Interdisciplinary Graduate Program in
Quantitative Ecology and Resource Management

APPLIED QUALIFYING EXAMINATION INSTRUCTIONS
Spring Quarter 2005
(June 9–14, 2005)

This packet contains:

- This cover sheet.
- Examination questions (in three parts) and hard copy of data for Questions 1 and 2. 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 1-2 page summary at the very beginning of your examination.
2. Clearly describe in your text the points that any diagrams or tables demonstrate.
3. All graphs should be labeled clearly and computer output annotated as need be.
4. Appendices should be numbered so that any references to the Appendix refer to a particular set of pages.
5. Number each page of the exam.
6. A unique 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.**
7. 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.
8. Completed examinations must be returned to the QERM office (Loew 304) by 10:00 a.m. on Tuesday, June 14. 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?

Dr. Conquest should be contacted if there are questions on the statistical portion of the exam. Her office phone is 221-7966, home phone is 206-325-7237.

Questions regarding the modeling portion of the exam may be directed to David Ford at edford@u.washington.edu. Office phone: 685-9995, Home phone: 323-9174. Mark Kot may also be reached by e-mail at kot@amath.washington.edu. Office phone: 543-0908.

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.

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QUESTION #1

Two species, 1 and 2, are perennial plants that colonize abandoned fields following shifting cultivation in a high mountainous region of the Andes. Species 1 is the primary colonizer and is succeeded by species 2. Species 1 forms a rosette, normally some 4 cm tall at its center with a radius of ~6 cm. Species 2 is a spike, typically extending up to 15 centimeters tall when mature The question arises whether Species 1 is a "nurse" species for Species 2, that is, if in some way Species 1 provides shelter or other favorable environmental conditions for Species 2.

Two sites have been investigated. On one, Site A, agriculture was abandoned 6 years before the data was collected and on the other, Site B it is thought that agriculture was abandoned some 15 years ago. There are two types of soil at both sites: a sandy soil and a loam. The predominant wind direction on both sites is from the south west.

At each site maps of plant locations have been made on 1m x 1m plots that each have their 0,0 points at the south west corner. Two maps were made in each site and soil type combination.

	Site A	Site B
Sandy soil	Plot 1 Plot 2	Plot 5 Plot 6
Loam	Plot 3 Plot 4	Plot 7 Plot 8

The data for each plot is presented on the unit square and in three columns: x coordinate, y coordinate and species indicator 1 or 2.

Using distance statistics in *spatstat* describe evidence suggesting that Species 1 may be a nurse species for Species 2, or that it may not be a nurse species. You should compare calculations on the data with calculations on distributions generated by known models. What are the principle features of the spatial distributions at both Site A and Site B and do you think soil type affects any of the ecological processes that are operating? Do limitations in the data affect your interpretation of the processes?

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QUESTION #2

This question and the accompanying data set pertain only to Species 2 (the spike). There are 30 early-stage plants and 30 late-stage plants. At each stage, 15 of the plants are from sandy soil and the other 15 from loam. Each plant has a height measurement and also the number of seeds produced. Use appropriate statistical analysis to investigate the effects of soil type and plant height on the number seeds produced for the two stages of plant growth, early and late. Discuss the effect differences between the two stages of plant growth; justify your results.

Column 1 = soil type; 1=sand, 2=loam.
Column 2 = height (cm), early stage plants.
Column 3 = number of seeds produced, early stage plants.
Column 4 = height (cm), late stage plants.
Column 5 = number of seeds produced, late stage plants.

