Practice Exam Questions --- The actual exam will have 6 to 8 pages (not 15).

Bren 201 First Hourly Exam Compilation

Multiple choice. Circle the one best answer for each question. (3 points each)

1) When an organism has a decreased ability to utilize one limiting resource but is better at utilizing a different limiting resource, this is known as:
    a. the R* value
    b. the carrying capacity
    c. a trade-off
    d. spatial heterogeneity
2) What are three important observations that informed Darwin's theory of evolution by natural selection?
    a. competition, density dependent growth, and inheritance
    b. exponential population growth, differential reproductive success, and competition
    c. competition, mutualism, and parasitism
    d. inheritance, variation in traits, and differential reproductive success
    e. exponential growth, logistic growth, and super exponential growth
3) In ecology, an isocline represents
    a. icy or frigid conditions that prevent plant growth
    b. changes in the conditions that permit coexistence of populations
    c. an environmental gradient slowly changing with time
    d. conditions under which a population's net growth rate is zero.
4) You know that the R* for soil nitrate of *Agrostis* is 0.24 mg/m^2 in natural habitats in your region. You find *Agrostis* in a habitat where the measured concentration of soil nitrate is 0.4 mg/m^2. What would happen to the abundance of *Agrostis* in this habitat?
    a) This cannot be determined without the mortality rate.
    b) It would increase
    c) It would decrease
    d) It would stay the same
5) There are about 300,000 species of plants living on the planet. Why do they coexist?
    a) There are several limiting resources
    b) Species have tradeoffs in their resource-use abilities
    c) Habitats have spatial heterogeneity
    e) Only a and c
    f) a, b and c
6) The nutrition transition is
    a. the tendency for diets to have more empty calories and meat as incomes rise
    b. the cause of declining birth rates in richer nations
    c. the tendency for people to eat too many calories as they age
    d. none of the above

A. For multiple choice questions, circle the ONE best answer (4 points each)

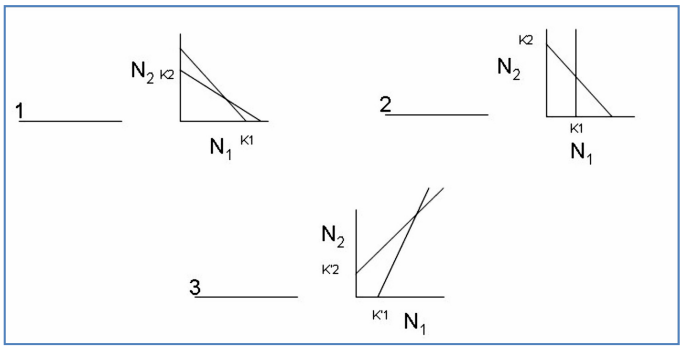
1. Prior to about 1970, the global human population was following "super-exponential" (also known as "orthologistic") growth. This meant that:
   a. The population was destined to crash in the near future
   b. The population was on a trajectory to reach an infinite size in a finite amount of time
   c. The population needed to switch to a different kind of growth at some point in the future
   d. Both (b) and (c)

2. Based on the model we discussed in class, a disease can only persist in a population if its R_0 is:
   a. Greater than zero
   b. Between zero and one
   c. Greater than one
   d. Greater than the carrying capacity of its host

3. A new disease is infecting the Yellow Bellied Canadian Condor. When the disease first appeared, an infected bird transmited the disease to four other birds before becoming immune. A vaccine for the disease has been recently invented, but it only successfully provides protection for 50% of individuals that are vaccinated. What is the minimum fraction of the population that must be vaccinated in order to eliminate this disease?
a. 100%
b. 75%
c. 50%
d. The disease cannot be eliminated with this vaccination.

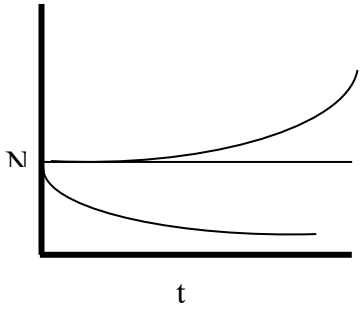
4. What is R*?
   a. The amount of resource needed to balance growth and death for a species
   b. The number of individuals of a species that can be supported by a single resource
   c. The lowest concentration that a species can draw a resource down to
   d. The largest population size that a species can support in monoculture
   e. Both (a) and (c)
   f. Both (c) and (d)

