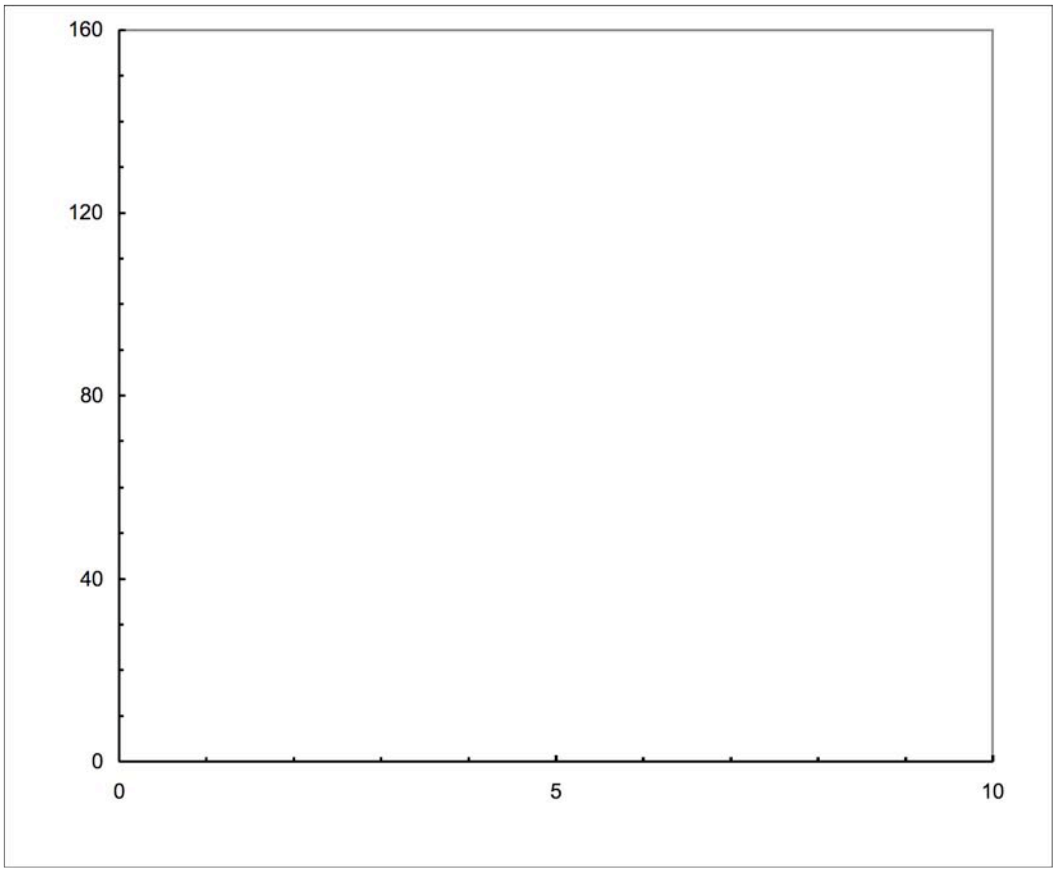
1. You are a limnologist studying several lakes in northern Ontario. The lakes have little input of nutrients from streams. You measure the concentrations of nitrate and phosphate every two months, and generate the following data. All units are in mg/L concentration. Using the graph paper provided below may help you answer the question.

	Trout Lake		Big Lake		Lake Balance	
	NO_3^-	PO_4^{3-}	NO_3^-	PO_4^{3-}	NO_3^-	PO_4^{3-}
January	149	8	140	10	143	9
March	113	6	113	9	128	8
May	97	5	41	4	63	4
July	37	1	5	2	31	2
September	51	2	26	3	16	1
November	133	7	83	7	92	6



a) Which lake is limited by the availability of P? By the availability of N? Explain your answer.

b) A resort-house development is proposed to be built around Lake Balance leading to the use of large numbers of septic systems around the lake. (Septic systems leach nitrogenous compounds into the groundwater, and the groundwater ultimately carries them to the lake). Would Lake Balance start to look more like Trout Lake or Big Lake over time?

c) The development goes ahead, and the concentrations of NO_3 in Lake Balance skyrocket. At the same time, the housing developments around the lake began to leach sewage into the lake, increasing its P supply. What might happen to the oxygen concentrations in the deep waters of Lake Balance over time and why? What is this process called?

