Why is restored peatland NEE so high?

Insights from three methods for CO_2 flux estimates

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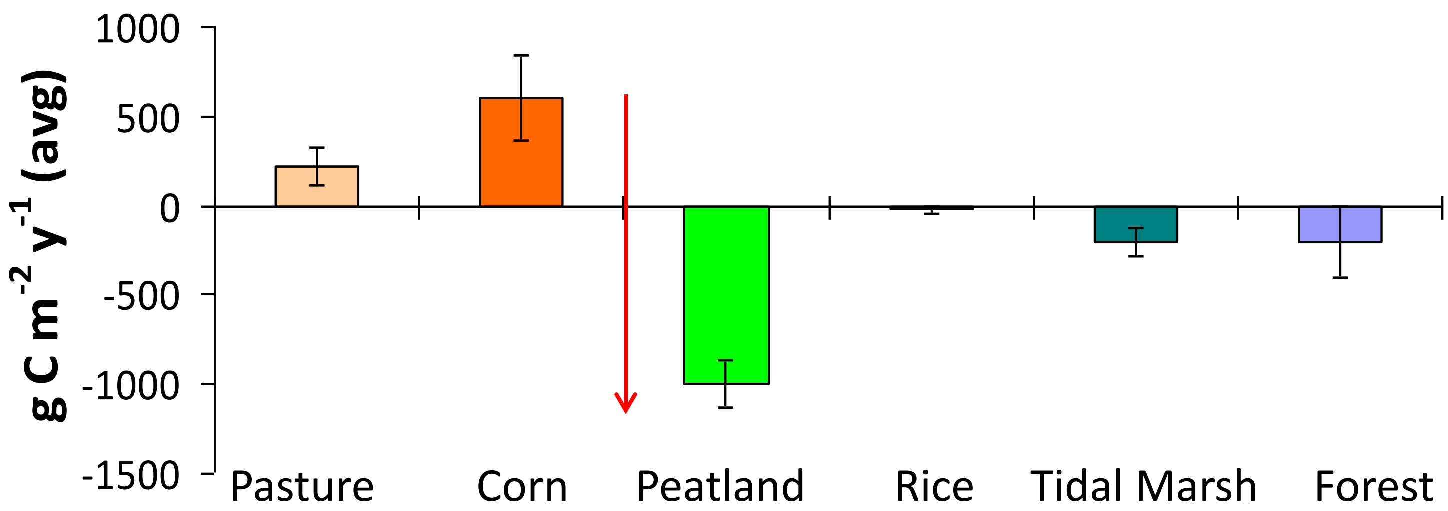
US Geological Survey, Menlo Park and Sacramento, CA

Freshwater marsh restoration on subsided Delta islands

(Peat fills the consistent 25-55cm accomodation space)

Estimates of NEE fluxes in San Francisco Bay-Delta lands



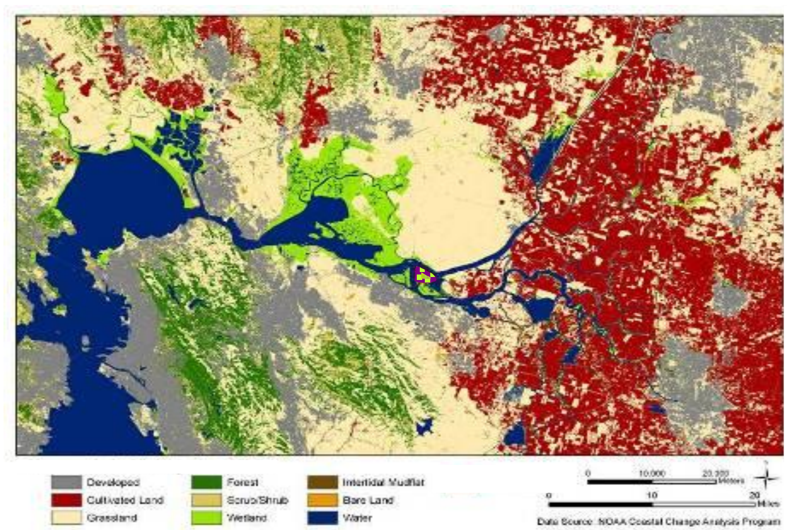


Image by Maggi Kelly, UCBerkeley

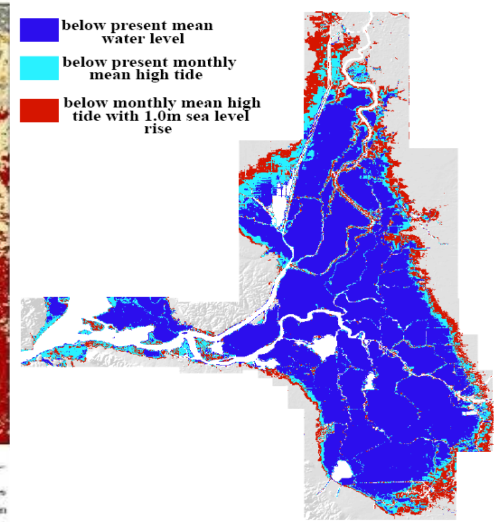
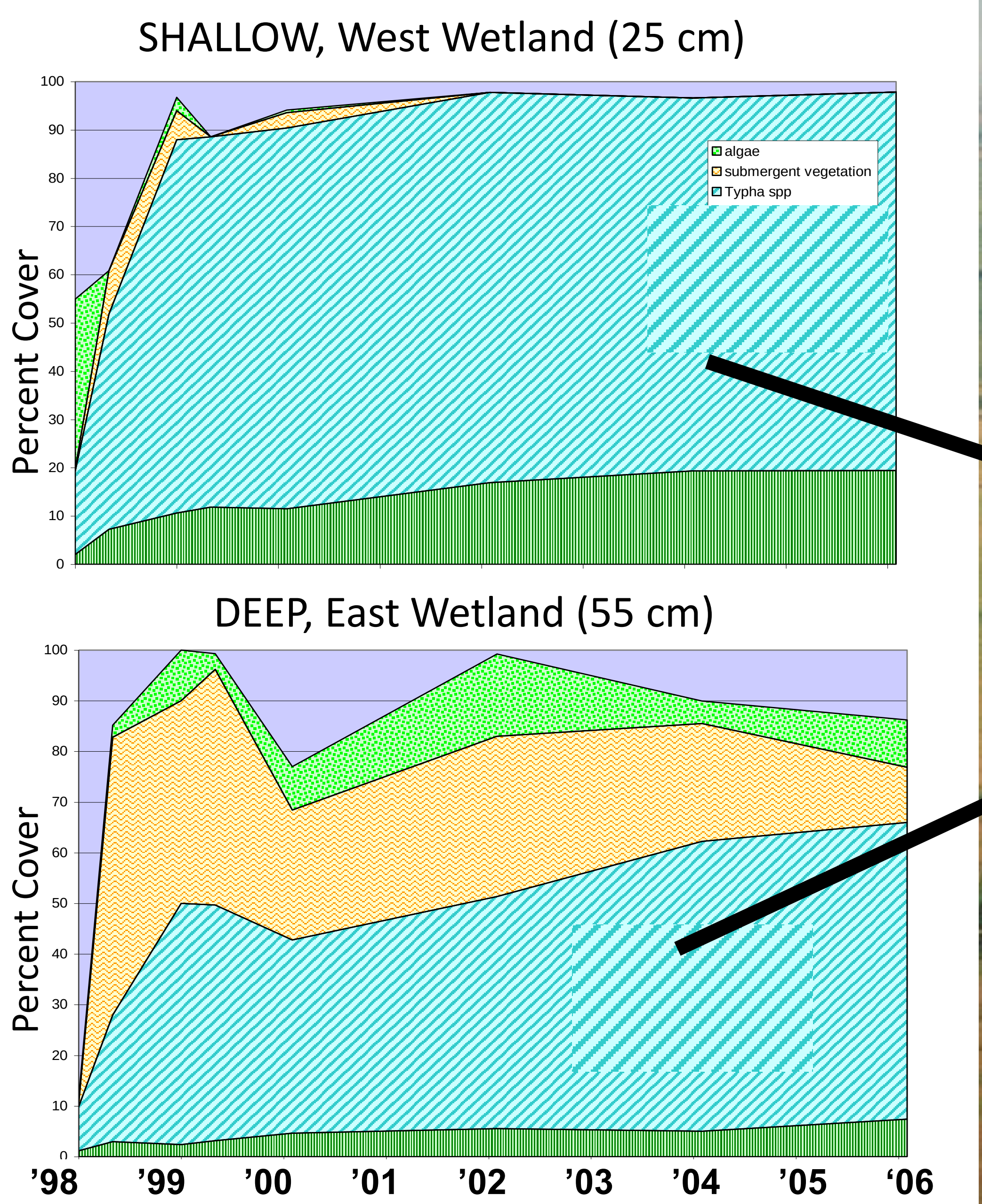
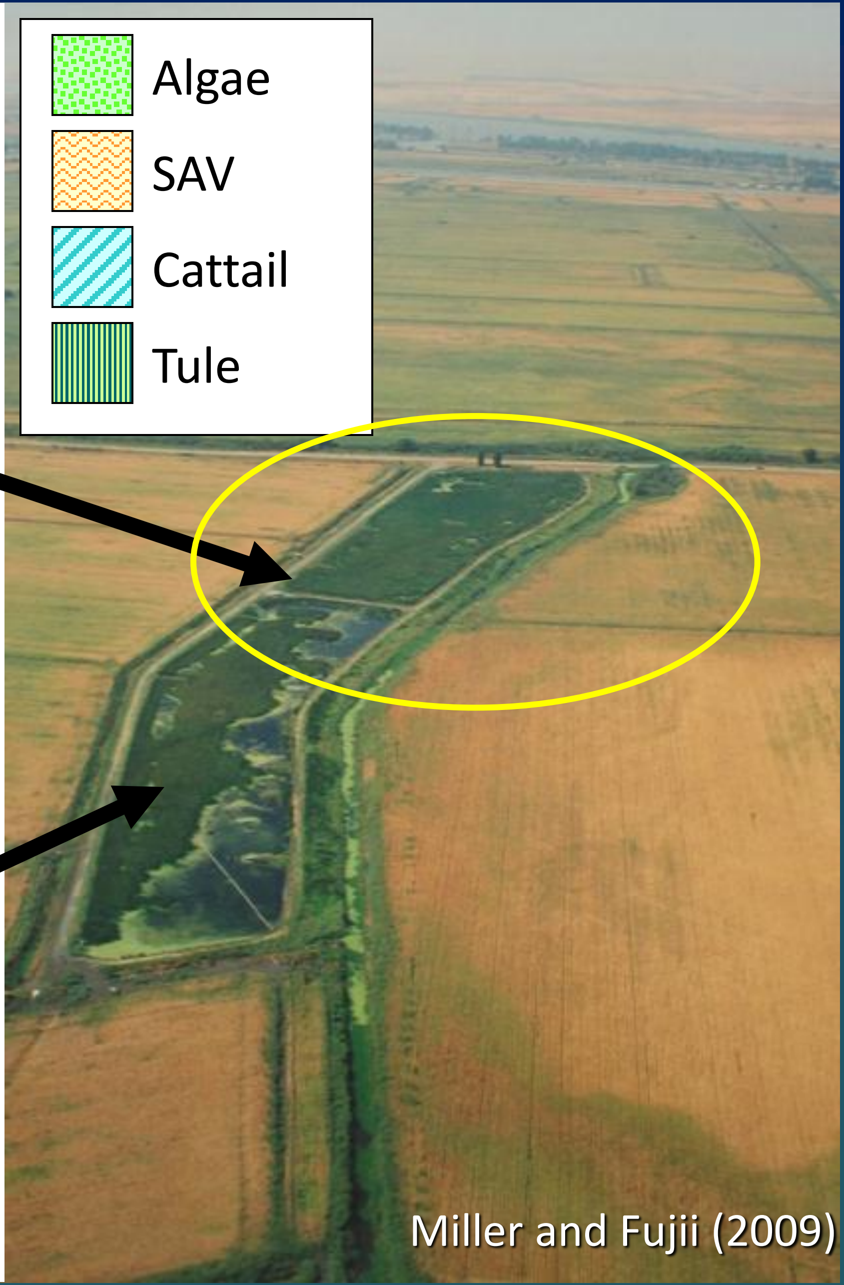


