

# Annex C: Modelling Great Britain demographic change



## C.1 SUMMARY

The ONS produce national populations projections up to 2083 and regional ('sub-national') projections to 2033. The aim of the first phase of this analysis is to follow the methodology employed by ONS and extend regional population projections to 2083.

## C.2 PROCESS OVERVIEW

The population projections follow, as far as possible, the methodology employed by the ONS in the generation of their national and sub-national projections. In general, the process is as follows:

### 1. Initialise the population.

Each projected year is based on trends from the previous 5 years so to start the projection 5-years' worth of data are required. Here, the projection begins from the year 2009, so the years 2004 – 2008 are required as initial data.

### 2. Age the population.

Before starting a new projection the population must be aged. The ONS national projections use single-year age groups up to age 89 and then use three groups to represent people aged 90–94, 95–99 and 100+. Therefore in these latter age groups only one fifth of the population will advance to the next group<sup>1</sup> (and none will advance from the final group). After initial aging there are no people in the 0–1 age group.

### 3. Fertility.

The number of births for a given region is calculated by multiplying the age-specific fertility rates (for all women aged 15–46 inclusive<sup>2</sup>) by the number of women in that age group. Because sub-national fertility data are not available, the total number of births is constrained to sub-national birth projections before being added to the population.

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1 By this we assume that the population is evenly distributed within the age cohorts 90–94 and 95–99. Typically a small degree of tapering might be more likely, in which case a very slight error is introduced to the model.

2 Any births to mothers aged 47 or over are redistributed under this assumption, which could introduce a bias of insignificant magnitude to the model.

#### 4. Mortality.

Mortality is calculated in much the same way as fertility: an age- and gender-specific mortality rate is calculated for each age group and this is multiplied by the number of people in that age group to calculate the number of deaths. As with fertility, sub-national mortality data are not available so the number of deaths is constrained to sub-national components of change totals.

#### 5. Migration.

Migration is the most complicated of the processes in the ONS projections and much of the data required to estimate migration is not available. Hence, migration in the projections below is estimated by calculating the difference in the size of the projected population (by age group) for a given region compared to the expected ONS regional projection. This residual can assumed to be the result of migration.

#### 6. Constraints.

Once the population in each region has been projected by one year, the entire population is constrained to the national population totals for the given year. Note that after 2033 this constraining no longer takes place because the ONS have only released a limited number of years of projection data. However, trends in births, deaths and migration will have been established by 2033 and the projection is able to continue these trends in the absence of constraining national data.

Description	Component	Filename(s)	ONS Source
<b>National-level data</b>			
National components of change – male/female	None. Used for comparing projected components of change to ONS expectations. (For information, does not affect projection.)	components_of_change_f.csv components_of_change_f.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08cc.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08cc.xls</a>
National population projections – male/female	Constraining. Used to constrain sub-national projections to national totals. Three different projections are required to constrain to different scenarios ('baseline', 'high', and 'low').	females_baseline.csv females_high.csv females_low.csv males_baseline.csv males_high.csv males_low.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08singyear.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08singyear.xls</a>  <a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wHfHleHmiUK08singyear.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wHfHleHmiUK08singyear.xls</a>  <a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wLflleLmiUK08singyear.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wLflleLmiUK08singyear.xls</a>

National fertility rates	Fertility. Used to calculate number of births per female age group.	fert_rate.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08asfr.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08asfr.xls</a>
National mortality rates – male/female	Mortality. Used to calculate deaths per age group.	mort_males.csv mort_females.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08mort.xls">http://www.statistics.gov.uk/downloads/theme_population/NPP2008/wUK08mort.xls</a>
<b>Sub-national data* †</b>			
Sub-national components of change – male / female	Fertility and mortality. For constraining number of births/deaths) in each area.	subnat_components_of_change_m.csv subnat_components_of_change_f.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/SNPP-2008/Table5.zip">http://www.statistics.gov.uk/downloads/theme_population/SNPP-2008/Table5.zip</a>
Sub-national population projections – male / female	Migration. For calculating projected/expected residuals).	subnational_projection-male.csv subnational_projection-female.csv	<a href="http://www.statistics.gov.uk/downloads/theme_population/SNPP-2008/Table2d.zip">http://www.statistics.gov.uk/downloads/theme_population/SNPP-2008/Table2d.zip</a>
<p>* The sub-national ONS data described here just cover regions in England. Hence the data for Scotland, Northern Ireland and Wales were extracted from the national projections and appended to the sub-national input files so that they are treated in the same manner as English regions. This is necessary because otherwise the sum of the sub-national projections would not match the expected national ONS UK projection data.</p> <p>† The model uses sub-national data at the district level. These are aggregated to government office regions for convenience at the end of the projection.</p>			

### C.3 REQUIRED DATA

The following table summarises the data that are required to run the projections. Filenames correspond to files that are available to download (at time of writing) along with the program source code.

