

Homework 4 (chapters 11-13):

1. Light is absorbed as it passes through water. The formula for calculating how much water reached a certain depth is:

$$I(z) = I_0 \exp(-k_e z)$$

Where:

$I(z)$ = light intensity at depth z

I_0 = Light intensity at the surface

k_e = Light extinction per unit of depth

z = depth (note: k_e and z must be in the same units, i.e. meters, feet, centimeters, etc.)

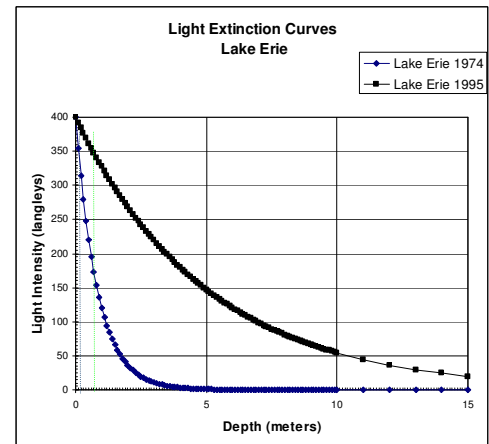
We will use the langley as a unit of light intensity; a langley is 1 calorie per square centimeter.

We will make several assumptions to simplify the calculations. We will assume that for all bodies of water, the solar radiation at the surface is 400 langleys. Further, we will assume that most phytoplankton require 350 langleys for optimal growth, and that the benthic cyanobacterium *Plectonema woolei* requires 50 langleys for optimal growth. Light extinction values are given in the table to the right. (Attach a printout of the data from part A to the end of your homework).

Habitat	Light Extinction ($k_e \text{ m}^{-1}$)
Lake Erie – 1974	1.2
Lake Erie – 1995	0.2
Lake Ontario – 1974	0.22
Long Island Sound	0.5
Open Ocean	0.05
James River Estuary	5.0
Lake Tahoe	0.08
Lake LBJ, Texas	0.30

A: On a single graph, plot the light extinction curves for each of the habitats in the table. A sample graph is presented to the right (ignore the dashed lines). Plot the depth to 25 meters.

- B. Prepare a table showing the optimum depth (in terms of light intensity) for phytoplankton and *Plectonema woolei* in each habitat.
- C. What factors affect light penetration?
- D. Compare and contrast the habitats in “light” of your answer to C.



2. Using data from Table 10.3 in Ricklefs, graph (use a x-y line graph, placing both lines on the same graph) the cumulative weight of eggs for fish using the two strategies. Over a 3-year period, which strategy is the best in terms of fecundity? Which strategy is the most fecund over 5 years? Briefly (1 paragraph) discuss the graph.

3. The classic experiment by Andersson on female choice in long-tailed widowbirds provides an interesting example of statistical analysis. According to the reconstruction by Ricklefs (pages 232-233), "... males with experimentally elongated tails attracted significantly more mates than those with shortened or unaltered tails." Using the data from Andersson (below), run *t*-tests to see if the average number of nests does vary *significantly* between the treatments. Add a paragraph interpreting your results.

Shortened	Control	Elongated
0	3	2
1	0	2
0	0	5
0	0	4
0	1	2
0	0	2
2	0	0
0	0	0
1	0	0

Table 1 - Average number of nests per male for 3 treatments of widowbirds¹.