Image by Noah Knowles, USGS

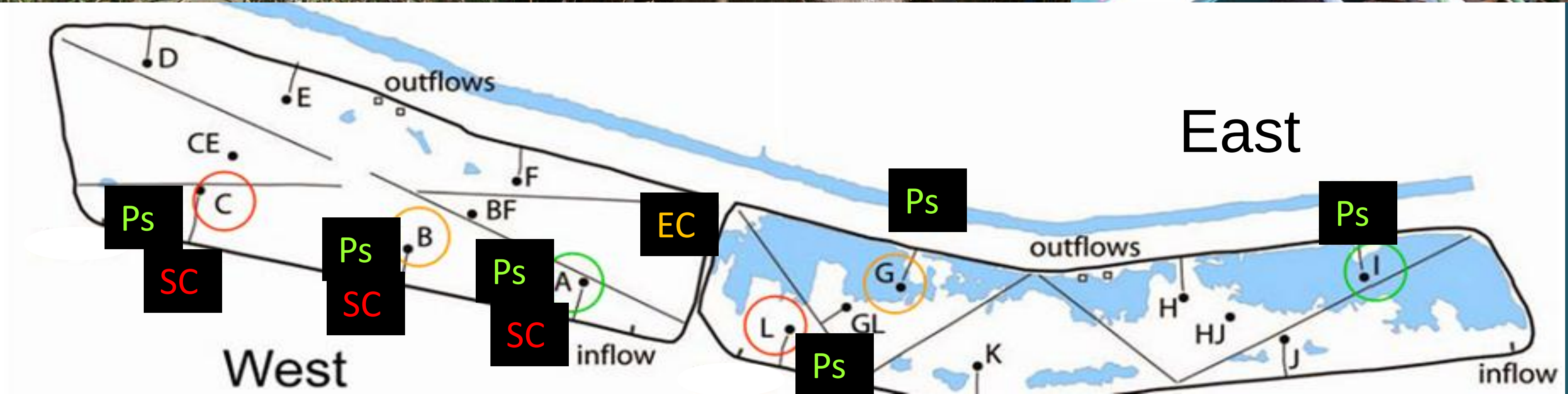
West Wetland (25 cm depth) had best coverage





Three Methods (August 29-Sept 2, 2011)

Eddy Covariance	Static Chamber	Leaf Photosynthesis



Leaf Photosynthesis

PHOTOSYNTHESIS

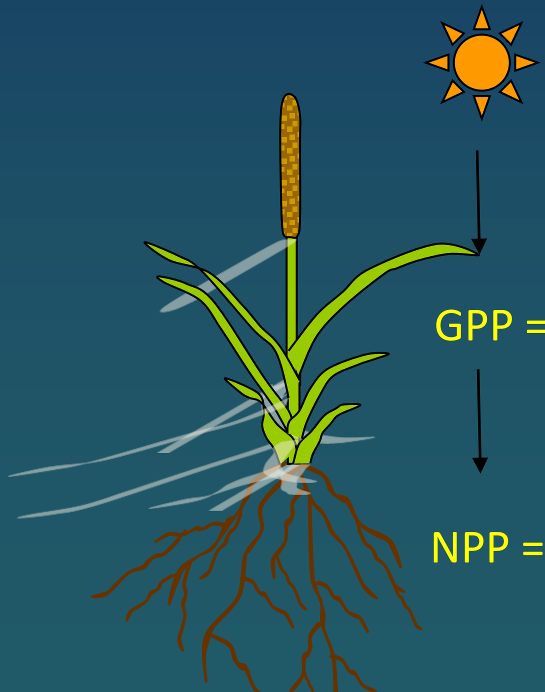
- LiCor XT6400 (light and CO_2 control)
- A:I and A:Ci Curves (link to annual PAR)
- Field Validation (May-September)
- 3 stations (A, B, and C)
- 3 species (Tule, Cattails (TYAN,TYLA))

RESPIRATION

- Root Fermentation (Ethanol)
- Porewater acetate (and other Volatile Fatty Acids)

Standing Biomass (NPP) and LAI

- Allometric *f*(density, height, diameter)



Photosynthesis

GPP = 1-5% solar energy

$R_{plant} = R_{plant\ growth} + R_{maintenance}$

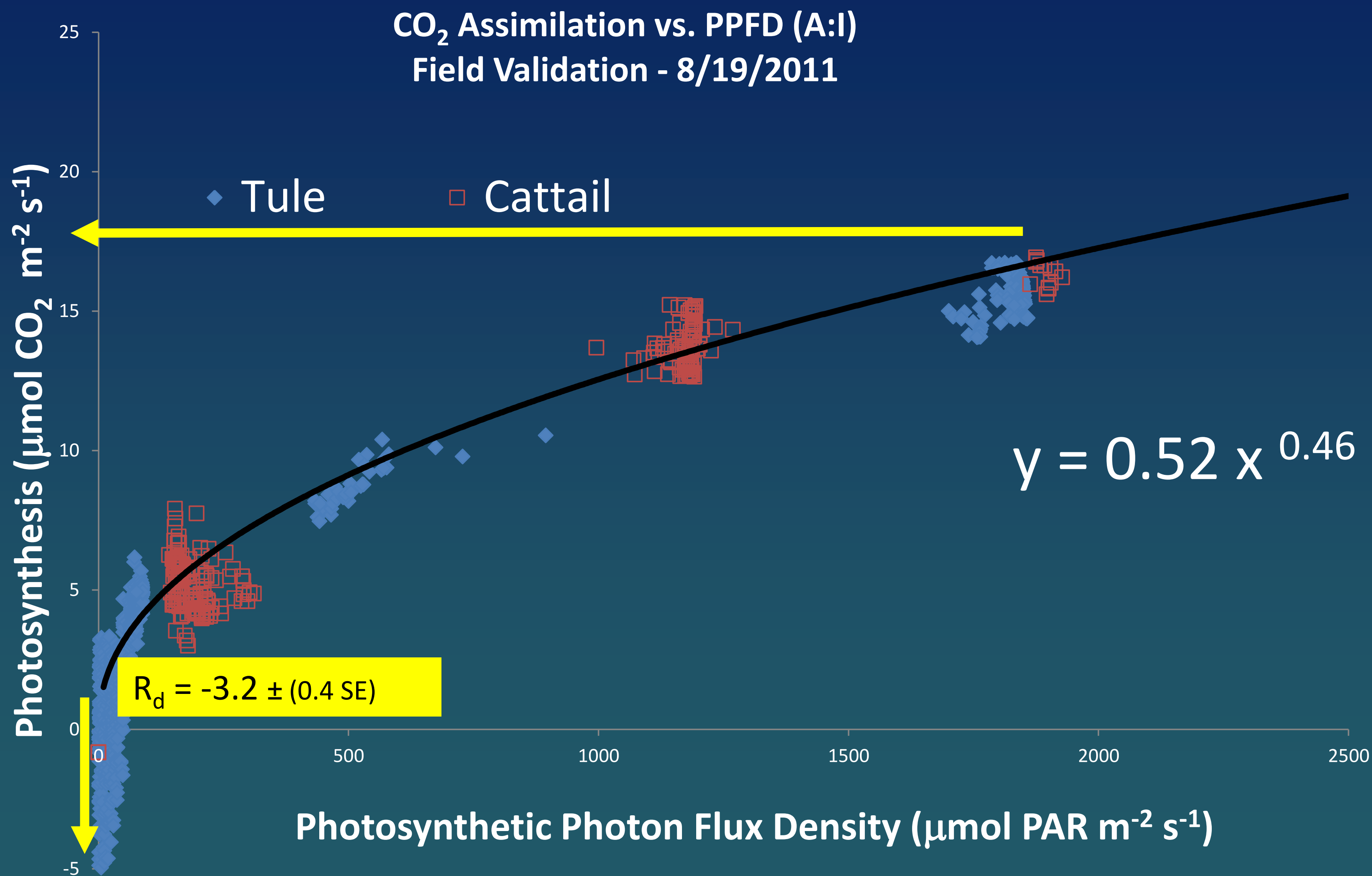
CO_2

Organic acids (fermentation)

