

1.018/7.30J Ecology 1: The Earth System

Problem Set 2, Fall 2009

Assigned: Ses #9

Due: Ses #13 at the beginning of class.

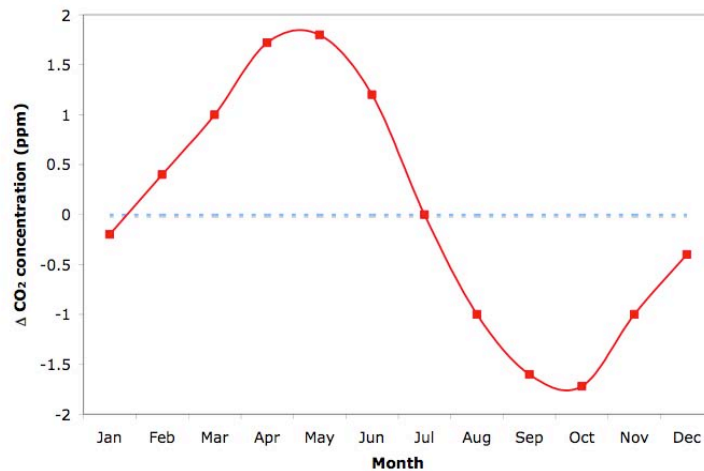
Please turn in your assignments (hard copy) to the TAs.

You may work individually or in groups of up to three.

1. (6 points)

a. Name the two major biological processes that are responsible for the coupling between the oxygen and carbon cycles. Write their reactions.

b. You measure the CO₂ concentration in the air over Alaska for one year and then plot your measured concentration minus the average annual concentration as a function of time. Explain the seasonal variation in CO₂ concentration illustrated in the figure below. Would you expect to see the same pattern if you measured CO₂ in the atmosphere over Chile? Why or why not?



c. The CO₂ concentration in the atmosphere has increased drastically as a result of human activities over the past 100 years. In addition, the global O₂ concentration in the atmosphere has decreased, as shown in the graph below. Please explain the seasonal variation in each year and the overall 5-year trend in the figure.

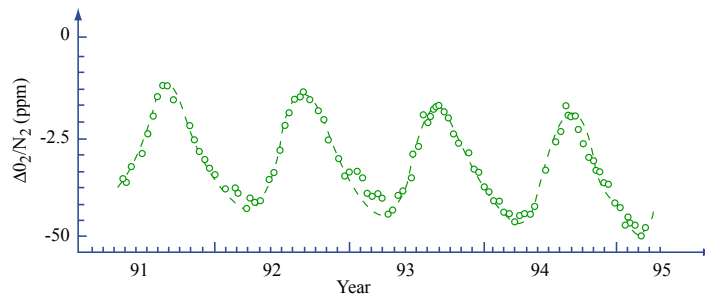
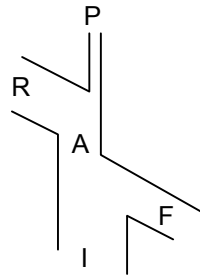


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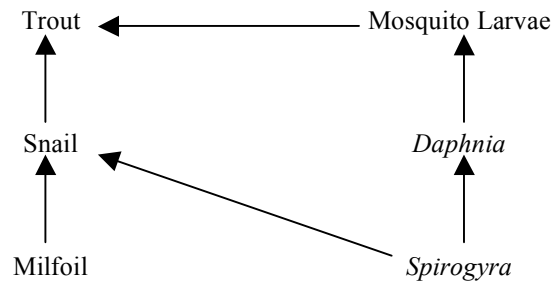
2. (7 points) You are a scientist studying elephant ecology in the Kibale Forest of Uganda. As part of your project you have collected the following data:

Kibale Forest	
Net Primary Production	856.0 kcal m ⁻² yr ⁻¹
Total Biomass of Elephants	9.70 kcal m ⁻²
Elephants	
Food Consumed (I)	67.5 kcal m ⁻² yr ⁻¹
Fecal Material and Urine Lost (F)	30.2 kcal m ⁻² yr ⁻¹
Maintenance Metabolism (R)	36.8 kcal m ⁻² yr ⁻¹
Growth (P)	0.50 kcal m ⁻² yr ⁻¹

- What is the exploitation efficiency of the elephants?
- What is the assimilation efficiency of the elephants?
- What is the production efficiency of the elephants?
- Below is an energy flow diagram for one elephant, Babar. Sketch the energy flow diagram of Babar if he was cold-blooded.



3. (7 points) The population dynamics of a natural pond system are dictated solely by the food web pictured below. Water milfoil (*Myriophyllum*) is an invasive Eurasian genus of aquatic plants found in North American lakes and ponds. *Spirogyra* is a form of filamentous green algae that are native to North American freshwater ecosystems.



- In order to help save the native *Spirogyra* population, you have a few measures available to you. You can either adjust the trout population (by adding more trout or by encouraging more fishing) or you can adjust the mosquito larvae population (by adding more larvae or by applying a biocide that only kills mosquito larvae). Which measure would be most effective at increasing the population of *Spirogyra*? Why? Clearly state all assumptions.
- A golf course is built upstream of the pond. The fertilizers from the runoff cause a 50% increase in the primary productivity of both milfoil and *Spirogyra*. By how much would you expect the productivity of snails and *Daphnia* to increase? Assume the ecological efficiency at each trophic level is 10%. Show calculations and explain your reasoning.

4. (6 points) Al Gore has another idea for his new movie, *More Inconvenient Truths*. He wants you to assess the impacts of climate change on the hydrologic cycle.

