Step 0. Start RAMAS EcoLab, and select "Random numbers," which is a program that produces random numbers. The program will display two uniform random numbers (between 0 and 1) on the screen. To get another pair of random numbers, click the "Random" button. (To quit, select "Exit" under the File menu, or press (Alt-X).)

Step 1. The Muskox population consisted of 31 individuals in 1936. Write down this number ($N = 31$) on a piece of paper. Repeat the following steps 31 times, once for each Muskox on Nunivak island in 1936. For each repetition, use a new pair of random numbers.

   Step 1.1. Use the first random number to decide if the animal produces an offspring or not. If the first random number is *less than* the fecundity value ($f = 0.227$), then *increase N* by 1, otherwise leave it as it was.

   Step 1.2. Use the second number to decide if the animal survives or dies. If the second random number is *greater than* the survival rate ($s = 0.921$), then *decrease N* by 1, otherwise leave it as it was.

Step 2. After repeating the above steps 31 times, record the final N. This is your estimate of the Muskox population size for 1937.

Step 3. Repeat Steps 1 and 2 four times, for a total of five trials. You will have 5 estimates for the Muskox population size for 1937. Comment on the amount of variation among the results of the five trials.

Exercise 2.2: Building a Model of Muskox

In this exercise, you will use RAMAS EcoLab to build and analyze a stochastic model of Muskox on Nunivak island.

Step 1. Start RAMAS EcoLab, and select the program "Population Growth (single population models)" by clicking on its icon. See the Appendix at the end of the book for an overview of RAMAS EcoLab. For on-line help, press (F1), double click on "Getting started," and then on "Using RAMAS EcoLab." You can also press (F1) anytime to get help about the particular window (or, dialog box) you are in at that time. To erase all parameters and start a new model, select "New" under the Model menu (or, press (Ctrl-N)).

Step 2. From the Model menu, select **General information** and type in appropriate title and comments (which should include your name if you are going to submit your results for assessment).

Enter the following parameters of the model.

Replications:	**0**
Duration:	**12**

Setting replications to 0 is a convenient way of making the program run a deterministic simulation, even if the standard deviation of the growth rate is greater than zero. Note that the last parameter of this window, whether to use demographic stochasticity, is ignored (it is dimmed and is not available for editing). This is because when the number of replications is specified as 0, the program assumes a deterministic simulation. This parameter is ignored because it is relevant only for stochastic models.

After editing the screen, click the "OK" button. (Note: Don't click "Cancel" or press (Esc) to close an input window, unless you want to undo the changes you have made in this window.) Next, select **Population** (under the Model menu). Recall that the Muskox population on Nunivak Island began in 1936 with 31 individuals and had an average growth rate of 1.148. Based on these, enter the following parameters in this screen.

Initial abundance:	**31**
Growth rate (R):	**1.148**

The parameter "Standard deviation of R" is not available for editing because we will first run a deterministic simulation, in which standard deviation will not be used. Similarly, "Survival rate (s)" is used only to model demographic stochasticity, so it is also ignored by the program when the simulation is deterministic.

For this exercise, you can ignore the last two parameters in this window (density dependence and carrying capacity); we will discuss density dependence in a later chapter. The default selection for "Density dependence type" is "Exponential," which refers to exponential growth with no density dependence. The last parameter is ignored because it is related to other types of density dependence. When finished, click "OK" and press (Ctrl-S) to save the model in a file.

Step 3. Select **Run** from the Simulation menu to start a simulation. The simulation will run for 12 time steps; you will see "Simulation complete" at the bottom of the screen when it's finished. For a deterministic simulation, this will be quite quick. Close the simulation window.

Step 4. Select "Trajectory summary" from the Results menu. Describe the trajectory you see. What is the final population size?

Step 5. Close the trajectory summary window. Select **General information** and change "Replications" to 100 by typing the number. Next, click the little box next to "Use demographic stochasticity" This will add demographic stochasticity to the model. The parameters should now be as follows:

Replications:	**100**
Duration:	**12**
☑ Use demographic stochasticity *(checked)*	

Click the "OK" button and select **Population** (again, under the Model menu). Recall that the survival rate of the Muskox population was 0.921 and that the observed standard deviation in the growth rate was 0.075. Based on these, enter the following parameters in this screen.

Initial abundance:	**31**
Growth rate (R):	**1.148**
Survival rate (s):	**0.921**
Standard deviation of R:	**0.075**

Click "OK," and select **Run** to start a simulation. While this stochastic simulation is running, after the first five replications, the program will display each population trajectory it produces (the program cannot display the population trajectories produced by the first five replications, because it uses them to scale the graph). Describe the trajectories in comparison with the deterministic trajectory. Do any of these trajectories look similar to the deterministic trajectory? What is the cause of the difference?

Step 6. After the simulation is completed, close the simulation window and save the model by pressing [Ctrl-S]. Then, select "Trajectory summary." You will see an exponentially increasing population trajectory. Describe the trajectory summary. What is the range of final population sizes? You can try to read the range from the graph, or if you want to be more precise, you can see the results as a table of numbers. To do this, click on second button from left ("show numbers") on top of the window. The first column shows the time step, the others show five numbers that summarize the abundance for each time step: (1) minimum, (2) mean – standard deviation, (3) mean, (4) mean + standard deviation, and (5) maximum.

Step 7. Select "Extinction/Decline" from the Results menu. What is the risk of decline to 31 individuals based on this curve?

It might be difficult to read the precise value of the risk from the screen plot. Do the following to record this number precisely:

Click the "Show numbers" button, and scroll down the window to where you see "31" in the first column. Record the probability that corresponds to this threshold level.

Exercise 2.3: Constructing Risk Curves

In this exercise you will construct an interval decline risk curve based on the Muskox model. If you have exited the program after the previous exercise,