### C.4 COMPONENTS

This section will outline the implementation of each projection component in more detail.

#### Fertility

The fertility component uses the concept of an age-specific fertility rate (ASFR) which is calculated, for each fertile age group (women aged 15 – 46 inclusive), by dividing the number of births to women of that age group by the number of women in the age group. This can be read directly from the ONS national fertility data. To model regional variation, the ONS sub-national projections also calculate a fertility differential by dividing the sum of 5 years historical sub-national ASFRs with the sum of the national equivalent ASFRs. This differential is used to calculate the current local ASFR. For the projections described here, however, there are no sub-national ASFR data available and so the national ASFR figure is used for all regions (and no differential requires calculation).

To limit the errors that will arise from the lack of sub-national ASFR data, once the number of births has been calculated the ONS sub-national components of change data are used to scale the total number of births, so that they match those expected in the sub-national projections. This birth scaling factor is also stored so that a trend can be calculated later. After 2033, when there is no ONS sub-national projection data, a linear regression is used to find the trend in the birth scaling factors and this estimated scaling factor is used to constrain the number of births post 2033.

### Mortality

Mortality works in the same manner as fertility by calculating a local age-specific mortality rate (ASMR) and an associated mortality differential in order to estimate the current local ASMR. As no sub-national mortality data are available, the projections below simply use the national ASMR for the projected year. Sub-national mortality is also scaled in the same manner as fertility, the exception being that there are separate scaling factors for male and female mortality.

### Migration

Due to unavailable data, calculating migration is not possible at this stage. However, having constrained the number of births and deaths for each region, it follows that the residual difference between the projection here and the ONS sub-national projection is a result of net migration. Therefore this residual is assumed to represent migration and is added to the sub-national population for the year being projected.

As with the fertility and mortality scaling factors, net migration totals are stored for each age group in each projected year. After 2033 (when there are no sub-national projection data) linear regression is used to find a trend in male and female migration totals, and these trends are used to estimate migration post 2033.

## C.5 SCENARIOS

The projections discussed here have been used to execute three different scenarios. The changes reflect ONS scenarios .

Scenario	Description	Fertility	Mortality	Migration
Baseline	The typical baseline projection under normal conditions. (See* page 24)	-	Assumes a 1% improvement rate (mortality drops by 1% per year)	-
High	High population: increased fertility and immigration, decreased mortality. (See* page 32)	Increased by 10%	2% improvement rate	Additional 33% immigration
Low	Low population: decreased fertility and immigration, increased mortality. (See* page 44)	Decreased by 10%	No improvement rate	Less 33% migration

\* Source: Office for National Statistics 2008-based National Population Projections. Available from [http://www.statistics.gov.uk/downloads/theme\\_population/NPP2008/NatPopProj2008.pdf](http://www.statistics.gov.uk/downloads/theme_population/NPP2008/NatPopProj2008.pdf)

## C.6 RESULTS

The following table and associated charts provide the results of the projections, disaggregated by government office region to 2080.

Population (millions)		2020	2030	2040	2050	2060	2070	2080
East Midlands 2008 baseline: 4.43 million	Low	4.71	4.90	4.96	4.96	4.95	4.96	4.96
	Medium	4.87	5.24	5.53	5.79	6.03	6.27	6.52
	High	5.04	5.59	6.12	6.66	7.17	7.69	8.24
West Midlands 2008 baseline: 5.41 million	Low	5.63	5.77	5.78	5.76	5.73	5.73	5.74
	Medium	5.75	6.04	6.28	6.52	6.76	7.04	7.35
	High	5.87	6.32	6.78	7.30	7.85	8.44	9.13
South West 2008 baseline: 5.21 million	Low	5.50	5.72	5.78	5.80	5.84	5.90	5.97
	Medium	5.74	6.20	6.57	6.93	7.28	7.66	8.06
	High	5.99	6.70	7.41	8.13	8.85	9.62	10.47
North East 2008 baseline: 2.57 million	Low	2.65	2.68	2.65	2.59	2.54	2.50	2.46
	Medium	2.70	2.80	2.88	2.95	3.02	3.11	3.20
	High	2.75	2.93	3.12	3.32	3.52	3.75	4.01
South East 2008 baseline: 8.37 million	Low	8.86	9.22	9.33	9.36	9.36	9.39	9.43
	Medium	9.18	9.86	10.43	10.96	11.46	11.97	12.51
	High	9.50	10.53	11.58	12.66	13.72	14.81	15.99
North West 2008 baseline: 6.87 million	Low	7.06	7.14	7.06	6.93	6.80	6.71	6.63
	Medium	7.17	7.41	7.59	7.77	7.97	8.21	8.52
	High	7.28	7.69	8.13	8.63	9.18	9.81	10.58
Yorkshire 2008 baseline: 5.22 million	Low	5.58	5.82	5.91	5.94	5.94	5.92	5.89
	Medium	5.75	6.18	6.53	6.85	7.12	7.38	7.62
	High	5.93	6.55	7.17	7.78	8.36	8.91	9.47