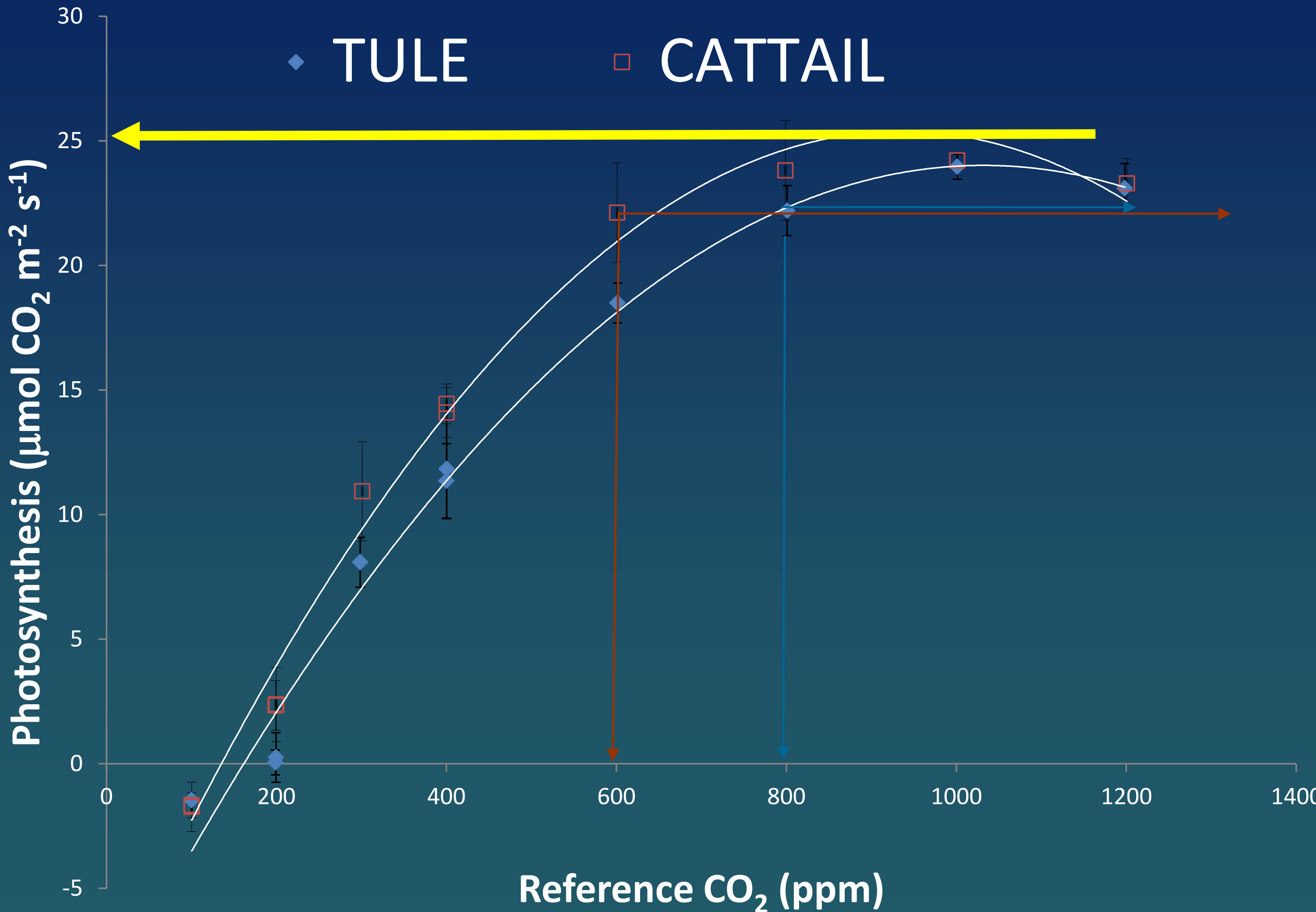
NPP = ~50% of GPP (40-85%, Lambers et al. 1998)

NPP/GPP = Carbon Use Efficiency

PAR strongly controlled leaf photosynthesis



Response to elevated CO_2 : evidence for use of recycled CO_2

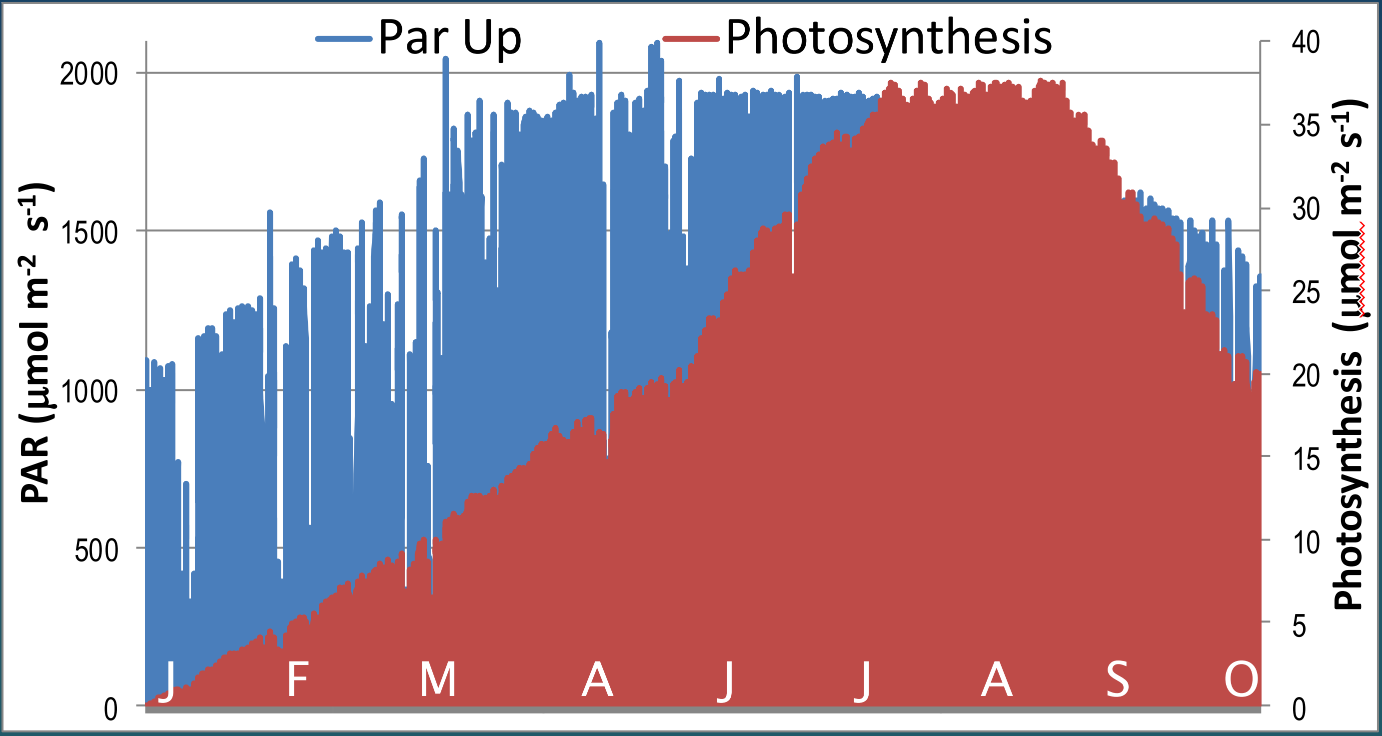


Carbon Use Efficiency: Annual GPP/NPP at Plot Scale (kg)