1. (3 points) Place each of the following letters next to the graph that most appropriately models the dynamics of the interspecific interaction.
    a. Facultative mutualism
    b. Predator prey
    c. Competition

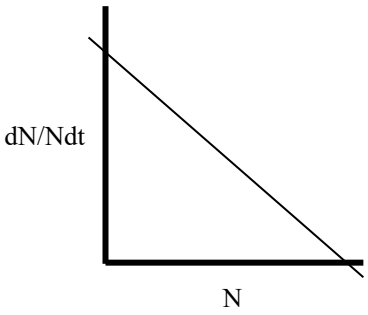


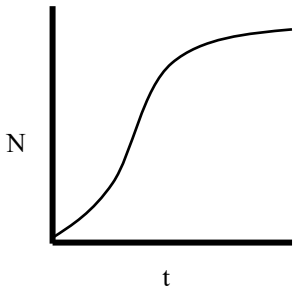
(2 pts extra credit – I just noticed that one graph is slightly wrong. Which is it? _____)

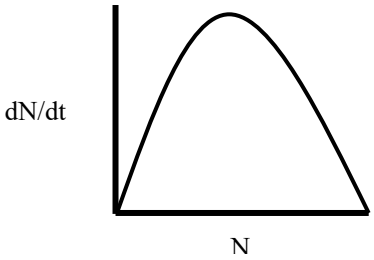
2. (3 points) This graph displays three curves that follow the exponential growth model. Match the appropriate r value to each curve: r = 0, r = -0.1, r = 0.1

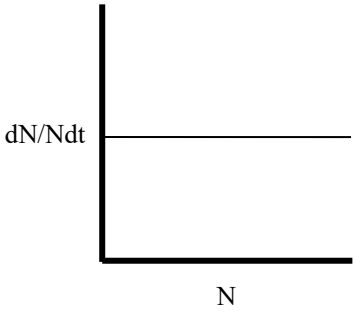


3. (8 points) Examine each of the graphs below.
    A. Label each graph that shows density-dependent growth as "DD"
    B. Circle each equilibrium point.
    C. Label each equilibrium point as "S" for stable and "U" for unstable.



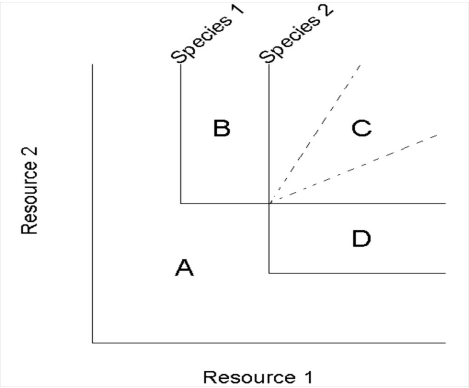






4. (4 points) Place each letter next to the predicted outcome of competition associated with that letter's zone in the figure.

_____ Neither species can survive
_____ Species 1 wins
_____ Species 2 wins
_____ Both species coexist



Short answer problems. Name_____

1) You are studying an annual flowering plant, the desert rose, that has r = (dN/dt)(1/N) = 1.000. You discover a new mutant that in all other ways is identical to the usual form but that has a per capita annual growth rate that is 0.001 yr^{-1} greater than that of the usual form. You mention your finding to a colleague, who says that the difference is way too small for it to be influenced by natural selection.
   a. You disagree. Present your case, including calculations of how long it would take for the new trait to increase a million-fold relative to the original trait. (7 points)

2. Are there evolutionary reasons why infectious diseases may once again become major health problems for humans? Explain. (5 points)

Name_____

2. Ecologists often assert that all species have a carrying capacity, or K. If you were to treat humans as just another species, and analyze human global population data, would you have found support for a K for humans using data from 1900 to 1970? What about for data from 1970 to the present time? Explain, and illustrate your answer with graphs. (10 points)

3. Two species of parrotfishes compete according to the Lotka-Volterra equations. You observe that Species 1 and species 2 both have carrying capacities of 10, and have $\alpha = 2$ and $\beta = 2$.

a. Draw isoclines for their competitive interaction, labeling all lines, points and axes.
b. Circle all equilibrium points, indicate if each is stable ("S") or unstable ("U"), and indicate which species win or coexist at each equilibrium point. (8 points)

c. When snorkeling on a series of reefs, you never observe both of these species together in the same region. Is this consistent or inconsistent with your competition graph? Explain. (5 points)

Name_____

4. You are a consultant for a land manager who has an invasive plant ("IP") species that is reducing profits by competing with a monoculture of ornamental grass ("OG") she sells to florists. IP stably coexists with OG, and, in doing this, reduces OG's abundance by half.

a. The land manager tells you that the only limiting resource is soil nitrogen. Do you agree? Why or why not? (5 points)

b. You find that there are 2 limiting essential resources, soil nitrate ("N") and soil water ("H2O"). The two plant species have the following R*'s for each essential resource.

