Matlab Project 1: Spotted Owl Populations

Due: Monday 4 February

Goal: Use linear algebra to model population dynamics

Background:

Read the description of the spotted owl population at the beginning of Chapter 5 (pages 265-266). To summarize, these owls have three distinct life stages: juvenile (up to one year old), subadult (one to two years), and adult (over two years). The population at year k can be described by a vector $\mathbf{x}_k = [j_k\ s_k\ a_k]^T$, where j_k, s_k, and a_k are the numbers of (female) owls in the juvenile, subadult, and adult stages, respectively. The changes in the population are modeled by the *stage-matrix model* $\mathbf{x}_{k+1} = A\mathbf{x}_k$, where

$$A = \begin{bmatrix} 0 & 0 & 0.33 \\ r & 0 & 0 \\ 0 & 0.71 & 0.94 \end{bmatrix}$$

Here, r is the *juvenile survival rate*, which gives the fraction of juveniles which survive to become subadults. The description in the text states that if $r = 0.18$ then the owl population will eventually die out, but that if r is larger the owls may survive. In this project you will verify these statements.

If you have not yet worked through the project "Getting Started with MATLAB", do so now. Then work through the steps below using MATLAB, typing the commands listed in **this font**. Write all answers on the answer sheet, staple the requested plots to it, and hand it in when due.

Step 1: Let $r = 0.18$ and suppose there are 100 owls in each life stage in the year 2000. Enter the matrix A above as **A** and the initial population $\mathbf{x}_0 = [100\ 100\ 100]^T$ as the vector **x0**. To compute the population in each stage and the total number of owls at year 2001, use the following MATLAB code:

```
x=x0;
x=A*x, total=sum(x)
```

Use the up arrow key to retrieve the last line and execute it two more times to compute the populations at years 2002 and 2003. *Record the results obtained so far in Table 1 on the answer sheet—round the numbers to integers.*

To compute populations out to the year 2030 it's tedious to proceed as above. Instead, use MATLAB repeat the calculation and store the results using the following code:

```
x=x0; P=x; for k=2001:2030, x=A*x; P=[P x]; end
P
```

The last line displays the matrix **P**, which stores the population at each year from 2000 through 2030 in columns 1 through 31 [note that MATLAB always indexes matrix entries starting from 1—often awkward, but it's a fact of (MATLAB) life]. *Use these results to complete the entries in Table 1, rounding all numbers to integers.* An easy way to get just the data you need is to use the following code:

```
M = P(:,[1 2 3 4 11 21 31]), sum(M)
```

Note that the MATLAB command **sum** applied to a *matrix* returns a vector containing the sum of each column.

Step 2: Type the following to plot the populations as functions of time:

```
year=2000:2030; plot(year,P)
```

Here **year** is a vector giving the year numbers; since the length of this vector matches the number of columns of the matrix **P**, the **plot** command plots the three rows as three separate lines of different colors. Label your plot using the following code:

```
title('Spotted Owl Populations: r=0.18')
xlabel('year'), ylabel('population')
legend('juvenile','subadult','adult')
```

Print the graph (to hand in with the answer sheet). Does it look like the owls will survive? Record your answer on the answer sheet.

Step 3: To see what might happen if environmental conditions were changed so that more juveniles survive, change the value of the juvenile survival rate r to 0.30 and repeat steps 1 and 2. To do this, type **A(2,1)=0.30** (check the resulting matrix) and then repeat the calculations of step 1 and the graph of step 2 (remember to change the value of r in the plot title). Does it look like the owls will survive? *Record your answers in Table 2 on the answer sheet (round numbers to integers) and print the graph (to hand in).*

Step 4: Repeat the above calculations and graphs for the following values of the juvenile survival rate r: 0.20, 0.22, 0.24, 0.26, and 0.28. You do *not* have to record all data or print graphs for these. Instead, *record the total population at year 2030 for each value of r in Table 3 on the answer sheet.*

Hand in the following:

1. The completed answer sheet. *DO NOT hand in the instructions (I already have a copy).*
2. A printed copy of your graphs from steps 2 and 3.
3. If you use an M-file (MATLAB script) to do these calculations, also attach a copy of it.

Note: You may work with *one* other person if you wish; if you do so, hand in only one copy of your work (with both names on top).

Remarks:

- The **for** command executes a loop. For further information about this or any other MATLAB command, use the **help** command (e.g, **help for**) or see the Help menu within MATLAB.
- To print a graph you can select **Print** from the **File** menu on the Figure window (or **Export** the graph to a file to include it in some other document).
- This project is adapted from the *Instructor's MATLAB Manual* by Jeremy Case and Jane Day.

Matlab Project: Spotted Owl Populations **Name:**_____

ANSWER SHEET **Name:**_____

Table 1: Populations when the juvenile survival rate is $r = 0.18$

Year	2000	2001	2002	2003	2010	2020	2030
Juvenile	100						
Subadult	100						
Adult	100						
Total	300						

Does it look like the owls will survive? Circle answer: YES NO

Table 2: Populations when the juvenile survival rate is $r = 0.30$

Year	2000	2001	2002	2003	2010	2020	2030
Juvenile	100						
Subadult	100						
Adult	100						
Total	300						

Does it look like the owls will survive? Circle answer: YES NO

Table 3: Total populations at year 2030

Juvenile survival rate r	Total population at year 2030	Do the owls survive?
0.18		YES NO
0.20		YES NO
0.22		YES NO
0.24		YES NO
0.26		YES NO
0.28		YES NO
0.30		YES NO

Graphs: Staple your graphs for steps 2 ($r = 0.18$) and 3 ($r = 0.30$) to this answer sheet.