- How is the hydrologic cycle expected to change over the next century? Be sure to note sources in your answer.
- Approximately 23% of the energy available at the Earth's surface is used for evaporating water (either evaporation from free water surfaces or transpiration from plants). How much water, in $\text{km}^3 \text{ year}^{-1}$, is evaporated? Assume the energy available at the surface of the Earth is 553 W m^{-2} , the latent heat of vaporization is $2.5 \times 10^6 \text{ J kg}^{-1}$, the density of water is $1.0 \times 10^{12} \text{ kg km}^{-3}$, the radius of Earth is $6.38 \times 10^6 \text{ m}$, and there are 31,536,000 seconds in a year.

c. Compare your answer to the values given by Oki and Kanae. Give three potential reasons why your answer is different.

e. AI heard that climate change could lead to extensive droughts over the midwestern United States. The figure below contains the difference between renewable freshwater resources (RFWR) of the future climate (predicted) and current climate for the months of June, July, and August in mm day^{-1} . Should AI include droughts over the Midwest in his movie? Why or why not? What negative impacts of climate change might this figure miss? (Hint: Only the difference in 20-year averages of June, July, August RFWR is shown)

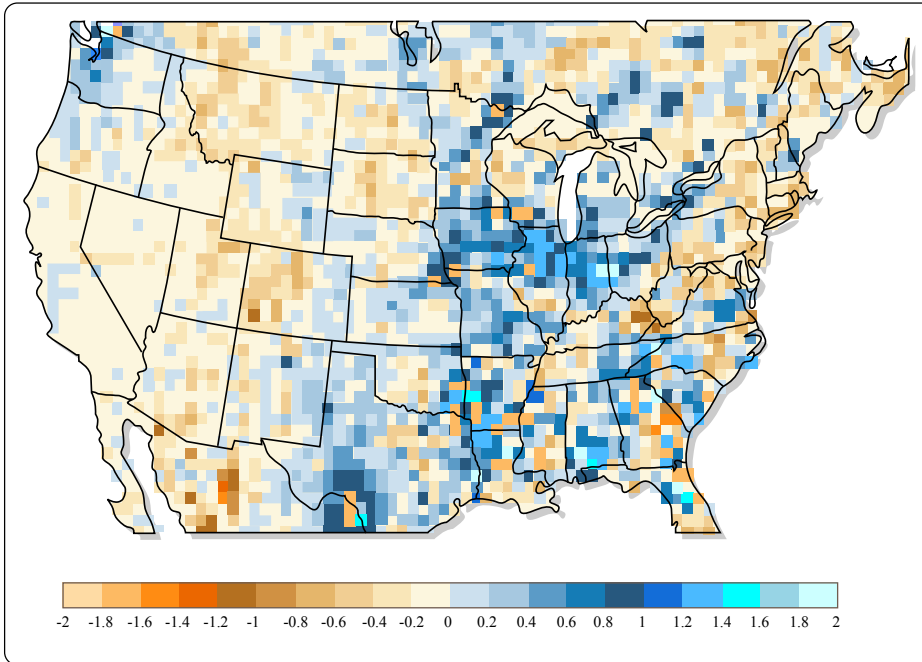
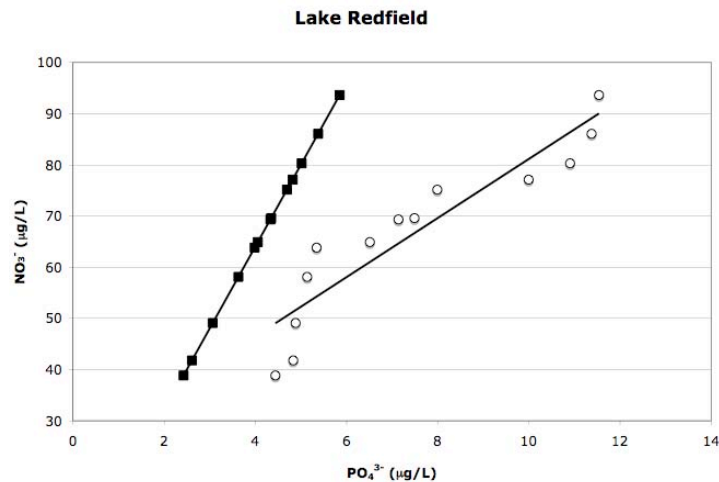


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5. (7 points) You're a consultant for ENVIRON and are hired to investigate the declining freshwater fisheries of Lake Redfield. You quickly determine that reduced fish populations are a result of low dissolved O_2 levels caused by phytoplankton blooms. You measure the effluent of the wastewater treatment plant and find an N:P = 4:1. You then measure runoff from an adjacent farm and determine the N:P ratio is 28:1. Carbon is plentiful. You sample the lake every week for one summer and plot your results (black squares). Ignore the white circles for (a).



a. Assume the natural (before wastewater effluent and agriculture runoff) N:P ratio of Lake Redfield was 16:1. Who should be blamed for the phytoplankton blooms, the farmer or the wastewater treatment plant? Explain your reasoning.

b. The human population surrounding Lake Redfield doubles and the following year the phytoplankton blooms are even worse. You collect samples and plot your results (white circles). Is the lake nitrogen or phosphorous limited? Why?

c. How would you expect the composition of the phytoplankton community to change between these two summers? (Hint: Think about different types phytoplankton)

d. Propose a solution to reduce the phytoplankton blooms in Lake Redfield.

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