Lab 8: Population Projection for Marbled Murrelets

In this lab exercise, we will build a population model for the Marbled Murrelet as a spreadsheet in Excel. The objectives of this exercise are: 1) to work with life-cycle diagrams and projection matrices, and 2) to demonstrate the basics of population modeling, particularly the concepts of asymptotic parameters and sensitivity analyses.

The Marbled Murrelet is a threatened species of seabird (Family *Alcidae*) that lives on the Pacific Coast. Murrelets spend most of their time within 2 km of the coast, where they feed on crustaceans and small fish, but they nest on the lateral branches of mature trees in old growth forests. Harvest of old growth forests has substantially reduced the available habitat for this species. Despite their unusual nest placement, murrelets are probably similar to other seabirds in their demography. Females do not start breeding until they are three years of age and are thought to be long-lived. Fecundity rates are low because females lay only a single egg per year and not all females breed every year. Fecundity rates are usually estiamated by surveys of juveniles at sea after breeding, and post-breeding age ratios are typically 2-10% juveniles. If converted to an annual estimate of fecundity, these age-ratios would yield fecundity values of 0.12 to 0.18 female offspring per breeding female. Survival rates are probably low among juveniles, and high among adult age stages. Estimates of demographic rates for Marbled Murrelets are as follows.

Age	Stage	Fecundity	Survival
0-1	Juvenile	0.00	0.63
1-2	Subadult 1	0.00	0.80
2-3	Subadult 2	0.00	0.90
3+	Adult	0.12	0.90

Building a population model

Population surveys for Marbled Murrelets are usually conducted after the breeding season to obtain data on population age-ratios. Accordingly, we will develop a population model based on post-breeding population surveys. As a first step, create a life cycle diagram and accompanying projection matrix that captures the demographic rates in the above table.

1. Next, open up a spreadsheet in Excel to develop a post-breeding population model. In cell A1: type ‘Marbled Murrelet Demography - Female Postbreeding Model’.

2. Create the following column headings: A4 = ‘Age’, ‘B4=’Stage’, D4=’Fecundity’, and E4=’Survival’.

3. Set up the demographic rates. In the columns below these headings, fill in the actual rates from the table above.

4. Set up the stage structure. In cell A13, type ‘Stage’ and then fill in the stages in A column below this through to cell A17.

5. Set up the population statistics. In cell A19, type 'Totpop' for Total population size. In cell A20, typ 'PropJuv' for proportion of juveniles. In cells A21-A23, type 'Prop1', 'Prop2' and Prop3' for the proportions of the other three age-classes. Finally, in cell A24, type 'Lambda' for the finite rate of population change.

6. Set up a projection period for 25 years. In cell B12, type 'Year 0'. Inc cell C12, type '1'. In cell D12, type =C12+1. Copy and paste this formula into cells D12 to AA12 for a 25 year projection.

7. Set up the initial population size. In cells B14 to B17, enter the following population sizes: juveniles = 1000 individuals, subadult1 = 500, subadult2 = 500 and adult = 10,000.

Calculations

1. Now you are ready to project the population for one time step. What formulae should you use to calculate the number of individuals in each of the four age-classes at year 1? You will need to return to the life-cycle diagram and projection matrix to determine the format of these expressions. Once you have determined these calculations, use the formulae to make the calculations in cells C14 to C17. Cut and paste the same formulae into cells D14/D17 to AA14/AA17 to make the projections for 25 years.

2. Set up population structure. Complete the calculations in cells B20 to B23 to calculate the proportions. Recall that =SUM(B14:B17) takes the sum of a range of a cells. Cutting and pasting =B14/B$19 would allow you to keep the same cell reference by row but would change for each column. Cut and paste these formulae into cells C20/C23 to AA20/AA23.

3. What formula should you use for Lambda in cell B24? Cut and paste this formula into cells C24 to AA24.

Questions

1. What happens to the proportions of each age-class and lambda as the population is projected over time? Do your conclusions change if the starting population is 24,000 birds instead of 12,000 birds? Do your conclusions change if the starting population is 70% juveniles and 10% for each of the other three stage-classes?

2. Is the population increasing, stable or decreasing?

3. What change in vital rates would be necessary to obtain a stable population? One at a time, modify F3, P0, P1, P2, P3 to obtain a stable population growth rate. You can do this iteratively or by using the Solver tool. Make a note of what value of each of these vital rates would be needed to reach this goal. Be sure to reset the demographic rates to the same starting values each time before modifying one of the other demographic rates.