EEBIOL 161
Plant Ecology
Nathan Kraft

Midterm exam – distributed Saturday October 23, 11:59PM (over CCLE); due by 11:59 PM Wednesday Oct. 27th.

We expect this exam to take *one hour and 10 min* to complete- the extra time is to give you flexibility due to COVID- related disruptions. To reinforce this, please observe all stated length limits on answers- we will disregard anything you write beyond the stated limits. Please compose your answers on this document and upload it to CCLE as a pdf (answers will go through *Turn It In*). *You may not hand write the exam*

Section I (5 questions, 5 points each): Short answer questions focused on key concepts (about 4 min each).

Section II (3 questions, 15 points each). In-depth questions (about 12 min each).

Section III (answer all parts, 20 points total). Population growth calculations and interpretation. (about 15 min total).

TOTAL: 90 points

Please define all abbreviations you might use. You may draw on lecture material, the textbook or section readings for your answers, but examples that we cannot readily verify with course content will not be given full credit. Be sure to answer all parts of a question. Please be precise in your answers- *points will be deducted for incorrect statements even if the correct answer is also given*.

This is an open book and open note take-home exam (due to COVID), and you may use a calculator or MS Excel/ Google Sheets for calculations. However, you may not consult with anyone about the exam, and you must craft your own answers. Plagiarism and other forms of cheating will result in a score of 0 for the exam and a referral of the case to the Dean of Students. Please acknowledge you have read and understood these instructions by typing your name and your UID below.

Name: Christina Kilkeary

UID: 605416454 **Date: 27 October 2021**

Equations you *may* find useful for the exam

$$\Delta H = SR_{in} + SR_{out} + IR_{in} + IR_{out} + H_{conv} + H_{cond} + H_{et} + H_{met}$$

$$\psi_{total} = \psi_{\pi} + \psi_{p} + \psi_{g} + \psi_{m}$$

$$\lambda = l + F$$

$$N_{t+1} = \lambda N_t$$

$$N_t = \lambda^t N_0$$

$$\lambda = e^{\left(\frac{\ln(Nt/N0)}{t}\right)}$$

$$l_0 = 1$$

$$l_x = \prod_0^{x-1} S_x$$

$$R_0 = \sum l_x F_x$$

$$G = \sum (x\, l_x F_x) / R_0$$

$$\lambda = R_0^{1/G}$$

$$RGR = LIE * LUE$$

Section I (*__5 questions__*, 5 points each): Short answer questions focused on key concepts (about 4 min each). *__We expect each answer to take a few sentences__*

I.A. What is meant by ***light use efficiency*** in plant growth? How does this concept help to explain the success of some understory tree species growing in forests even though they never reach the height of the canopy?

Light use efficiency is how well plants are able to process the sunlight that they receive. Understory tree species growing in forests rely on light use efficiency because even though they do not get as much sunlight as the tall canopy species, they dedicate extra energy to processing it since they don't need as much energy to grow tall.

I.B. Ecologists can draw inferences from ***__observations__*** and from ***__field manipulations__***, among other things. What is the difference between the two? Next, give one strength and one weakness of *field manipulations* relative to *observations*.

While observations are non-experimental and involves a researcher not intervening in nature, field manipulations are experiments where researchers apply treatment or change to notice the resulting differences. A strength of field manipulations in comparison to observations is that researchers can have relative control over the variable of interest that they want to test. A weakness of field manipulations, however, is that sometimes intervention may cause artificial results that are not representative of the natural population due to the new involvement of humans.

I.C. What is meant by ***turgor pressure*** in a leaf? How to plants maintain turgor in their leaves while transpiring?

Turgor pressure in a leaf is the positive pressure caused by a high amount of water within the plant cells. This gives leaves support and hydrostatic structure. Plants can maintain turgor in the leaves while transpiring because they are constantly replenishing water through their roots. Also, plants can increase the solute within their cells so that the osmotic gradient floods their cell with water and maintains turgor pressure.

