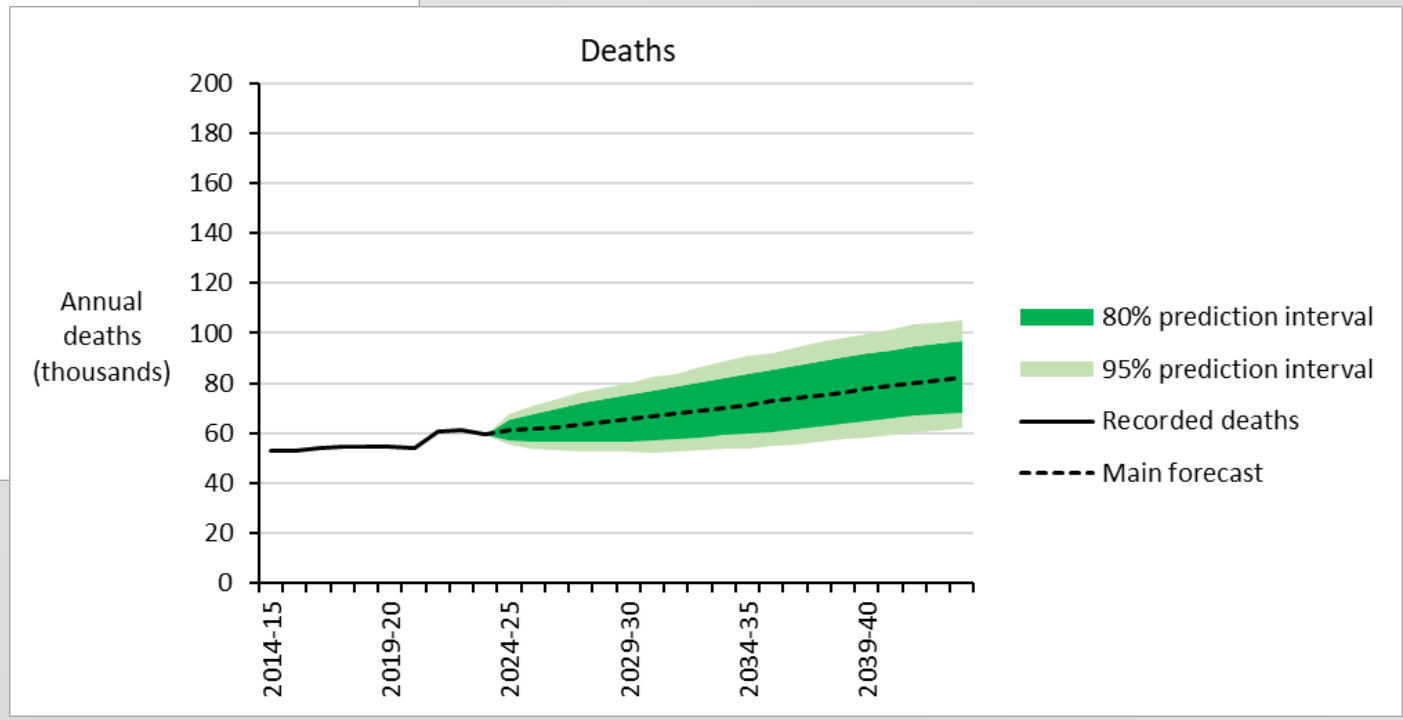
Population by age 5 years into the forecasts