London 2008 baseline: 7.67 million	Low	8.34	8.76	8.96	8.99	8.86	8.66	8.47
	Medium	8.47	9.03	9.47	9.76	9.86	9.82	9.66
	High	8.60	9.31	9.98	10.49	10.80	10.91	10.83
East 2008 baseline: 5.72 million	Low	6.16	6.46	6.59	6.64	6.65	6.66	6.65
	Medium	6.41	6.97	7.42	7.82	8.16	8.47	8.75
	High	6.67	7.49	8.28	9.06	9.77	10.45	11.12
Wales 2008 baseline: 2.99 million	Low	3.09	3.14	3.10	3.03	2.96	2.90	2.82
	Medium	3.17	3.31	3.41	3.48	3.55	3.62	3.70
	High	3.26	3.50	3.73	3.96	4.18	4.41	4.66
Scotland 2008 baseline: 5.17 million	Low	5.30	5.30	5.15	4.91	4.64	4.38	4.12
	Medium	5.39	5.52	5.56	5.52	5.43	5.34	5.24
	High	5.49	5.75	5.96	6.13	6.25	6.34	6.44

### C.7 DEMOGRAPHIC CHANGE

In the Principal Scenario, the population of Great Britain increases from its current level of 61 million to 72 million by 2033, and to 84 million by 2083.

The population will become progressively more elderly, and these increases are most significant amongst the very elderly. The population aged 85 and over starts at 1.3 million in 2008 and more than doubles to 3.3 million by 2033 and increases by a factor of 5 to 7.4 million by 2083. At the present time, the more elderly age groups are heavily skewed towards women (68% of people aged 85 or over are women), but this ratio will decline with increasing life expectancy (to 58% in 2033 and 53% in 2083). Demographic ageing will have a profound impact on the provision of health and social services such as housing for which utilisation tends to increase with age, but for other infrastructure services such as transport and ICT the reverse may be true. The changing population by age and gender is shown in Figures 1–3.

The ethnic composition of the population will also become increasingly diverse over time through a combination of ongoing positive net immigration and the youthful age structure of minority groups, some of which are also maintaining fertility at levels significantly above replacement. The population which is not characterised as White British grows from 11 million in 2011 (17%) to 18 million (25%) in 2031 and 25 million (32%) by 2051. Post-2051, projections of ethnic populations are not available.

Figure 1: Population pyramid – 2008 (Source: Project).

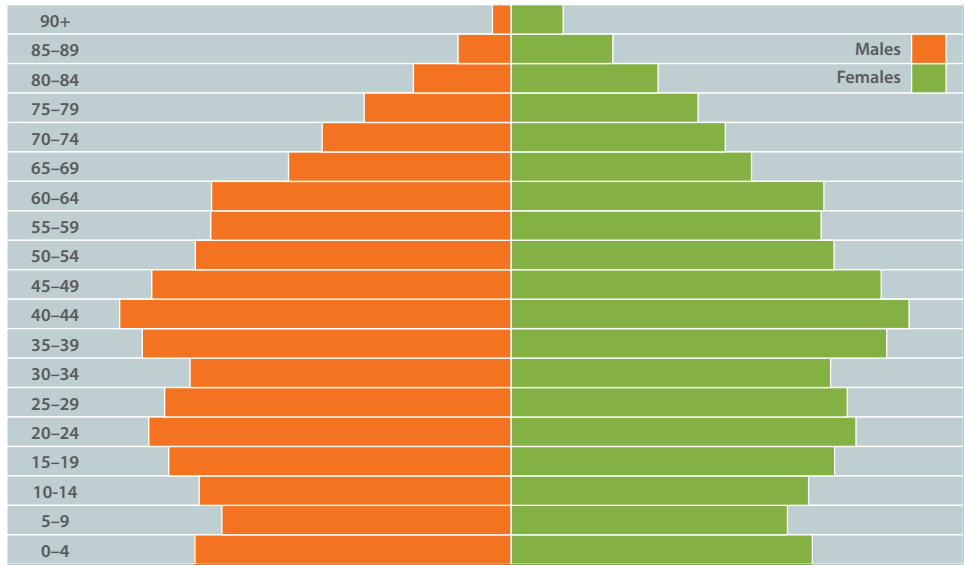


Figure 2: Population pyramid – 2033 (Source: Project).

