Plant Ecology, Examination 2
November 13, 2001 Name _________**KEY**_____________________

Please restrict your response to the space available. Answer directly and fully - don't beat around the bush. The point values for each question are given in parentheses. Any notes you added to Wanda's notebook printout may be helpful in answering the exam.

During the past month we have examined photosynthetic characteristics of *Kallsalot bell*a, an attractive shrub with deep purple flowers from Mediterranean climate regions of southern California. We took our instrumentation to the field and measured the photosynthetic performance of different leaves within the canopy. *K. bella*, what a beautiful plant to work with - the photosynthetic responses were easy to measure and highly repeatable. At first, we measured the light-saturated photosynthetic rate for leaves at different positions in the canopy. We controlled ambient [CO_2] at 370 ppm, leaf temperature at 25 °C, and relative humidity at 60%. From those observations, we obtained the following data. Each observations represents a separate leaf within the canopy.

leaf location	Maximum photosynthetic rate (μmol CO_2 m^{-2} s^{-1})	Leaf conductance to CO_2 (mol m^{-2} s^{-1})	Photon flux (% of full sun)	Intercellular [CO_2] (ppm)
1	25	**0.208**	100	250
2	19	**0.158**	80	250
3	10	**0.083**	52	250
4	5	**0.042**	23	250

1 (12) Please calculate the leaf conductances to CO_2 and insert those values into the table above.

Correct answers are worth 3 points each

2 (10) Please provide the mechanistic explanation for why the maximum photosynthetic rate (measured at 100 % full sun) measured on different leaves decreases with leaf position in the canopy.

The maximum photosynthetic rate decreases with leaf location, because leaves deeper into the canopy are exposed to lower light levels. In response to decreasing light regimes, leaves acclimate by decreasing their photosynthetic capacity.

3 (10) Are the maximum photosynthetic rate and leaf conductance values above **negatively** correlated with each other? Yes or no. Why or why not?

4 points No 6 points Maximum photosynthetic rate and leaf conductance are positively correlated with each other. We expect this positive correlation because as photosynthetic capcity increases leaves must increase the inward diffusion rate of CO_2. The only way to do thisis by increasing leaf conductance which means greater diffusion rates through stomatal openings.

Well, once we had measured the maximum photosynthetic rates on *K. bella* leaves, we measured the photosynthetic dependence on intercellular [CO_2] (called the A - c_i response curve). The data were collected under experimental conditions in which we kept the incident photon flux density (PFD) at full sunlight (2,000 µmol m^{-2} s^{-1}), leaf temperature at 25 °C, and relative humidity at 60%. In each of these curves, the response at low CO_2 (50-200 ppm) was linear and later at high CO_2 saturated. Observations for *K. bella*:

leaf location	Initial slope of the A - c_i curve	Leaf nitrogen content (%)
1	0.125	4.0
2	0.093	3.0
3	0.050	1.6
4	0.025	0.8

4 (10) What is the nature of the relationship between the initial slope of the A-c_i curve and leaf nitrogen content? From an ecophysiological perspective, why is this pattern to be expected?

5 points The initial slope of the A-c_i curve and leaf nitrogen content are positively and linearly correlated with each other.

5 points We expect this relationship because the vast majority of nitrogen in leaves is associated with photosynthetic proteins. An increase in photosynthetic protein content per unit leaf area, especially Rubisco, results in a higher photosynthetic rate at any particular intercellular CO_2 concentration.

5 (10) Why is maximum photosynthetic rate positively correlated with leaf nitrogen content?

The maximum photosynthetic rate is positively correlated with leaf nitrogen content for the exact same reason as stated above in the previous answer. The vast majority of nitrogen in leaves is associated with photosynthetic proteins. An increase in photosynthetic protein content per unit leaf area, especially Rubisco, results in a higher photosynthetic rate.

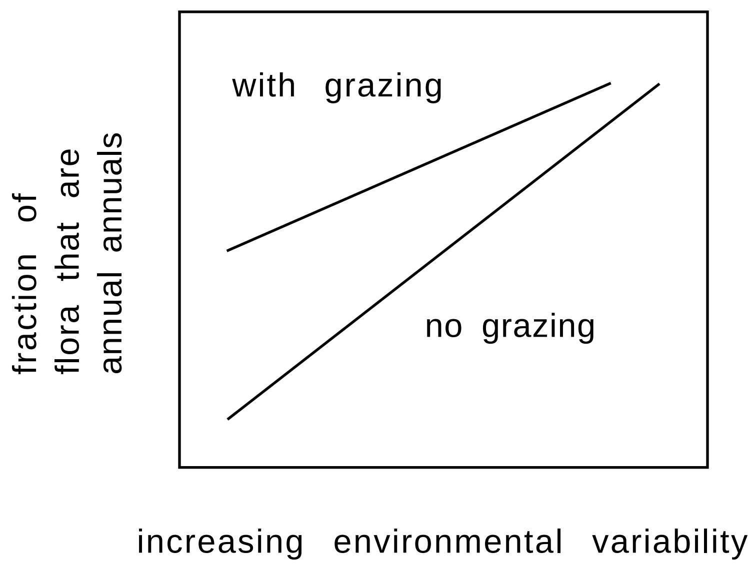
6 (10) Why is the initial slope of the A-c_i curve steeper in leaf location 1 than in leaf location 4?