	Nitrate	Water
OG (Ornamental grass)	$R_{OG,N}^* = 0.05$	$R_{OG,\ H20}^* = 0.2$
IP (Invasive plant)	$R_{IP,N}^* = 0.1$	$R_{IP,\ H2O}^* = 0.1$

Draw a graph illustrating resource competition between these species, labeling zero-growth isoclines, regions of coexistence or dominance, axes etc. Mark with an "X" the region on the graph indicative of the landowner's land. (8 points)

c. How could the landowner create conditions for which OG would be the superior competitor and displace IP? Justify and explain your answer by referring to your resource competition graph. (6 points)

1. What is required for two competing species to stably coexist? Answer in one sentence.

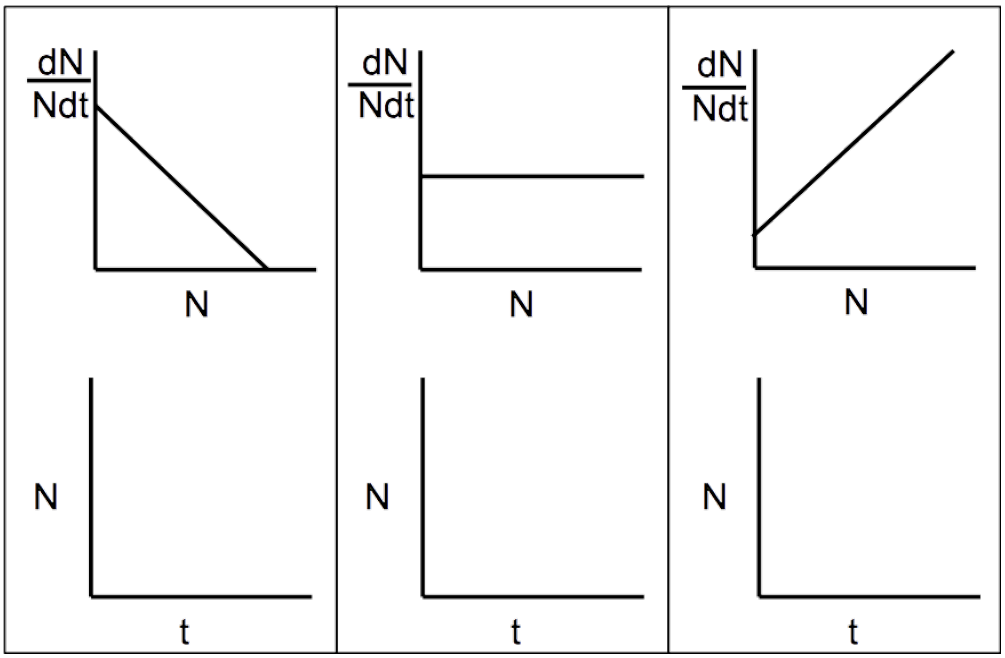
3. For each of the three cases below,

(a) on the axes immediately below a graph, draw the trajectory of population size versus time that corresponds with the graph above it;

(b) mark the axes for each upper figure for points corresponding to the parameters "r" or "K", if relevant;

(c) indicate which graphs show density independent (DI) or density dependent (DD) growth, if relevant.

Case A Case B Case C



3. A new fungal disease is infecting the vineyards of Southern California. The disease kills all known varieties of grapes once it infects a vineyard. In the year since it first appeared, the number of infected vineyards increased from 1 to 2.

a. Assuming that the disease is following exponential growth, what is "r" for the fungus population?

b. A major vineyard seeks your advice, wondering if there is any cause for alarm since it took a full year for just one new vineyard to be infected. Assuming that the observed rate of increase, r, continues unabated, what would your answer be? Show your calculations and explain.

