The Effects of Nitrogen Fertilization on Biosphere-Atmosphere Water and Carbon Fluxes

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Introduction – 1

- Several studies suggest that southern U.S. forests can act as a large terrestrial carbon sink.

- These forests are generally situated at sites with moderate to poor soil fertility (e.g. Oren et al., 2001).

Introduction – 2:

- Fertilization increases leaf area index and leaf carboxylation capacity → increase in GPP – e.g. Baldocchi et al., 2001).

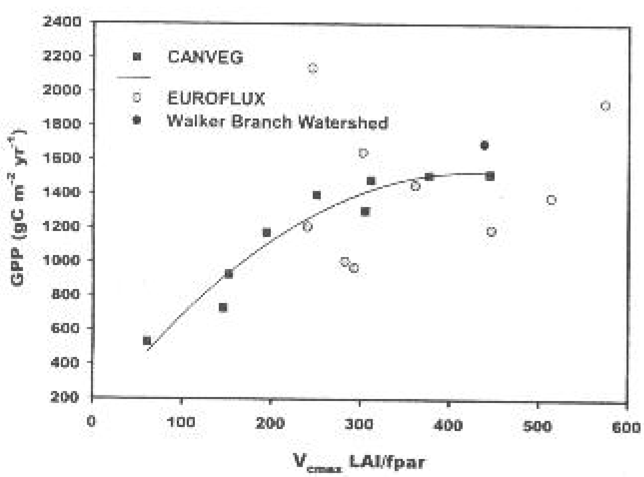


FIG. 12. The relation between gross primary productivity (GPP) and plant physiological capacity using field data and a biophysical model. The index of plant physiological capacity is a function of the maximum carboxylation velocity of photosynthesis (*V*cmax), leaf area index (LAI), and the fraction of absorbed visible sunlight (*f*par). The Euroflux field data are reported in Valentini et al. (2000).

- Fertilization can increase respiring biomass.

Question:

How does Nitrogen fertilization alter

CO_2 and H_2O Fluxes?

<u>Case study</u>

Southeast Tree Research and Education Site (SETRES) – 2.

A large-scale genotype × nutrition interaction experiment designed to quantify the effects of fertilization on C- cycling in *a managed southern pine forest* in North Carolina (operated by the *U.S. Forest Service*).

<u>Experiment</u>

After **6 years** of fertilization at SETRES:

- Leaf Area Index Doubled (1.5 → 3).
- Maximum Leaf Carboxilation Capacity Increased by 20%.
- Respiring Biomass Increased by ~ 48%.

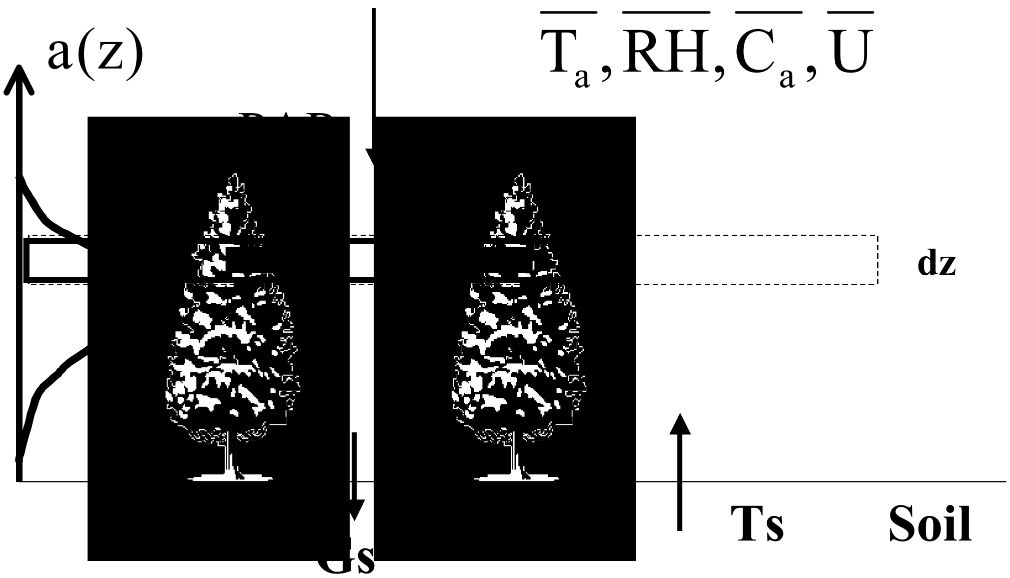
Approach:

Combination of:

- Short term micrometeorological measurements (e.g. eddy-correlation flux measurements collected in September-October of 2000).
- Long-term measurements: mean meteorological conditions, net primary productivity, LAI, respiratory components.
- Coupled ecophysiological, radiative and energy, hydrologic, and turbulent transport models.