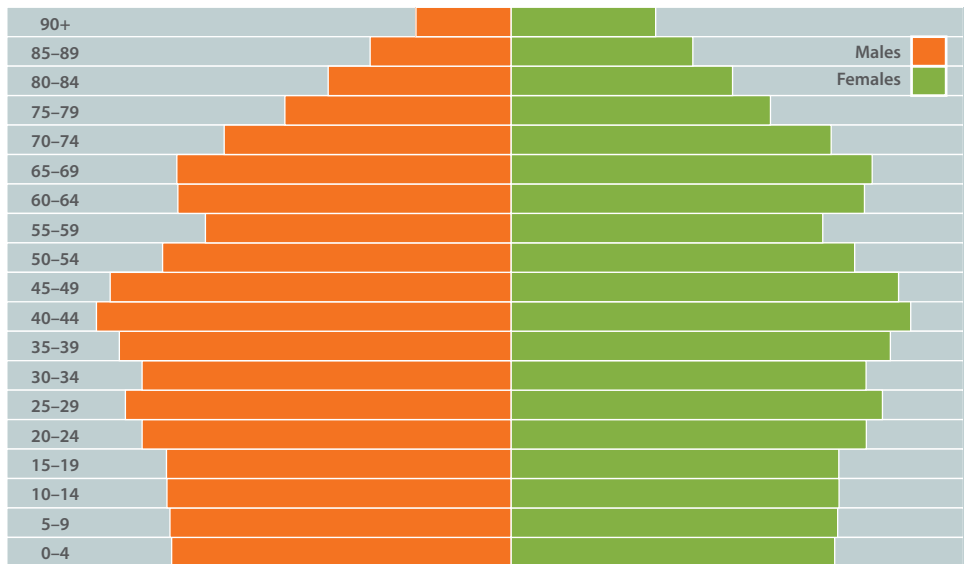
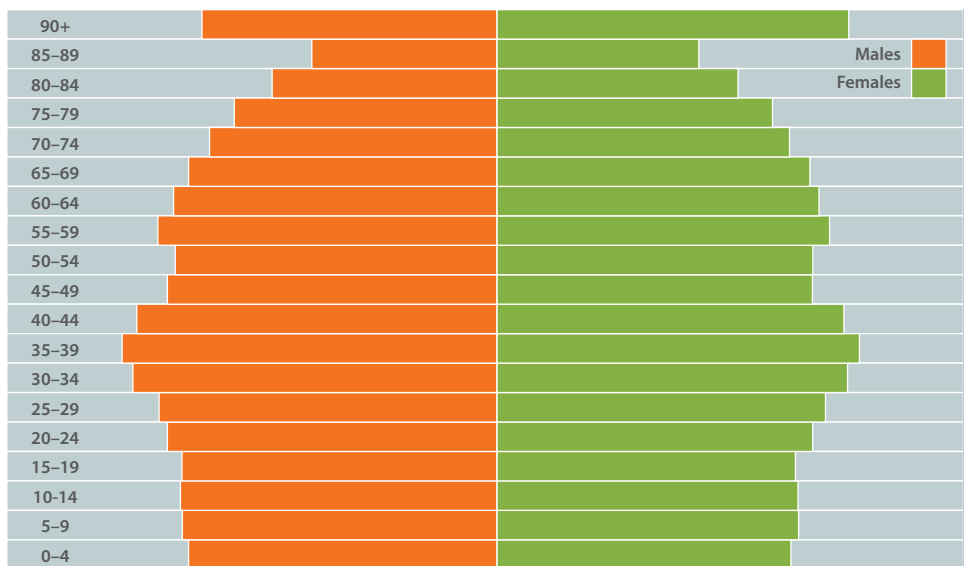


Figure 3: Population pyramid – 2083 (Source: Project).



Average household size has decreased significantly over a prolonged historical period, falling from more than 3 persons per household (pph) in 1961 to its current level of 2.33 pph e.g. because of increasing participation rates in higher education and the formation of households at ever younger ages. At some point this process must be naturally limiting, and could go into reverse with the advent of the phenomenon of ‘boomerang children’ and larger household sizes amongst the ethnic minority groups. Nevertheless ONS estimates a continued reduction in average household sizes down to 2.16 pph in the 25 year projection (to 2033). Continuation of this trend implies average household size below 2 pph by 2083 (see Figure 4).