Bonus: To mitigate the effects of the added nitrate from sewage coming from the new homes surrounding Lake Balance, the local wastewater treatment authority proposes an innovative solution. Rather than trying to install a sewer system across the entire, remote area, they propose using denitrifying bacteria to convert the nitrate in groundwater to nitrogen gas. They set up an anaerobic ground system and test it. Initially they find that there are fast rates of denitrification, but these rates soon slow down. There is still a lot of nitrate to be reduced and the environment is still anaerobic. What would you recommend adding to the system to help spur further denitrification?

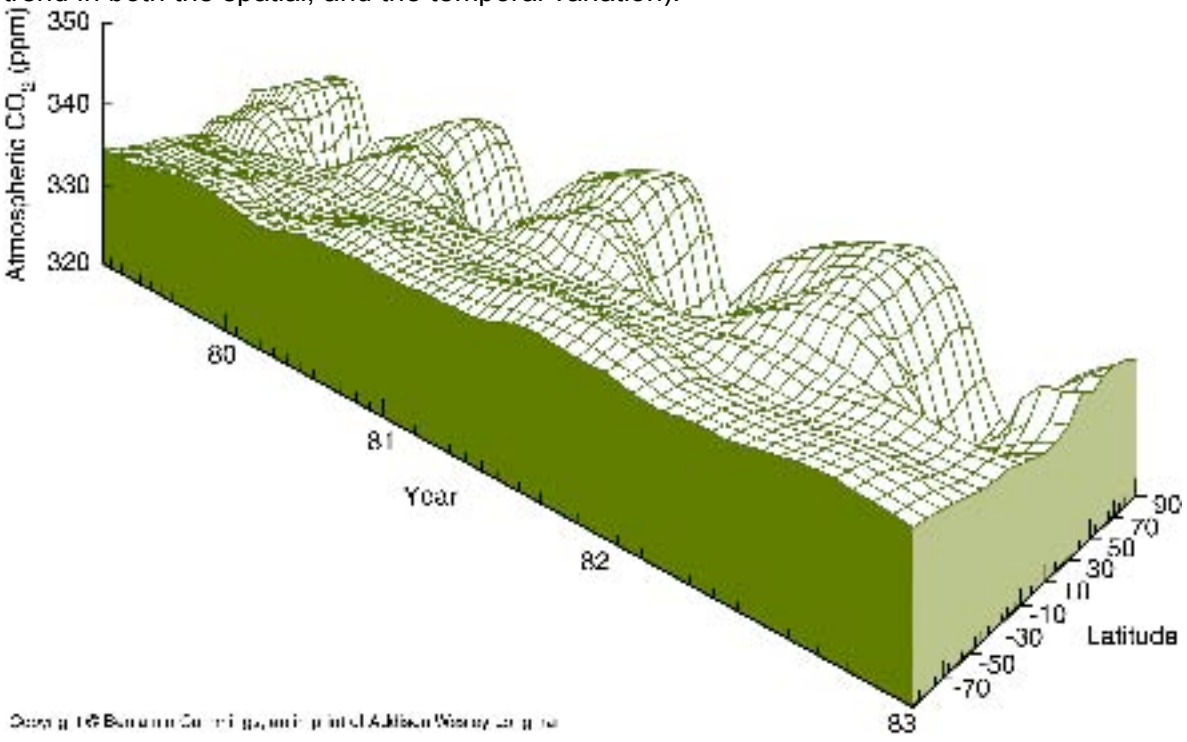
2. With respect to the carbon cycle, please answer each of the following questions in a sentence or two:

a) Which 'compartment', terrestrial or marine, has the slowest biological carbon turnover? Why do these compartments differ in terms of organic carbon turnovers?

b) Which has the longest mean residence time for CO2, the deep-sea, or ocean surface waters? Why ?

c) Fossil fuel burning and deforestation release about 9.1 petagrams of CO2 per year. In which compartments (atmosphere, ocean, etc) does the manmade CO2 end up in, and in approximately what proportions?

d) What explains the trends shown in annual CO2 variation in the plot below? (Explain the trend in both the spatial, and the temporal variation).