Example 1: NSW

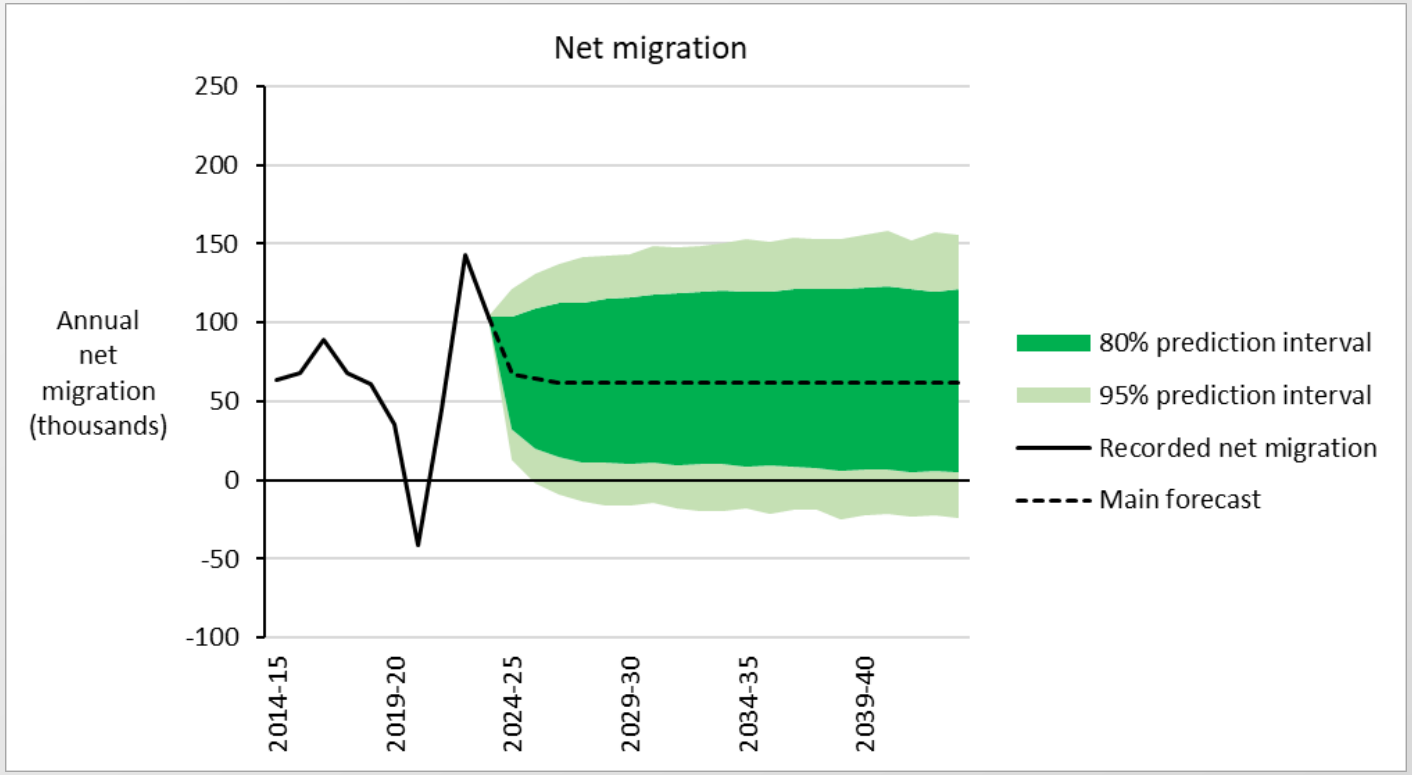
Births and deaths





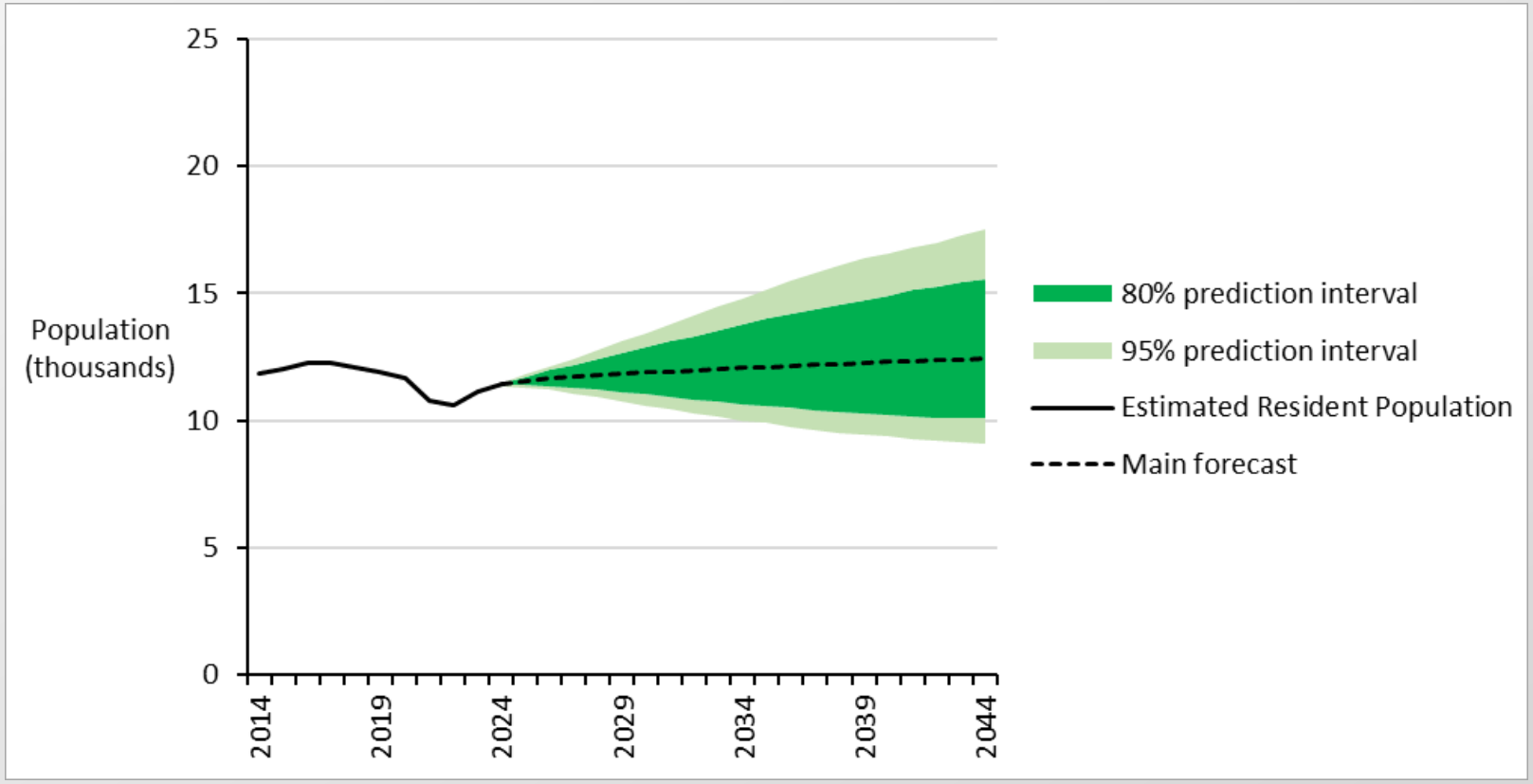
