FW364
Midterm I - PRACTICE EXAM
February 2012

Mass Balance Practice Questions

1. You are a climate change modeler that is interested in how carbon flows through ecosystems. As a good ecosystem modeler, you start by developing a conceptual diagram of carbon flow. Draw a stock-and-flow model for carbon flow through an ecosystem with two trophic levels (plants and herbivores) and stocks for detritus and CO_2. Please label the model with words that describe each flow process.

2. Lake Michigan has a residence time of approximately 99 years and a volume of 4,900 km^3. Assuming the flow into Lake Michigan is the same as the flow out of Lake Michigan, what is the flow rate into Lake Michigan in units of km^3/yr? What is the flow rate in units of m^3/s? What is this assumption called that we are making in this problem?

3. Lake Linguini has a water residence time of 10 years, a surface area of 1 km^2, and an evaporation rate of 0.001 m/day. If precipitation rate is equal to evaporation rate and total inflow of water from the watershed (overland plus groundwater flow) to the lake is 100 m^3/day, what is the volume of the lake? You can assume there are other outflows from the lake for which we do not have data; you can also assume precipitation and overland plus groundwater flow are the only inputs.

4. Continuing with Lake Linguini in Question 3, assume that the precipitation rate is twice the evaporation rate. What is the volume of the lake in this case?

5. Fill in the blanks in the analogies below using the given word options (there are more word options available than you will use; some word options may be used more than once). Note: there will not be analogies on the test.

Word options:
Assimilation
Incorporation
Photosynthesis
Photosynthesis minus respiration
Respiration

Analogies:

Net primary production is to plants as _____ is to animals.

Assimilation is to animals as _____ is to plants.

Photosynthesis minus respiration is to plants as _____ is to animals.

6. A zebra population consisting of 10,000 individuals, each with a carbon content of 20 kg, consumes 10% of net primary production and has a carbon turnover time of 2 years. Zebra are herbivores and incorporate an average of 40% of what they consume. If the turnover time of plant biomass is 1 year, what is plant biomass in this ecosystem?

Quantitative Tools Practice Questions

In the problems below, choose between each pair of model categories

7. The residence time equation: $T = S / F$, is an example of which type of model:

static or dynamic

deterministic or stochastic

8. The equation: $N_{t+1} = N_t \lambda_t$ is an example of which type of model:

static or dynamic

discrete or continuous

deterministic or stochastic

9. The equation: $N_{t+1} = N_t (1 + b' - d' - e') + I$ is an example of which type of model:

static or dynamic

discrete or continuous

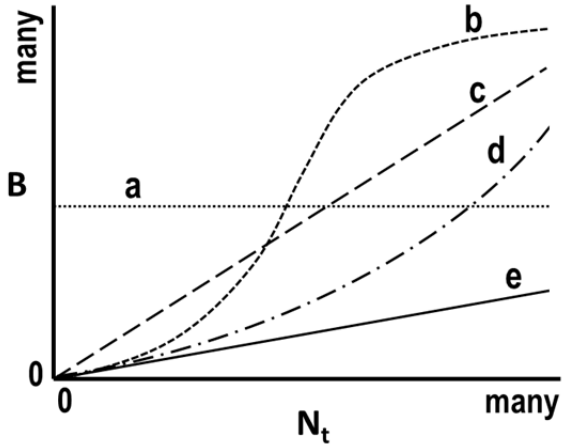
deterministic or stochastic

10. Which of the methods below could we use if we were interested in forecasting population size across multiple time periods for a population with immigration and emigration as described in the equation in Question 9?

obtain analytical solution or use numerical simulation

Population Growth Practice Questions

11. Below is a figure that shows five options for per capita birth rates (b'). If we define the number of births to be equal to the current population size multiplied by the per capita birth rate (i.e., B = b'N), which b' option(s) below could fit our equation for the number of births?



12. Starting from the simple observation that population growth between any two consecutive years for a population that reproduces annually is equal to the population size during the first year plus the number of individuals born less the number of individuals that die that year, derive the equation we use to forecast growth between consecutive time periods (express the growth rate in this equation using the finite population growth rate parameter, λ).

13. From the equation you derived in Question 12, we can derive the equation $N_t = N_0 \lambda^t$ to forecast population growth at any time in the future from any time in the past. An important application of this equation is for determining the doubling time for a population, which can be expressed mathematically as the time when $N_t = 2N_0$. Beginning with the equation to forecast population growth ($N_t = N_0 \lambda^t$), derive the equation that we use to forecast the doubling time for any population exhibiting **discrete** growth.

14. How would the equation you derived in Question 13 change if we were interested in calculating quadrupling time?

15. A bass population has a per capita birth rate of 5% per year and a per capita death rate from natural causes of 6% per year. Assuming that the population is closed, how long will it take for the population to double?

16. For the bass population in Question 15, assume that population size is currently 1500 bass. If we harvest at a rate of 1.5% per year, how many bass will there be 10 years from now?

17. We will now relax the assumption that the bass population in Questions 15-16 is a closed system. If bass leave the lake (emigrate) at a rate of 2% per year and a constant 200 bass are stocked each year, and the starting population size is 1500 bass (with the same birth, death, and harvest rates above), how many bass will be in the lake the following year?

18. An elk population in Yellowstone National Park consists of 600 individuals and has an average population growth rate (λ) of 1.10 per year. Wolves have recently been re-introduced to the park as part of an overall effort to restore the Yellowstone ecosystem. The new wolf population is expected to kill about 5% of the elk population per year. Assuming that elk birth rate and rates of other types of mortality do not change in response to wolf predation, how many fewer elk will there be in 10 years as a result of wolf re-introduction? Is it reasonable to assume that wolves will not affect elk birth rate or mortality from other factors? Why or why not?

19. Just last week I found a carton of eggnog in my refrigerator that I bought sometime in early December. Upon opening the container, there was undoubtedly a thriving bacteria population inside the carton. Given that bacteria grow **continuously** and have an instantaneous population growth rate of 0.60 per day, and assuming the initial population size was just a single bacterium, how many bacteria would be in my eggnog carton after sitting in the fridge for 60 days?

Population Variation Practice Questions

20. Bluegill can be found in both ponds and lakes. In which of these locations would **demographic** stochasticity have a greater effect on bluegill population growth? Assume there are many more bluegill that can live in a lake than in a pond.

    a. Pond population
    b. Lake population
    c. Demographic stochasticity would have a similar effect on both populations

21. In which population would **environmental** stochasticity have a greater effect?

    a. Pond population
    b. Lake population
    c. Environmental stochasticity would have a similar effect on both populations

22. The table below shows the results from 500 replications of a stochastic model that forecasted population size of bottlenose dolphins from this year to next year. Across all 500 replications, 71 individuals was the smallest number forecasted. Using the data below, fill out the remaining two columns of the table (*cumulative number of trials* and *probability of decline*).

Population size	Number of trials	Cumulative number of trials	Probability of decline to N_c
71	2		
72	3		
73	7		
74	16		
75	36		
76	74		
77	165		

23. Assume that a management goal for the dolphin population in Question 22 is to keep the population size greater than 75 individuals because smaller populations are too likely to go extinct. What is the probability that this management goal will **not** be met? (i.e., what is the probability that the dolphin population size will be **75 or fewer** dolphins next year?)

24. The figure below is an explosion risk curve for muskox on Nunivak Island (Figure 2.7 in the textbook). What is the approximate probability that the population will explode to 200 or more muskox?