

INSTITUTE AND FACULTY OF ACTUARIES

AUDIT TRAIL

November 2015

CA2: Model Documentation, Analysis and Reporting

Paper 1

Analysis for the ASPB

Overview

The purpose of the model is to check and summarise a recent survey of the Blue Bird in Actuaria for the Actuaria Society for the Protection of Birds (“ASPB”). The model also compares the results with a survey carried out in 1985 and projects forward the Blue Bird population to 2025 taking into account migration from the neighbouring country South Actuaria.

Assumptions

This section summarises all the assumptions made throughout the model. More detail is given in the specific section below:

- The census information from the ACSO is correct and suitable for use in this analysis.
- **In the 1985 survey, apart from the one incorrect value, the ASPB data is correct and suitable for use in this analysis.**
- **In the 2015 survey, apart from the two missing values, the ASPB data is correct and suitable for use in this analysis.**
- **The individual postal areas in 1985 are assumed to have the same density as the combined postal area in 1985.**
- **Blue Birds are evenly distributed across each postal area.**
- Each sighting is of only one Blue Bird.
- The bird densities increase the further south the postal area.
- **The growth rate in numbers of birds is $2.1 / 2.0 = 1.05$ per year and does not change over time to 2025. In other words, the underlying fertility and mortality rates do not vary over time.**
- **The migration factor of 2% does not change over time to 2025.**
- **Blue Birds do not migrate any further north once they reach postal area AB.**
- **South Actuaria is subject to the same growth rate in numbers of birds over time (1.05) which increases the birds migrating into Actuaria to the same degree.**
- **There is no migration into South Actuaria.**
- **The maximum bird density of 120 birds per square kilometre applies to all postal areas including South Actuaria. This assumption is equivalent to assuming that Blue Birds cannot survive in a postal area once the maximum density is reached. The birds would either die or migrate away from Actuaria altogether.**

Contents

This audit trail describes the calculations and checks within the following worksheets in the model:

- Data – containing all the raw data for the model
- 1985_Survey – checking and correcting for errors in the 1985 survey and converting the data into metric measurements
- 2015_Survey – checking and correcting for errors in the 2015 survey
- Comparison – comparing the 1985 and 2015 surveys and illustrating the comparison with a chart
- Projection – projecting the Blue Bird numbers forward to 2025 and illustrating the comparison of all three results with a chart

“Data” sheet

This sheet contains three tables of data:

1. The data from the 2015 ASPB survey. Total responses and successful sightings of the Blue Bird are given by postcode.
2. Census data from the ACSO, giving the population and size in km² of each of the eight postal areas.
3. The data from the 1985 ASPB survey which gives the bird density by postal area.

“1985_Survey” sheet

This sheet links through the raw data from the 1985 survey results (columns A:B). There is a check in column D that checks the ratio between adjacent postal areas is reasonable and less than a reasonable upper bound (5% selected). This check suggests that combined area {EF GH} is incorrect. A correction is made in column E for {EF GH}. It is assumed that the decimal place is missing and that the correct figure is 1.1. See cell F9.

This sheet also converts the density in birds per mile² to density in birds per km² in the following way:

- The conversion factor of 0.62 miles in 1 km is stated in cell C3.
- In cell C4, the number of square kilometres in one square mile is calculated. This is equal to $(1 / 0.62)^2 = 2.60$.
- Bird density in square km is equal to bird density in square miles divided by 2.60. See columns C and G.

The check is repeated on the corrected data in column H.

The final metric table by individual postal area is set out in columns J:K.

- For the three combined areas {AB CD}, {EF GH} and {JL LM}, the individual areas are assumed to have the same density as the combined area.

e.g.. AB and CD both have density 0.08, being the same density as {AB CD}

This sheet also includes two charts of the bird density per square kilometre before the data correction and afterwards.

“2015_Survey” sheet

This sheet links through the raw data from the 2015 ASPB survey from “Data” in columns A:D. In column E, the sighting rate is calculated by dividing the number of sightings (column D) by the number of responses (column C). Column F checks the ratio between adjacent postcode areas is consistent and less than a reasonable upper bound (50% is selected).