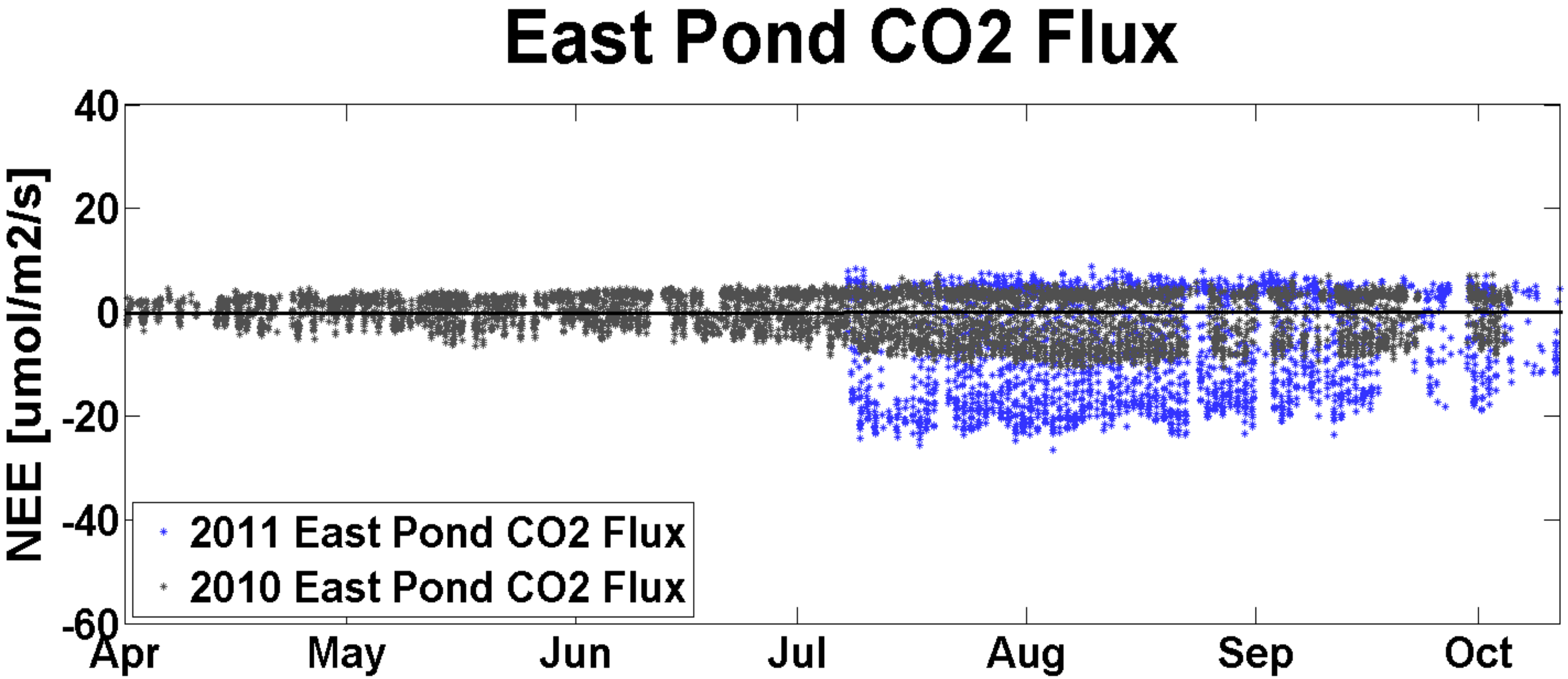
AGPP = Annual gross photosynthesis
= (Photosynthesis x Curve-fit LAI)
= 0.5231 $(PAR)^{0.46}$ x LAI

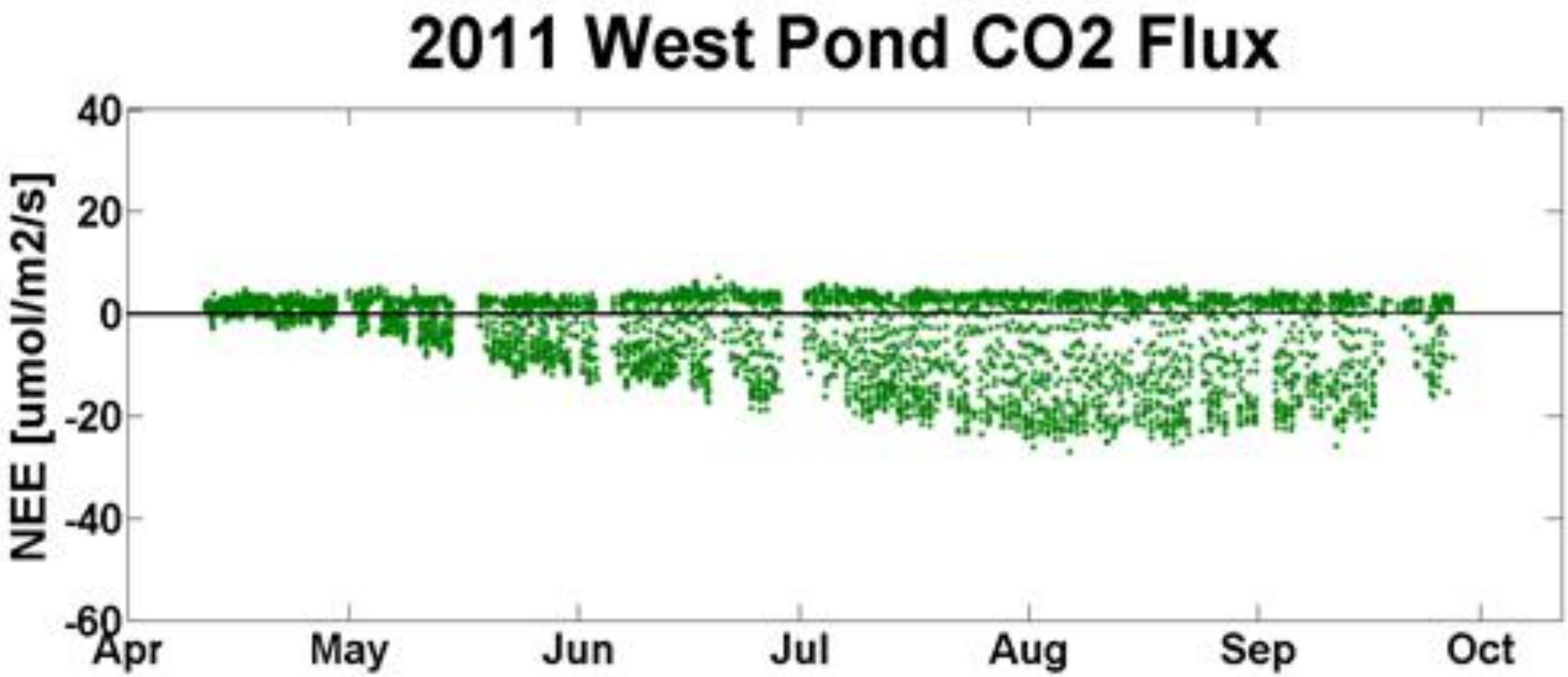
ANPP = Annual net biomass production
= allometric biomass (Miller and Fujii 2009)
= biomass x turnover rate

Station	Peak LAI	ANPP	GPP	CUE
A	6	7	9.9	0.70
B	2.4	4.4	6.8	0.63
C	2.2	3.2	4.9	0.68

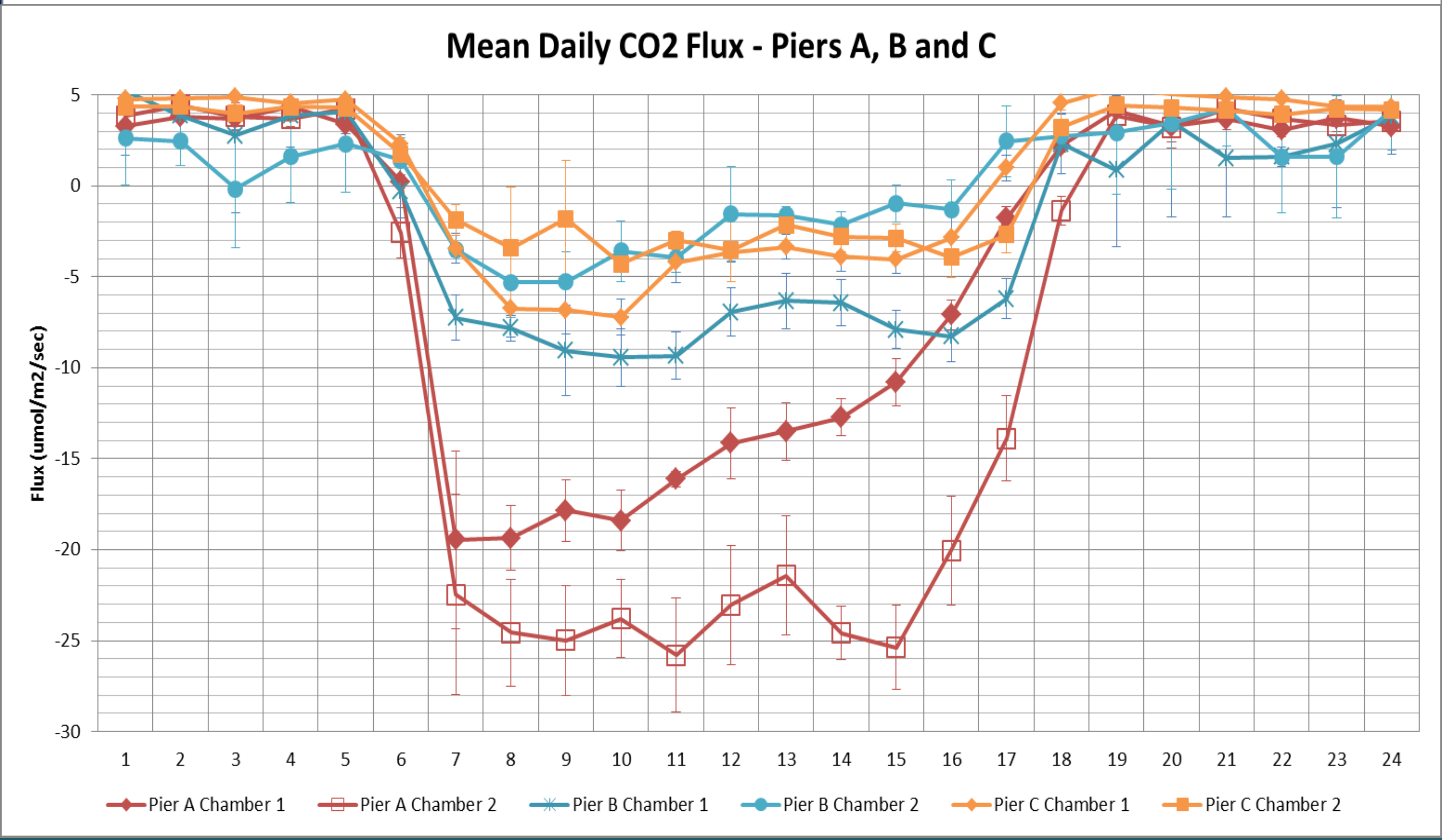


Kristin Byrd in Tule Thatch


East Pond CO2 Flux
NEE [umol/m2/s]
40
20
0
-20
-40
-60
Apr
May
Jun
Jul
Aug
Sep
Oct
2011 East Pond CO2 Flux
2010 East Pond CO2 Flux