I.D. What is meant by ***bi-stability*** in an ecological system? How does bi-stability relate to the challenge of restoring a tropical forest that has been converted to a savannah?

Bi-stability in an ecological system means that with a big enough disturbance, an area can switch from one biome to another and be difficult to switch back. These biomes are so difficult to switch back because they can shift their entire species composition. Disturbances, such as fires, can result in widespread transitions of tropical forests to savannahs and change their biome states to be potentially irreversible.

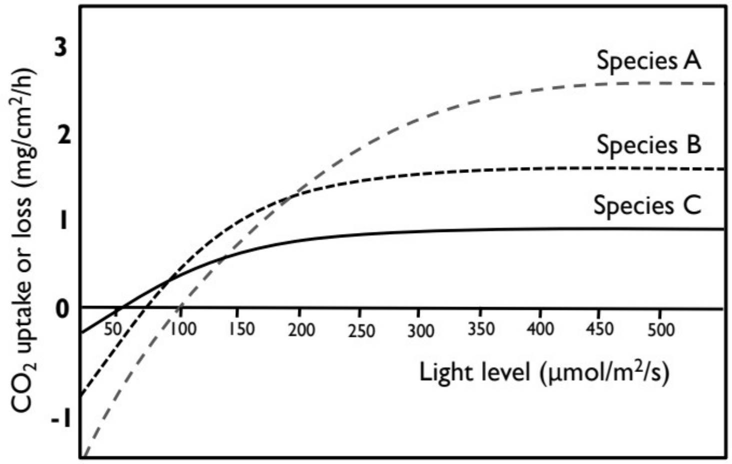
I.E. Briefly explain why grasses using ***C4 photosynthesis*** outperform ***C3*** grasses in hot, dry climates. Next, explain why C3 grasses outperform C4 grasses in cool, temperate climates.

C4 grasses outperform C3 plants in hot, dry environments because they spatially separate CO2 fixation and the production of sugar allowing it to be more photosynthetic and water efficient. Since water is of utmost value in dry climates, C4 photosynthetic plants outperform C3 plants. However, their performance comes at a cost and in climates where water is not scarce (cool, temperate climates) C3 plants outperform C4 plants because C4 plants require more energy and ATP for their photosynthesis.

CONTINUE TO SECTION II

Section II (*3 questions*, 15 points each). In depth questions (12 min each).

II.A. You have been given photosynthetic light response curve data for three species shown at right, but species names and all other ecological information have been lost. You can assume that the species are from the same forest, and that light conditions vary throughout the forest depending on disturbance history.



Why do the light response curves all have negative Y axis intercepts? (2 points) (should take 1-2 sentences)

The light response curves all have negative Y-axis intercepts because they have net CO_2 loss when the amount of light is not high enough. This is the point before there is enough sunlight for the gross photosynthetic rate to be high enough to break even with the respiration.

Predict which **single** plant species (if any) would be ***most*** abundant in the following light environments (3 points):

<20 µmol/m^2/s: Species C

500 µmol/m^2/s: Species A

120 µmol/m^2/s: Species B

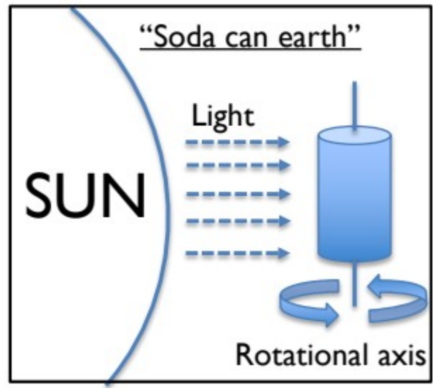
What is one phenotypic difference you would expect to see between leaves of species A and C? Why? (5 points) (should take a few sentences)

Species C would compete best in low light conditions. One phenotypic quality would be that the leaves of Species C would be much thinner with less tissue packed together in the mesophyll. This is because shade leaves rely on a low operating/maintenance cost that lower the amount of light they require to break even with their respiration rate. Species A in comparison would be much thicker so that it could absorb as much light as possible. With a high Amax, Species A can fix CO2 at a faster rate because it has so much tissue packed into the mesophyll space for photosynthesis to make up for its high operating cost.