CANVEG INPUT FORCING VARIABLES

Atmospheric Forcing



Multilevel Model:

Requires ecophysiological, radiative, energy, drag, respiration-temperature functions for wood, plant, and forest floor.

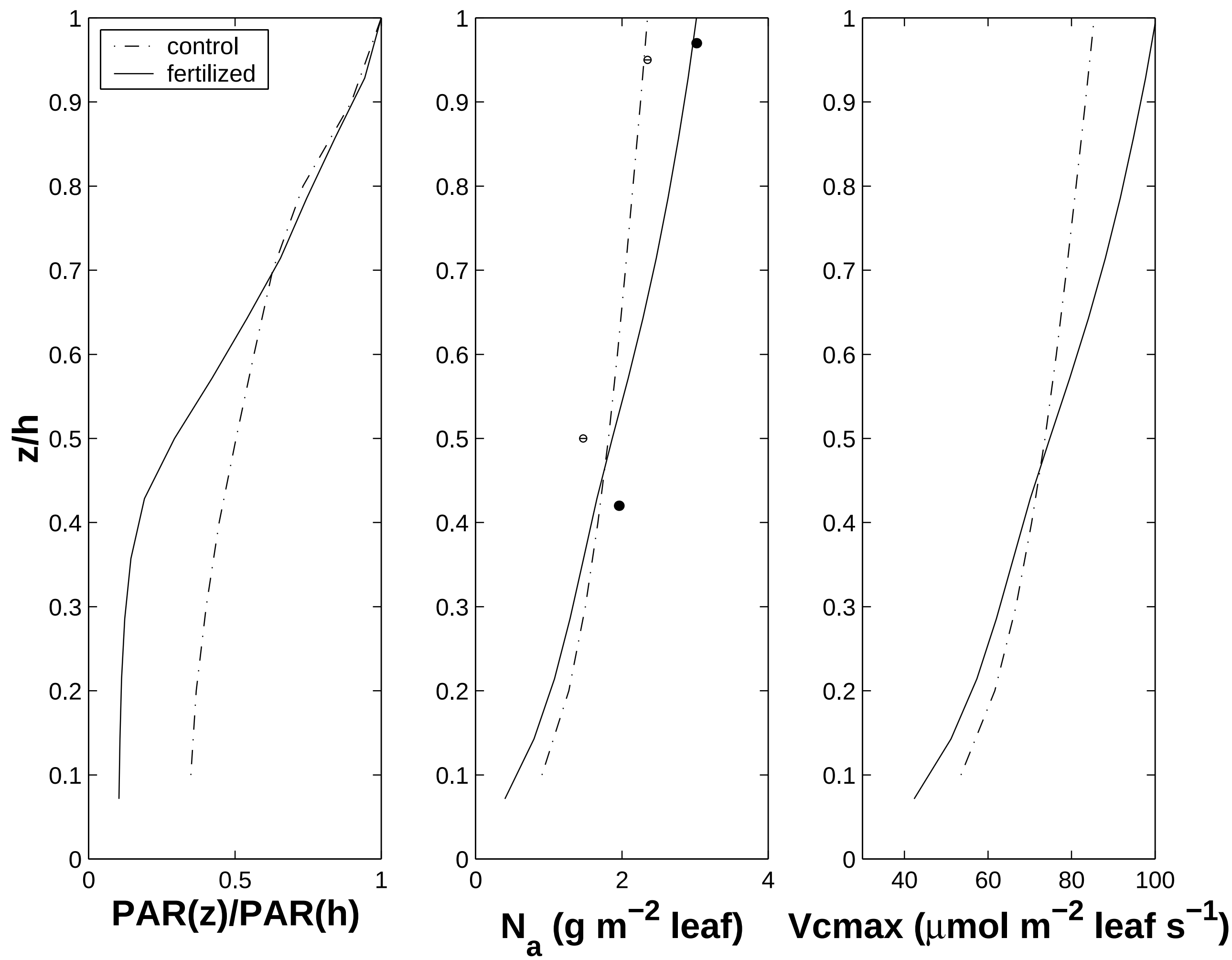


Figure 1: Fertilization Effects on Leaf Area Density, Light and Maximum Catalytic Capacity of Leaves.