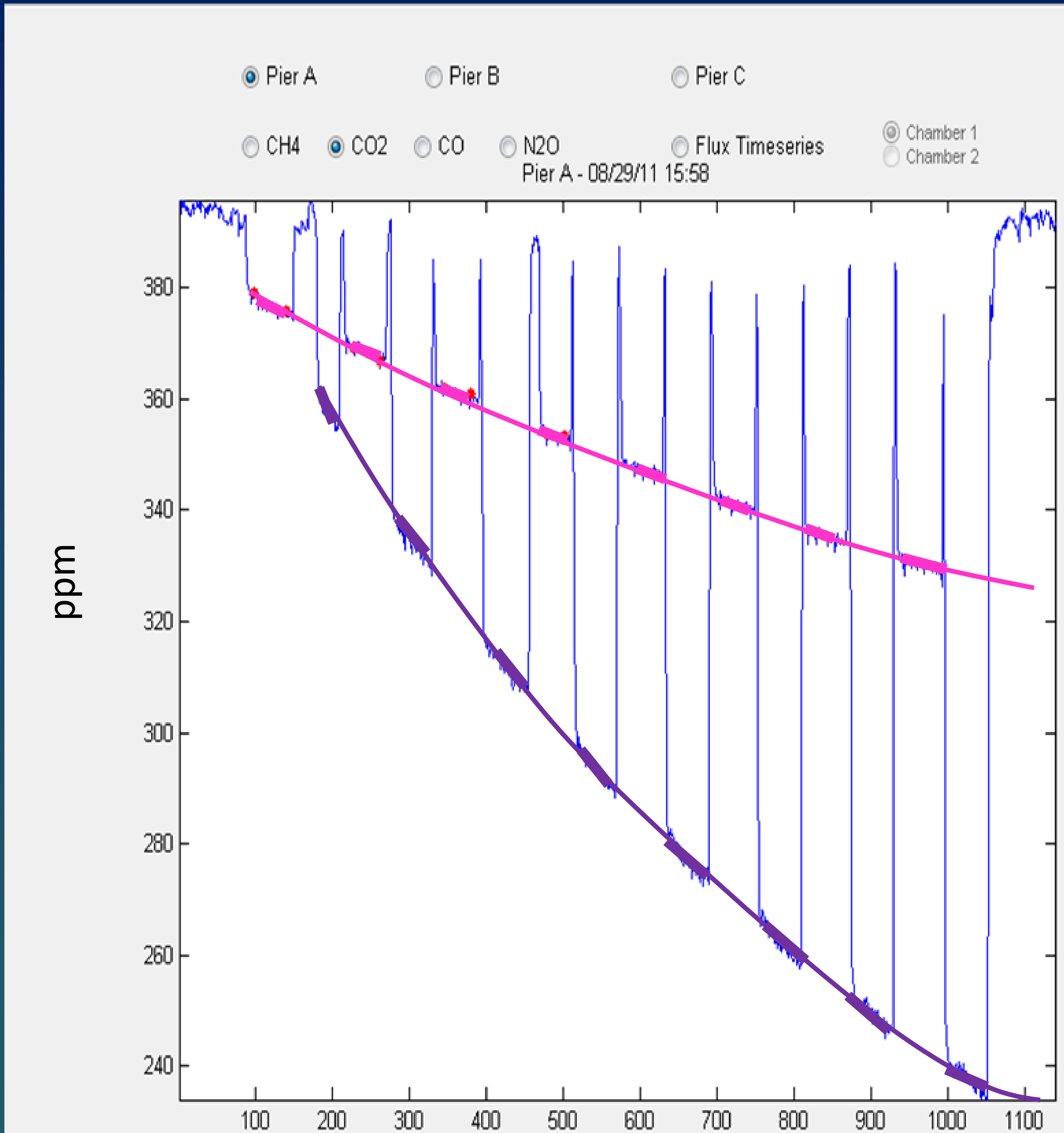

2011 West Pond CO2 Flux
NEE [umol/m2/s]
40
20
0
-20
-40
-60
Apr
May
Jun
Jul
Aug
Sep
Oct

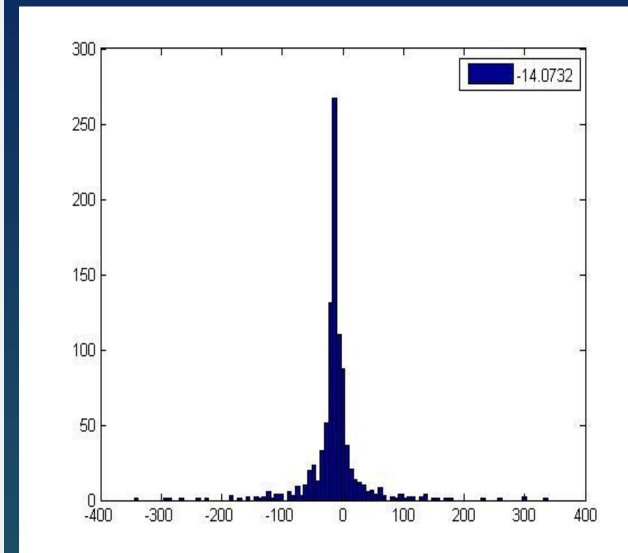
Static Chamber NEE

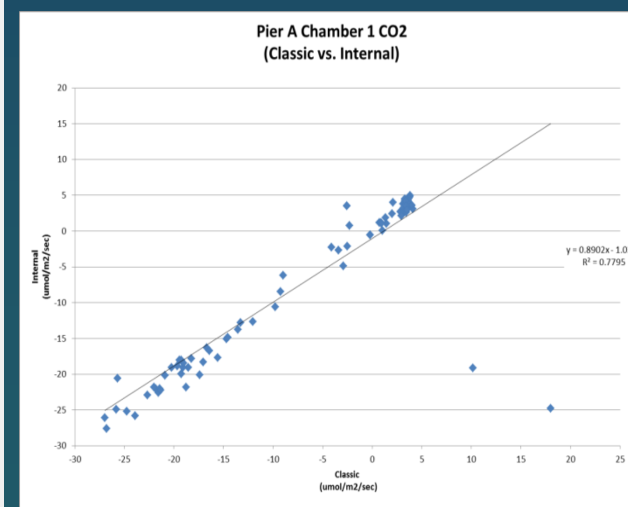


Static Chamber NEE Calculations

Classic (8 median points)
Classic (all points)
Internal (handselected)
Internal (median slope)

