Annual CO_2 Exchange in Irrigated and Rainfed Maize-Based Agroecosystems

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Objective

Report results from the first three years of measurements of net ecosystems CO_2 exchange (NEE) from the tower flux systems

Address the following questions:

- How does the seasonal and annual CO_2 exchange of maize compare with that of soybean?
- What is the impact of irrigation on the CO_2 exchange of these crops?
- How does the annual CO_2 exchange of a continuous maize system compare with a maize-soybean rotation?

- University of Nebraska Agricultural Research and Development Center near Mead, NE
- Three cropping systems
  - Site 1: Irrigated continuous maize (*Zea mays, L.*)
  - Site 2: Irrigated maize-soybean (*Glycine max. [L.] Merr.*) rotation
  - Site 3: Rainfed maize-soybean rotation
- Sites 1 and 2: Center-pivot irrigation systems

- Prior to initiation of the study
  - Sites 1 and 2 had a 10-year history of maize-soybean rotation under no-till
  - Site 3 had a variable cropping history of primarily wheat, soybean, oats, and maize grown in small plots with tillage

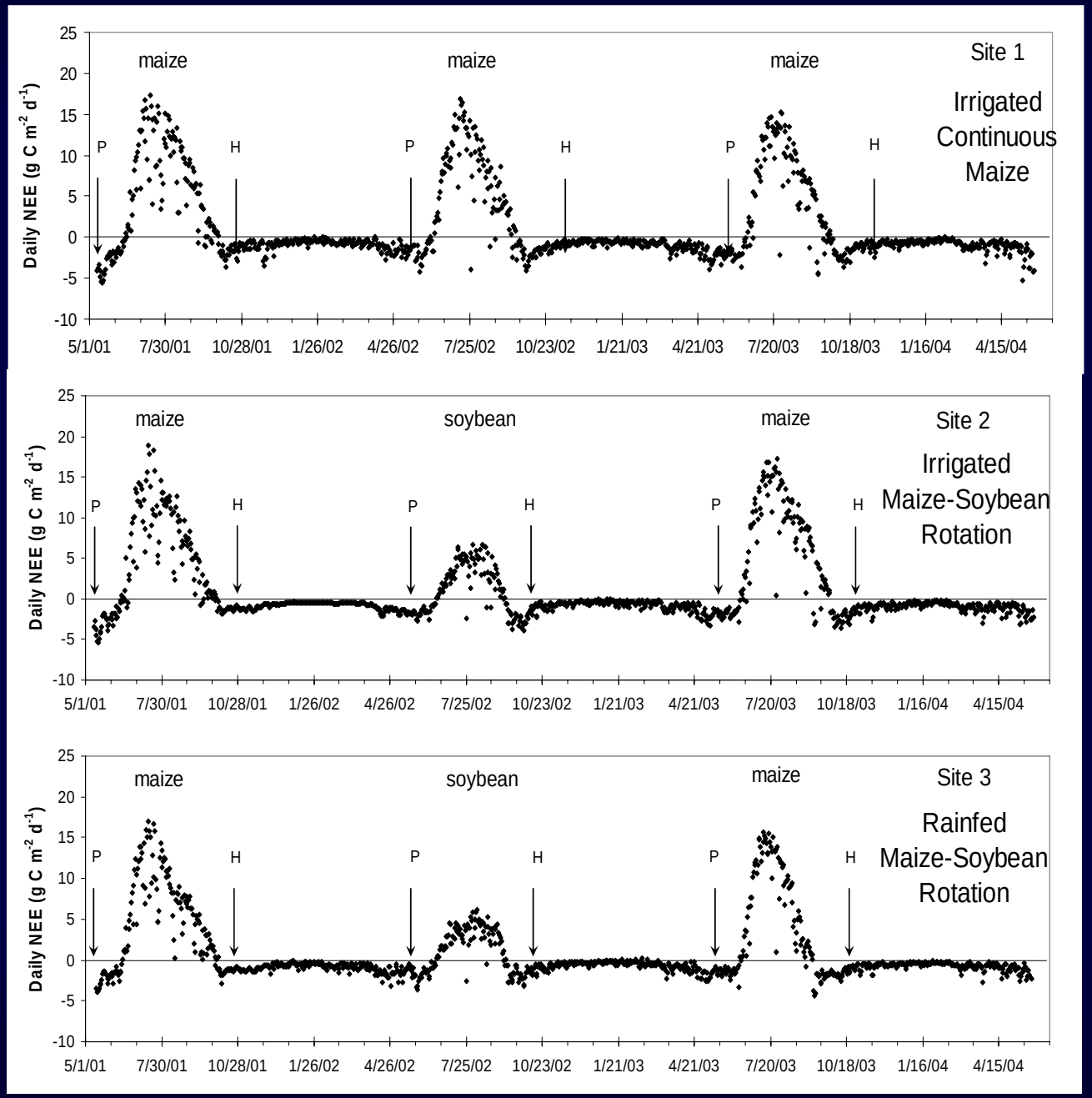
- All three sites were uniformly tilled by disking prior to the initiation of the study to humogenize the top 0.1 m of soil and incorporate P and K fertilizers, as well as previously accumulated soil residues
- Since initiation of study in 2001
  - All sites under no-till
  - BMP