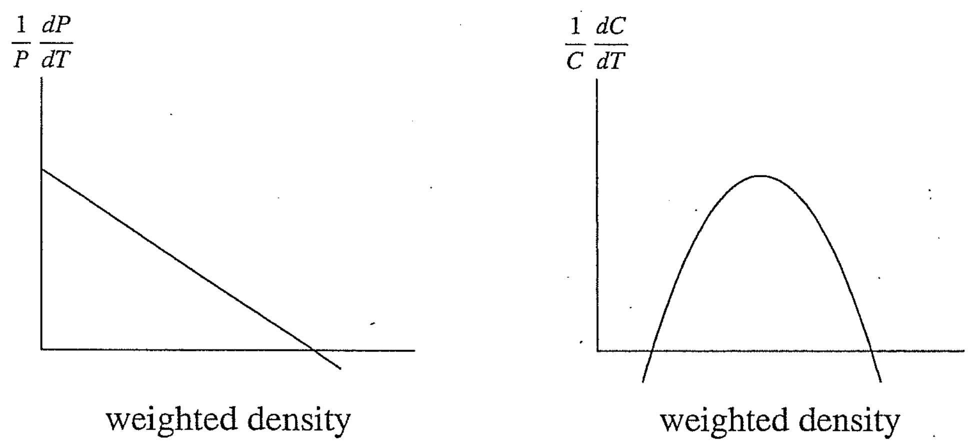
1	2.9	0	6.1	0
1	5.5	28	6.1	1
1	4.6	12	9.7	12
2	4.5	13	13.1	67
1	2.2	1	6.2	2
2	3.1	5	6.1	1
1	4.0	10	6.1	0
2	4.6	12	6.6	1
2	4.2	10	6.9	1
1	2.7	6	9.8	13
1	2.3	3	6.6	0
2	4.5	15	16.6	139
1	3.8	7	10.1	17
2	3.0	2	6.0	0
1	2.7	3	6.4	0
1	4.4	6	6.2	0
2	3.4	7	7.9	4
1	6.9	130	6.0	1
1	8	3	6.9	3
1	1.5	1	6.6	0
2	3.4	3	9.5	9
2	3.2	4	6.1	0
1	2.9	2	6.1	3
2	3.5	4	6.4	0
2	1.7	0	19.1	81
2	5.6	42	9.7	9
2	6.0	50	6.1	3
1	2.7	2	8.1	7
2	3.8	10	8.2	3
2	5.3	28	6.9	2

QUESTION #3:

3. Background

Early successional species often facilitate the colonization and growth of late successional species. For example, late colonizing species may thrive in the shade and soil conditions beneath pioneer "nurse plants." As they grow, these late-colonizing plants may eventually outcompete and kill their nurse plants.

Several scientists have developed simple pioneer–climax models to describe the interactions that may occur between populations of an early pioneer species and a late climax species. The pioneer (P) thrives at low densities and has a per capita growth rate that decreases with a weighted density of plants in the community (see Figure below). The climax species (C), in contrast, does poorly at low densities. It has a per capita growth rate that increases with (weighted) density, eventually exceeds that of the pioneer species, and falls back down at high densities. The weighting of densities is different for the two species, reflecting differences in intraspecific and interspecific effects.



You will be asked to analyze a simple pioneer–climax model.

Problem

Please analyze the simple pioneer–climax model

$$\frac{dP}{dT} = F(P, C)\,P\,, \qquad \frac{dC}{dT} = G(P, C)\,C\,, \tag{1}$$

where

$$F(P, C) = r\left[1 - \frac{(P + b_{12}\,C)}{K_0}\right], \qquad \text{(2a)}$$

$$G(P, C) = s\left[1 - \frac{(C + b_{21}\,P)}{K_1}\right]\left[\frac{(C + b_{21}\,P)}{K_2} - 1\right]; \qquad \text{(2b)}$$

P is the density of the pioneer species, C is the density of the climax species, T is time, and r, s, K_0, K_1, K_2, b_{12}, and b_{21} are positive parameters.

Give some serious thought as to the best way to proceed, but do, in any case, include the following items in your answer:

(1) Briefly describe the biological meaning of the terms in this model. Also, describe the biological signifi cance of the various parameters.

(2) What and where are the zero-growth isoclines for this model? Where, in the phase plane, does the pioneer population increase and/or decrease? Where does the climax population increase and/or decrease? What are the possible orientations of the zero-growth isoclines?

(3) How many equilibria can occur in this system? How many equilibria are on the axes (corresponding to the extinction of one or the other species)? How many equilibria can occur in the interior of the fi rst quadrant (corresponding to coexistence of the two species)?

(4) What is the nature (focus, node, saddle point, etc.) and the stability of each equilibrium? How are the stabilities affected by the positions and orientations of the zero-growth isoclines? Can attractors other than equilibria occur for this sytem?

(5) Draw phase portraits for interesting parameter regimes. Please draw as many qualitatively distinct phase portraits as makes good biological sense. Describe the biological implications of each phase portrait.

(6) Is the pioneer–climax model most like a predator–prey, a competition, or a mutualism system? Please discuss. Be sure to justify your answer.