Looking at the data, your friend exclaims "Species B is the best adapted species! Species A and C are clearly inferior!" Do you agree? Explain. (5 points) (should take about one paragraph)

I do not agree. Species B has an average maximum assimilation rate (Amax) as well as an average light compensation point (LCP) when compared Species A and C. So, although Species B does not have any "weaknesses" in the trade-off system it also doesn't share in any of the advantages as well. Species A, B, and C are all most likely from the graph of the same ecological fitness.

II.B. Imagine we discover a new a planet just like earth in every respect ***except*** that it is shaped like a cylinder oriented at a perpendicular (90°) angle to the sun, and it is not tilted on its axis of rotation (see drawing). *Ignoring the flat areas of "soda can earth" at the poles*, predict how the ***global*** climate of "soda can earth" will differ from the climate of our earth which, as you know, is a sphere and is tilted on its axis of rotation. It may be helpful to compare and contrast "soda can earth" with our planet in explaining your rationale.



First difference in global climate: Temperature does not vary based on latitude

Explain the reason for this difference: (about 1 paragraph)

Because the poles are not angled away from the sun, in the "soda can earth" there will not be variation in temperature based on latitude. On a global earth, temperature variation increases, and mean temperature decreases because of the angle of incidence of a surface to the sun's rays. With a soda can shape, the angle of incidence is eliminated, and each part of the earth gets a similar amount of light. With this it eliminates temperature variation as well as a high equatorial heat since the equator is eliminated. Seasonal changes will likely be eliminated as well.

Second difference in global climate: Coriolis effect would not exist

Explain the reason for this difference: (about 1 paragraph)

In the global earth, the earth spins at a faster speed at the equator than the rest of the globe causing the Coriolis effect. In the Coriolis effect, the pattern of circulation in the oceans and atmosphere in the Northern Hemisphere is clockwise and in the Southern Hemisphere is counterclockwise. The equator spinning faster than the rest of the globe causes the change in trajectory of air. With the soda can shaped earth, there are no changes in rotational force as the latitude changes and therefore no change in the trajectory of air. This in effect causes no gyres in the ocean and removes circulation of the oceans that effect the climate.

II.C. Pick two terms of the organismal energy balance equation that are important for plants in general, and briefly explain the underlying physical mechanism of energy transfer. Describe how a plant could adjust each of these terms through changes in physiology, morphology **or** habitat selection.

First term (use words, not symbols): Solar radiation

Briefly explain the mechanism of energy transfer. (1-2 sentences)

Solar radiation (in) is the energy that comes from the sun into the plant and solar radiation (out) is the light that is reflected from the plant.

How can plants modify this term? Give an example. (1 paragraph)

Plants can modify solar radiation by changing the structure and appearance of their leaves. Some species of plants have deposits of salt on their leaves that increase the leaf's albedo. This causes much of the solar radiation to be reflected and not absorbed. Another example of a strategy to decrease solar radiation is to have angled leaves. At the mid-point in the day, when temperatures are at their highest, the leaves are angled away from the sun and decrease the surface area that sunlight hits and is absorbed. Instead, the leaves are angled so that they can fully absorb the less intense solar radiation in the morning and late afternoon when temperatures are not as hot.

Second term (use words, not symbols): Heat convection

Briefly explain the mechanism of energy transfer. (1-2 sentences)

Heat convection is the heat transport by a volume of fluid like air or water. The air blowing over a leaf is transporting heat away from the leaf.