Landscape-level (Eddy Covariance) Measurement of CO_2 and Other Fluxes

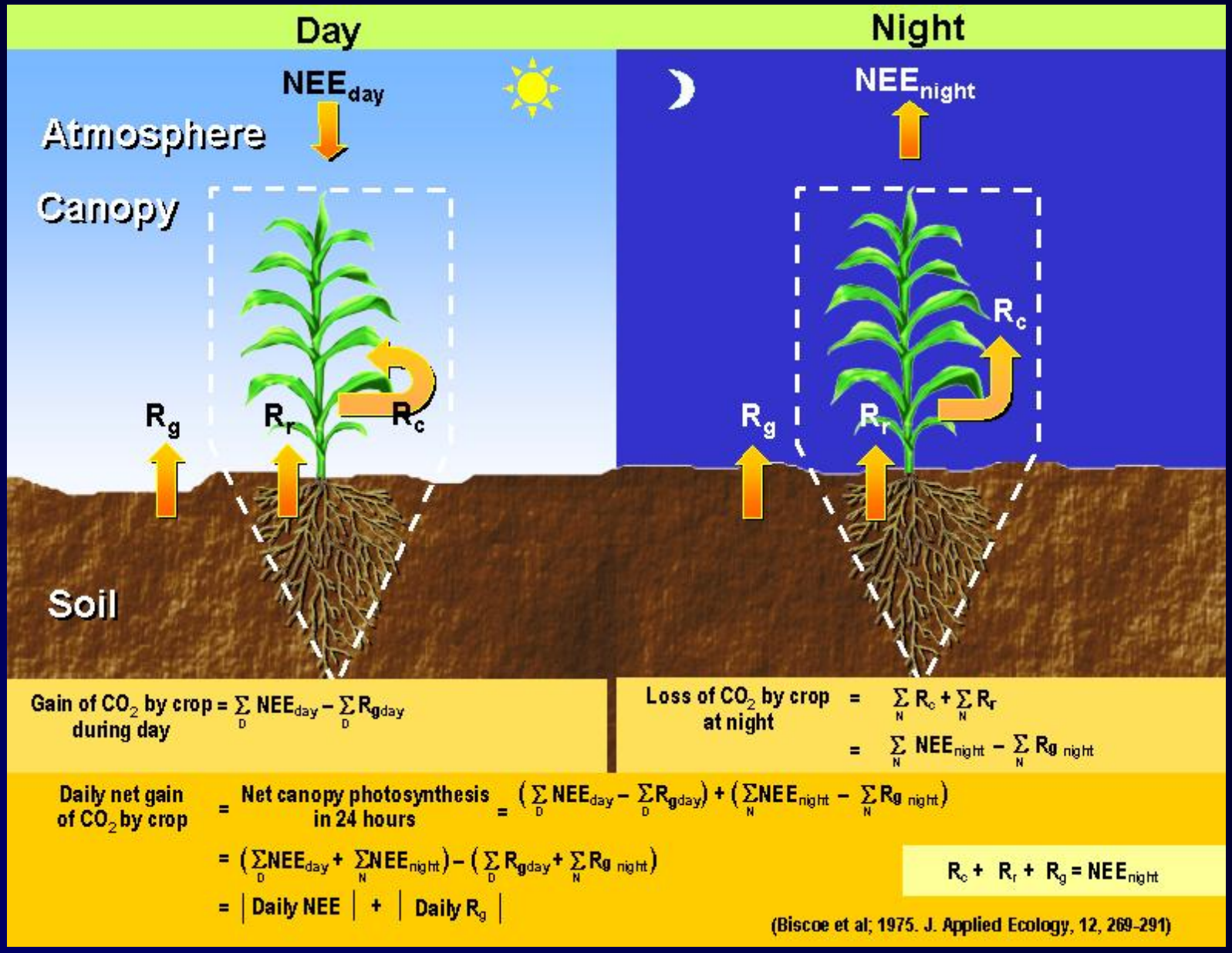
Measuring Components of Solar Radiation

Close Up of Eddy Covariance Flux Sensors

Net Ecosystem CO_2 Exchange (NEE): Three Years



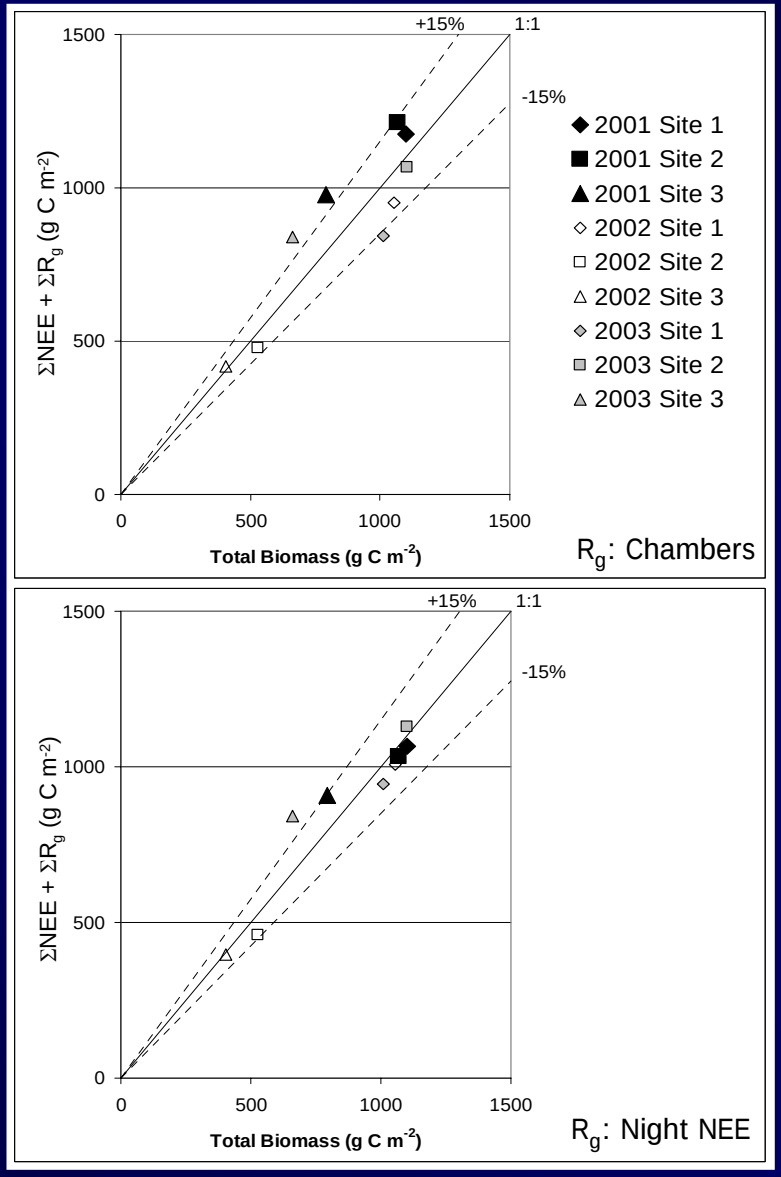
NEE-Biomass Relationship



Estimating Microbial Respiration (R_g)

- Soil surface CO_2 flux measurements (F_s)
  - Two different kinds of chambers:
    - ✓ Model LI-6200, Li-Cor, Lincoln, NE
    - ✓ Hutchinson & Mosier (1981) type chamber
  - Used data from field measurements of maize soil respiration in root excluded and non-root excluded soil to estimate Rg
- Night NEE data
  - Adjusted for plant respiration based on leaf gas exchange measurements
  - Adjusted for night/day temperatures
  - Applied measurements of root excluded vs. non-root excluded soil respiration to estimate Rg, as mentioned above

