Quantitative Ecology and Resource Management

APPLIED QUALIFYING EXAMINATION INSTRUCTIONS

Spring Quarter 2007 (June 14-19, 2007)

This packet contains:

- This cover sheet.
- Examination questions and hard copy of data. 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 write-up 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 19. 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 Loveday Conquest:
conquest@u.washington.edu (does not check for e-mails over weekend or evenings)
home phone: 206-325-7237, office: 206-543-1708.
You may also contact Mark Kot at kot@amath.washington.edu.

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.

QERM 2007

Applied Exam

1. Background and Data

The white-eyes are a homogeneous family (Zosteropidae) of small arboreal birds. They are widely distributed in the Old World, with representatives in Africa, Asia, and Australia. They also inhabit most of the islands of the Indian Ocean and the Pacific Ocean. White-eyes are not especially strong fliers. Their success at colonizing remote islands is instead thought to stem from their gregariousness: Except when breeding, white-eyes move and disperse in large flocks. The chances that enough pairs reach an island to colonize successfully, when carried there by wind and weather, thus appears to be greater than in less gregarious species. White-eyes are mainly insectivorous, but they also eat nectar and soft juicy fruit with the help of their brush-tipped tongues.

Scientists have studied a population (of one well-known species) of white-eyes for over 40 years. This population inhabits an isolated, 16 ha island. Individuals have been color-banded since 1964 and data suggest that there is little immigration to or emigration from the island. A census of the number of surviving adult birds, at the beginning of each breeding season, is available for 1967–1993 (see Table 1). Four major tropical cyclones, occurred during the course of this time series, prior to the 1967, 1972, 1980, and 1992 breeding seasons.

Table 1: Annual Census

Year	Population	Year	Population
1967	255	1981	381
1968	434	1982	483
1969	407	1983	419
1970	326	1984	465
1971	293	1985	392
1972	225	1986	408
1973	421	1987	437
1974	376	1988	417
1975	398	1989	343
1976	347	1990	396
1977	325	1991	403
1978	341	1992	375
1979	476	1993	432
1980	354		

The breeding activity and nesting success of banded birds were carefully monitored between 1979 and 1993. During those years, nestling and fledgling white-eyes were also banded. Finally, investigators surveyed the island for the main white-eye predator, the brown tree snake *Boiga irregularis*, a tree-climbing nest predator. Table 2 shows data on the number of adults, the number of adults that attempted to breed, the number of banded nestlings or fledglings, the percentage and number of banded young that survived to breeding, and the number of predators for the years 1979–1992.

Table 2: Breeding Success

Year	A	B	C	D	E	F
1979	476	383	301	13.95	42	13
1980	354	314	287	13.94	40	18
1981	381	327	324	27.47	89	03
1982	483	370	259	22.39	58	13
1983	419	368	319	19.75	63	14
1984	465	348	281	16.73	47	05
1985	392	328	282	17.38	49	15
1986	408	317	231	31.17	72	06
1987	437	316	139	22.30	31	20
1988	417	365	301	15.28	46	10
1989	343	288	392	23.47	92	09
1990	396	317	369	20.87	77	17
1991	403	335	309	22.01	68	14
1992	375	315	237	20.68	49	14

A = number of adults
B = number of breeding adults
C = number of young banded at or near the nest
D = % of young that survived until 1st breeding
E = number of young that survived until 1st breeding
F = number of predators

Since the above data are long-term, have little observation error, and are from a closed population, they may tell us something about the factors that regulate the growth of natural populations.

2. Questions

(1) One model that can be used to analyze the population data in Table 1 is the simple difference equation

$$N_{t+1} = N_t \exp(a + b N_t + \sigma Z_t), \tag{1}$$

where N_t is the population size at the start of breeding season t and Z_t is a random variate that accounts for environmental disturbance. (Assume that Z_t has a normal distribution with standard deviation 1.)

What kinds of population regulation are present in this model? What is the biological interpretation of the parameters a and b? What do you expect of these parameters, e.g., with regards to sign and magnitude ?

Analyze the above difference equation in the absence of environmental variation (for $\sigma = 0$). Find all equilibria and analyze their stability. What other dynamics do you expect to arise from this model (for appropriate choices of the parameters a and b) ? Use bifurcation diagrams, Lyapunov exponents, and/or whatever other tools you have at your disposal to characterize the dynamics of the above model. Be sure to discuss the effects of the parameters a and b on the dynamics of the model.

(2) Difference equation (1) may also be rewritten as

$$\ln\left(\frac{N_{t+1}}{N_t}\right) = a + b\,N_t + \sigma\,Z_t\,, \tag{2}$$

meaning that the logarithm of the rate of increase between one year and the next can be expressed as a linear function of the population size for that year.

Analyze the data in Table 1 to obtain estimates, standard errors, and 90% confidence intervals for the parameters a and b, and the error variance σ^2. What assumptions are you relying upon to get the standard errors and the 90% confidence intervals?

(3) "Is fledgling survival density dependent ?" Investigate the effect of the population size, the number of birds attempting to breed, and the number of predators on fledgling survival. Justify your model. Use an $\alpha = 0.10$ level of significance. Investigate 1986 to see whether it is an "unusual year" in terms of its predictor values and/or its observed fledgling survival. Compute a 90% confidence interval for the fledgling survival for 1986.

(4) The interaction between environmental stochasticity and deterministic dynamics is an important topic in population ecology. Generate population time series (of moderate length) by simulating equation (1) for a variety of dynamic regimes and noise levels, i.e., for different choices of a, b, and σ. For each time series, plot N_{t+1} as a function N_t, plot $\ln(N_{t+1}/N_t)$ as a function of N_t, and assess your ability to extract the deterministic portion of equations (1) and (2) from empirical data. What trends and patterns do you observe ? Can you provide an explanation ?

(5) A number of ecologists have suggested that time lags may be important factor in population models. Analyze the second-order difference equation

$$N_{t+1} = N_t \exp\left(a - b\,N_{t-1}\right).$$

Compare and contrast your analysis with your earlier analysis in question 1. What is the effect of introducing an explicit time lag into equation (1) ?

Table I

yr	pop	rate	log.rate
1967	255	1.702	.53178
1968	434	.9378	-.0642
1969	407	.8010	-.2219
1970	326	.8988	-.1067
1971	293	.7679	-.26407
1972	225	1.871	.62653
1973	421	.8931	-.113
1974	376	1.0585	.05686
1975	398	.8719	-.1371
1976	347	.9366	-.0655
1977	325	1.049	.04806
1978	341	1.396	.33353
1979	476	.7437	-.2961
1980	354	1.076	.0735
1981	381	1.268	.2372
1982	483	.8675	-.1421
1983	419	1.110	.1042
1984	465	.8430	-.1708
1985	392	1.041	.0400
1986	408	1.071	.0687
1987	437	.9542	-.04685
1988	417	.8225	-.19535
1989	343	1.1545	.1437
1990	396	1.018	.0175
1991	403	.9305	-.0720
1992	375	1.152	.1415
1993	432	NA	NA

Table II

year	adults	breeds	banded	per.surv	no.surv	predators
1979	476	383	301	13.95	42	13
1980	354	314	287	13.94	40	18
1981	381	327	324	27.47	89	03
1982	483	370	259	22.39	58	13
1983	419	368	319	19.75	63	14
1984	465	348	281	16.73	47	05
1985	392	328	282	17.38	49	15
1986	408	317	231	31.17	72	06
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