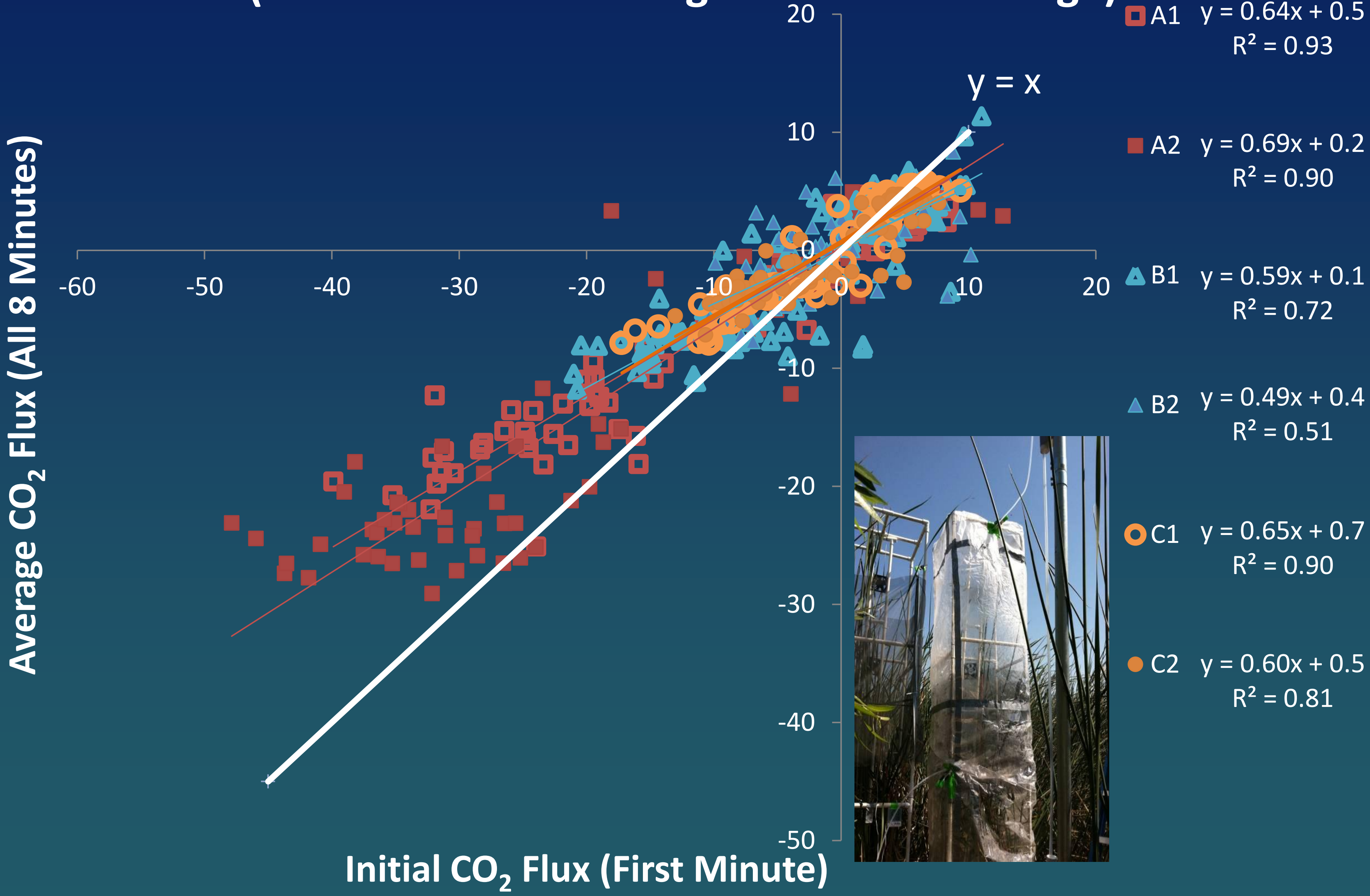






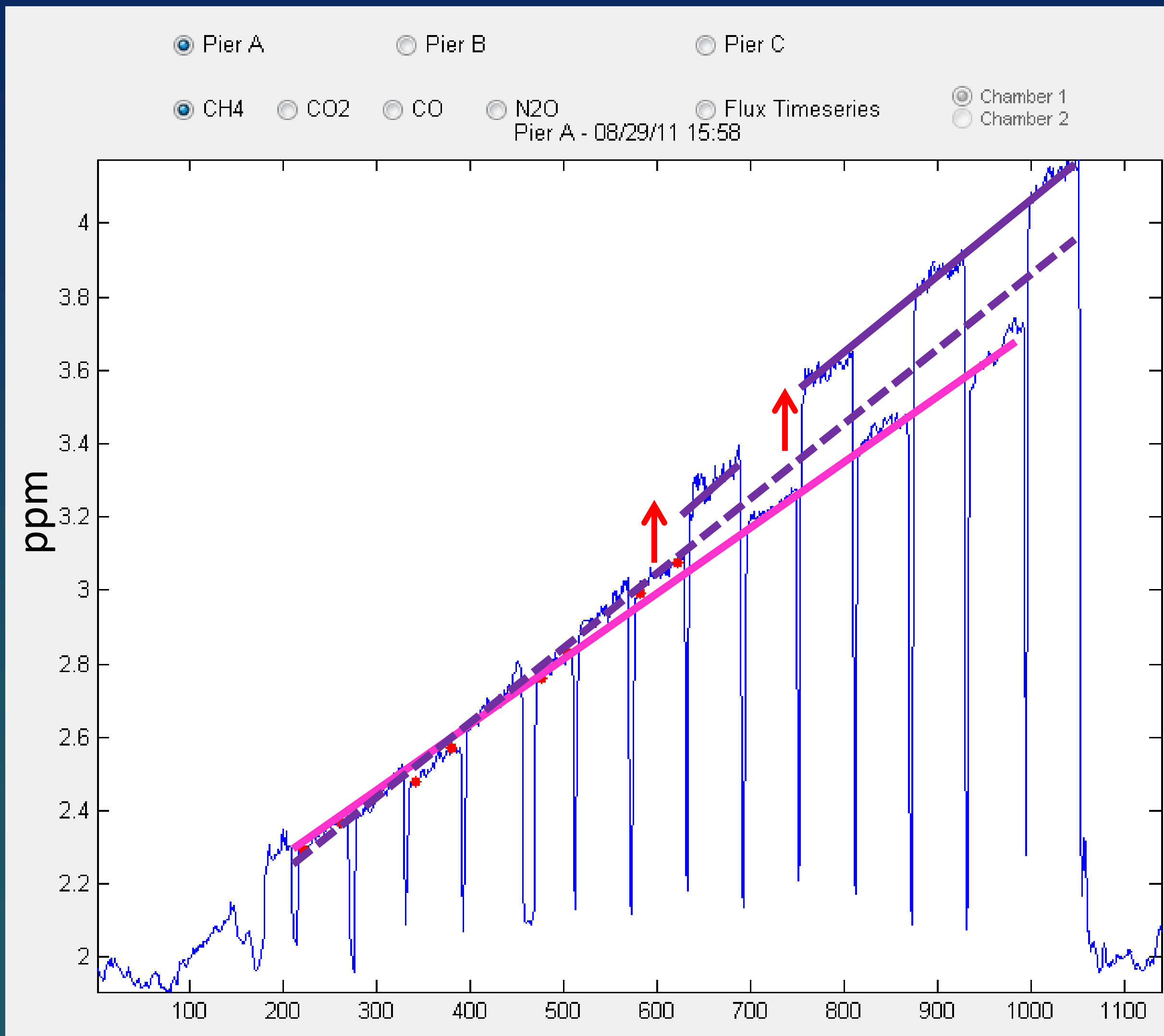
Chamber Effect

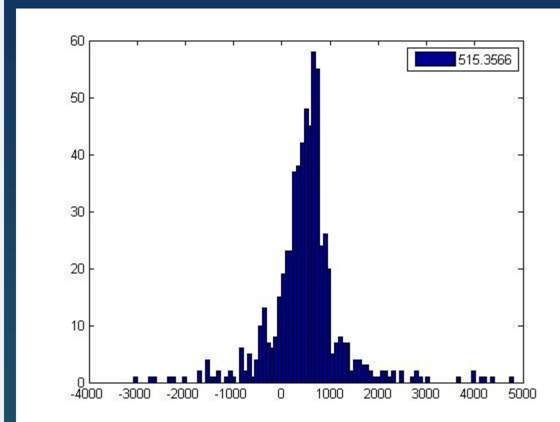
(first minute is 1.5-2x greater than average)

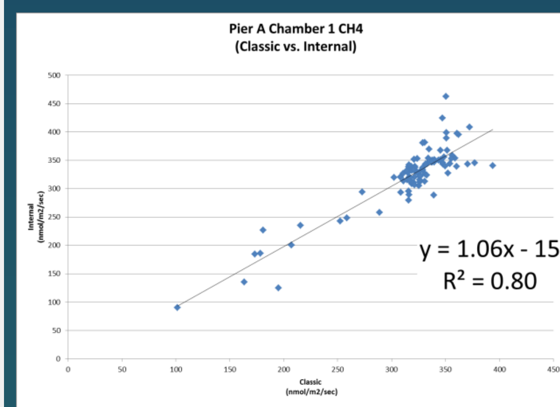


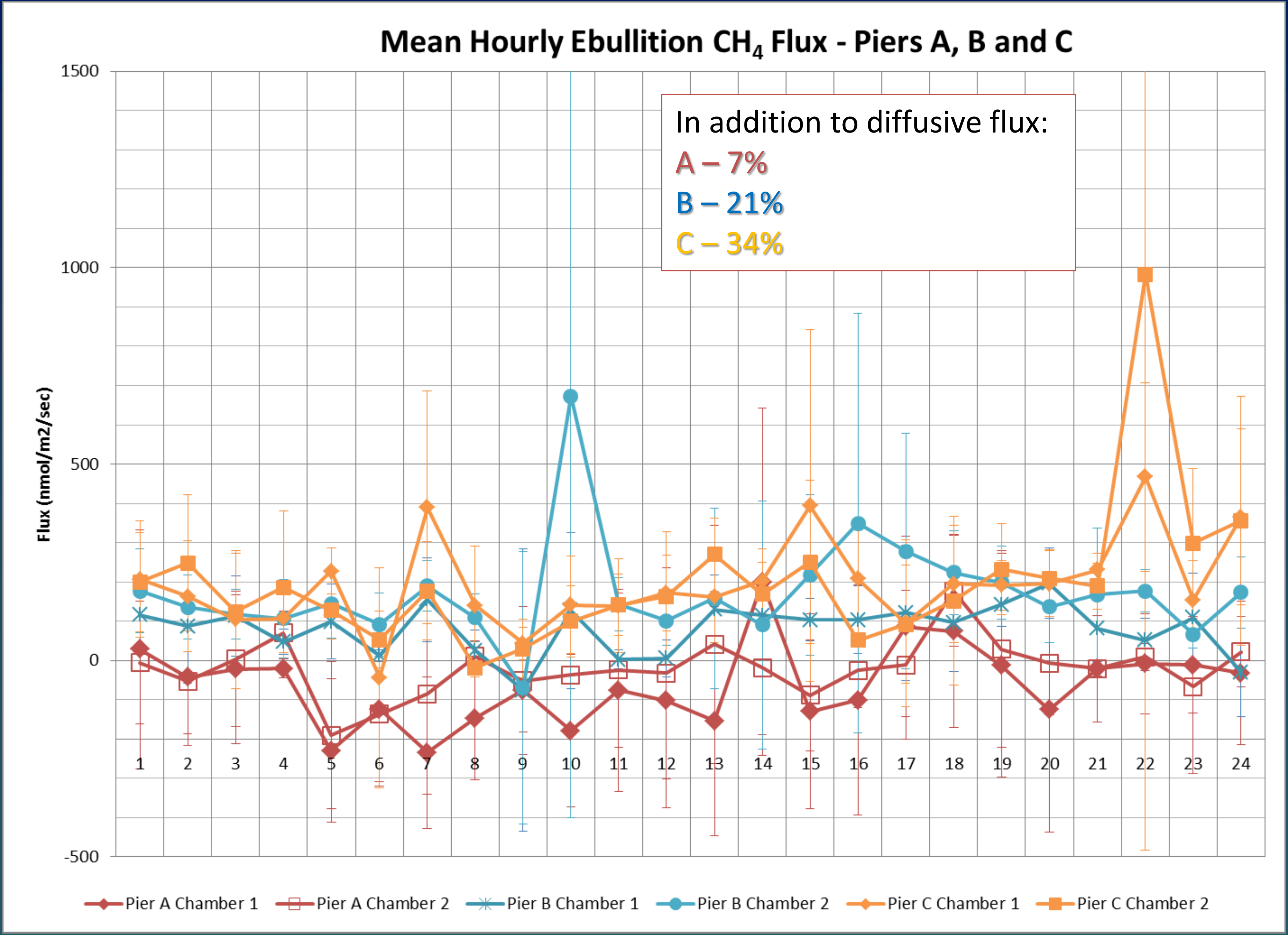
Static Chamber CH_4 Ebullition

Classic (8 points)
Classic (all points)
Internal (handselected)
Internal (median slope)