NEE – Biomass Relationship
(Cumulative values between planting and physiological maturity)



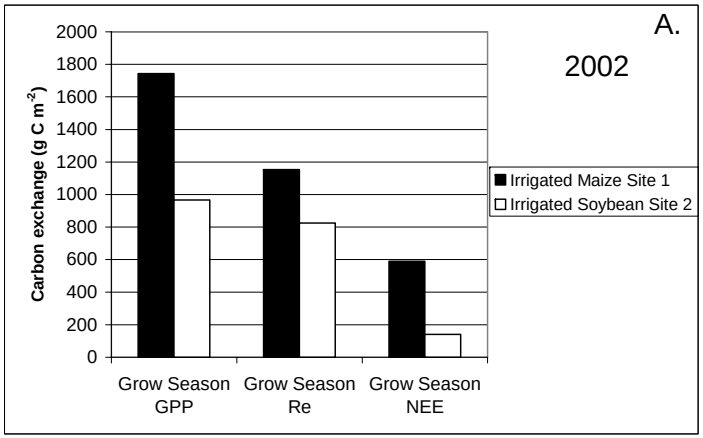
Ecosystem Respiration (Re) and Gross Primary Production (GPP)

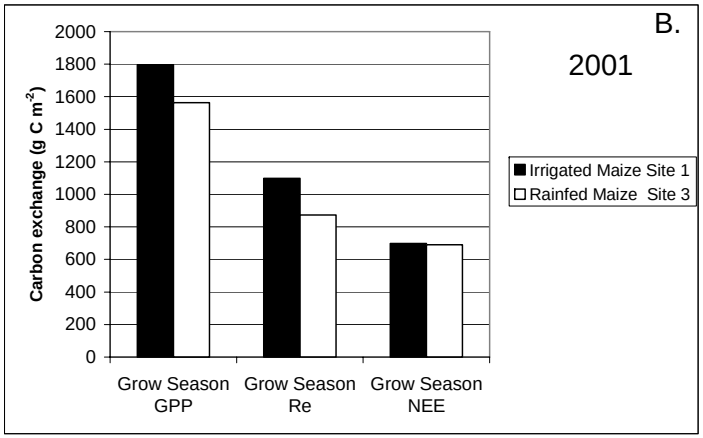
$$Re_{night} = NEE_{night}$$

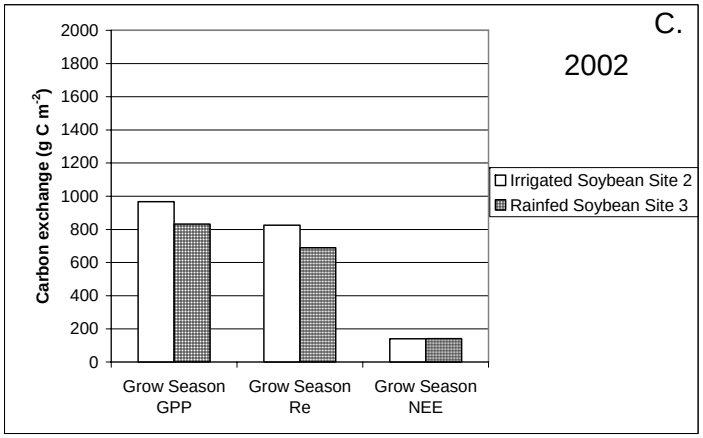
$$Re_{day} = NEE_{night} * Q_{10}^{(T_{a,day} - T_{a,night})/10}$$

$$|GPP| = |NEE| + |Re|$$

Integrated magnitudes of GPP and Re (over a growing season)