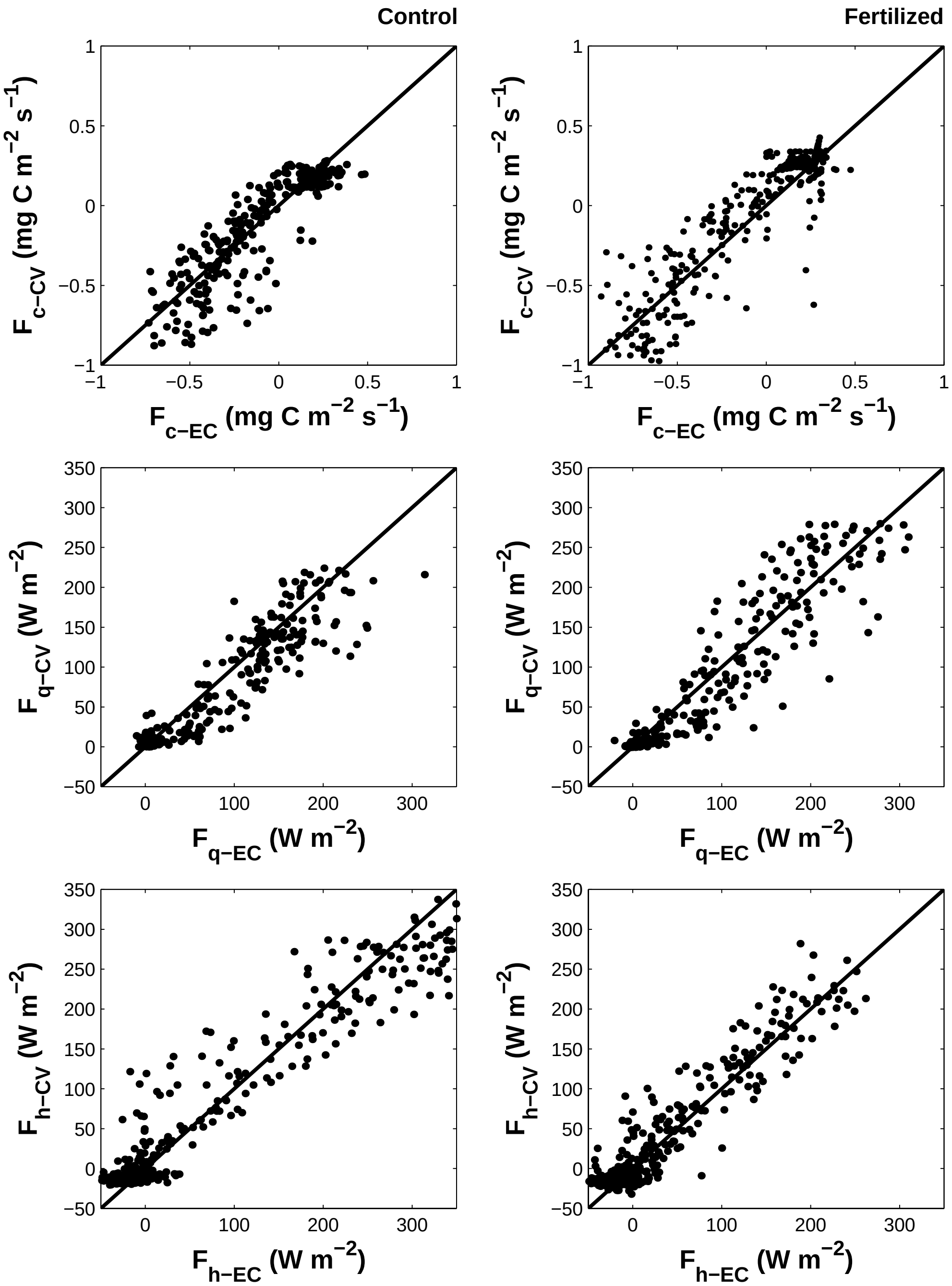


Figure 2: Comparison between Model and Measurements.

