Measurements and Modeling of Net Carbon Exchange over a Southeastern Loblolly Pine Plantation at the Duke Forest *AmeriFlux* Site

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Introduction:

- **Research thrust focuses on understanding and quantifying the linkages between net carbon exchange, water and energy budgets, and ecological attributes.**

Table 1a: Components of the carbon cycle in years 1999 and 2000.

Process	**Carbon (g C m^{-2} y^{-1})**	
	1999	**2000**
NEE	630	790
Forest Floor	998	1340
Above Ground	450	490
GPP	2078	2620

- Mean LAI increased by 18% from 1999-2000.

- Oren et al., (2001) report dramatic increase in growth - reflected in a greatly enhanced NEE (25%).

- Clark et al. (1999) – reported similar NEE enhancement for the Florida Ameriflux slash pine. They attributed the enhancement to radiation differences.

Table 1b: Components of the water cycle in years 1999 and 2000.

Process	Water ($mm\ y^{-1}$)	
	1999	**2000**
Net Radiation	1261	1312
Precipitation	1214	1006
Interception	311	272
Transpiration (sapflux)	533	519
Measured LE (EC)	575	614
Runoff	370	215

- Based on Tables 1 and 2, ecosystem water-use efficiency, defined as GPP/Transpiration increased from 3.9 g C/mm to 5.05 g C/mm (or ~ 30%).

Based on a simplification to the Cowan-Farquhar (1977) model, Katul et al. (2000) derived the following for leaf water-use efficiency:

$$WUE \approx \frac{C_a}{D}\left[1-\frac{C_i}{C_a}\right]$$

C_a and C_i are atmospheric and intercellular CO_2 concentrations. D = Vapor Pressure Deficit.

LEAF-LEVEL MEASUREMENTS:

- Stable isotopes measurements in 1999 and 2000 suggest that C_i / C_a did not vary appreciably (<7%).

- WUE should be caused by differences in D.

METEOROLOGICAL MEASUREMENTS:

- D in 1999 was 32% higher than in year 2000 (Schafer et al., 2001) – despite higher precipitation!!

- The reduction in D between 1999 and 2000 can be attributed to the more even distribution in precipitation **during the growing season** of year 2000 (and not temperature variation).

Conclusion:

- Hence, unlike the Florida Slash Pine, in which NEE differences (610 and –740 g C m^{-2} y^{-1}) were "induced" by net radiation differences, while precipitation distribution differences was the key driver for Duke Forest (630 – 790 g C m^{-2} y^{-1}).

- Even for the same species and region, variations in C-budgets cannot be studied in isolation from energy and water cycles.