Non-Growing Season (Autumn/winter/spring)CO_2 Exchange

Daily Re: Correlated with soil temperature

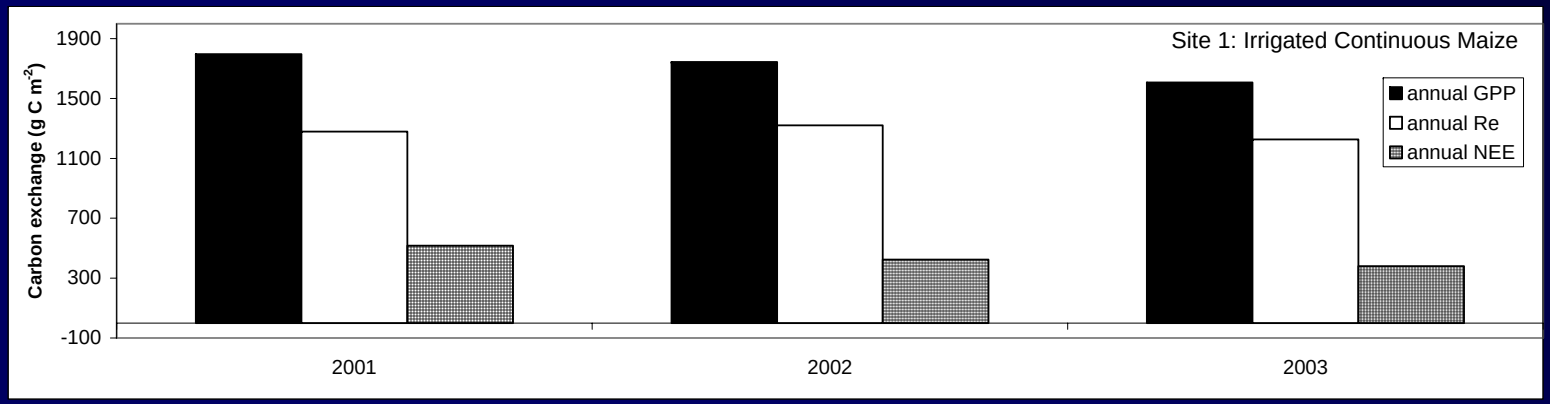
(R^2 = 0.59 to 0.71, P < 0.01)