Figure 5 shows the regional change in 25 year and 75 year projections. The fastest growing regions are the south and east of England. The north of England, Wales and Scotland, are expected to exhibit much lower growth rates. In the 25 year projection (2008–2033) the East, South-East, Yorks & Humberside, South West and East Midlands all have growth of 20% or more. The North, North-West and Scotland have growth of 10% or less. These trends are exacerbated over the 75 year projection period, with growth approaching 60% in the South West, whereas Scotland has close to zero growth.

However, there are major uncertainties. Modelling demographic change depends on three primary sets of assumptions, regarding fertility, migration and life expectancy. In this analysis we represent the major uncertainties through two scenarios. In the high scenario, it is assumed that each of the individual components of change points to an acceleration of growth in the population, thus higher fertility, increasing life expectancy and more net migration. Conversely, in the low scenario each component is associated with reduced growth, hence lower fertility, restricted improvements in life expectancy and a marginal net migration balance.

The variations between the three major scenarios are substantial. In the high scenario, additional population from the principal scenario is 4.5 million over 25 years and 21 million over 75 years. In the course of time, increasing fertility and immigration within the family age groups gives an accelerating pattern of growth (the increase in 2033–2083 is much more than linear to 2008–2033). In the low scenario, population change is initially sluggish and becomes negative after 2033.

Figure 4: Household Size Projections. Source: ONS (2010) Household Projections, United Kingdom, 1961–2033.

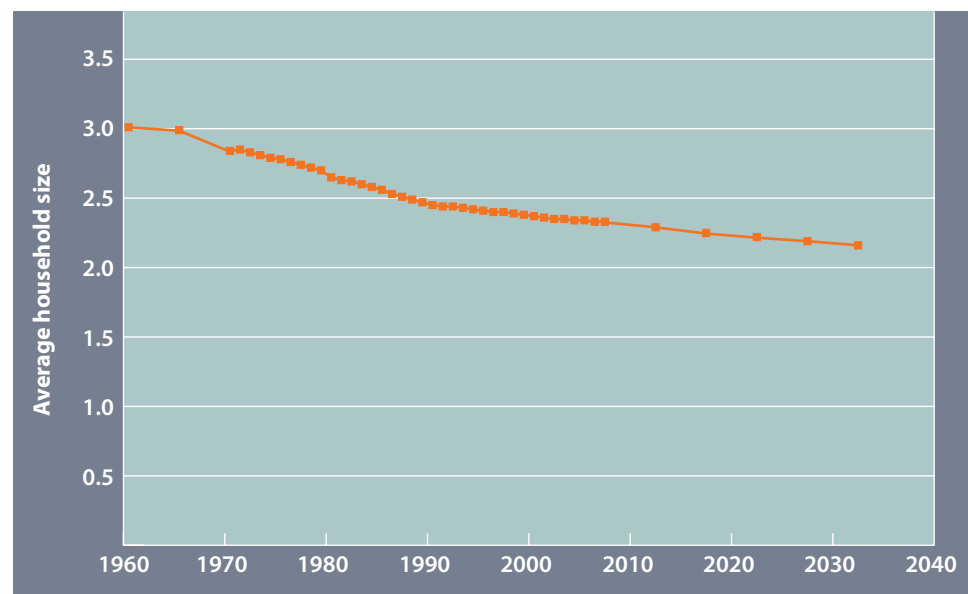
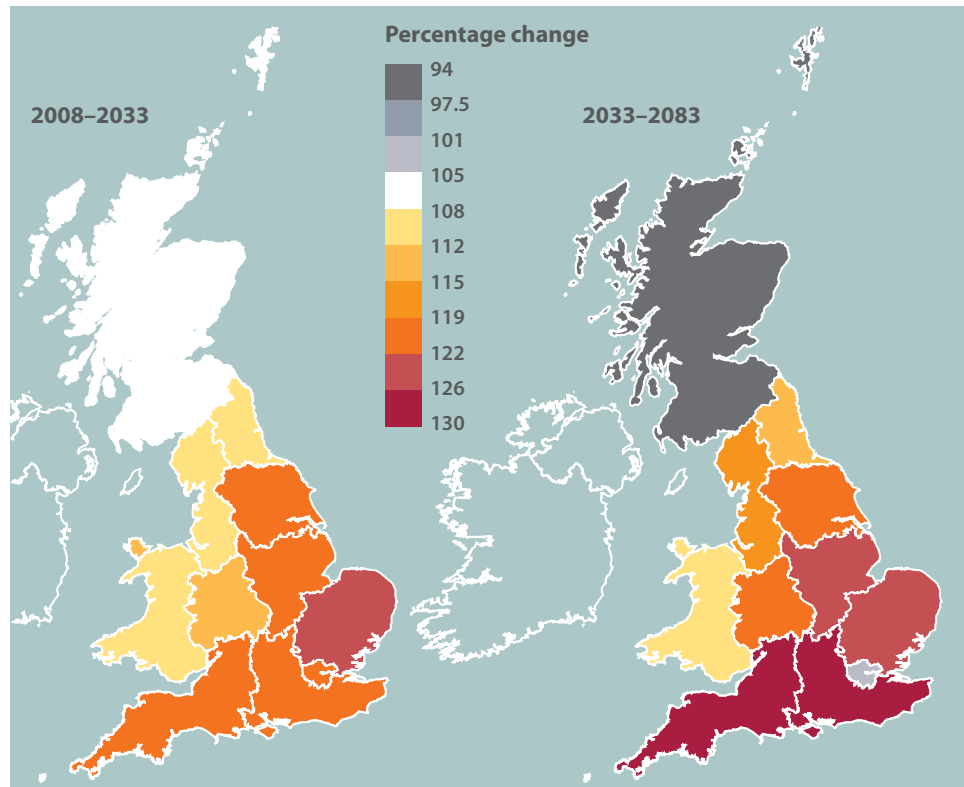




