Ecological Problem Solving

FW 364

Exercise 4

**Due: October 8, 2013**

**Learning objectives**: In this lab, we will work through a concrete example in which uncertainty in our knowledge about an ecological system affects the nature of our predictions about future population size. In working through this exercise, we reinforce the distinctions between deterministic and stochastic prediction, uncertainty in parameter estimation (λ) versus uncertainty of population forecasts (*Nt*), and environmental stochasticity versus demographic stochasticity. We also introduce the concept of risk, as in the probability (risk) of extinction.

We will take our model of blue whale dynamics, add stochasticity (“random” uncertainty), and construct risk curves for the population (i.e., determine risk of the population falling below a critical size). The stochastic version of the blue whale model can only be analyzed with a simulation software program. We will use Ramas EcoLab. Follow the general guidelines given in Exercise 2.2 of the text (posted on website) for constructing the stochastic model.

Part A: Investigating effect of uncertainty in λ on population growth and risk of decline

Run simulations assuming average net population growth rates (λ) of 1.02 and 1.05. For each of these two values, examine the effect of standard deviations of λ varying from 0.04 to 0.12, using a step of 0.02 (i.e., a total of 5 values for the standard deviation for each λ). In all cases, assume survival = 0.90, use 10,000 whales as the starting density, run each trial for 50 years, and run 200 trials for each set of parameter values. You can choose whether or not to include **demographic** stochasticity in your simulations; just be sure to be consistent about (and circle below) whether you include demographic stochasticity or not. Compare the average final population size from your stochastic simulations to deterministic runs (you can only do one deterministic run for each λ). Fill in the table of your results, including the deterministic outcomes,

What are your assumptions?

Did you include demographic stochasticity in your simulations? Yes No

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| Table 1. Effect of uncertainty in lambda | | | | |  | | |  | | |  | | |  | | |
|  | Input parameters | | | | | | Final density | | | Final density | | |  | | |
|  | lambda | | SD | | | | mean | | | SD | | | <7000 risk | | |
| Deterministic | | 1.02 | | 0.00 | |  | | |  | | |  | | |
| Stochastic | | 1.02 | | 0.04 | |  | | |  | | |  | | |
| Stochastic | | 1.02 | | 0.06 | |  | | |  | | |  | | |
| Stochastic | | 1.02 | | 0.08 | |  | | |  | | |  | | |
| Stochastic | | 1.02 | | 0.10 | |  | | |  | | |  | | |
| Stochastic | | 1.02 | | 0.12 | |  | | |  | | |  | | |
|  | |  | |  | |  | | |  | | |  | | |
| Deterministic | | 1.05 | | 0.00 | |  | | |  | | |  | | |
| Stochastic | | 1.05 | | 0.04 | |  | | |  | | |  | | |
| Stochastic | | 1.05 | | 0.06 | |  | | |  | | |  | | |
| Stochastic | | 1.05 | | 0.08 | |  | | |  | | |  | | |
| Stochastic | | 1.05 | | 0.10 | |  | | |  | | |  | | |
| Stochastic | | 1.05 | | 0.12 | |  | | |  | | |  | | |
|  | |  | |  | |  | | |  | | |  | | |

Include a TRAJECTORY SUMMARY plot for **one** of your stochastic simulations (be clear as to the λ and SD used for the trajectory summary)

Record results from each simulation that will enable you to answer the following questions:

How does increasing uncertainty in λ (as measured by the standard deviation of λ) affect: 1) the uncertainty of population forecasts after 50 years, and 2) the risk of falling below 7,000 whales (which is a dangerously low level with respect to the long-term persistence of this species)?

Plot relationships that illustrate these two effects.

Discuss the shape of the relationships for each value of λ and compare the relationships to each other. Remember that we can obtain the risk of the population falling below a certain critical size (i.e., threshold) from data for an extinction risk curve.

Part B: Investigating the effect of duration (time) on risk of decline

Using the lower growth rate from Part A (λ = 1.02) and full range of standard deviations of λ (0.04 to 0.12 in steps of 0.02), compare the risk of the population falling below 7,000 whales after 15 years with the risk after 50 years. Use the same survival rate (0.90), starting population size (10,000 whales), and number of trials (200) as Part A. You will have to run separate simulations for 15 and 50 years (you can use your simulations for 50 years from Part A instead of running new simulations, if desired), since Ramas does not allow you to stop and then resume a simulation (i.e., you cannot use a 50 year simulation and look at output after 15 years).

What are your assumptions?

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| Table 2. Effect of simulation duration | | |  |  |  |
| duration | lambda | SD | Mean Population Size | Standard Deviation | <7000 risk |
| 15 | 1.02 | 0.04 |  |  |  |
| 15 | 1.02 | 0.06 |  |  |  |
| 15 | 1.02 | 0.08 |  |  |  |
| 15 | 1.02 | 0.10 |  |  |  |
| 15 | 1.02 | 0.12 |  |  |  |
| 50 | 1.02 | 0.04 |  |  |  |
| 50 | 1.02 | 0.06 |  |  |  |
| 50 | 1.02 | 0.08 |  |  |  |
| 50 | 1.02 | 0.10 |  |  |  |
| 50 | 1.02 | 0.12 |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Plot the relationship between risk of falling below 7,000 whales and uncertainty in λ for both durations.

Comment on how the duration of the simulation affects the risk of falling below 7,000 whales.

Part C: Investigating the effect of demographic stochasticity and population size on risk

Lastly, examine how the effect of demographic stochasticity varies with initial population size (we will use two populations that differ in initial size, as opposed to modeling the same population starting at different sizes). Because we need more precision in this part, use 1000 trials. Run simulations for 50 years for two populations, blue whales (N0 = 10,000) and California sea otters (N0 = 100), having identical population growth rates (1.02) and standard deviation of λ (0.06), **with and without demographic stochasticity**. Record the standard deviation of final population size and the risk of falling to 70% of the initial abundance (i.e., 0.7 N0, corresponding to at or below 7,000 for whales and 70 for otters) for each simulation.

What are your assumptions?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 3. Effect of population size and demographic stochasticity | | | | |  |
| N | lambda | SD | demographic  stochasticity | SD | <0.7N risk |
| 100 | 1.02 | 0.06 | no |  |  |
| 100 | 1.02 | 0.06 | yes |  |  |
| 10000 | 1.02 | 0.06 | no |  |  |
| 10000 | 1.02 | 0.06 | yes |  |  |

Based on your results, comment on how demographic stochasticity affects a large versus a small population.