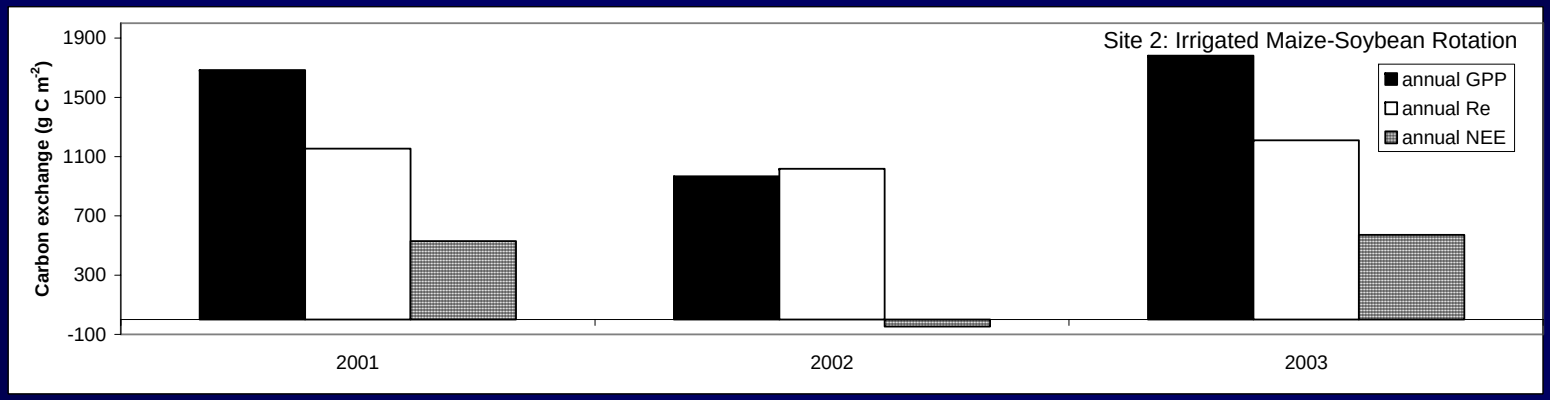
Highest Re: Near harvest time

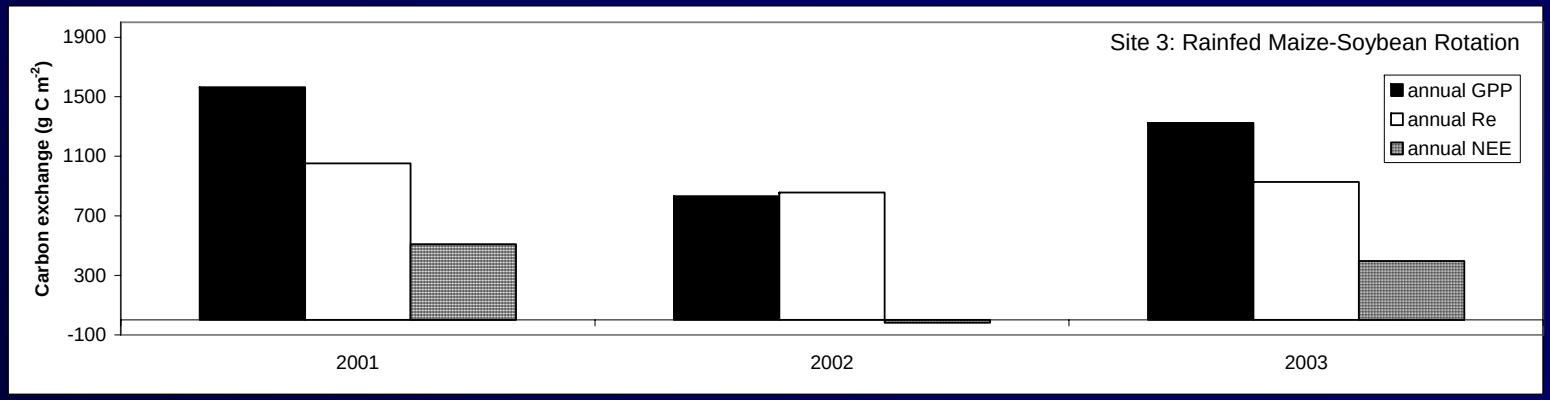
Spring

$Re_{non\text{-}growing}$ = 0.15 to 0.25 $Re_{growing}$

Annually integrated magnitudes of GPP and Re







Annual Carbon Balance

$$NBP = \text{Annual NEE} - C_g + I_c$$

where: NBP = Net Biome Production
NEE = Net ecosystem CO_2 exchange
C_g = Amount of C removed with harvested grain
I_c = CO_2 released from irrigation water
(Estimated using *in vitro* direct measurements of CO_2 release from irrigation water applied to soil)

Annual Carbon Budget (g C m^{-2} yr^{-1})

	Year 1 2001-02	Year 2 2002-03	Year 3 2003-04
	Site 3: Rainfed maize-soybean rotation		
	Maize	Soybean	Maize
Annual NEE	510	-18	397
Grain C removal during harvest (C_g)	335	153	297
NBP	175	-171	100

Annual Carbon Budget (g C m^{-2} yr^{-1})

	Year 1 2001-02	Year 2 2002-03	Year 3 2003-04
	Site 1: Irrigated continuous maize		
	Maize	Maize	Maize
Annual NEE	517	424	381
Grain C removal during harvest (C_g)	521	503	470
Estimated CO_2 release from irrigation water (I_c)	43	39	49
NBP	7 to 28	-69 to -50	-77 to -52

Annual Carbon Budget (g C m^{-2} yr^{-1})

	Year 1 2001-02	Year 2 2002-03	Year 3 2003-04
	Site 2: Irrigated maize-soybean rotation		
	Maize	Soybean	Maize
Annual NEE	529	-48	572
Grain C removal during harvest (C_g)	518	183	538
Estimated CO_2 release from irrigation water (I_c)	41	26	45
NBP	21 to 42	-225 to -212	45 to 68

Annual Carbon Budget (g C m^{-2} yr^{-1})

	Year 1 2001-02	Year 2 2002-03	Year 3 2003-04
	Site 3: Rainfed maize-soybean rotation		
	Maize	Soybean	Maize
Annual NEE	510	-18	397
Grain C removal during harvest (C_g)	335	153	297
NBP	175	-171	100

Annual Carbon Budget (g C m^{-2} yr^{-1})

Cropping system	NBP
Rainfed maize-soybean rotation (Site 3)	+2 (years 1 and 2 average) -36 (years 2 and 3 average)
Irrigated continuous maize (Site 1)	-46 to -25 (3 year average)
Irrigated maize-soybean rotation (Site 2)	-102 to -85 (years 1 and 2 average) -90 to -72 (years 2 and 3 average)

Conclusions

Accounting for the grain C removed during harvest and the CO_2 released from irrigation water, our tower eddy covariance flux data over the first three years suggest that, at this time:

- The rainfed maize-soybean rotation system is C neutral
  - Consistent with results from ongoing studies in Illinois and Minnesota
- The irrigated continuous maize is nearly C neutral or a slight source of C
- The irrigated maize-soybean rotation is a moderate source of C