4. Use the Excel file Module2data.xls on the server to do the following:

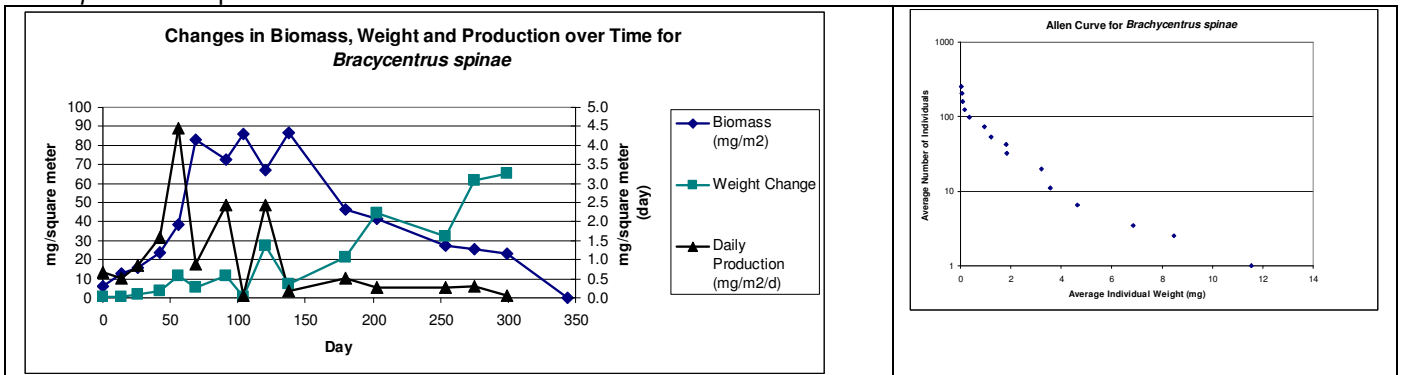
A. Fill in Table DA2-1 using steps 2-4 in the text and paste the completed spreadsheet here:

B. Plot an Allen curve using the average individual weight (column E) and density(column H). *Use a log scale* to best visualize the pattern in this graph. It should resemble the graph in Part E, below. Insert the graph here:

C. Calculate the total production by these caddisflies over the course of the year and estimate the total production from the daily production.

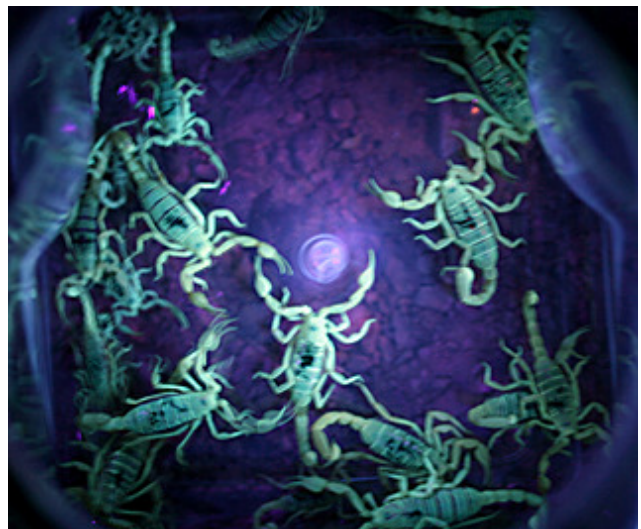
D. Estimates for single species of freshwater invertebrates range from less than 1 mg/m²/year up to extremes of ~8 g/m²/day for highly productive species (e.g., those that have both high biomass and fast growth rates; Huryn and Wallace 2000). How does the caddisfly production (total production, not the estimate) in this example compare to these invertebrate production estimates?

E. Compare daily production values with biomass and growth (changes in weight) during each interval by reproducing and replacing the figure below, using different symbols for each data series (also delete the Allen Curve graph). Which factor or factors contribute most to production and at what part of the Allen curve is *B. spinae* most productive?



¹ From M. Andersson, 1982. Female choice selects for extreme tail length in widowbirds. *Nature*. 299:818-820.

- F. Often, interval production is highest at some intermediate point on the Allen curve, when numbers are still fairly high, individuals are larger than when they were born or hatched, and growth is still fairly rapid. Is this the case with *B. spinae*?
- G. Calculate production for other sampling intervals using the instantaneous growth method and compare them with the increment summation estimates. Place the table DA2b from the excel spreadsheet here.
- H. How well did the instantaneous growth method track with the actual growth? Convince me with more than the numbers plotted above.
5. In May of 2007, Drs. McShaffrey, Brown and Spilatro accompanied the spring expedition to the dinosaur quarry in the Utah desert. At the site, they used UV lights at night to locate scorpions in the camp and its immediate vicinity (i.e. all the way to the latrine). On May 17th, they captured and marked 31 scorpions, which were then released. On May 18th, an informal survey revealed 8 scorpions, one of which was marked. On May 19th, 17 scorpions were captured and examined closely for the markings. Of the 17, 2 were marked. Answer these 4 questions:
- What estimate of scorpion numbers do you obtain using the mark-recapture formula for May 17th?
 - What estimate of scorpion numbers do you obtain using the mark-recapture formula for May 18th?
 - Discuss the accuracy of these estimates and note any problems with them.
 - Would you wear sandals in camp?



