

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: _____	Vegetation: _____	Vegetation: _____	Vegetation: _____
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.

3 (6). Obviously the forest stand is much taller than 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?

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?

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:	Vegetation:	Vegetation:	Vegetation:
Relative canopy height (%)	leaf N by level (%)	leaf N by level (%)	Light saturated photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)	Light saturated photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)
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.

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.

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.

Below are the photosynthetic and intercellular CO₂ data for well watered and droughted plants as shown on page 467 of Wanda Weatherly's notebook.

Photosynthesis watered μmol CO ₂ m ⁻² s ⁻¹	Intercellular CO ₂ watered μL L ⁻¹	Photosynthesis droughted μmol CO ₂ m ⁻² s ⁻¹	Intercellular CO ₂ droughted μL 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 CO₂ value of leaves exposed to both well-watered and droughted conditions remained at 250 μL L⁻¹ under daytime conditions. Keep in mind that the experimental measurements were done in an atmospheric environment of 370 μL L⁻¹ CO₂. Acclimation had occurred. Please describe the **combination** of biochemical, nitrogen content, and stomatal changes that had occurred within leaves exposed to drought such that the intercellular CO₂ value of leaves exposed to either well-watered and droughted conditions remained at 250 μL L⁻¹ under daytime conditions.

BONUS Questions

10 (14). Given the Ohm's Law analogy for describing the relationships between photosynthetic rate, stomatal conductance, and intercellular CO₂ values, please calculate the stomatal conductances of both control and treatment plants under midday conditions and insert those values below. Remember that 1 μL 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

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