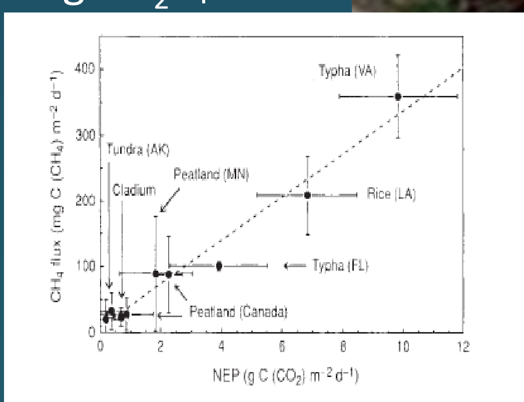





Mean Hourly Ebullition CH_4 Flux - Piers A, B and C
In addition to diffusive flux:
A – 7%
B – 21%
C – 34%
Flux (nmol/m2/sec)
1500
1000
500
0
-500
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Pier A Chamber 1
Pier A Chamber 2
Pier B Chamber 1
Pier B Chamber 2
Pier C Chamber 1
Pier C Chamber 2

Spatial Differences (August 2011)

	C	B	A
mg CO_2 m^{-2} d^{-1}	-0.2	-15	-49
Spp/Stem Density	TYAN (79)	TYAN (41)	SCAC (226)
Abvgr. Biomass (kg)	2.0	1.8	4.4
Water Depth (cm)	17cm	17cm	20cm
Water Temp (Hi/Lo)	18/16	18/16	20/18
mg CH_4 m^{-2} d^{-1}	0.7	0.5	0.4
GWP mg CO_{2eq} m^{-2} d^{-1}	+17	-3	-40

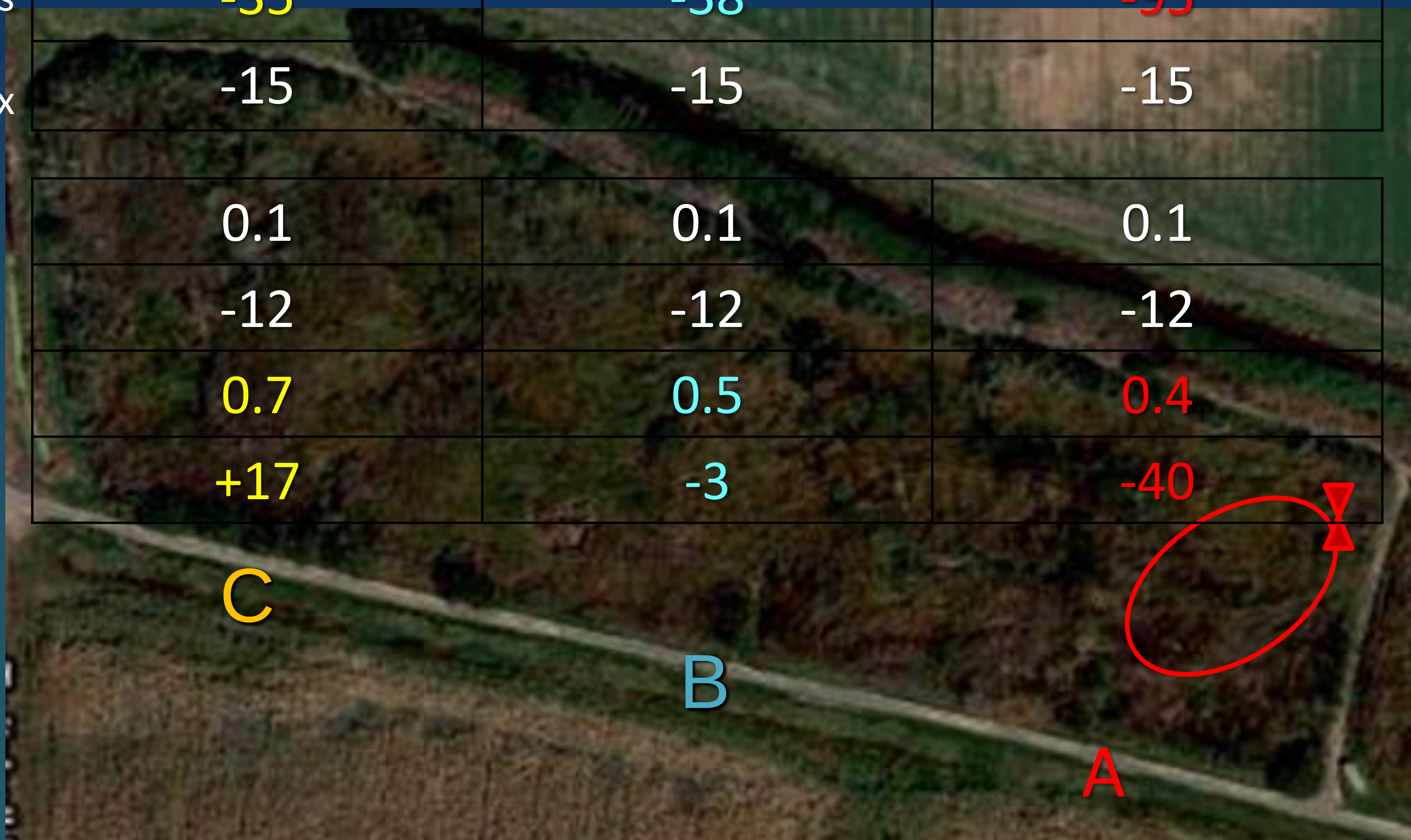


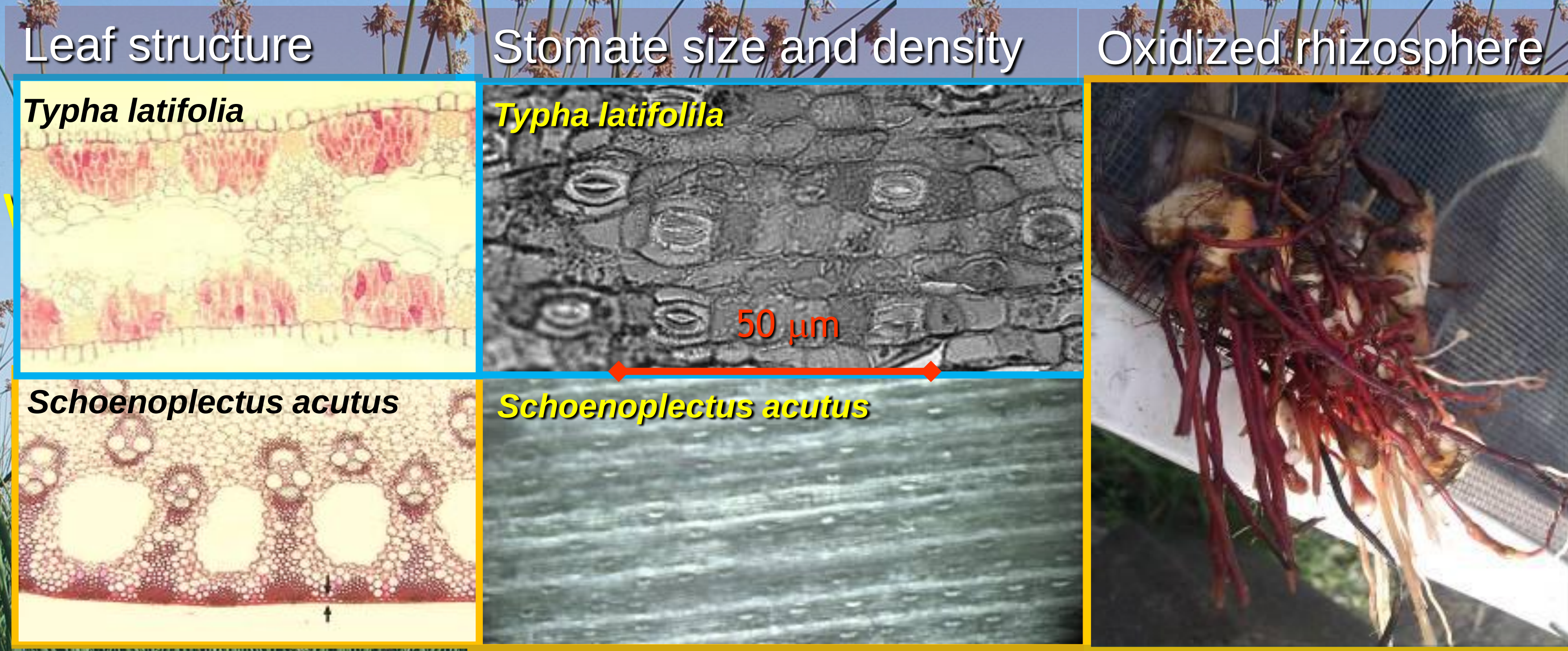
NPP vs CH4
Whiting and Chanton 1993

METHOD COMPARISON (August 2011)

mg CO_2 m^{-2} d^{-1}

	C	B	A
Chamber	-0.2	-15	-49
Photosynthesis	-35	-38	-95
ECFlux	-15	-15	-15
mg CH_4 m^{-2} d^{-1}	0.1	0.1	0.1
GWP	-12	-12	-12
mg CH_4 m^{-2} d^{-1}	0.7	0.5	0.4
GWP	+17	-3	-40