Study Questions:

1. Are most weeds annuals or perennials? Why?
2. Open the Dinowin program and delete the word "species" in the SPECIES BOX. In the LOCATION BOX, use the down-arrow at the right to choose AB from the list. Now, go to COMMUNITY on the MENU BAR at the top of the window. Choose PRODUCE DINOSAUR COMMUNITY from the list. After the calculations are complete, click on CONTINUE WITH COMMUNITY ANALYSIS to proceed to the ecosystem model. Use the Default model (carnivore biomass should be 933 kg). Use the data in the chart to fill in the table below (Note: Since the dinosaur carnivores at the top of the food chain act as both secondary and tertiary consumers, you will have to first determine what portion of their total 933 kg biomass comes from acting as a secondary consumer and what portion comes from acting as a tertiary consumer. These values can easily be determined from the values in the diagram).

	Biomass	Biomass as % of Plant Biomass
Plants	1,200,000 kg	100%
Total Primary Consumers		
Total Secondary Consumers		
Total Tertiary Consumers		

3. Does the data above indicate that a pyramid of biomass exists in the default dinosaur community model (above)? Does the model correspond to the generalization that 10% of the energy of one trophic level is available to the next? Explain your answers.

You are asked to determine the size of the population of carp in a lake on a college campus. Being enterprising, you have your Ichthyology class seine 187 fish from the lake. You mark these fish by making small clips on the tails, an accepted practice that has been studied and shown not to alter the fishes' behavior. The next day, you sponsor a contest to see who can catch the most carp and biggest carp. First prize in each category is \$25, second prize is \$10, and third prize is \$5. You have 274 entrants who pay \$5 each. All carp caught are brought to you to be weighed. After the contest, your final tally shows that 253 fish have been caught, of those 107 were marked.

4. What is your estimate of the population of carp in the lake?
5. How much money did you clear on the contest?

Homework 5 (chapter 14)

You are given a container with 100 paramecia, ample water, and food. Each individual will produce 7 offspring (excluding itself) in a week. 93% of the individuals survive from one week to the next. Assume an individual always reproduces before it dies.

1. What is the birth rate and the death rate in the population?
2. Use a spreadsheet to calculate the population growth over a period of 10 weeks and graph the results.
3. Is the population growing exponentially? How do you know?

Some of the best-known examples of exponential growth among higher life forms are based on tribbles. A classic case study is provided by Spock and McCoy (SD4825). A tribble, in an artificial environment, fed sufficient food (quadrotriticale), and kept at 20^o C, reproduces every 12 hours. An average litter is 10 for the newborn, 12 for young adults, and 9 for mature adults. It takes four months to pass through each age class; the average life-span (in captivity) is one year. In captivity (in the absence of predators) 99% of the newborns reach the young adult stage and 87% of the young adults reach maturity. It is rare for a mature tribble to die before its reproductive life is finished. Tribbles are hermaphroditic and are "born pregnant" (McCoy SD4848).

4. Starting from a single newborn tribble, how many tribbles would there be after 3 days in a grain hold full of quadrotriticale? Calculate the population at each generation time (12hrs) and plot the results.
5. In an actual case at Deep Space Station K-7, it was later estimated that the actual population (given the conditions stated above) was 1,561,773 (Spock and McCoy SD4825). Was the population limited by physical constraints (the size of the hold, supply of grain) or by the reproductive potential of the tribbles? Explain your reasoning.

On a small space station such as K-7, where food supplies are limiting, (outside of grain holds) tribbles respond by increasing their generation time from 12 hours to four months, and by reducing average litters to 1.5, 2, and 1 for the newborn, young adults, and mature adults, respectively. This means that a given tribble will only produce one litter of offspring during each of its life stages - a total of three litters.

