February 10, 1995

FW 662 Midterm Exam

This exam is a take-home, open-book exercise. There are 6 questions; you must answer <u>all</u> of them. You may use any reference material (class notes, assigned reading, library material, etc.). Under <u>NO</u> circumstances are you to discuss this exam with classmates or any other individual. Your are to work independently and you should not confer with others. If you need clarification on a question, please see the instructor. This exam is to be turned in by 8:00 am Monday, 15 February, at the start of class. Turn in this sheet and the test questions with your answers. Typed, short, concise answers will be graded more generously than hand-written, long, rambling responses. **Identify your answer sheets with your SSN only.** Only put your name (via your signature) on this sheet.

By my signature below, I certify that I have not collaborated with anyone concerning any material related to this examination.

________________ ________________________________ ____________________

SSN Signature Date

1. (30 pts.) The Rocky Mountain Arsenal (RMA) was recently enclosed within a deer-proof fence, all 40 km^2. The mule deer population in the area is expected to expand, as emigration is no longer possible. To avoid excessive population growth, RMA managers propose removing adult female deer from the compound each December using a technique reminiscent of the goose round-ups used in Fort Collins and Denver on geese. Kansas has already agreed to take all the mule deer does Colorado will provide. Further, the idea of a herd dominated by mature bucks appeals to Denver residents, who enjoy viewing the wildlife. The RMA managers are concerned with what number of the adult females would have to be removed each year to maintain the population at 1/3 of carrying capacity for the enclosed area. They recognize that density-dependent fawn survival probably occurs on the Arsenal, however, lack a functional relationship between fawn survival and density. As a result, they propose to use a modification of the function developed at Little Hills by Bartmann et al. (1992):

$$S = \frac{\exp(1.200 - 0.0525D)}{1 + \exp(1.200 - 0.0525D)}$$

where S is over-winter fawn survival (1 Dec. through 15 June) and D is deer density (deer/km^2) on 1 Dec. In addition, they expect fawn recruitment to stay at 70 fawns per 100 does on 1 Dec., and expect survival of all female deer other than fawns to be 0.9 and survival of all male deer other than fawns to be 0.7. The sex ratio of fawns is 50:50. Assume that the population is currently at carrying capacity.

1a. *What percentage of the adult females should be removed each year to have the population eventually reach and maintain itself at 1/3 of the carrying capacity predicted by these relationships?*

1b. What will be the buck:doe ratio in the long-term population after this program is initiated?

I'm expecting you to use some modeling technique to first compute the expected carrying capacity, then develop a curve relating the expected population size and buck:doe ratio to percentage of females removed. You may want to include a disk with your computer work, particularly if you have difficultly solving the problem. In addition, if you can work out how the solve the problem analytically, I'll be pleased, and your grade will reflect this.

2. (25 pts.) The Denver Zoo plans a new turkey exhibit. Because of the high reproductive rate of these birds, they do not want them reproducing. The market for zoo turkeys is not profitable. Hence, the decision is made to sterilize the birds when they are put into the exhibit. Given an annual survival rate of 0.8 for each bird and assuming no senescence, how many birds should be placed in the exhibit on January 1, 1995 to have a 90% probability of having 2 birds left on January 1, 2000? What is the mean number of birds left on January 1, 2000 if you are 90% sure that 2 will be left?

As with problem 1, this problem also has an analytical solution. I don't expect you to know how to solve it analytically. However, you have the tools at your access to approximate the answer numerically. Providing your numerical solution would help me evaluate your answer if you get off on the wrong track and don't get a correct answer.

3. (25 pts.) The local Bluegills Unlimited group stocked 10 pounds of bluegills (*Lepomis macrochirus*) in a local pond in 1990. The biomass of bluegills has been estimated by electrofishing and seining each year since:

Year	Biomass (lbs)
1991	25
1992	84
1993	223
1994	501

The members of the club have worked hard to make the pond a success, including lots of hours in generating these biomass estimates. They now want to enjoy the fruits of their labors, and want to set a regulation that will maximize the yield of bluegills from this pond for the indefinite future. You have been hired by the club to estimate the biomass of bluegills that can be removed from the pond each year based on the above data.

3a. What is your recommendation for the harvest?

3b. What concerns do you have about this recommendation? Likewise, what would you emphasize to club members about the value of your recommendations (i.e., how would you justify the large consulting fee you have charged the club)?