4. The starflower and the poppy are two species of annual plants that compete with each other according to the Lotka-Volterra equations. You observe that, when growing by itself, each species reaches and maintains a population size of 100 individuals per m^2. You do experiments that show that competition coefficients are $\alpha = 1/2$ and $\beta = 1/2$.

a. Draw isoclines for their competitive interaction, labeling all lines, points and axes.

b. Circle all equilibrium points, indicate if each is stable ("S") or unstable ("U"), and indicate which species win or coexist at each equilibrium point.

c. When surveying a large area of the desert where these two species both occur, you never observe both of these species together in the same sites. Rather, you observe large patches made up solely of one or the other species. Is this observation consistent or inconsistent with your competition graph? Explain.

5. The Pacific Mussel and the invasive Mediterranean Mussel compete for resources in Puget Sound. There are 2 primary limiting essential resources that both species require for growth and survival: zooplankton and algae.

a. The two mussel species have the following R* values for each essential resource:

	Zooplankton	Algae
Pacific mussel	RPacific,Z* = 0.4	RPacific,A* = 0.15
Mediterranean mussel	RMed,Z* = 0.25	RMed,A* = 0.3

Draw a figure illustrating resource competition between these mussel species (zooplankton on the x-axis, algae on the y-axis) as a function of their resource limitations.

b. These two mussel species had long coexisted in Puget Sound. Assuming optimal forging, indicate, with an "X" labeled 'coexistence' on your graph above, a zooplankton and algal combination for Puget Sound that would be consistent with this coexistence.

c. If nutrient runoff from nearby Pino Noir vineyards were to cause Algae populations to spike, and remain elevated for a long period of time, would this possibly change the outcome of competition? Show how this might influence the "X" that you marked above, and explain whether either species is able to out-compete the other.

6. 1. In California, about 80% of the total population has been successfully vaccinated against measles ever since the year 2000. Prior to the invention of a vaccine, about 95% of the population contracted measles at some point during their lifetime. Using the model of disease dynamics that we introduced in class, answer the following questions:

a. What is the R_0 for measles in this population?

b. Prior to vaccinations, what was the average age of infection for measles? For simplicity, assume an average lifespan of 80 years.

c. What should the average age of infection for measles currently be among people who were not successfully vaccinated?

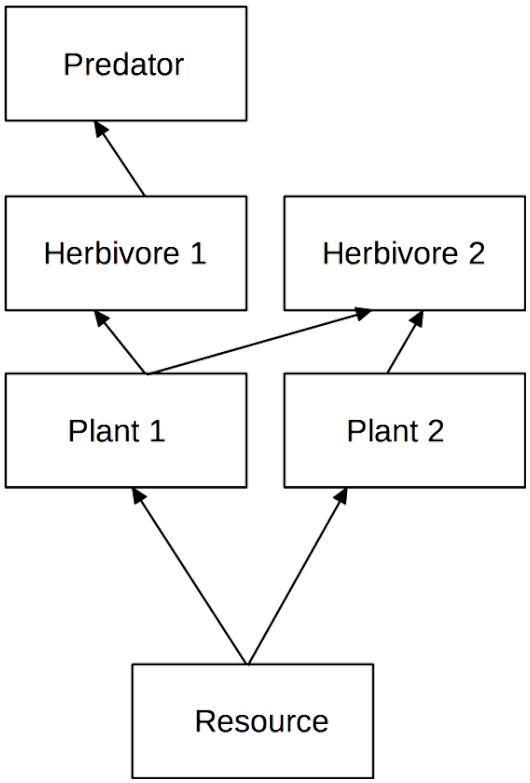
d. If there were an outbreak of measles in California today, what is the maximum fraction of the total population that could contract measles?

e. Assuming that the modern measles vaccine is only 95% effective, what fraction of the population would need to be vaccinated in order to prevent measles from being able to spread in the population?

7. Natural processes introduce about 150 x 10^{12} grams of biologically-active nitrogen to the world's terrestrial ecosystems annually. Human activities introduce about an additional

a. 30 x 10^{12} g/yr.
b. 180 x 10^{12} g/yr.
c. 2 x 10^{15} g/yr.
d. Humans only modify natural fluxes; no additional nitrogen is introduced.

8. Consider the following food web. If extra resource R were to be added to the system, which components of the food web would increase in abundance?



What would be the effect of added resource if a mutant variety of Plant 2 appeared that was totally resistant to all herbivory?