6. Given these conditions, track an initial population of 100 newborn, 230 young adults, and 120 mature adults through 10 generations. Graph the size of each class and the total population at each generation.
7. What is the stable age distribution for the above population?
How long does it take the population to reach a stable age distribution?
What is R for the above population?
8. Reproduce the first 5 columns of data (Age, Number Alive, Survivorship, Mortality rate and Survival rate) of table 14.4 on page 277. You must have the spreadsheet calculate the latter 3 columns; you may not type these in. Paste a copy of the spreadsheet with the answers and a second copy showing the formulas used into your answers.
9. Examining scales taken from dead fish, you determine that of the 895 fish represented, 785 died before reaching 1 year of age; 50 died between the ages of 1 and 2; 30 died between the ages of 2 and 3; 25 died between the ages of 3 and 4; and the rest died between the ages of 4 and 5. Complete a static life table *using a spreadsheet*. There should be 4 columns: age interval, number dying during age interval, number

surviving at beginning of age interval, and the number surviving as a fraction of newborns. Turn in a copy of the spreadsheet showing the values and a separate copy showing the formulas. An example of this type of spreadsheet is Table 14.5 on page 280.

Study Questions

1. In the library, obtain data from *World Resources* on crude birth and death rates, as well as population levels in 1995, for an African country of your choice. What will its population be in 2025 according to our model? According to the World Resources Institute? Why is there a difference?

Homework 6 (chapters 14-17)

1. Use the Ecocyb program to model populations growing logistically. Manipulate the variables to produce graphs showing:
 - A. a smooth approach to equilibrium.
 - B. a damped approach to equilibrium.
 - C. oscillation between two points.
 - D. oscillation between four points.
 - E. Chaos.

Turn in one copy of each of the graphs, showing the parameters used to generate it. More credit will be given to those who do not use the program's built in defaults to generate the graphs.

2. Use the Ecocyb program to produce a graph showing increasing values of R_0 on the x-axis and population values on the y-axis for $R_0 = 0$ to $R_0 = 4$.
3. Calculate the probability of extinction for a population of 200 individuals, a birth rate of 0.7, a death rate of 0.7, over 100 years. Then, calculate the probability of extinction if the birth and death rates are equal to 0.3.

You are given a strain of *Paramecium*. The initial birth rate is 0.8, but your experimentation shows that for every 100 ADDITIONAL *Paramecium* in the culture, the birth rate drops by 10%. The initial death rate is 0.3; again, your data shows that deaths increase by 15% for every 100 additional organisms. Note: you should be using a single birth and death rate throughout, that is, the the addition of each individual affects the birth and death rates immediately; the effect does not kick in only when there are another additional 100 organisms.

4. Start with 10 organisms. Track the population over 20 generations. Graph the results.
5. What is K equal to in the above example?
6. If you wanted to sell *Paramecium* to first-year biology students, how many could you sell per day on a sustainable basis (assume the generation time is two days)?
7. Pretend you are a fish farmer. Your bass normally have a birth rate of 500, a death rate of 498, a density dependent birth rate of 0.01, and a density dependent death rate of 0.01. Assume further, that after taking biotechnology at Marietta College, you possess the ability to manipulate genetically **one** of these parameters (you only got a "C" in the course). Use the model to change this parameter and maximize the maximum sustainable yield without entering chaotic growth. Bonus points to the team who can show the greatest increase.

8. Box turtles are not endothermic, but do they regulate their body temperatures? The following data was obtained from an outdoor enclosure in which box turtles were allowed to run free. The data loggers were placed on the turtles and in their enclosure. The data is contained in the file HW6-2007q.XLS. Use this data to do the following:
- A. Graph the data on a single chart.
 - B. Calculate the average, minimum, and maximum temperatures for each of the loggers, as well as the standard deviation of the data.
 - C. Use an ANOVA analysis to determine if any of the loggers recorded a significant difference in temperature.
 - D. Use the information above to determine if the box turtles were regulating their temperature. Explain and defend your answer.