The initial slope of the A-c_i curve is steeper in leaf location 1 than in leaf location 4 because the leaf in location 1 contains more photosynthetic protein and therefore has a greater capacity to fix CO_2. This is an acclimation response wherein a plant does not normally invest additional protein into a leaf if there is no capacity to utilize that additional protein for photosynthetic carbon gain. High photosynthetic enzyme content is associated with high resource environments and vice versa.

On a recent series of field trips through the deserts of North America with students, we collected the following remarkable data. Basically, these data suggest that there is a relationship between precipitation patterns and the life form of plants in the habitat. None of these habitats were grazed by cattle or sheep.

Coefficient of variation in annual precipitation	Fraction of the entire flora that are perennials	Faction of the entire flora that are annuals
2.5	0.45	0.55
1.0	0.90	0.10
1.9	0.70	0.30
1.6	0.75	0.25
0.5	0.94	0.06
3.5	0.17	0.83

7 (15) When we visited desert locations that were highly grazed we saw a very different relationship between the life form distribution and variability in precipitation. Graph the pattern we saw above for the relationship between the coefficient of variation in annual precipitation and the fraction of the entire flora that are annuals. Onto this graph now place the modified relationship when we separately look at grazed sites along this environmental gradient. Provide a brief explanation for why this different grazing related pattern occurs.



In environments where year-to-year variability in precipitation is low, annuals should be uncommon as shown. However, when grazing is added, the fraction of annuals in a low variability environment will increase because this disruption reduces the probability that all organisms will survive from year to year. This means that organisms with shorter life cycles (i.e. annuals) will increase in abundance and that perennials will decrease in abundance. At high variability sites, the fraction of annuals is already high and thus little change should be expected.

Yesterday in class, we had a very excited discussion on what parameters to measure in an exotic weed that is invading Utah's arid land ecosystems. This plant is *Heterotheca grandiflora* (telegraph weed). It has dimorphic seeds and seems to be spreading throughout the southern portions of the state at an alarming rate. We know that this plant is a member of the Asteraceae and that it is an annual. In summary, we came up with the following as parameters to measure in each plant. Obviously students had different reasons to measure the different parameters, but I wonder just how many of these measurements are really relevant to understanding the "bet-hedging" strategy used by this plant. Parameters proposed to measure on each plant:

a _ yes ___ the number of ray versus disk flowers
b _ no ____ flower color and petal length
c _ yes ___ biomass produced of seed type 1 versus seed type 2 on each plant
d _ no ____ biomass of the carpels associated with each flower head
e _ yes ___ biochemical composition of seed type 1 versus seed type 2 on each plant
f _ yes ___ dispersal distance of seed type 1 versus seed type 2 on each plant
g _ yes ___ germination rates of seed type 1 versus seed type 2 on each plant
h _ yes ___ growth rates of seed type 1 versus seed type 2 following germination
i _ no ____ photosynthetic rates on plants developing from seed type 1 versus seed type 2
j _ no ____ determinate versus indeterminate flowering
k _ yes ___ seed coat thickness of seed type 1 versus seed type 2 on each plant

7 (11) Place a "yes" or a "no" into each blank space, indicating whether or not variation in this character is indeed thought to be related to bet-hedging associated with plant dimorphism.

8 (12) Justify your answers for
(b) **There is no identifiable connection between flower color, petal length, and seed dimorphism.**
(f) **Dimorphic seeds are often of different masses or have different pappus or dispersal structures. Thus, dispersal distance should be different between dimorphic seed types.**
(g) **Dimorphic seeds often have different seed coat thicknesses. Thicker seed coats reduce water imbibition and thereby reduce germination rates. Thus, germination rates should be different between dimorphic seed types.**

9 (10) **BONUS** Justify your answers for
(a) **Ray and disk flowers in a composite head are usually associated with producing different seed types in dimorphic-seed plants. While the number of ray flowers is fixed, the number of disk flowers can be variable depending on the quality of the environment. Thus, the ratio of ray-to-disk flowers should influence the number of dimorphic seed types produced.**
(e) **In dimorphic seeds, different energy storage forms are used to fuel early growth at a fast versus slow pace. Also, per unit seed mass, different seed types may contain vastly different energy amounts.**
(k) **Seed coat thickness is associated with germination rate - a common differences in dimorphic seeds.**