Quantitative Ecology and Resource Management

APPLIED QUALIFYING EXAMINATION INSTRUCTIONS

Spring Quarter 2006 (June 15-20, 2006)

This packet contains:

- This cover sheet.
- Examination questions (in two parts) and hard copy of data for Questions a. and b. Joanne will also e-mail the data to you. Please check and make sure that you receive these e-mails. If there are problems please e-mail Joanne ASAP.

INSTRUCTIONS:

1. Provide a 1-3 page summary at the very beginning of your examination.

2. For each question, your writeup should include a narrative (including any pasted in tables, graphics, etc.) showing the thought process of the analysis, the results at each step, and how that leads to the next step.

3. Clearly describe in your text the points that any diagrams or tables demonstrate.

4. All graphs should be clearly labeled and computer output annotated as need be.

5. Your unique student identification number is located at the top of this instruction sheet. This identification number must be clearly marked on **EVERY** page of the examination. **DO NOT INCLUDE YOUR NAME ON THE EXAMINATION.**

6. Number each page of the exam.

7. Appendices should be numbered so that any references to the Appendix refer to a particular set of pages.

8. If you print any pages in color please provide 4 copies of each colored sheet. If using only black print, 1 copy of the exam is sufficient.

9. **Completed examinations must be returned to the QERM office (Loew 304) by 10:00 a.m. on Tuesday, June 20. If you turn it in early please leave it in Joanne's Loew Hall 304 mailbox.**

LIBRARY HOURS:

REMEMBER libraries may be CLOSED Saturday and Sunday, so any reference materials you might need should be checked out before then.

QUESTIONS?

Questions regarding the exam should be directed to David Ford at edford@u.washington.edu. Office phone: 685-9995.

If you need to reach Joanne feel free to e-mail her at jbesch@u.washington.edu, or call her at home phone at 525-2414, or cell phone at 206-661-5054.

Investigation of the cause of summer decline in vole populations

Vole populations sometimes decrease abruptly in the middle of the breeding season. This phenomenon is known as the "summer decline" in vole populations. Many hypotheses have been advanced to explain the driving factors for this decline. Predation is a major cause of death in vole populations but, predation alone has been claimed to be insufficient to produce the population declines that are sometimes observed in the breeding season.

One suggestion is that there are interactions between extrinsic (i.e., predation) and intrinsic (i.e., social organization) factors that explain the summer decline of vole populations. The loss of individuals through predation provides vacant space for unfamiliar immigrants and this predator-induced turnover (predation and subsequent immigration) causes disruptions of social organization followed by reduced reproduction and survival. Female voles have a distinct territory, that only they occupy (frequently around 80 m^2), and a home range which is a larger area and overlaps with that of neighboring females. Males have a larger territory (frequently around 420 m^2) and mate with a number of females. Voles eat seeds, tubers, shoots, foliage and insects, and forage throughout their home range.

One hypothesis is that male turnover is the driving force through which predation interacts with social factors to reduce population growth. There are three behavioral reasons for this hypothesis: First, predation in voles is often observed to be higher in males than in females. Second, males roam over large areas and interact with several females within their home range so that the turnover of one male will affect several females. Third, males are known to be the dispersing sex and so the sex most likely to immigrate and appropriate a vacant territory. There are also two demographic reasons behind this hypothesis. First, intruding males in several mammal species are known to be infanticidal, to increase their own reproductive success, i.e., when a new male occupies a new territory it kills the young of the females it will mate with and that were sired by the females' previous mate. Second, the presence of unfamiliar males may postpone breeding due to the Bruce effect. The Bruce effect is when females reabsorb their fetus in early gestation as a response to the vicinity of unfamiliar males. This effect is thought to be a female's adaptation to avoid carrying through a litter that will suffer from infanticide just after birth. Instead, the female will mate with the new male and carry and wean his litter.

An experiment was conducted to test the prediction that the interaction between extrinsic (i.e., predation) and intrinsic (i.e., infanticide and the Bruce effect) factors could be promoted by the replacement of lost males by immigrant males. The experiment was assigned to 18 independent root vole populations and male turnover was simulated in nine of these populations. This was done by simulating predation through the removal of males from the population and simulating immigration by reintroducing unfamiliar males.

The experiment was performed on eighteen plots (each 50.0 X 33.4 m) located in meadow vegetation of the same type as natural vole habitat and enclosed by steel sheet walls that prevented movement of voles, or other animals, in or out of the plots. Plots were protected from avian predators. All voles were removed from each plot prior to the experiment then 20 non-pregnant adult females and 4 adult male root voles were randomly assigned to each plot. This population size and area is typical of that found in natural vole populations.