Column H:K summarises the total number of responses by area using the SUMIF() function and an overall response rate is calculated by postal area. The response rate is the number of responses per head of population.

The checks highlight two postcodes that have missing data.

- Cell C9 – the response for postcode CD3 is missing. The correct value for this is assumed to be the average of all the other postcodes in area CD. See cell M9.
- Cell D29 – the sighting for postcode LM6 is missing. The correct value for this is assumed to be the average of the sightings across the other LM postcodes, which is then applied to the total responses received in LM6. See cell N29.

The corrected responses and sightings data from column M and N is re-checked in column P using the same check as in column F. There are no further errors.

The summary of response rate by postal area on the corrected data is set out in columns R:U.

This sheet also includes two charts of the sighting rate by postal area of the raw data (before corrections) and also of the corrected data.

“Comparison” sheet

This sheet calculates the number of Blue Birds km² from the underlying data and compares the results of the two surveys.

The 2015 survey data is linked through from the 2015_Survey sheet in columns A:E.

In columns G:Q the summary calculations are set out as follows, based on each postal area from AB to PQ going down the rows:

- Total Responses (column J) are calculated by using the SUMIF() function on the individual responses by postcode.
- The Total Response Rate is calculated in column K by dividing the Total Responses by the Population in each area.
- Total Sightings (column M) are calculated by using the SUMIF() function on the individual sightings by postcode.
- The Sighting Rate is calculated in column M by dividing the Total Sightings by the Total Responses.
- The Sighting Rate is applied to the overall population to calculate an estimate of the total number of Blue Birds in each postal area. This requires the assumption that Blue Birds are evenly distributed across each postal area and that only one Blue Bird is seen for each sighting.
- Finally, the Bird Density for the 2015 survey is calculated in column O, with the bird density from 1985 linked through in column P from “1985_Survey”.

A check on the bird density rates is included in column Q. This shows an increasing trend against the postal areas going from north to south which supports the suggestion that more Blue Birds exist the further south you go in Actuarial.

A chart comparing the two sets of survey results is constructed. The bar chart shows the densities from both the 1985 and 2015 survey results for each postal area. The increasing bird densities in the south is clear from this chart.

Projection

This sheet projects forward the postal area bird densities from the 2015 survey. The projection period is 10 years, so the densities are projected forward to the year 2025.

The parameters of the projection are in cells C14:C17. These are:

- Growth rate – every 2.0 birds in the population become **2.1** birds (on average) year on year. This implies a growth rate of **5%** per annum. This assumes the underlying fertility and mortality rates do not vary over time.
- Migration North factor – each year, on average, **2%** of the number of Blue Birds migrate out of a particular postcode area and into the next, going from south to north (so from postcode PQ to AB).
- Maximum Density – this is **120** birds per square kilometre and assumed to be the same for all areas and across all years.

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The Growth rate and Migration North factors are assumed to apply to the birds in South Actuarial as well.

The calculations are set out in columns A:M. Firstly, the land areas and 2015 bird populations are linked through from the "Comparison" sheet, one row for each postal area. The birds migrating in from South Actuarial are calculated in row 12. Columns D:M calculate the number of birds in each successive year, taking into account the Growth rate and the Migration North factor.

For instance, for area EF, the number of birds in 2016, denoted N(EF,2016) is derived from the parameters and the 2015 number as follows:

$$N(EF, 2016) = [N(EF,2015) \times (1 - 2\%) + N(GH,2015) \times 2\%] \times (1 + \text{Growth rate}\%)$$

Note that this formula applies the growth factor to the birds in the same area and also to the birds migrating in from the south neighbouring area.

The value of N for all areas and time periods is subject to the maximum density value of 120. The MIN() formulae is used to cap all projected numbers in the table at this maximum. This formula uses the table in columns O:Y which calculates the density in each postal area and year after migration in the year.

Conditional formatting has been applied to the population projection table to highlight any postal area / year cell where the maximum density has been reached.

The chart on this sheet shows the results of the projection to 2025 against both the 1985 and 2015 surveys. The projection to 2025 shows a significant increase in the densities towards the north, with the maximum densities being reached in areas NO and PQ (and also South Actuarial) by 2025 or before.

END OF AUDIT TRAIL