February 12, 1993

FW 662 Midterm Exam

This exam is a take-home, open-book exercise. There are 5 questions; you must answer all of them. You may use any reference material (class notes, assigned reading, library material, etc.). Under NO 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

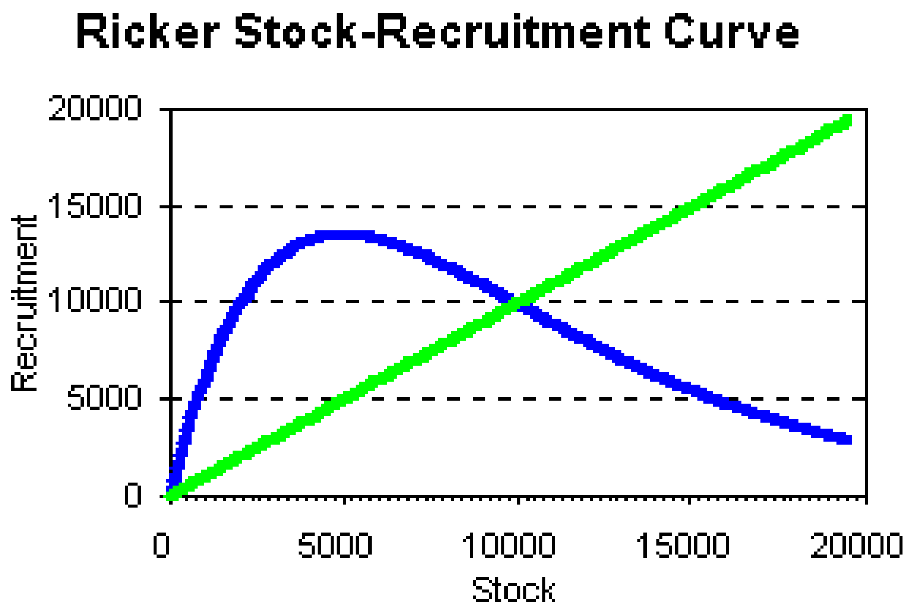
1. (40 pts.) The Rocky Mountain Arsenal (RMA) was recently enclosed within a deer-proof fence, all 40 km^2. The mule deer population in the area is expected to expand, as emigration is no longer possible. To avoid excessive population growth, RMA managers propose injecting female deer with a slowly releasing compound that will sterilize them for life. Once a female has been injected, she will never have another fawn. The RMA managers are concerned with what percentage of the adult females would have to be injected to maintain the population at 1/2 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. *What percentage of the adult females will have to be sterilized to maintain the population at 1/2 of the carrying capacity predicted by these relationships.* 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 to percentage of females sterilized. 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 my pleasure.

2. (15 pts.) The Colorado Division of Wildlife uses a variation of the Leslie matrix population projection model (POP II) for setting harvest quotas for mule deer and elk. Among the many inputs to this model, it requires the over-winter survival rates for each age and sex class in the model, a winter-severity index for each year, the reproductive output of each female age class for each year, and the harvest of young of the year, other females, and other males. Survival rates for each year are adjusted up or down depending on the winter severity index for the year using a pre-defined function built into the model. No density dependence is included in the model per se. How would you view this model as a tool for setting harvest quotas? Would you expect that CDOW biologists would tend to err by being too conservative, too liberal, or right on? Explain your rationale for your answer.

3. (10 pts.) The local Bluegills Unlimited group collects Christmas trees each year to place in local bluegill (*Lepomis macrochirus*) ponds to improve the habitat and increase the survival of younger age classes. The sunken Christmas trees are thought to provide shelter from the bluegill's main predator, largemouth bass (*Micropterus salmoides*). The local fisheries biologist has developed the following stock-recruitment curve for bluegills in Bluegill Lake:



where the Ricker equation

$$\text{Recruits} = \text{Stock}\ \exp\left[R_0\left(1 - \frac{\text{Stock}}{K}\right)\right]$$

has parameters R_0 = 2 and K = 10000. *How do you think the addition of the Christmas trees to Bluegill Lake will affect this stock-recruitment curve?* I'm not asking for exact quantitative changes, but rather qualitative changes. A graph showing the old curve, and how you expect the new curve to look, plus your reasoning for the expected changes, will be acceptable.

4. (25 pts.) Your colleague comes into your office all excited. He claims to have developed a model of minimum viable population size for grizzly bears in Yellowstone National Park. He enthusiastically shows you model output, with the population not going extinct in over 8000 years (the number of rows in her spreadsheet), although you notice a lot of variation in the population size (range from 15 to 500). Your curiosity gets the best of your better judgement, and you show a bit of interest by asking how come the population shows such high variation. He tells you that the model incorporates temporal variation in the age-specific survival and reproduction rates. Each year's rate is picked from a uniform distribution centered around the mean rate observed in the Craighead and Craighead grizzly bear report. The upper and lower bounds on the uniform distribution are selected to be $\pm$30% of the average rate, although no survival or birth rate is allowed to be less than 0.1. He says this temporal variation is more than adequate to realistically model the observed variation in the real population, and he claims that the bear population really isn't in any

danger of going extinct. *Do you agree with her conclusions?* Provide relevant arguments to justify your answer. *Use what you've learned in this course to discuss issues relevant to this model.*

5. (10 pts. total, 2 pts. each) Short answers please, i.e., 1-2 sentences each.

a. Both a sandhill crane (*Grus canadensis*) and a northern bobwhite (*Colinus virginianus*) population are unhunted. The crane population has an adult annual survival rate of 0.90, whereas the bobwhite population has an adult annual survival rate of 0.4. If a hunting season was imposed on each of the populations that harvested 10% of the population, which would be most likely to demonstrate compensatory mortality? Why?