Homework 7 (chapters 17-18)

1. Suppose the populations represented in the EcoCyb predation model are deer and wolves living on an island. Further, suppose that the island can sustain up to 1000 deer. Use the model to manipulate parameters so that you A) maximize the deer population, B) maximize the wolf population, and C) maximize both populations. Your plan must be in written form showing all parameters used for each of the optimizations and must also include graphs of the results. Bonus points to the team with the best answer.
2. Many times, it is important to know what percent of the sky is occluded by the canopy of a forest. The more of the sky that is covered by the canopy, the less light reaches the ground and is available for photosynthesis by plants on the forest floor. In the past, a device called a spherical densiometer was used to make this estimate. This simple instrument consists of a mirror with an etched grid. It is held in front of the body and the number of squares occupied by sky is counted. A few simple calculations then yields percent canopy cover.

Electronics allow for an update of this method. A camera is used to obtain an image of the canopy overhead. The image is digitized and placed on a computer where it can be analyzed with image analysis software. This question will introduce you to the software and techniques of image analysis.

Follow the steps below:

Part 1 – Installing the Software:

If it isn't already installed, install the Scion Image Analysis Software on your computer. This is done by running the program SetupWin.EXE located in the K:\Programs\Nih directory. Reboot the computer and start the Start:Programs:Scion Image: Scion Image.exe program.

Part 2 – Image Analysis:

1. Open File - Dcanopy.bmp in the data directory under canopies (K:Drive).
2. Select Options:Threshold.
This automatically determines the threshold. Pixels lighter than the threshold will be counted as sky; darker pixels will be counted as leaves or trunks.
3. Select Process:Binary:Make Binary.
This reduces the picture to black or white.
4. Select Analyze:Options.
Only the Area box should be checked.
Max Measurements should be 8000.
5. Select Analyze:Measure.
6. Record the area (number of square pixels) in the Info window (write it down).
7. Select Edit:Invert.
Now, the sky is in black - these particles will be counted.
8. Select Analyze:Analyze Particles.
The Include Interior Holes box should be checked.
The Reset Measurement Counter box should be checked.
If you get a warning about losing measurements that are not saved, ignore it.

9. Select File:Export
Choose the save measurements option.
Choose the Save as Text File Option.
Name the file Dcanopy.txt and save it to the scratch drive you normally use.
10. Open File – 01tropical_forest_canopy.bmp
11. Select Options:Threshold
Slide the bar separating the white and black portions of the LUT (look up table) up and down. Note how the image changes. Adjust the slider until the trees are black and the sky is white.
12. Continue with steps 3-9 as before. Call this file Ccanopy.txt
13. Open File – 01light_gap.bmp
14. Select Options:Threshold
Slide the bar separating the white and black portions of the LUT (look up table) up and down. Note how the image changes. Adjust the slider until the trees are black and the sky is white.
15. Continue with steps 3-9 as before. Call this file cypress.txt

Part 3 – Data Analysis:

1. Close Scion and open Excel.
2. From Excel, open one of the text files you just saved. It should import cleanly as a delineated text file.
3. Now open the second file using Notepad and highlight the data.
4. Use Edit:Copy to copy the data.
5. Use the Window menu to switch back to the first Excel File.
6. Use Edit:Paste to insert the data into a column next to the first column of data.
7. Repeat steps 3-6 for the third file you saved.
8. Insert a blank row at the top and label the columns.
9. Save the file with a new name as an Excel Worksheet.

Now that you have the data, it should be a simple task to calculate the canopy coverage. The data in the Excel spreadsheet represents the coverage of sky in the 3 pictures. Each cell represents a different chunk of sky; some are bigger than others. Use the data in the spreadsheet to complete this table:

	Deciduous	Tropical Rain Forest	Tropical Rain Forest Light Gap
Total Area of Image (pixels)			
Total Area of Sky (pixels)			
Total Area of Canopy (pixels)			
Percent Canopy Cover			

Which forest allows the most light to reach the forest floor? The least?

Study Questions:

1. Highly contagious viruses do not necessarily evolve less virulence; viruses that are spread by a vector often do. Describe this in terms of r and K selection. Is this type of language appropriate here? Why or why not?