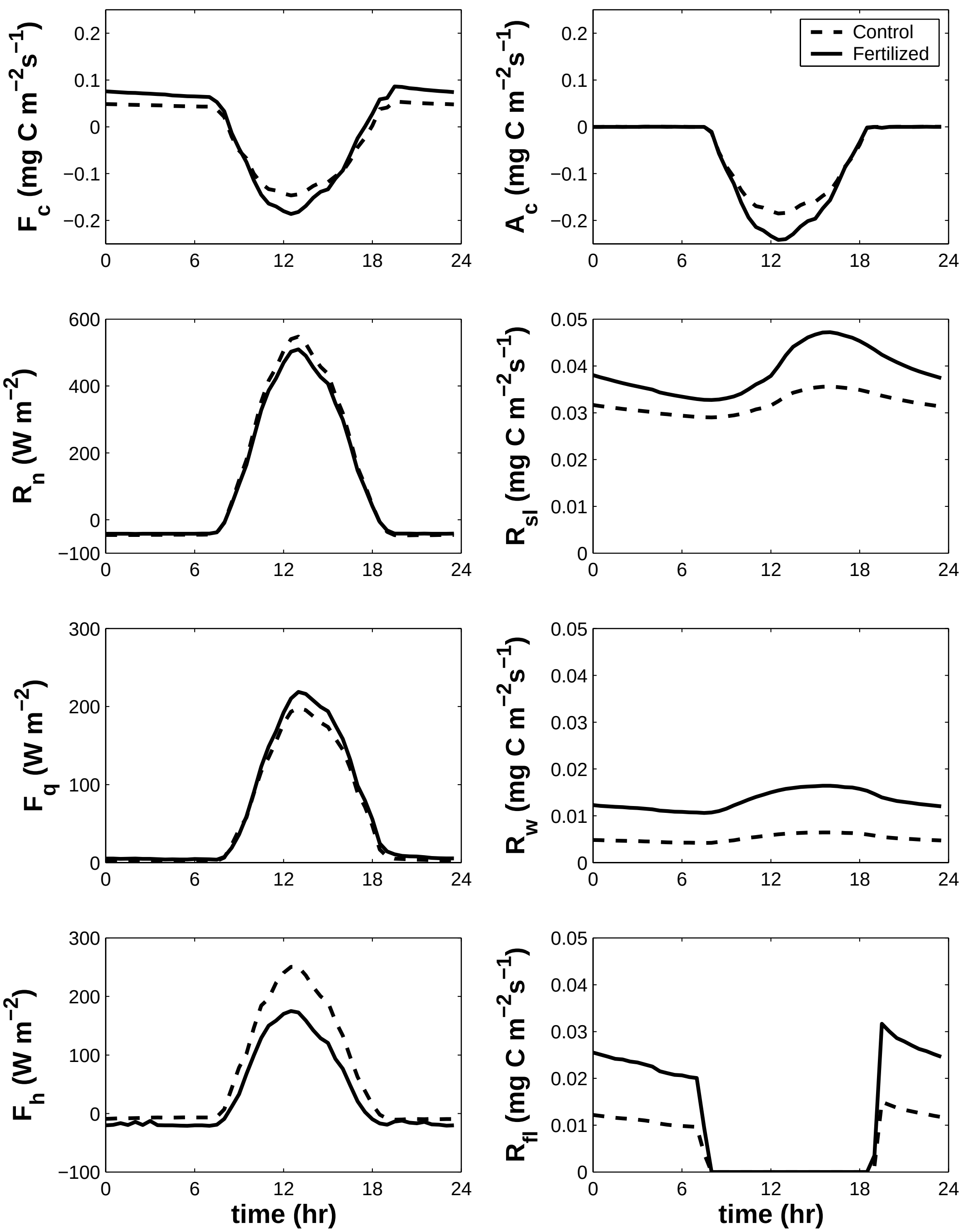


Figure 3: Fertilization Effects on Land-Surface Fluxes.