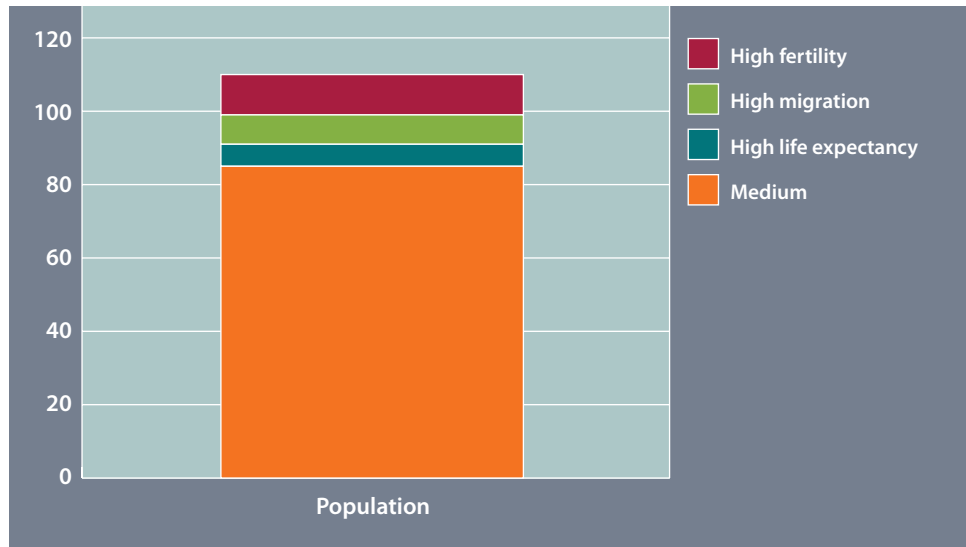
Figure 5: Population Projections  
(Source: Project).



The three major components of fertility, migration and life expectancy all contribute significantly to population growth (Figure 6). The high fertility scenario contributes about 11 million additional persons to the Principal scenario over a 75 year projection period. High migration adds about 8 million, and high life expectancy about 6 million. The contribution of individual components is skewed as greater fertility will lead to more young people, longer life expectancy leads to more old people, and migration is mostly associated with economic migrants of working age. Thus in the high scenario population growth is fairly balanced, although with a continuous build-up in the most elderly 90+ age group. These distributions would be significantly more skewed in more mixed scenarios. In the principal, 27 million people are aged 65 and over by 2083, but with high life expectancy this rises to 35 million, and if both fertility and net migration are low this represents as much as 38% of the total population. On the other hand, if enhancements to life expectancy follow the low scenario, then the population aged 65 and over rises only to 21 million and with high levels of fertility and net migration this could be as little as 19% of the total population.

All of the demographic projections are subject to the influence of government policy and other external influences at local, national and global scales. For example, border controls or quotas could influence migration; while investment in medical research and health care facilities could affect life expectancy. Fertility rates are understood to be affected indirectly by the performance and outlook for the economy. Regional housing policy could strongly determine local demographics, which might ultimately be responsive to infrastructure effects such as the availability of water or congested transport networks. These feedbacks will be explored in later phases of the ITRC project.