Example 1: NSW

Net migration



Example 2: Darlinghurst SA2

Total population of Darlinghurst SA2



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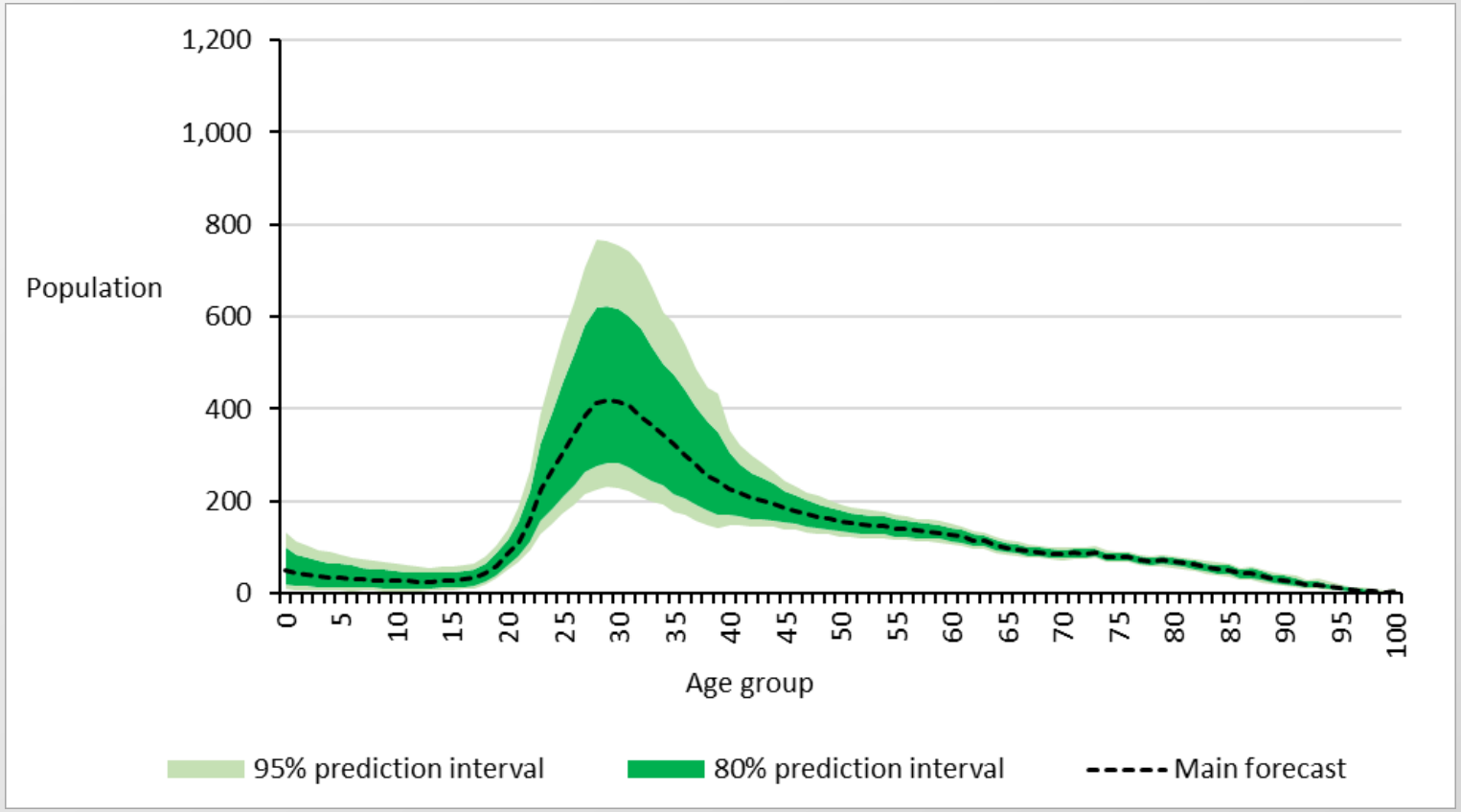