3. In class and in your readings, you learned about the long-term ecological experimentation done at the Hubbard Brook Experimental Forest in New Hampshire.

a) Explain the biogeochemical mechanisms by which clear-cutting leads to increased NO_3^- leaching from forest soils.

b) Explain biogeochemically why there is more Ca^{2+} ion leaching from clear-cut forests.

c) Over the last fifty years, even in intact forests ,Ca^{2+}has been depleted from the soils. Explain what was the ultimate cause of this depletion, and how it caused it.

d) What is wollastonite (exact chemical formula), what were they doing with it at Hubbard Brook and why?

4. Below is a table of the annual fish catch from an ocean basin that is a self-contained ecosystem. It has roughly yielded this catch for over a decade. A local ecology class has estimated the primary productivity of the basin to be around 2 x 10^7 metric tons of carbon. You do a quick check to see if their measurements are in the right ballpark. Do you think their estimate is correct? Why or why not? Explain your answer in detail, and what assumptions you have made to arrive at your answer.

Fish Species	**Trophic Level Occupied**	**Amount Harvested Annually (tons carbon x 10^3)**
Cod	3	100
Flounder	2	50
Catfish	2	30
Bluefish	4	10

5. True or False

____ Phytoplankton draw down more CO2 per mass than terrestrial photosynthetic organisms.
____ The concentration of carbon dioxide in the atmosphere is positively correlated with ambient temperature of the planet.
____ If humans did not emit huge amounts of carbon dioxide, the carbon cycle and its fluxes would be constant and balanced.
____ The eutrophication of lakes and rivers due to increased phosphorus concentrations will cause an increase in photosynthesis that will offset a substantial amount of carbon.
____ Coral reefs will probably be able to adapt to the new changes in ocean pH, as they have in the past.

6. A population of 100 ferrets is introduced to a large island in the beginning of 1990. Ferrets have an intrinsic growth rate, r_{max} of 1.3 yr^{-1}.

a. Assuming unlimited resources—i.e., there are enough resources on this island to last the ferrets for hundreds of years—how many ferrets will there be on the island in the year 2000 and what is the doubling time of the population? (Show your work!)

b. A small population ferrets is introduced to an island where resource limitation is a significant problem. The population is growing according to the Logistic equation. When the population reaches 300 ferrets, you measure its growth rate, and find it to be 1.0 $year^{-1}$ What is the carrying

capacity, K, of this island for this species of ferrets? Show your work. [Hint: the measured growth rate has the units ferret per ferret per year, and it is not r_{max}. You know from question I that r_{max} is 1.3 $year^{-1}$]

c. You have decided to go into the ferret meat business on the small island described above. At what density should you maintain the ferrets in order to have the maximum output of ferrets? Explain your answer.

7. A recent collection of fossil skulls of *Unicornia imaginarus* showed the following age of death distribution:

Age	# of skulls
0-1 yr	36
1-2 yr	8
2-3 yr	14
3-4 yr	12
4-5 yr	10
5-6 yr	26
6-7 yr	34
7-8 yr	50
8-9 yr	12
9-10 yr	4

a) Tabulate the complete life table for this species

x	n_x	l_x	d_x	q_x	L_x	T_x	e_x	$\log(l_x)$
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

b) Plot the survivorship curve for this species. What can you infer from this concerning the nature of the species?

c) Discuss the assumptions involved in drawing conclusions from such a table.

1.018J / 7.30J Ecology I: The Earth
Fall 2009