Figure 6: Components of Growth (Source: ONS).



## DATA TABLES

The following table displays the data used in modelling these results.

Table 1: UK Population in Thousands (Source: Project)									
	2008	Males	Females	2033	Males	Females	2083	Males	Females
0–4	3580.2	1832.7	1747.4	3844.4	1967.6	1876.9	4191.5	2144.8	2046.8
5–9	3279.4	1676.4	1603.0	3871.4	1977.3	1894.1	4288.1	2188.0	2100.1
10–14	3533.8	1808.2	1725.6	3897.0	1994.8	1902.3	4297.4	2201.4	2096.0
15–19	3861.1	1984.6	1876.5	3898.4	1997.6	1900.8	4268.8	2190.8	2077.9
20–24	4100.7	2100.2	2000.4	4199.3	2138.8	2060.5	4489.8	2292.0	2197.9
25–29	3958.0	2008.2	1949.9	4389.5	2235.7	2153.8	4637.2	2350.1	2287.1
30–34	3714.3	1861.0	1853.3	4198.0	2139.0	2059.0	4972.5	2532.0	2440.4
35–39	4315.9	2137.7	2178.2	4470.5	2270.8	2199.7	5130.4	2607.1	2523.3
40–44	4577.1	2268.9	2308.2	4721.3	2403.7	2317.7	4920.1	2504.9	2415.2
45–49	4229.8	2083.1	2146.7	4571.2	2324.0	2247.3	4488.1	2292.0	2196.2
50–54	3703.4	1830.1	1873.3	4012.9	2020.2	1992.7	4436.5	2237.3	2199.2
55–59	3539.0	1740.9	1798.1	3579.4	1771.7	1807.7	4674.0	2358.5	2315.4
60–64	3550.7	1736.2	1814.5	3981.0	1931.5	2049.5	4491.6	2249.4	2242.2
65–69	2684.5	1289.9	1394.7	4031.8	1937.5	2094.3	4323.3	2144.6	2178.7
70–74	2337.6	1094.9	1242.7	3519.5	1663.0	1856.6	4035.7	1999.0	2036.7
75–79	1935.9	851.3	1084.6	2815.6	1311.1	1504.5	3745.2	1826.8	1918.4
80–84	1418.8	565.9	852.9	2344.7	1059.9	1284.7	3241.8	1563.2	1678.6
85–89	897.6	307.0	590.6	1871.1	816.7	1054.4	2693.4	1287.2	1406.1
90+	410.0	107.2	302.8	1389.9	551.0	838.9	4500.9	2051.7	2449.2
<b>Total</b>	<b>59,627.9</b>	<b>29,284.5</b>	<b>30,343.3</b>	<b>69,607.2</b>	<b>34,511.7</b>	<b>35,095.4</b>	<b>81,826.2</b>	<b>41,020.7</b>	<b>40,805.5</b>

Table 2: Ethnic Projections

Source: Pia Wohland, Phil Rees, Paul Norman, Peter Boden, Martyna Jasinska (2010) Ethnic Population Projections for the UK and Local Areas, 2001-2051, Working Paper 10/02, School of Geography, University of Leeds, Leeds LS2 9JT.

ETHNIC GROUP	2001	2011	2031	2051
White British	51,469	52,423	53,668	52,477
White Irish	1451	1529	1601	1615
Other White	1465	2746	5307	7705
Black Caribbean	246	351	610	895
White and Black Caribbean	83	143	291	463
White and Asian	197	318	633	1013
Other Mixed	162	276	566	915
Indian	1070	1438	2150	2864
Pakistani	761	1041	1655	2322
Bangladeshi	289	377	563	760
Other Asian	253	378	641	914
Black African	574	649	753	820
White and Black African	500	792	1393	2001
Other Black	99	130	202	281
Chinese	254	427	766	1084
Other Ethnicity	238	515	1072	1592
<b>ALL</b>	<b>59,111</b>	<b>63,533</b>	<b>71,872</b>	<b>77,720</b>

	2008	2033	2083
East Midlands	4429.9	5332.6	6593.8
West Midlands	5408.8	6114.4	7455.8
South West	5211.6	6321.0	8192.5
North East	2571.4	2830.4	3236.2
South East	8370.2	10,047.8	12,674.8
North West	6874.6	7472.3	8626.6
Yorkshire	5218.3	6296.3	7687.6
London	7667.8	9186.2	9592.2
East	5716.5	7114.5	8837.9
England	51,469.1	60,715.4	72,897.4
Wales	2990.3	3347.4	3718.3
England and Wales	54,459.4	64,062.9	76,615.6
Scotland	5168.5	5544.3	5210.6
<b>Great Britain</b>	<b>59,627.9</b>	<b>69,607.2</b>	<b>81,826.2</b>

