Formulas

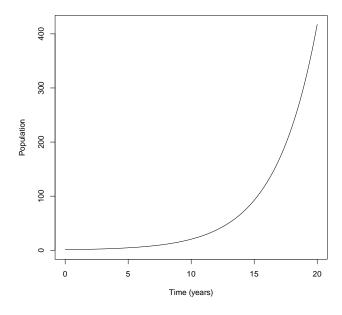
discrete time growth:

- $N_T = N_0 \lambda^T$
- $\lambda = f + p$
- $\mathcal{R} = f/(1-p)$

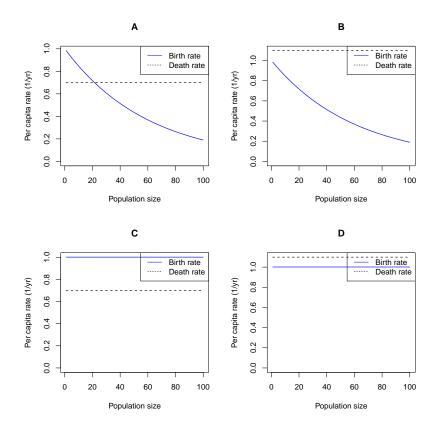
continuous time growth:

- $N(t) = N(0) \exp(rt)$
- r = b d
- $\mathcal{R} = b/d$
- 1. This class argues that every population regulates itself:
 - A. Directly and immediately
 - **B.** Directly, but not necessarily immediately
 - C. Immediately, but not necessarily directly
 - D. Either directly or indirectly and either immediately or with a delay

Use the picture below for the next two questions. It shows a time series for a continuous-time birth-death model.



- **2.** This picture shows a population that is:
 - A. Increasing arithmetically
 - **B.** Increasing geometrically
 - C. Increasing arithmetically on the log scale, but geometrically on a linear scale
 - **D.** Increasing geometrically on the log scale, but arithmetically on a linear scale
- **3.** Which of the four pictures below shows the assumptions that generated this time plot?

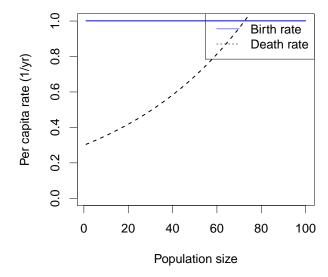


- **4.** Choose the most precise correct answer. A gypsy moth population grew from 100 pupae/hectare to 2000 pupae/hectare in 2008, and then to 5000 pupae/hectare in 2009. The 2009 change was larger than the 2008 change:
 - A. On the linear scale
 - **B.** On the log scale
 - C. On both scales
 - **D.** On neither scale

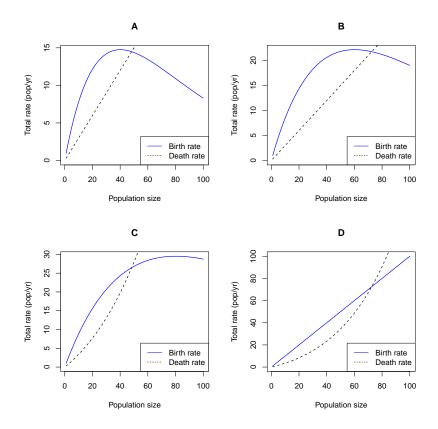
5. All of the following mechanisms can change gypsy moth population growth rates. Which of the following is *least* like to *regulate* growth rate in the sense discussed in class?

- A. Conflict between gypsy-moth caterpillars
- B. Viral diseases
- C. Gypsy-moth damage to the trees
- **D.** Drought damage to the trees
- **6.** Which of the following is the *least* likely scenario for a density-dependent per capita response? As population density goes up:
 - A. Birth rate goes down and death rate goes up
 - B. Birth rate goes down and death rate goes down faster
 - C. Birth rate goes up and death rate goes up faster

Use the picture below for the next three questions. It shows the assumptions made for a continuous-time birth-death model.



