**Lab 6**

**Due Nov. 5, 2013**

**Age Structure Problems**

1. When is it important to use age-structured models? What are some examples of how age structure can affect population vital rates (i.e., λ, birth rate, survival)?
2. Age structure is incorporated into models as a type of (*circle the best answer below*):
3. Deterministic variation
4. Stochastic variation
5. What age class and year do the following describe?

3N2   2N1

1. What is the difference between a cohort and an age class?
2. Calculate the average (across all years) survival rates and fecundities for each age class based on the yearly census data below. You can assume the fecundity of age 0 individuals is zero and that all adult age classes (ages 1 through 3) have the same fecundity.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Census year** | | | |
| **Age** | **2008** | **2009** | **2010** | **2011** |
| **0** | 46 | 43 | 39 | 42 |
| **1** | 29 | 30 | 26 | 24 |
| **2** | 9 | 12 | 14 | 13 |
| **3** | 5 | 3 | 5 | 4 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Survival rates** | | | | |
| **Age** | **S1** | **S2** | **S3** | **Ave S** |
| **0** |  |  |  | **0.62** |
| **1** |  |  |  | **0.46** |
| **2** |  |  |  | **0.35** |
| **3** |  |  |  | **0.00** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fecundities** | | | | |
| **Age** | **F1** | **F2** | **F3** | **Ave F** |
| **0** |  |  |  |  |
| **1 thru 3** |  |  |  |  |

1. Construct the Leslie matrix for the population in question 5 given the survival and fecundity rates you calculated.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

1. Using the Leslie matrix you just constructed in question 6, what transitions do the matrix elements below represent? Are these transitions biologically possible in an age-structured model?

Element in row 1, column 3:

Element in row 3, column 2:

Element in row 3, column 3:

1. Continuing with the data from questions 5-7, forecast population size in 2012 using the vector of age-structured population size in 2011. Write your answer in the column provided below. Additionally, fill out the total population size (last row of the table) for each year.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Census year** | | | | |
| **Age** | **2008** | **2009** | **2010** | **2011** | **2012** |
| **0** | 46 | 43 | 39 | 42 |  |
| **1** | 29 | 30 | 26 | 24 |  |
| **2** | 9 | 12 | 14 | 13 |  |
| **3** | 5 | 3 | 5 | 4 |  |
| **Total** |  |  |  |  |  |

1. Considering the five years of data in the table from question 8, the population appears to be declining slightly through time, but the age classes are maintaining relatively stable proportions. What is the term that describes this state?
2. Given the state in question 9, what important (single) parameter can describe the survival rates and fecundities in the Leslie matrix?
3. **Excel Exercise:** In this exercise, we see the Leslie matrix in action. This lab reinforces the idea of age structure and illustrates how population demography influences population growth rate. Most commercial fisheries are managed using (and much basic research uses) age or stage structured models; this lab exercise simulates multiple fishery management scenarios that depend on the age structure of a population.

**Developing a brook trout Leslie matrix in Excel**

In this exercise, we will build an age-structured model of a Michigan brook trout population and use it to inform the restoration and management of a fishery. The DNR wants to restore brook trout to a portion of a trout stream above an impassable dam. Brook trout were eliminated from this portion of the stream many years ago by a combination of habitat alteration and overfishing. We have obtained detailed demographic data from the remaining brook trout below the dam. We will use this data to parameterize our model. We will then use the model to decide how to stock above the dam to achieve the most rapid recovery of the population, and then how to manage the fishery once the population has been re-established. This would be hard without matrix models!

To parameterize the population model, first download the Excel file: **BrookTrout.xlsx** from the course website. Within this file, you will find data on the abundance and per capita egg production of each age class (age 0 to age 6, with age 0 fish defined as fingerlings) for the years 1984-1997. The abundance data can be used to estimate average survival rates from one year to the next for each age class, as well as the standard deviations of these rates. To accomplish this, you must supply the correct formulas in the box labeled: “age-specific survival rates”. To get fecundity, the egg production data (i.e., number of eggs per female) can be multiplied by the **average survival rate from egg to fingerling** (= 0.0029; see spreadsheet) to estimate the number of fingerlings (age 0 fish) produced per female in each age class. The standard deviation of per capita fingerling production can be estimated in a similar way. Once age-specific survival and fecundity (fingerling production) rates have been estimated, save the Excel file. Be sure to include these survival and fecundity estimates (with their standard deviations) in below. **The best way to present the survival and fecundity information is as two Leslie matrices: one matrix of the survival and fecundity rates and one matrix of the standard deviations of the survival and fecundity rates.**