Plant Ecology, Examination 2
November 12, 2005

Name:+3 points for adding 5460 after name
Student ID ___________________________

Please restrict your response to the space available; do not extend your answers to the back of the paper. 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 printouts of Wanda Weatherly's notebook are allowed in answering the exam. All page references refer to Wanda's notebook.

1 (12). Below are the data from page 465 of Wanda Weatherly's notebook. Please enter **'forest'** or **'wheat'** in the blank space to correctly identify the vegetation type associated with the LAI profiles and the leaf angle profiles.

	Vegetation: **forest**	Vegetation: **wheat**	Vegetation: **wheat**	Vegetation: **forest**
Relative canopy height (%)	LAI by level	LAI by level	leaf angle by level (degrees above horizontal)	leaf angle by level (degrees above horizontal)
100	1.20	0.05	72	45
90	1.25	0.05	70	33
80	1.00	0.05	68	21
70	0.60	0.10	64	14
60	0.20	0.35	58	9
50	0.10	0.65	50	7
40	0.05	0.75	42	5
30	0.03	0.70	33	3
20	0.02	0.60	21	2
10	0.00	0.60	12	2
0	0.00	0.55	3	0

2 (12). Provide the correct explanation for the vertical leaf area index distributions for the forest stand, given the observed leaf angle distributions with height.

Given the shallow leaf angles, light is attenuated quickly with depth in the forest canopy. Given that the bulk of the LAI is distributed at the top of the forest canopy and that the leaf angle is shallow, then light will be quickly attenuated in the upper canopy layers. The leaf angles should become progressively shallower with depth into the canopy in order to intercept any light that penetrates from above.

3 (6). Obviously the forest stand is much taller that the wheat field or any other shrub or grass vegetation that might naturally occur in the region. What are the competitive and microclimate advantages to having such a vertical LAI profile in the forest?

The competitive advantage to having the LAI distributed at the top of the forest canopy is that little light penetrates to middle and lower heights where shrubs, grasses, and other understory species would be located. That is, the trees intercept the light before it reaches the shorter life forms. The microclimate advantage to having tree leaves at greater height is by avoidance of the hottest part of the microclimatic profile (the soil surface), the evaporative demand is reduced..

4 (12). Why do you expect the patterns of observed leaf angles in the wheat stand (which are similar to all other grass canopies as well) given the observed vertical LAI distribution?

The observed LAI pattern for the wheat (grass) canopy is to have the majority of the LAI in the lower portions of the canopy. In order for light to penetrate far into the canopy, the leaf angles of the upper canopy leaves must be very steep.

5 (12) Below are the photosynthesis and nitrogen content data for both forest and wheat canopy types and as a function of canopy height (from page 466 of Wanda's notebook). Please enter **'forest'** or **'wheat'** in the blank space to correctly identify the vegetation type associated with the leaf N profiles and the leaf photosynthetic rate profiles.

	Vegetation: **forest**	Vegetation: **wheat**	Vegetation: **forest**	Vegetation: **wheat**
Relative canopy height (%)	leaf N by level (%)	leaf N by level (%)	Light saturated photosynthesis rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)	Light saturated photosynthesis rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)
100	2.8	3.2	19.0	22.0
90	2.5	3.3	16.0	22.0
80	2.1	3.3	12.0	23.0
70	1.9	3.4	10.0	24.0
60	1.7	3.7	9.0	25.0
50	1.5	3.8	8.0	26.5
40	1.3	3.6	6.0	25.0
30	1.1	3.3	4.0	23.0
20	0.9	2.9	2.5	19.0
10		2.6		16.0
0		2.2		13.0

6 (12). Why do we expect the observed leaf N profiles for the **forest** canopy? Please include in your answer some reference to the observed LAI patterns on the previous page.

We expect that plants will allocate nitrogen in leaves in such a way so that photosynthetic rate is maximized. This is accomplished by allocating the highest nitrogen amounts into leaves receiving the highest light levels. The nitrogen allocation pattern for tree leaves should be one where the highest nitrogen concentrations occur in the upper canopy leaves.