4. (5 pts) Define the following population projection matrix:

$$\begin{bmatrix} 0 & fs_0 & fs_0 \\ s_1 & 0 & 0 \\ 0 & s_2 & s_2 \end{bmatrix}$$

For each of the following functions, assume that the term on the left is replaced in the above matrix with the term on the right. Which of the functions will result in density dependence? In a sentence or 2, explain your reasons.

a. $f = f_0 - 0.1N$

b. $s_0 = a - bN$

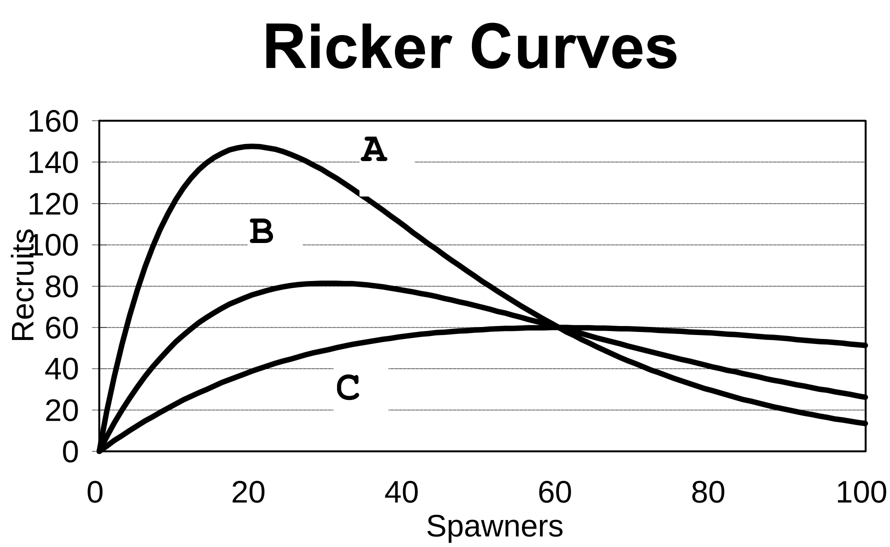
c. $s_1 = \beta_0 - \beta_1 N^{1/3}$

d. $s_1 = s_2$

e. $s_1 = \frac{s_2}{2}$

5. (10 pts) A nuclear power plant that currently operates in a Florida marsh is to be closed down. Both the wood ibis (*Mycteria americana*) and American coot (*Fulica americana*) inhabit this marsh year round. One of the major impacts of the power plant has been mortality of flying birds hitting power lines. These power lines will be removed as part of the decommissioning of the plant. Banding studies during the time that the plant has operated have estimated the wood ibis adult survival rate of 0.92 (SE 0.03) and the coot adult survival rate of 0.52 (SE 0.05). Which of these species would you expect to be least impacted by the removal of the power lines, i.e., which of these species would you expect to see the least increase in population size given that the power lines result in noticeable mortality? Why? Short answers please, i.e., 2-3 sentences.

6. (5 pts) In the following graph of 3 Ricker curves, which population would provide the most harvestable fish? Why? Short answers please, i.e., 2-3 sentences.



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1. The carrying capacity was K=40.3 deer/km^2 without removal. To achieve 1/3 of K, you needed to remove 13.05% of the does each year. The final sex ratio is either 72.47 bucks per 100 does, or 81.93 bucks per 100 does if calculated after the removal of does. Most of you did fine on this problem. Some of you messed up the removal and reproduction process, which is what this problem is really about.

2. I expected you to construct a pure death process with survival of 0.8, and duplicate this model for lots (>=1000) of times to compute the mean population size and the number of times the population in year 2000 was 2 or more. Then, for various starting values, you should have found that N0=11 gives a mean of 3.604 and probability of 2 or more birds of 0.92. However, N0=10 gives a mean of 3.277 and probability of 0.889. I haven't worked out an analytical solution! I took off ½ credit if you computed the mean correctly, but did not understand that I wanted 2 birds left with probability 0.90.

3. I expected you to fit a logistic or Ricker equation to the observed data using nonlinear least squares and log-transformed values to standardize the variance across the range of observed values. I found K=752.08 and R0=1.886, giving MSY=354.667. Fitting a straight line to (N(t+1)-N(t))/N(t) lost you 10 points -- this is the induced regression problem, and you would find a relationship where there is none. For the second part, I wanted some discussion about 1) assuming a model with constant K (assumption that the system and habitat are not changing through time), 2) impact of stochasticity on the estimates, and to have a complete answer, 3) some discussion about how to test you predictions even as they are implemented (i.e., adaptive management). Nobody suggested adaptive management! Some of you discussed time lags and age structure, but I'm not sure these would be a big deal for bluegills. All of you whined about the lack of data, but nobody suggested how to implement some harvest and continue to collect data. Also, nobody tested the hypothesis of exponential vs. density dependent growth in a rigorous fashion. I was also unhappy to see some of you saying MSY=K/2. K/2 is the population size that generates the MSY <u>under</u> the logistic model.

4. Parts a, b, and c are all density dependent because the parameter is a function of N, d and e are both density independent because the parameter is not a function of N.

5. I accepted either answer for this question, depending on your justification. You could argue that the ibis would show the least response because the survival rate is already so high that it is unlikely to increase further. In contrast, you could argue that the coot would show the least response because it is more likely to demonstrate compensatory mortality, and hence a change in the force of mortality from the power lines would not cause an overall change. I didn't like this question after I looked at your answers.

6. Curve A is the correct answer -- that is the curve that gives the greatest number of recruits per spawner.