7. Which of the four pictures below could be generated by the same model as the picture above?



- **8.** The highest total population net growth rate (dN/dt) in this model is seen:
 - A. When the population is very small
 - **B.** When the population is between the two equilibria
 - C. When the population is at the nonzero equilibrium
 - **D.** When the population is very large
- 9. The model illustrated above predicts that the population will decrease:
 - **A.** When the population is very small (only)
 - **B.** When the population is very large (only)
 - C. When the population is very small or very large
 - **D.** When the population is between the two equilibria
 - E. When the population is at the nonzero equilibrium

10. If a simple model assumes individuals are independent of each other, then _____ death rates should _____ with the size of the population.

- A. per capita; increase
- B. per capita; decrease
- C. total; increase
- **D.** total; decrease
- 11. If we are modeling the spread of coronavirus with one of our population models, then a "death" would correspond to a person:
 - **A.** Catching the disease
 - **B.** Either catching the disease or recovering
 - C. Dying from the disease
 - **D.** Either dying from the disease or recovering
- **12.** Which of these is *not* a likely mechanism for the population of coronavirus to regulate itself?
 - A. People recovering from the disease and becoming immune
 - **B.** People changing behaviour in response to the disease
 - C. Viral evolution
 - **D.** A vaccination campaign
- 13. Modern humans have been very successful over the last 100 kiloyears. Considering the lifespan of a single human, it would be most accurate to say that the instantaneous rate of increase r has been:
 - **A.** A little greater than zero
 - **B.** Much greater than zero
 - C. A little greater than one
 - **D.** Much greater than one
- **14.** A population of shrubs is growing exponentially with a characteristic time of 4 yr. Its doubling time will be approximately
 - **A.** 0.17 yr
 - **B.** 0.36 yr
 - **C.** 1 yr
 - **D.** 2.8 yr
 - **E.** 5.8 yr

Use this information for the next two questions. A population of small plants has discrete, overlapping generations. Adults survive each year with a probability of 1/2 (and thus they have an average lifespan of two years). Each reproducing adult produces an average of 20 seeds each year, of which an average of 10% survive to reproduce in the next year. We model this population using a discrete-time model with time step of 1 year, and we count individuals just before reproduction.

15. What are the values for survival p and fecundity f for this model?

- **A.** p = 1/4 and f = 1
- **B.** p = 1/2 and f = 1
- **C.** p = 1/4 and f = 2
- **D.** p = 1/2 and f = 2

16. What can you say about the finite rate of increase λ and the reproductive number \mathcal{R} for this population?

- **A.** \mathcal{R} and λ both = p + f
- **B.** \mathcal{R} and λ are both > p + f
- C. $\mathcal{R} = p + f$, but λ is larger
- **D.** $\lambda = p + f$, but \mathcal{R} is larger

17. Simple models of continuous-time regulation can be useful, but *cannot* explain:

- A. Why exponential growth often occurs at low density
- B. Why total population growth is usually highest at intermediate density
- C. Why some populations fluctuate periodically
- ${f D}.$ Why populations may not persist in an area even if they can complete each step of their reproductive cycle

Name	Macid	Tutorial section	Version 3
Short-answer	questions		
-		necessary work and equations. nen the correct information is	•
reproducing at a	constant per-capita r g at a constant per-c	favorable environment. They at e of 0.3 new indiv per indepita rate of 0.1 per day. V	iv per day and
a) Write an equati through time (not	~	sumptions about how this pop	ulation changes
b) What are the bi	irth rate b , death rate	d and growth rate r ?	
c) How many bacte	eria do we expect to s	see after a day?	
d) How many bact	eria do we expect to s	see after a week?	
c) How many bacto		see after a day?	

- 19. A car uses 7L of gasoline per 100km.
- a) (2 points) How far can the car go on 10L of gasoline? Show work with units.
- b) (2 points) If $1L = 1m^3$ and 1km = 1000m, write the fuel consumption of the car in the simplest form (consumption should be higher if the car uses more gas for a given distance).

c) (1 point, extra credit). Can you find a clear explanation for the simplest units of fuel consumption?