ECOL 302 – Second midterm examination – Fall 2006

Put your name at the top of each page NOW. All questions are worth 8 points each. ANSWER IN THE SPACE ALLOTTED OR LESS. Use graphs or equations in your answers wherever you want or need to. Use correct units where applicable. You will need some of the following equations:

\[
\begin{align*}
\frac{dN}{dt} &= rN \\
\frac{dN}{dt} &= rN\left(\frac{K - N}{K}\right) \\
N_{t+1} &= \lambda N_t \\
G &= \sum l(x)m(x)x/\sum l(x)m(x) \\
N_t &= N_0e^{rt} \\
\ln N_t &= \ln N_0 + rt \\
r &= b - d \\
r &= \ln R_0 /G \\
N_{t+1} &= N_t(1 + r_0(K - N_t)/K) \\
R_0 &= \sum l(x)m(x)l(x) = S(x)/S(0)
\end{align*}
\]

(1) What is the equation that is used to determine how many individuals are added to a population that is exhibiting Malthusian (exponential) growth:

\[
\frac{dN}{dt} = rN \quad (N_t = N_0e^{rt} \text{ would be used to predict population size at time } t)
\]

Briefly state one of the assumptions that we make when using the Malthusian growth equation:

**Closed population; constant environment; all individuals the same; continuous**

(2) Describe or name the type of population dynamics illustrated in figures A through C (for C, focus on the part of the curve that is in the dashed circle).

(A) **negative exponential growth**

(B) **logistic growth**

(C) **Allee effect**

(D) On figure B below, label the equilibrium point. Mark and label where the population would be growing at a maximal rate
You introduce 5 individual fruit flies of the species *Ceratitis capitata* to an incubator filled with ripe apples to see how fast this species of fruit flies can grow. You provide ample food to the fruit flies, eliminate any predators, and hold the incubator at a constant temperature. In the table below are the results from the first 4 days after the introduction. Using the axes provided, plot the results and estimate the value of $r$. Remember to label the axes.

<table>
<thead>
<tr>
<th>Time since introduction (days)</th>
<th>N</th>
<th>ln(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.00</td>
<td>1.6</td>
</tr>
<tr>
<td>1</td>
<td>6.05</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>7.39</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>9.03</td>
<td>2.2</td>
</tr>
<tr>
<td>4</td>
<td>11.02</td>
<td>2.4</td>
</tr>
</tbody>
</table>

The slope is equal to $r$:

$$r = \frac{(2.4-1.6)}{(4-0)} = 0.2 \text{ individuals per (individual*time)}$$
(4) Populations rarely exhibit exponential growth as the environment usually limits their growth.
    (a) Give a brief definition of density dependent limits to growth (e.g. how does it differ from a density independent factor?).

    An effect where crowding, density, increased numbers, etc. leads to consumption of resources which limits growth (by a reduction in births or an increase in deaths).

    (b) Give ONE example (from class and/or your readings) of a population that was limited by food, water, space or territory. How did the researchers show it was a limiting factor?

    Food: Flatworms limited by calories– fed earthworms
    Pond Snails limited by nutrients (and calories) – fed spinach
    Red Grouse limited by nutrients – supplemented the heather with fertilizer
    Algae limited by phosphorus – sewage causes eutrophication

    Water: Quail – water storage system
    Annual flower germination – natural variation in precip.

    Space and territory: Barnacles in the rocky intertidal
    Bustards/geckos – artificial tree stumps added
    Flycatchers – nest boxes added
    Great tit – nest boxes added
    Bats – bridges give nesting sites
    Coqui/tree frogs – artificial nesting for reproductive adults
    Birds feeding on spruce budworms – hunting revealed more birds than territories

(5) On one graph (below) show the relationship between birth and death rates as functions of N for logistic growth. Label axes and lines clearly.
(6) You have been studying a population of clickers that is growing according to the logistic equation. If the carrying capacity is 750 clickers and the intrinsic rate of growth is 1.7 individuals/(individual*month), what is the maximum possible growth rate for the population?

The growth rate for the population is $dN/dt$. To solve this, you must first determine $N$, population size. From the plot of $dN/dt$ vs. $N$, we know that the maximum possible growth rate for a population growing according to the logistic model occurs when $N = K/2$, here $N = 350$ clickers. Plugging this into the logistic equation:

$$dN/dt = rN [1- (N/K)]$$
$$= 1.7(375)[1-(375/750)]$$
$$= 318.75 \text{ individuals / month}$$

(7) For the following figure, a hypothetical population is growing according to a logistic growth model.

(a) What assumption of the logistic model is being relaxed?

That population size ($N$) responds instantaneously to carrying capacity ($K$)

(b) What phrase would describe the dynamics of the growth pattern of this population?

The population is in a stable limit cycle
(c) What parameters make up the ratio that govern how this population changes with respect to carrying capacity (besides N)? Briefly and qualitatively describe the value of the ratio that produces this form of dynamics.

**Time lag (T) and responsiveness (1/r).** The ratio is \( T/1/r \) or \( T\cdot r \). To have a stable limit cycle the ratio must be relatively large – this can be due to a long time lag, or a slow responsiveness (fast intrinsic rate of growth).

(8) After several years of careful study, you collect the following life-table data for a population of kangaroo rats. Complete the life-table analysis by filling in \( l(x) \). Complete the calculations listed below. Show correct units where appropriate.

<table>
<thead>
<tr>
<th>Age (years): x</th>
<th>S(x)</th>
<th>m(x)</th>
<th>l(x)</th>
<th>l(x)m(x)</th>
<th>l(x)m(x)x</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
<td>5</td>
<td>0.2</td>
<td>1</td>
<td>1</td>
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<td>2</td>
<td>100</td>
<td>10</td>
<td>0.1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Calculate:
(a) Net reproductive rate: \( R_0 = R_0 = \Sigma l(x)m(x) = 2.0 \) clickers

(b) Generation time: \( G = \Sigma l(x)m(x)x / \Sigma l(x)m(x) = 3/2 = 1.5 \) y

(c) Estimated intrinsic rate of growth: \( r = \ln(R_0)/G = 0.693/1.5 \)

\[ r = 0.462 \text{ individuals/(indiv.*y)} \]
(9) **On one graph** (below) show the survivorship curves that you would expect for (1) humans and (2) fish (draw 2 different curves). Label axes and lines clearly.

(a) Describe in words what the curve illustrates for human survivorship:

**High probability or survival early in life; probability of mortality increases in older individuals**

(b) Describe in words what the curve illustrates for fish survivorship:

**Low probability or survival early in life; probability of mortality decreases in older individuals**

![Graph showing survivorship curves for humans and fish](image)

(10) Ideal free distributions are based on an argument that involves natural selection. What would happen to an individual's fitness if it were to deviate from the IFD (assume deviation does not include introducing despots into the population)? Why would this happen?

**An individual's fitness would decrease because the IFD assumes individuals will use habitats so as to maximize their fitness. Fitness will decrease because the individuals would no longer be using habitats (and resources) optimally.**