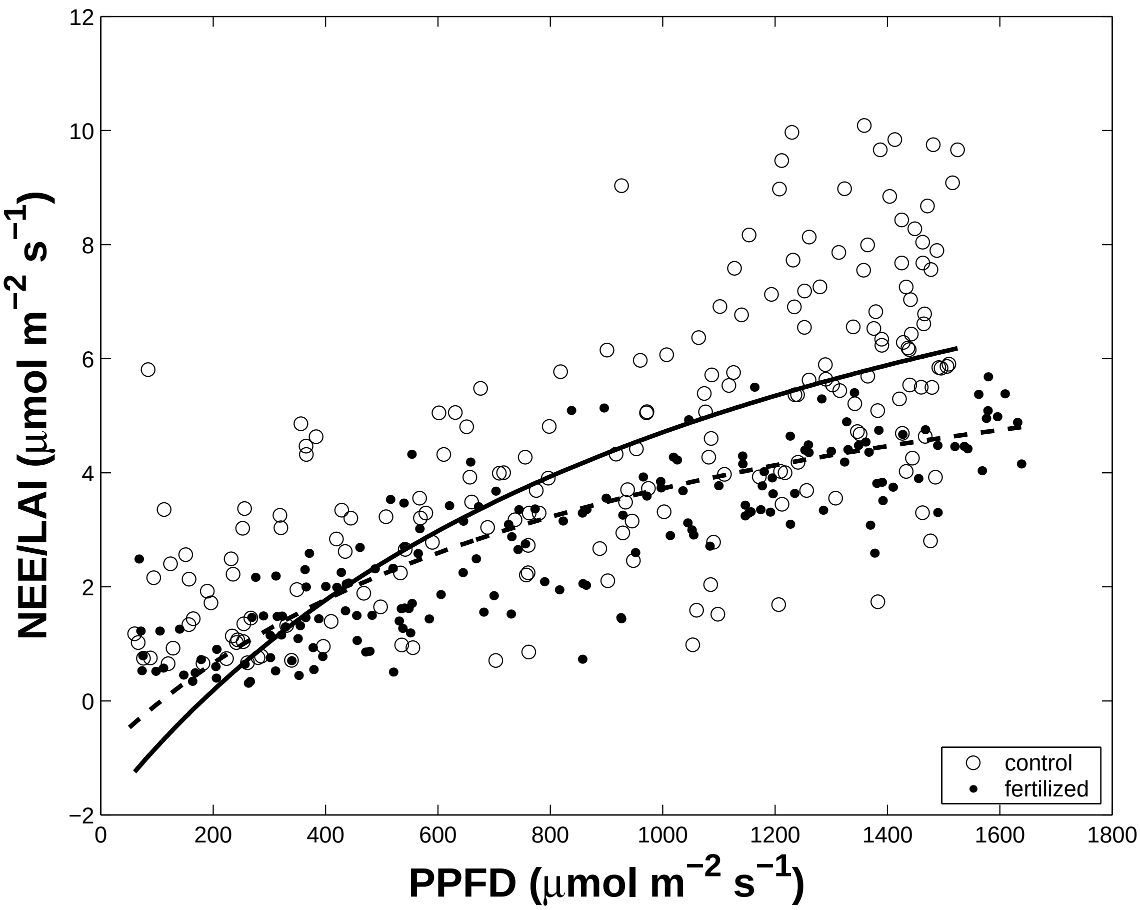


Figure 4: Fertilization Effects on

Daytime CO_2 Fluxes per LAI.