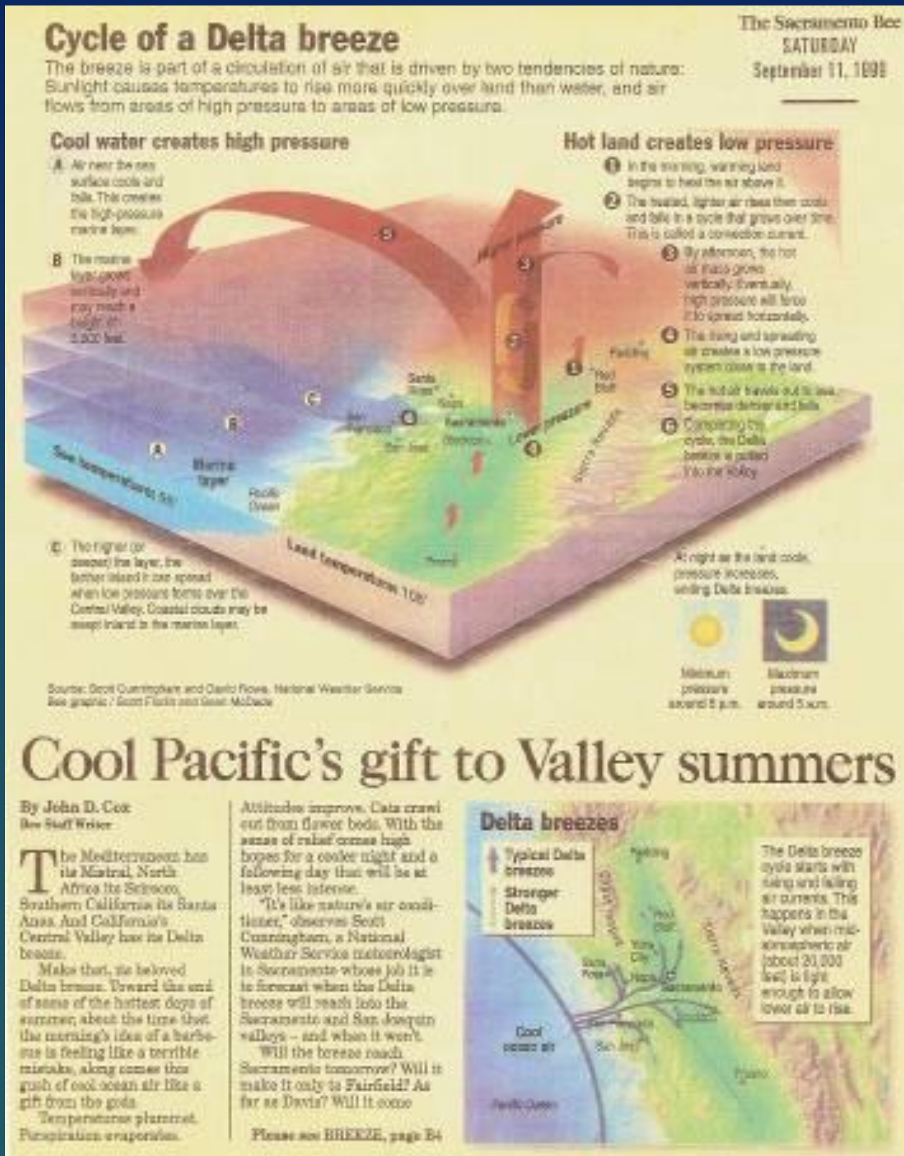


1) THE PLANTS

a) Moderate GPP w/high vertical LAI and low respiration

b) Tule: Lignified, aerenchymous, high stomatal density

2) Delta Breeze – Limit to nighttime respiration?



The Sacramento Bee
SATURDAY
September 11, 1999

Cycle of a Delta breeze

The breeze is part of a circulation of air that is driven by two tendencies of nature: Sunlight causes temperatures to rise more quickly over land than water, and air flows from areas of high pressure to areas of low pressure.

Cool Pacific's gift to Valley summers

By John D. Cox
Bee Staff Writer

The Mediterranean has its Mistral, North Africa its Sirocco, Southern California its Santa Anas. And California's Central Valley has its Delta breeze.

Make that, its beloved Delta breeze. Toward the end of some of the hottest days of summer, about the time that the morning's idea of a barbecue is feeling like a terrible mistake, along comes this gush of cool ocean air like a gift from the gods.

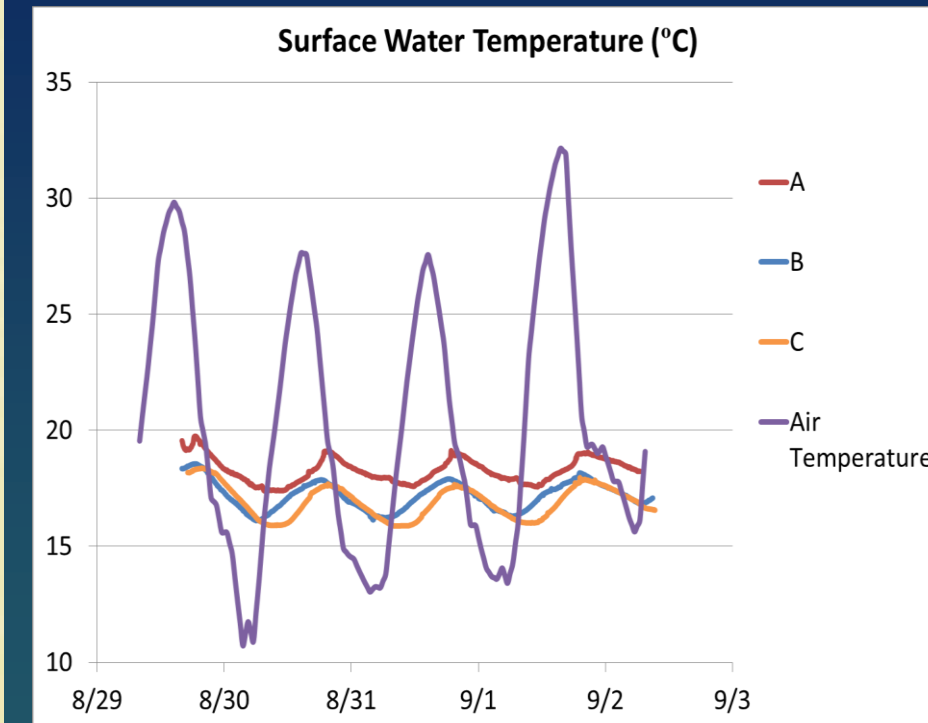
Temperatures plummet. Perspiration evaporates. Attitudes improve. Cats crawl out from flower beds. With the sense of relief comes high hopes for a cooler night and a following day that will be at least less intense.

"It's like nature's air conditioner," observes Scott Cunningham, a National Weather Service meteorologist in Sacramento whose job it is to forecast when the Delta breeze will reach into the Sacramento and San Joaquin valleys – and when it won't.

Will the breeze reach Sacramento tomorrow? Will it make it only to Fairfield? As far as Davis? Will it come

Please see BREEZE, page B4

Warm days (>30°C)

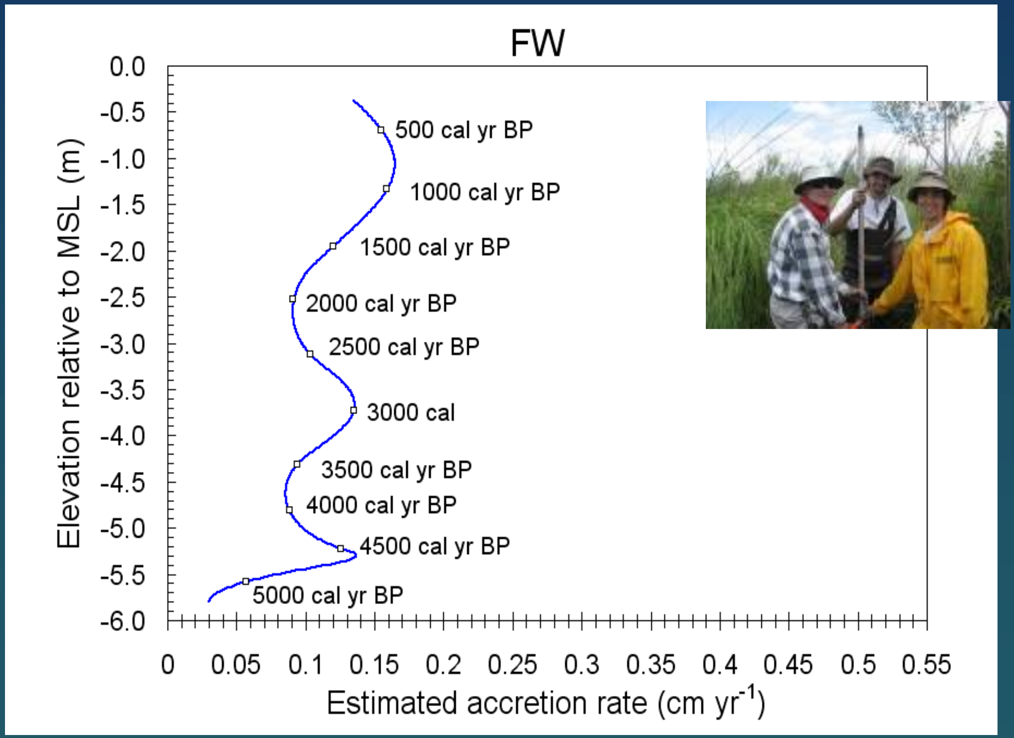


Cool nights (<15°C)

3) Constant, large accomodation space

“not your normal freshwater tidal wetland”

Freshwater tidal wetlands accrete peat at average rates of only ~1.5 mm yr^{-1} (RSLR)



Drexler et al. (2009) Wetlands

Method Pro's and Con's

EC Flux -

- Large footprint
- Annual flux
- Cannot separate CO_2-flux processes
- Cannot separate CH_4-flux processes

Chamber-

- Good spatial variability
- CH_4-flux separated into diffusion or ebullition
- Annual flux must be modeled

Leaf Photosynthesis -

- Direct calculation of GPP and stress response
- Process-based separation of CO_2-flux
- Annual flux requires modeling w/ PAR and LAI

Thank you.

lwindham@usgs.gov

December 2012: Special Session on Peatland Accretion Processes (Drexler, Harden, Windham-Mye