Scenario	Description	Fertility	Mortality	Migration
<b>Baseline</b>	The typical baseline projection under normal conditions.	-	Assumes a 1% improvement rate (mortality drops by 1% per year)	-
<b>High</b>	High population: increased fertility and immigration, decreased mortality.	Increased by 10%	2% improvement rate	Additional 33% immigration
<b>Low</b>	Low population: decreased fertility and immigration, increased mortality.	Decreased by 10%	No improvement rate	Less 33% migration

Table 5: Population , Great Britain, 2008-2083; three scenarios (Source: Project)			
	2008	2033	2083
Low	59,627.86	65,215.85	63,004.53
Principal	59,627.86	69,607.18	81,826.20
High	59,627.86	74,076.14	102,711.8

Figure 7: Comparison of Projections. Source: Project; ONS (2009).

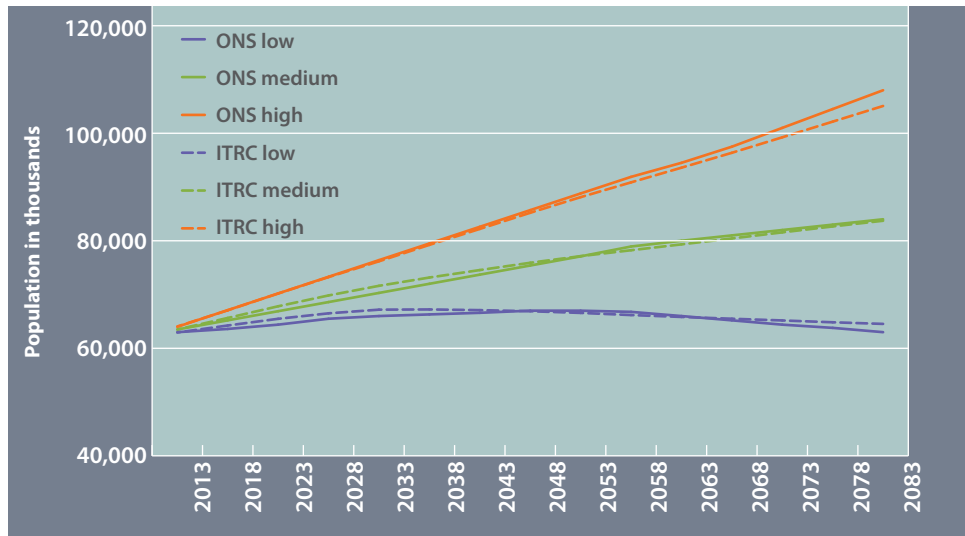


Table 6: Population growth by components: Source – ONS Variant Projections

	2083 Medium			2083 High			Male-Change	Female-Change
	Total	Males	Females	Total	Males	Females		
0-4	4192	2145	2047	5419	2775	2644	29%	29%
5-9	4288	2188	2100	5533	2825	2708	29%	29%
10-14	4297	2201	2096	5499	2819	2680	28%	28%
15-19	4269	2191	2078	5392	2770	2622	26%	26%
20-24	4490	2292	2198	5626	2876	2750	25%	25%
25-29	4637	2350	2287	5790	2937	2853	25%	25%
30-34	4972	2532	2440	6257	3190	3067	26%	26%
35-39	5130	2607	2523	6456	3285	3172	26%	26%
40-44	4920	2505	2415	6115	3119	2997	24%	24%
45-49	4488	2292	2196	5477	2806	2671	22%	22%
50-54	4436	2237	2199	5250	2655	2595	19%	18%
55-59	4674	2359	2315	5615	2843	2772	21%	20%
60-64	4492	2249	2242	5433	2737	2696	22%	20%
65-69	4323	2145	2179	5295	2650	2644	24%	21%
70-74	4036	1999	2037	4946	2482	2464	24%	21%
75-79	3745	1827	1918	4450	2212	2238	21%	17%
80-84	3242	1563	1679	4058	2010	2048	29%	22%
85-89	2693	1287	1406	3628	1804	1824	40%	30%
90+	4501	2052	2449	8838	4218	4620	106%	89%
<b>Total</b>	<b>81,826</b>	<b>41,021</b>	<b>40,806</b>	<b>105,076</b>	<b>53,012</b>	<b>52,064</b>	<b>29%</b>	<b>28%</b>