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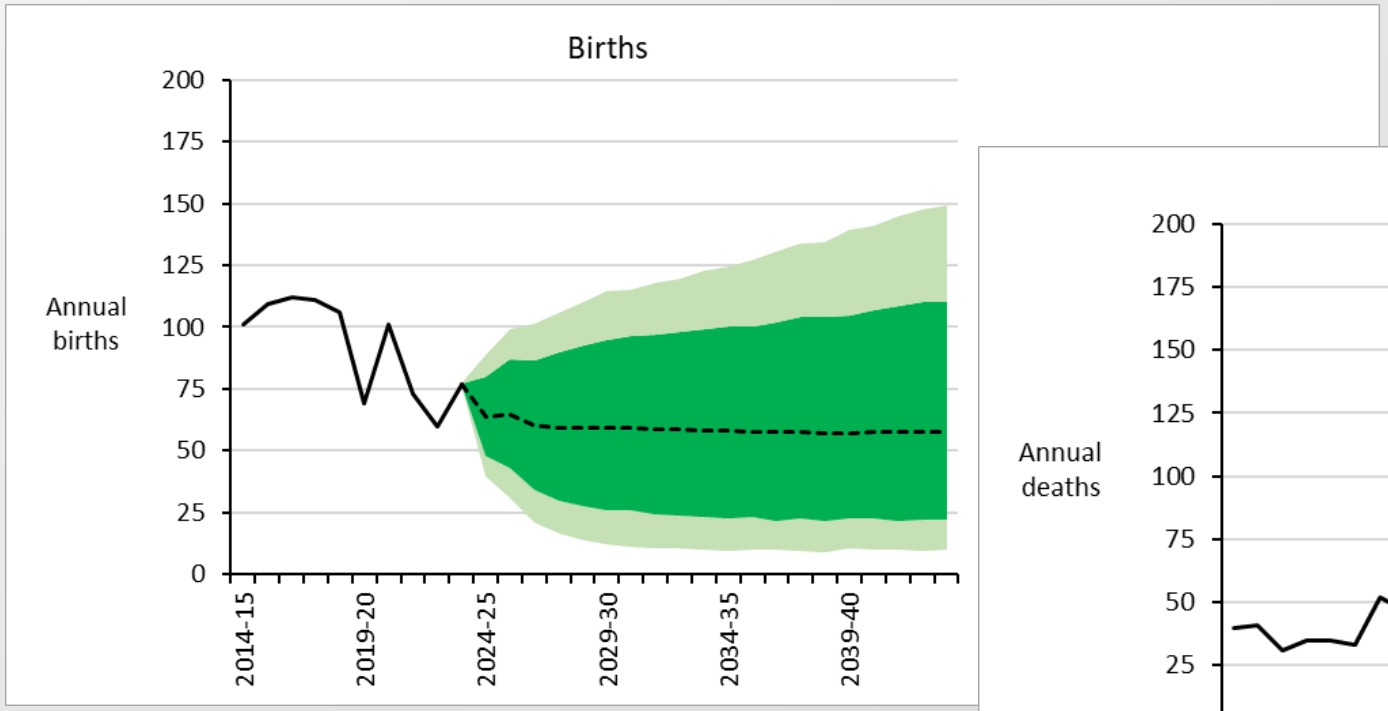
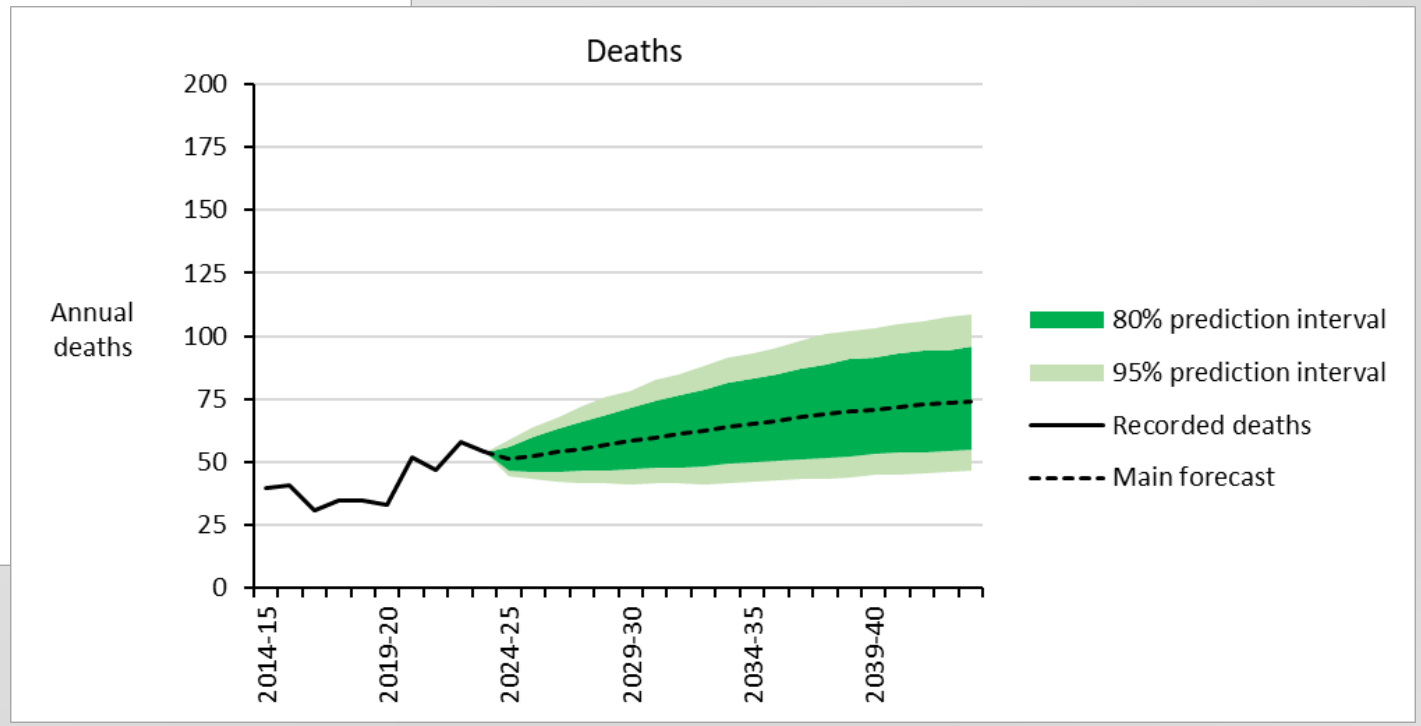
Births and deaths