In the nine treated plots the experiment had three phases:

1) A pre-manipulation interval of 19 days without trapping during which male and female territories established and females would become pregnant. Note that some small gradual amount of mortality from the initial 20 voles would be expected

2) A manipulation period of 14 days, consisting of removing one male by live trapping and introducing one foreign male every third to fourth day. That is, there were four male removals and introductions in each of the nine treatment plots; this rate was based on estimates of natural mortality. The manipulation period cover the period of birth of the first cohort in the population. On average those females still alive delivered their first cohort of pups (i.e., baby voles) 24.6 $\pm$ 0.53 days after their first release. Note that pups are usually weaned at 16 days old and will stay in the nest until they are weaned and so would not be caught in traps until that time or later, i.e., 24.6 + 16 = 40.6 days after the start of the experiment.

3) After the manipulation period the populations were left undisturbed for 25 days before ending the trial by continuously live-trapping for three whole days to ensure the capture and removal of all animals still alive in the area.

Female populations were exhaustively trapped: T1 = day 4 after establishment; T2 = day 19 at the end of the pre-manipulation interval; T3 = day 33 at the end of the manipulation period; and T4 = 58 at the end of the post manipulation phase. This data file is in Appendix A.

The spatial organization of voles was quantified at the end of the manipulation period by performing a short-term trapping session to obtain as many spatial locations as possible per individual (traps were checked every 30 min for 24 h; i.e., 48 trap checks). During this short-term trapping session all individuals known to be alive were captured at least once. The home range of each female was estimated by calculating the minimum convex polygon of its capture locations and overlap in home ranges is estimated as the overlap of these minimum convex polygons.

What was unexpected in this experiment was that female survival in the plots where males were replaced decreased as the estimated overlap of female home ranges increased. This suggests that there may be antagonism between females, possibly between those that have mated with introduced males and those that have not, or possibly related to the presence and absence of nestlings with a female.

Question A. Describe how you would construct an individual based model, to be implemented in an object oriented mode in C++, that would simulate mating and reproduction in these voles and could be used to investigate the possible effects of male replacement, infanticide, the Bruce effect, and possible antagonism between females over a complete year. Given the time available to you we do **NOT** expect a completed and fully functional model but you should describe the practice of good modeling and how you would apply it in this case. Be careful to:

1. describe the system,
2. define the bounds of the model you propose,
3. describe how you would calibrate the model,
4. define sensitivity analyses you would perform, and
5. describe how you would assess the model.
6. Describe the objects that you would use in the C++ program, how you would design their constructors and destructors, how you would program spatial interaction and give some discussion and preliminary code for one or more classes.

Question B.
1. Find a suitable statistical model to relate final adult female survival to percentage of the home range overlapping with other females at the end of the manipulation period, keeping in mind that there are two populations, treatment and control. The data set for this part is listed below. Note that the variable "females" is the number of females at the end of the manipulation period; "hr.overlap" is the home range overlap at the end of the manipulation period; and the variable "surv.females" is the number of surviving females at the end of the post-manipulation period.

2. For home range overlap = 30%, compute the difference in survival between the Treatment and Control groups, along with a 95% confidence interval for this difference.

3. There is an "extreme" data point in this data set that may be influential in terms fitting models to the data. Find this data point and describe its effect on the analysis in part [B1].

Data for Question B are as follows:

Col. 1 = Unit ID # [idunit]
Col. 2 = % of homerange overlap [hr.overlap]
Col. 3 = number of females during manipulation period [females]
Col. 4 = number of surviving females, post-manipulation period [surv.females]
Col. 5 = Control or Treatment group [tcgroup]

```
idunit hr.overlap females surv.females tcgroup
1  11.4 17 17 C
2  24.3 16 16 C
3  25.7 13 13 C
4  35.7 14 14 C
5  38.6 15 15 C
6  51.4 14 14 C
7  05.0 15 12 C
8  11.4 14 12 C
9  12.9 15 13 C
10 27.1 14 12 T
11 38.0 15 10 T
12 08.8 14 12 T
13 23.1 14 12 T
14 28.6 20 15 T
15 35.7 14 11 T
16 42.3 19 15 T
17 37.8 14 09 T
18 54.6 14 03 T
```

APPENDIX A: Female population counts at times T1, T2, T3, T4

females	time.period	tcgroup
16	1	C
17	1	C
22	1	C
17	1	C
20	1	C
13	1	C
16	1	C
18	1	C
18	1	C
23	1	T
16	1	T
18	1	T
17	1	T
18	1	T
13	1	T
16	1	T
14	1	T
19	1	T
10	2	C
21	2	C
22	2	C
13	2	C
22	2	C
16	2	C
17	2	C
10	2	C
13	2	C
18	2	T
17	2	T
16	2	T
14	2	T
20	2	T
15	2	T
20	2	T
15	2	T
07	2	T
17	3	C
16	3	C
13	3	C
14	3	C
15	3	C
14	3	C
15	3	C
14	3	C
15	3	C
14	3	T
15	3	T
14	3	T
14	3	T
20	3	T
14	3	T
19	3	T
14	3	T
14	3	T

22	4	C
41	4	C
35	4	C
38	4	C
38	4	C
31	4	C
31	4	C
27	4	C
27	4	C
19	4	T
17	4	T
26	4	T
19	4	T
22	4	T
21	4	T
21	4	T
14	4	T
23	4	T