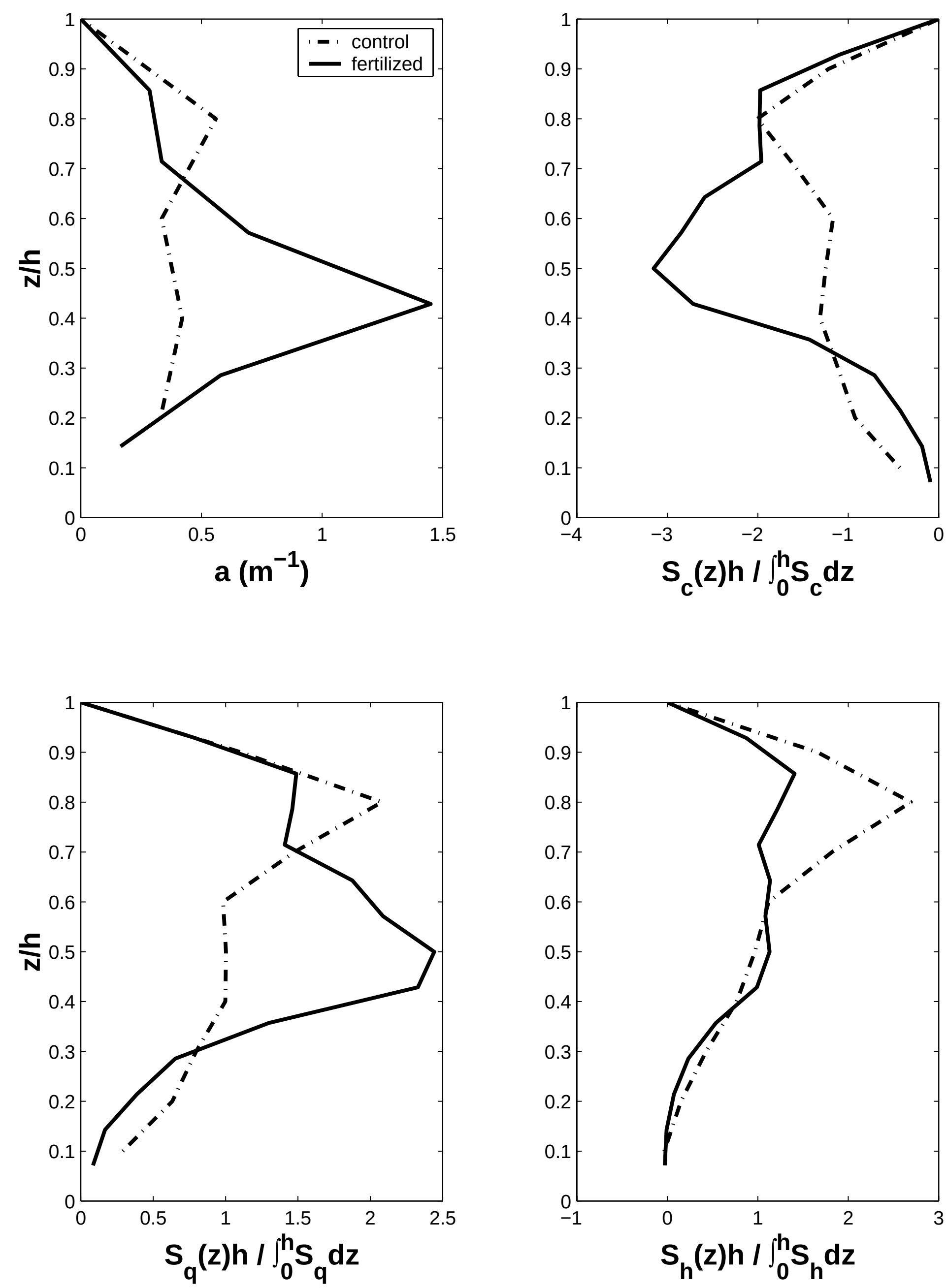


Figure 5: Fertilization Effects on Vertical Distribution of Scalar Sources and Sinks.