How can plants modify this term? Give an example. (1 paragraph)

One adaptation that plants can have to be cooler and increase convective heat loss is having leaves that are lobed with bump margins around the boundaries. In order to stay cooler, plants want leaves that create a smaller layer of still, hot air above their leaves so that the heat can be taken away from the plant. Even with the same amount of surface area, if a leaf is lobed with bumpy margins, it decreases the continuous path length for air moving across the leaves and decreases the friction that makes air stay.

Section III (20 points). Population growth calculations and interpretation. Answer all 4 parts, which are on 2 pages. Calculators are permitted. *Show all your work for full credit.* (~15 min)

You are following two populations of daisies. Population 1 is found inside a National Park and Population 2 is found on a private ranch that is subject to frequent grazing. In both populations only half of the seedlings (age 0) survive to become one-year old plants, and only 20% of the one-year olds survive to age two. Two-year old plants in both populations produce 10 offspring per individual.

In Population 1, half of the two-year olds survive until their third year. In this population, three-year olds reproduce, bearing twenty offspring per individual, and subsequently die.

In Population 2, due to the effects of grazing, no two-year old plants survive to age 3.

Shockingly, you discover that, *for both populations*, the number of seedlings (age 0) is equal to the first three digits of your UID number, the number of one years olds is equal to digits 4-6 of your UID, and the number of two year olds is equal to the last three digits. The number of three year olds in population 1 is equal to the sum of all nine digits of your UID (e.g. UID 123456789 = 45 three year olds)

Part 1: Fill in the following life tables (4 points). *If calculations are required, please spell out the calculations in the cells* (e.g. write "2+2=4", not just "4")

Population 1

x	n_x	S_x	l_x	F_x	l_xF_x	xl_xF_x
0	605	0.5	1	-	1*0=0	0*1*0=0
1	416	0.2	0.5	-	0.5*0=0	1*0.5*0=0
2	454	0.5	0.1	10	0.1*10=1	2*0.1*10=2
3	35	0	0.05	20	0.05*20=1	3*0.05*20=3

Population 2

x	n_x	S_x	l_x	F_x	l_xF_x	xl_xF_x
0	605	0.5	1	-	1*0=0	0*1*0=0
1	416	0.2	0.5	-	0.5*0=0	1*0.5*0=0
2	454	0	0.1	10	0.1*10=1	2*0.1*10=2

(Question continues on next page)
Section III (continued)
Part 2: How many individuals do you expect to see in each age class in population 1 one year in the future? *Show all of your work.* (4 points)

605*0.5 = 302.5 = **303 one-year old's**
416*0.2 = 83.2 = **83 two-year-old's**
454*0.5 = 227 = **227 three-year old's**

(303*0) + (83*10) + (227*20) = **5370 seedlings**

Part 3: Calculate the generation time for population 2. ***Show all of your work***. (2 points)

R = sum (l * F)
= (1*0) + (0.5*0) + (0.1*10)
= 1
G = sum (x * l * F) / R
= [(0*1*0) + (1*0.5*0) + (2*0.1*10)] / 1
G = 2

Part 4: Assuming the vital rates (Sx, lx and Fx) above do not change over time, how does grazing impact the ***long-term*** population growth rates of the daisies? Briefly explain your answer (100 words max) and *show all the calculations* needed to support your conclusion (10 points).

Grazing impacts the long-term population growth of the daisies because it completely stops it. With no two-year-old plants surviving to age 3 and having the opportunity to reproduce twenty offspring each, their population stays stable with a lambda value of 1. You can compare this to the same population without grazing in a National Park that has long-term population growth and a lambda value of 1.15.

Population 2:
Lambda = $R_0^{1/G}$
Lambda = 1^(1/2) = **1**

Population 1:
R = sum (l * F)
= (1*0) + (0.5*0) + (0.1*10) + (0.05*20) = 2
G = sum (x * l * F) / R
= (0*1*0) + (1*0.5*0) + (2*0.1*10) + (3*0.05*20) = 5
Lambda = $R_0^{1/G}$

Lambda = 2^(1/5) = **1.15**