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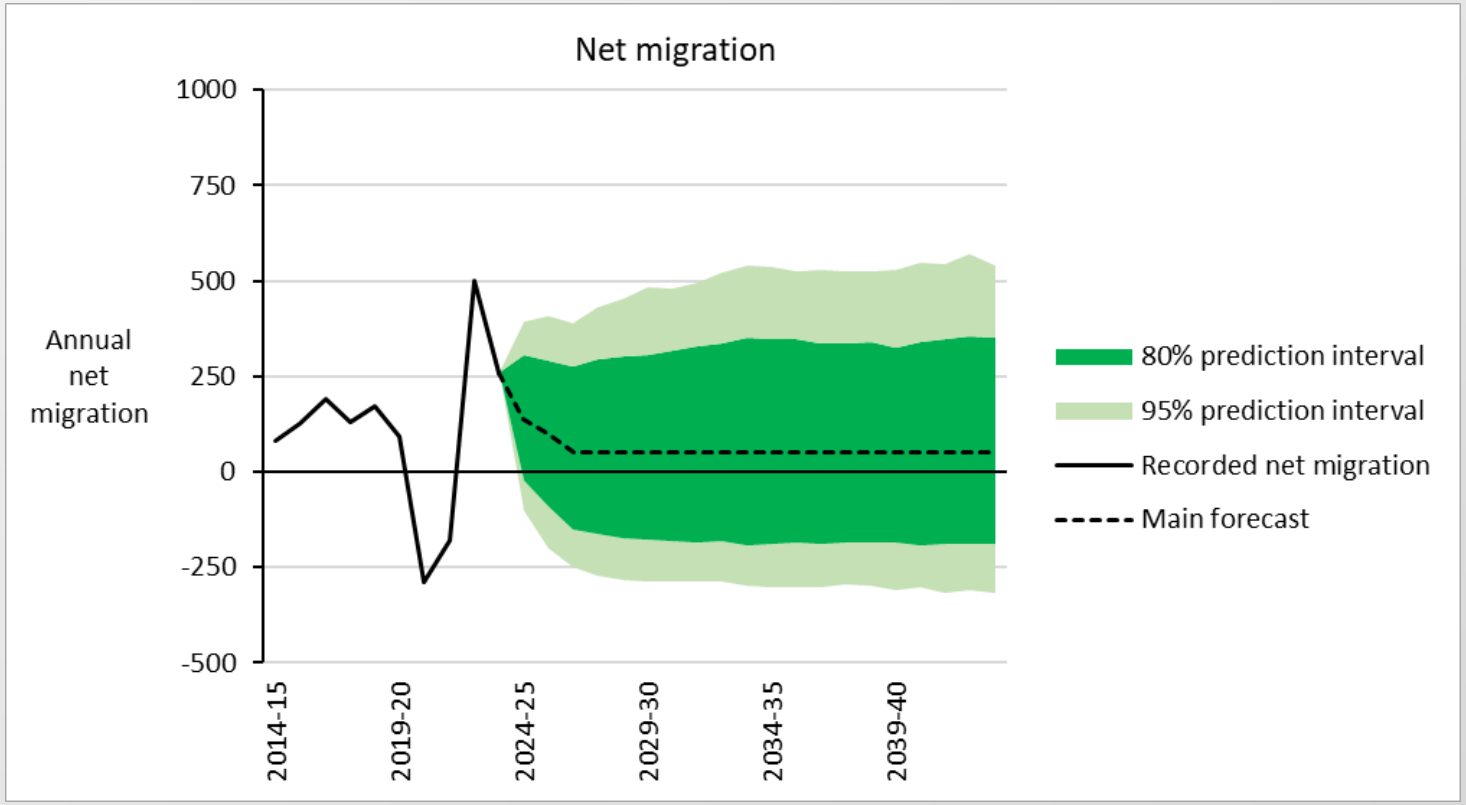
Net migration



Final remarks

All population forecasts are subject to error.

The smaller the population, and the further out it extends into the future, the larger the possible error.

So is it worth producing population forecasts for small areas? Yes, but they are best presented with uncertainty ranges (preferably created by a probabilistic model).

Avoid the range between high and low projection series as a measure of uncertainty!

Demographic forecasters and users need to work together to ensure that probabilistic forecasts can be used effectively in planning and decision-making.

For very small populations, a five-year age group probabilistic model could be created.

Questions

Any questions or comments?

More information

Information about probabilistic forecasts

Probabilistic population forecasts for Australia
https://drtomwilson.com/forecasts

FAQ about probabilistic forecasts
https://drtomwilson.com/forecasts#faq

Recommended academic papers

Keilman, N (2018) Probabilistic demographic forecasts. *Vienna Yearbook of Population Research* 2018 pp. 25-25.

Bijak, J. et al. (2015) Probabilistic population forecasts for informed decision making. *Journal of Official Statistics* 31(4) pp. 537-544.

Brief bio.

https://drtomwilson.com/about

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