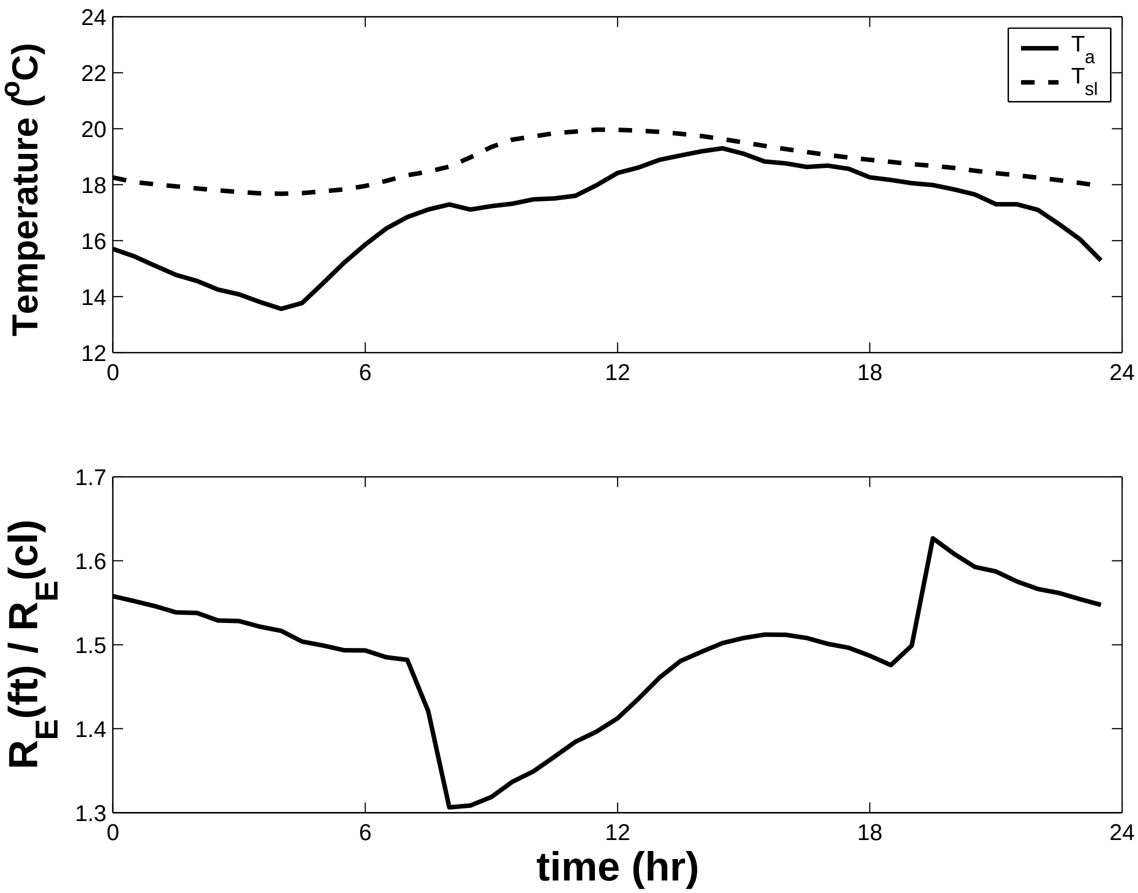
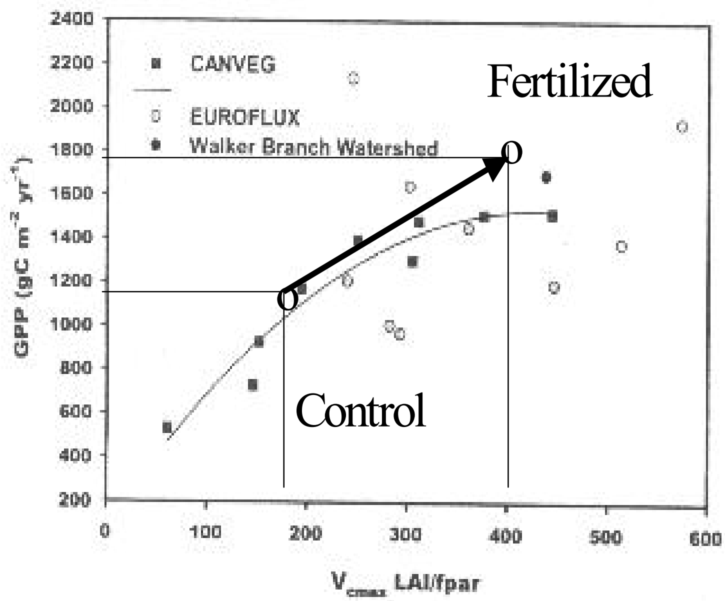


Figure 6: Fertilization Effects on

Ecosystem Respiration.

Annual carbon balances (g C m^{-2} yr^{-1})

Data in Baldocchi et al. (2001):



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Fertilization increases V_{cmax} and LAI

Annual carbon balances (g C m^{-2} yr^{-1})

Variable	Control	Fertilized
Gross Primary Productivity	-1220	-1795
Respiration Components		
(i) Forest Floor	1107	1140
(ii) Above-ground Woody	156	395
(iii) Foliar	63	133
Total Ecosystem Respiration	1326	1668
Net Ecosystem Exchange (NEE)	**+106**	**-127**
Daytime NEE	-525	-993
Nighttime Ecosystem Respiration	695	901
Woody Increment	121	403

Fertilized ~ Sink for CO_2

Unfertilized ~ Source for CO_2

CONCLUSIONS

- Increases in LAI and $V_{c\max}$ were not linearly translated to comparable increase in NEE.

- Compensatory mechanisms are likely to exist at the end of the growing season in which light transmission is reduced and temperature is high.

- On annual time scales, these compensatory effects are not sufficiently large to offset overall gains in carbon storage with fertilization.

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3) *US Forest Service*.