7 (12). Why do we expect the observed leaf N profiles for the **wheat** canopy? Please include some reference to the observed LAI patterns on the previous page.

In the wheat canopy, light penetrate farther in than in the forest canopy. Because of the steep leaf angles in the wheat canopy, more of the leaves deeper into the canopy are exposed to high light levels. Thus, we should see a leaf nitrogen profile that is more or less uniform with height.

8 (12). Describe the evidence from the data table above that allows one to conclude that when comparing wheat leaf and forest leaf photosynthesis patterns, the intrinsic leaf-level photosynthetic rates do not differ between forest and crop species even when they have the same nitrogen contents.

If one plots the relationship between light-saturated photosynthetic and leaf nitrogen content for both forest and wheat leaves, you will see that these two slope relationships are identical. Based on this similarity, then the intrinsic photosynthetic rates will not differ between leaf types. The reason we do see a variation in photosynthetic rate at different heights in wheat and forest leaves is because of the differential leaf nitrogen allocation patterns.

Below are the photosynthetic and intercellular CO_2 data for well watered and droughted plants as shown on page 467 of Wanda Weatherly's notebook.

Photosynthesis watered $\mu mol\ CO_2\ m^{-2}\ s^{-1}$	Intercellular CO_2 watered $\mu L\ L^{-1}$	Photosynthesis droughted $\mu mol\ CO_2\ m^{-2}\ s^{-1}$	Intercellular CO_2 droughted $\mu L\ L^{-1}$
0	50	0	50
5	100	3	100
10	150	6	150
15	200	9	200
20	250	12	250
25	300	15	300
28	350	17	350
30	400	18	400
32	450	19	450
33	525	20	525
34	600	21	600

9 (10). Interestingly, the intercellular CO_2 value of leaves exposed to both well-watered and droughted conditions remained at 250 $\mu L\ L^{-1}$ under daytime conditions. Keep in mind that the experimental measurements were done in an atmospheric environment of 370 $\mu L\ L^{-1}$ CO_2. Acclimation had occurred. Please describe the **<u>combination</u>** of biochemical, nitrogen content, and stomatal changes that had occurred within leaves exposed to drought such that the intercellular CO_2 value of leaves exposed to either well-watered and droughted conditions remained at 250 $\mu L\ L^{-1}$ under daytime conditions.

Biochemical leaves adjust to drought by decreasing their intrinsic photosynthetic capacity. Mechanistically, this is accomplished by an overall reduction in photosynthetic protein levels. Since protein content and nitrogen content are linearly related to each other, then both a reduction in photosynthetic capacity and a reduction in leaf nitrogen content under stress are expected. The stomatal conductance must also decrease with water stress in order for the reduced photosynthetic capacity to result in an identical intercellular CO_2 value. If stomatal conductance had not decreased while intrinsic photosynthetic capacity decreased, then the result would have been a higher intercellular CO_2 value.

BONUS Questions

10 (14). Given the Ohm's Law analogy for describing the relationships between photosynthetic rate, stomatal conductance, and intercellular CO_2 values, please calculate the stomatal conductances of both control and treatment plants under midday conditions and insert those values below. Remember that 1 $\mu L\ L^{-1}$ is the same as 1 ppm.

Midday leaf conductance to CO_2 for well-watered leaves, mol $m^{-2}\ s^{-1}$	Midday leaf conductance to CO_2 for droughted leaves, mol $m^{-2}\ s^{-1}$
0.17	**0.10**

The algebra …..

$A = (c_a - c_i)*g$ therefore, $g = A/(c_a - c_i)$

Well watered $g = 20/(370 - 250) = 0.166$

Droughted $g = 12/(370 - 250) = 0.100$

11 (3) What kind of forest would you expect to find in the Weatherly, PA region?

A temperate deciduous forest