Computer Laboratory, Exercises 4 and 5, Discussion.

Objective: Explore discrete stochastic models, and age-specific models.

Exercise 4.
1. Examine the stochastic spreadsheets `BIRTH.WB2`, `DEATH.WB2`, `BIRDEATH.WB2`, and `LOGISTIC.WB2` I've provided in the `MODELS\STOCHAST subdirectory`. Recompute each spreadsheet (`F9`) and graph the output (`F11`) to see how different realizations of the random process look. Both the Poisson and Binomial approaches are provided. Note that the death spreadsheet also explores individual heterogeneity and temporal variation in the death rate. Be sure to understand the distinction between the different layers of this spreadsheet.

2. Compare the form of the stochasticity in the various layers of these models. What is the random variable in the different layers?

3. Is the function `@CRITBINOM(10,0.4,@RAND)` the same as applying a survival probability of 0.4 to each of the 10 animals in the population?

Exercise 5.
1. Program an age-specific population model in a spreadsheet. For input data, use results from the Piceance Basin for mule deer. Assume 65 fawns (both males and females) are born for 100 does 1.5-years old and older. This is a simplifying assumption. In reality, a female does not have a fawn on her first birthday, and has a reduced birth rate on her second birthday compared to adults 3 years old and older. However, when helicopter surveys are performed in December, 1.5-year-old does cannot be distinguished from older females. Hence, the fawn doe ratio (65:100) includes these non-reproducing animals. This artifact of classification can result in some interesting anomalies in the data: a year class failure (all fawns dying in a bad winter) results in a high fawn:doe ratio the next year (because no non-reproducing 1.5-year olds are in the population). Assume fawn survival is 0.35 for the first year, and 0.90 thereafter. Assume a sex ratio of 50:50. I compute $\lambda = 1.014$ (see the spreadsheet `AGESTRUC.WB2`). Is this the answer you get?

2. What is an approach to avoid having to specify many age classes for long-lived species?

3. What is λ for these data? Does your answer agree with your neighbor's? What is different between your 2 models?

4. What is the expected age ratio for this population when it reaches a steady state? That is, what is the stable age distribution.

5. Any ideas on what the variance of λ would be, or how to compute it?

6. Look at enough models from other class members to get some ideas about how you each

interpreted the problem slightly differently.

7. Examine the sensitivity to λ with respect to the input parameters. How can this be done in the spreadsheet?

8. The `LESLIE.WB2` spreadsheet demonstrates Leslie matrices with before and after birth pulse formulations, plus different initial age ratios.

9. For discussion, what is the MSY of a Leslie matrix?

Useful Statistical Distributions for Population Modeling

Distribution	Purpose	Variable	Parameters	Mean	Variance	Bounds	pdf = $f(x)$
Normal	Temporal variation in K, R_0, and λ	x	μ, σ	μ	σ	$-\infty, +\infty$	$\frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$
Beta	Temporal variation in survival, mortality, and pregnancy rates	x	α, β	$\frac{\alpha}{\alpha+\beta}$	$\frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$	0, 1	$\frac{1}{B(\alpha, \beta)} x^{\alpha-1}(1-x)^{\beta-1}$
Exponential	Time until next event	t	λ	$\frac{1}{\lambda}$	$\frac{1}{\lambda^2}$	$0, \infty$	$\lambda e^{-\lambda x}$
Binomial	Number of “successes” from n trials	x	p, n	pn	$np(1-p)$	0, 1, ..., n	$\binom{n}{x} p^x (1-p)^{n-x}$
Poisson	Litter size, counts	x	λ	λ	λ	$0, 1, ..., \infty$	$\frac{e^{-\lambda}\lambda^x}{x!}$