b. Assume the instantaneous mortality equation $n_\theta + m_\theta - n_\theta m_\theta$, where n_θ represents natural mortality in an unfished population, and m_θ represents fishing mortality in a situation with no natural mortality. How could you estimate these two parameters in a bluegill (*Lepomis macrochirus*) population where the fishing season is open all year (including ice fishing)?

c. If the data analyzed by Smith and Reynolds (JWM 56:306-316) were extended 4 more years to increase the power of the analysis, would they have been able to distinguish between density-dependent effects and hunting effects? Explain.

d. Why do you suppose additivity was proposed as the first model of competing risks of mortality ?

e. A major powerline is put across a duck marsh. About 100 mallards are killed per year out of a resident population of about 5000. Local environmentalist demand that the power company release 100 mallards each year to mitigate the damage caused by the power line. As the biologists for the power company, how do you respond to their demands? Explain your logic.

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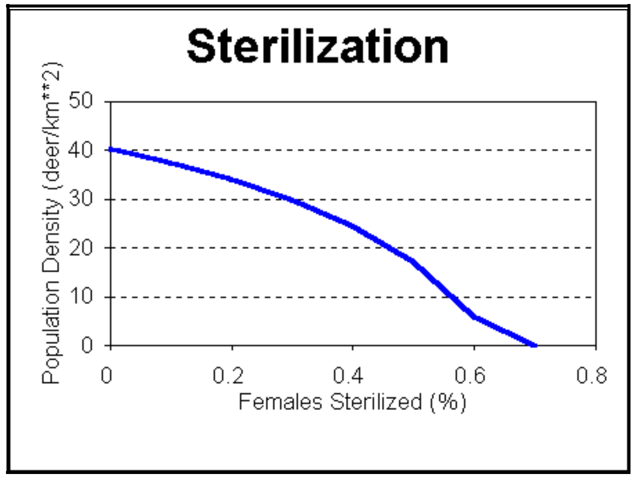
1. I tried to make the problem easy by not worrying whether you considered a subadult age class. Assuming that the recruitment rate of 0.7 fawns per doe was for every female >1 year old, a value of K=40.13 results, and you need to sterilize ~46.6% of all adult females. With a subadult age class, you need to sterilize ~38.5% of adult females. Some of you examined the number of does you needed to sterilize each year, which should be in the range of 8-9%. A common problem was leaving out ( ) in the denominator of fawn survival. A copy of a simple spreadsheet (MIDTERM.WQ1) that solves this problem will be put on the CLL network on Friday morning.



2. Many of you misinterpreted how POPII is used, so I had to grade quite different answers. CDOW uses POPII to estimate the population after a harvest is removed, not to project to what the population will be at the time of the harvest. In either case, I wanted you to point out the model lacks density dependence, and hence MSY is not a concept of the model. Further, harvest quotas would tend to be too conservative because the lack of density dependence means no compensatory mortality. Some credit was given for discussion of the lack of stochasticity of the model, although I think that most of you threw this in not recognizing whether stochasticity would really make much difference in decisions on harvest quotas. Others pointed out the influence of poorly estimated parameters in the model input.

3. I wanted you to argue some change in either (or both) of the parameters of the Ricker equation. The Xmas trees should increase the habitat, and hence increase K, causing the equation to cross the 45^o line further from the origin. The value of R_0 should increase because the death rate should decrease. Note that R_0 is not interpreted as the intrinsic rate of increase, because the predation rate would be assumed a constant proportion with no trees, and larger with trees because of a smaller death rate. An increase in R_0 causes the Ricker curve to increase in height, but still cross the 45^o line at the same location as the initial curve (same K).

4. The stochastic model incorporates only temporal variation, and this variation is modeled in a very strange way with the uniform distribution. Survival is constrained to be at least 0.1, so that the population can <u>never</u> actually go extinct, given that real numbers are used in the model. Further, no demographic variation is incorporated in the model, so when the population is at very low levels (i.e., <20), the increased chance of extinction from demographic variation is not modeled. The survival and reproductive rates are selected from a uniform distribution each model year, so 8000 years is a realistic run of the model to examine the probability of extinction. You don't need to perform multiple runs for this long of time trace. Several of you assumed that

values of survival and reproduction were only selected from the uniform distributions at the start of the run. If this were the case, why did the population vary from 15 to 500? Constant survival and reproduction rates result in density dependence, and hence a final population of in the limit either 0 or ∞. The final weakness of the model is the lack of density dependence.

5a. Bobwhites, because survival is much smaller than the cranes, allowing for much greater compensation. The threshold for additive mortality is much larger for bobwhites.

5b. Probably you can't estimate these parameters, certainly not m_0. n_0 can be estimated if fishing is removed, requiring a major perturbation to the system. Splitting the lake into replicate areas doesn't make sense to me because the investigator couldn't control immigration and emigration. However, I gave credit for lots of crazy designs.

5c. The hunting and density-dependent effects are still confounded, so still cannot be distinguished.

5d. Probably because it is the simplest and most intuitive. Note that mortality risks are still competing, even under additive mortality. Under additive mortality, we can compute the change in survival with changes in the number of sources of mortality, unlike under compensatory mortality.

5e. Compensatory mortality probably operates with a resident mallard population, so removing 100 of 5000 (2% mortality) is most likely compensated by a reduction in other sources of mortality. However, politics being politics, as a biologist for a power company, you will probably put out >100 mallards and benefit from the PR effort! Or, to quote a nice answer read at 11:00 pm Monday night: "Tell them dead ducks make good raccoon food so the power lines are good for the environment, and if they don't quit complaining they won't be watching any TV tonight".