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5. Perrovirus, a disease of dogs, has an R_0 of 5 for its spread among dogs. Just as you are hired by the Santa Barbara Department of Public Health, perrovirus is discovered in Carpenteria, a few miles away. A vaccine is available for perrovirus. Your first task at your new job is address the following questions:

a. What would be the average age of disease onset if no dogs were vaccinated, assuming that dogs live 10 years? (show calculations; 4 points)

b. If 60% of dogs are successfully vaccinated, how does that change the probability a non-vaccinated dog gets perrovirus compared to zero vaccination? (show calculations; 4 points)

c. What proportion of dogs would need to be successfully vaccinated to prevent the invasion and spread of perrovirus in Santa Barbara? (show calculations; 4 points)

d. This strain of perrovirus can be spread to humans by infected dogs, and from humans to other humans and also back to dogs. Each of these modes of spread happens with the same success as for the dog-to-dog transmission that led to a dog-to-dog R_0 of 5.
Assuming that there is one dog for every person in Santa Barbara, what would be the R_0 for the spread of perrovirus among the combined dog+human population of Santa Barbara? Why? (4 points)

e. Using the R_0 value you calculated in (d), what proportion of the dog + human population would have to vaccinated to eliminate perrovirus from Santa Barbara? (2 points)

Name_____

6. Because of your ecological expertise, you are hired by a geo-engineering firm that proposes to fertilize the ocean with iron as a way to have algae remove more CO2 from the atmosphere and sequester this carbon in ocean sediments as the algae sink to the bottom. You know that iron is a major limiting nutrient for phytoplankton (algae) in large regions of the world's oceans, and that all algae that are not eaten by zooplankton eventually settle to the bottom of the ocean, where they do not decay.

Given what you know about top-down versus bottom-up processes in food chains, for what types of food chains could this geo-engineering likely achieve its objective? For what types would it be unlikely to do so? Explain. (10 points)

5. A. (6 points) A bison farmer with a typical density, free-roaming, disease-free herd must contend with a new disease that has moved into his region. In newly infected free-roaming herds of typical size, there are two new infections produced by each infected individual. What proportion of his herd would the bison farmer have to successfully vaccinate to prevent this disease from spreading through his herd? Show your work and briefly explain it.

B. (6 points) A second farmer does not graze his bison, but rather feeds them while they are confined at a population density 25-times that of a typical density herd. What proportion of this herd would the second bison farmer have to successfully vaccinate to prevent this disease from spreading through this herd? Show your work and briefly explain it.

C. (5 points) Both farmers maintain their herds such that the average life expectancy of the bison is 3 years. Bison older than 6 months survive when infected by this new disease, but the disease invariably proves fatal to bison calves much youger than 6 months. The first farmer decides not to vaccinate any of his animals. Is this a wise decision? Why?

D. (5 points) What should the second farmer do, and why? Show your calculations.

8. (6 points) What are the major factors limiting global human population size today?

9. Your first assignment as a UN field agent is to find out why some communities in Kenya have had a steady deterioriation in water quality, and others have not. Your field work shows that (1) wells in both types of communities are recharged by rains that readily percolate through sandy soils; (2) both community types are located in intact native grasslands, and both have many species of native herbivores (plant-eating animals); (3) the major difference you observe is that communities with low water quality lack large predators, whereas those with large predators have high water quality.

A. (8 points) What mechanisms are likely to be causing this pattern? Explain your logic. Illustrate as needed.

B. (4 points) Based on your hypothesis, propose two distinct actions that should allow the communities with low water quality to improve the quality of their well water.

10. (6 points) Is evolution occurring today? What types of evolutionary changes might be of greater societal importance?

11. (3 points) What is required for two competing species to stably coexist? Answer in one sentence.

12. You and a few friends become shipwrecked on a beautiful deserted island that has water but too few edible plants for survival. To survive you must catch fish, using your hands. You get pretty good at it, but discover you are competing with sea lions for the only viable fish species, a grouper.

You decide to determine the outcome of this competition. You estimate carrying capacities, finding for sea lions that $K_S = 100$ sea lions, and that each person displaces 1/3 of a sea lion (which is a competition coefficient). The carrying capacity for people is $K_P = 200$ people and each sea lion displaces 4 people, which is their competition coefficient.

Your friends love the island and ask you if they could safely live there forever. Using the data above, determine the outcome of competition between sea lions and people on this island. Illustrate your answer with a Lotka-Volterra graph with all intercepts and isoclines labeled, arrows (vectors) shown, and the equilibrial outcome explained. What is your scientific answer? Why? (9 points)