Greenhouse gas dynamics in response to added organic matter in a freshwater mitigation wetland in southeastern Virginia

R. Scott Winton

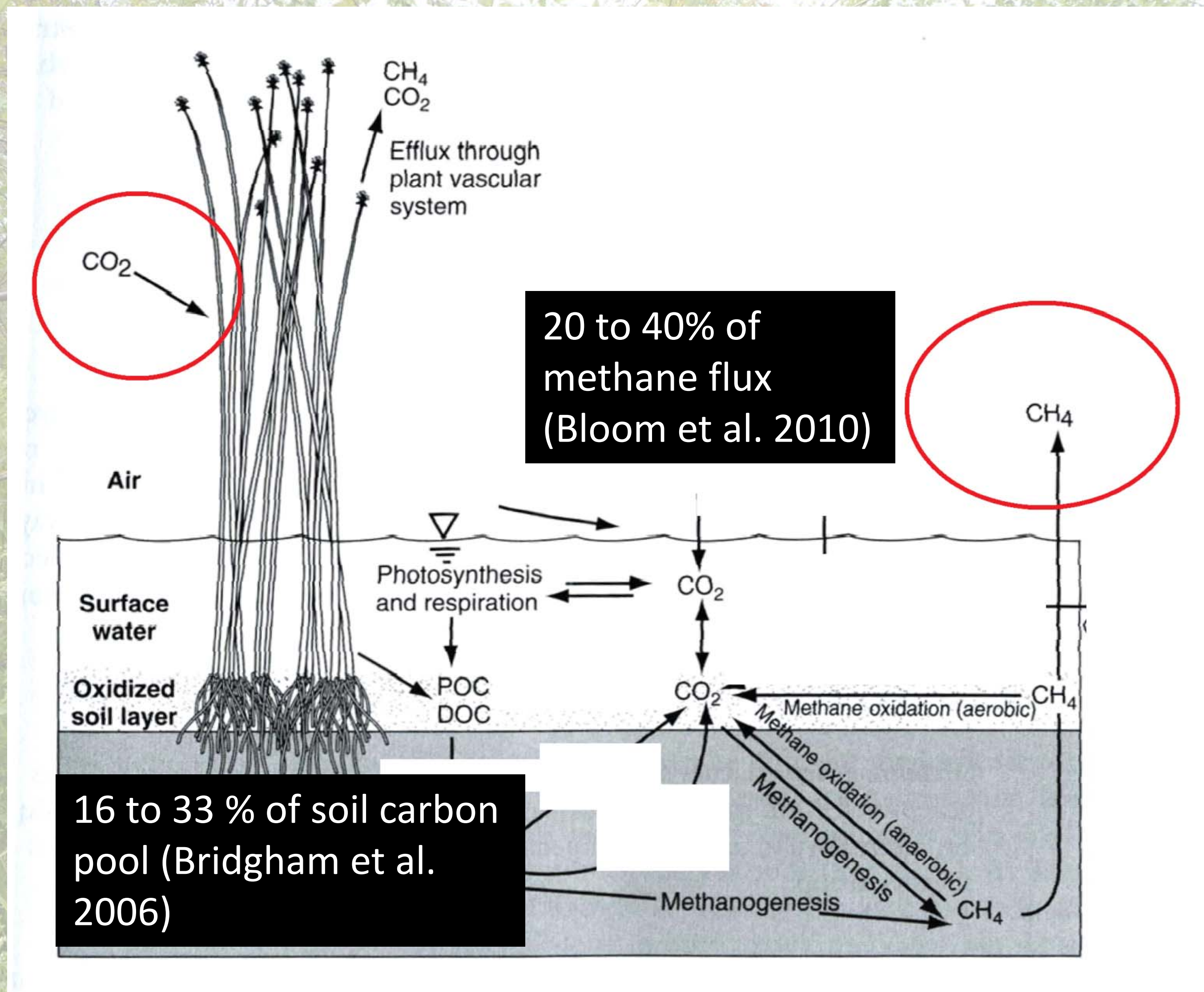
Curtis J. Richardson

Duke University Wetland Center, Durham, NC

Outline

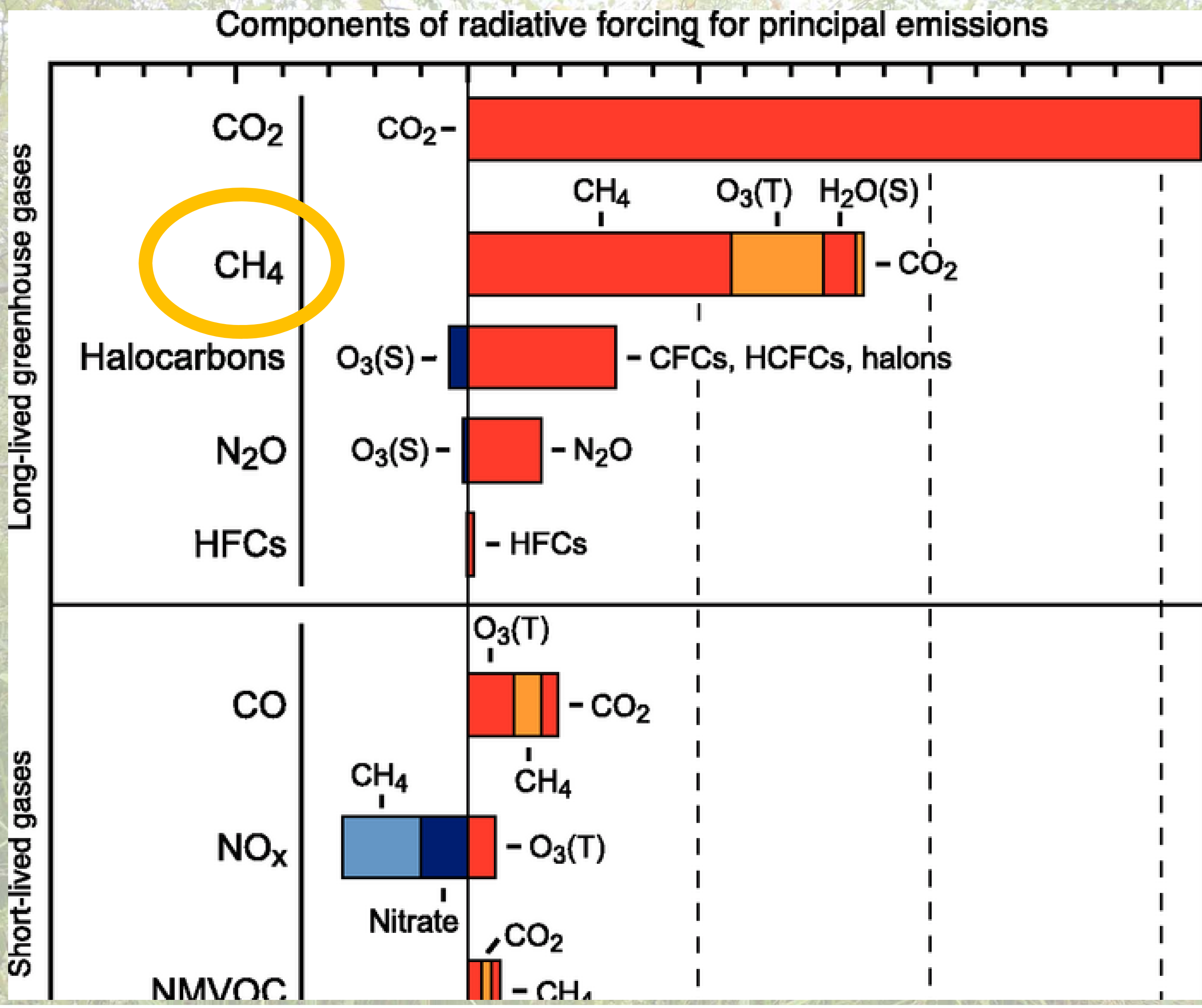
- Why worry about GHG emissions from restored wetlands?
- Introduce study site
- Results
- Preliminary conclusions
- Further Study

Wetland Carbon Cycle



Modified from Mitsch and Gosselink (2007)

Methane



IPCC 2007

Bridgham et al. 2006

The Carbon Balance of North American Wetlands

"large CH_4 emissions from conterminous US wetlands suggest that creating and restoring wetlands may increase net radiative forcing..."

Mitsch et al. 2012

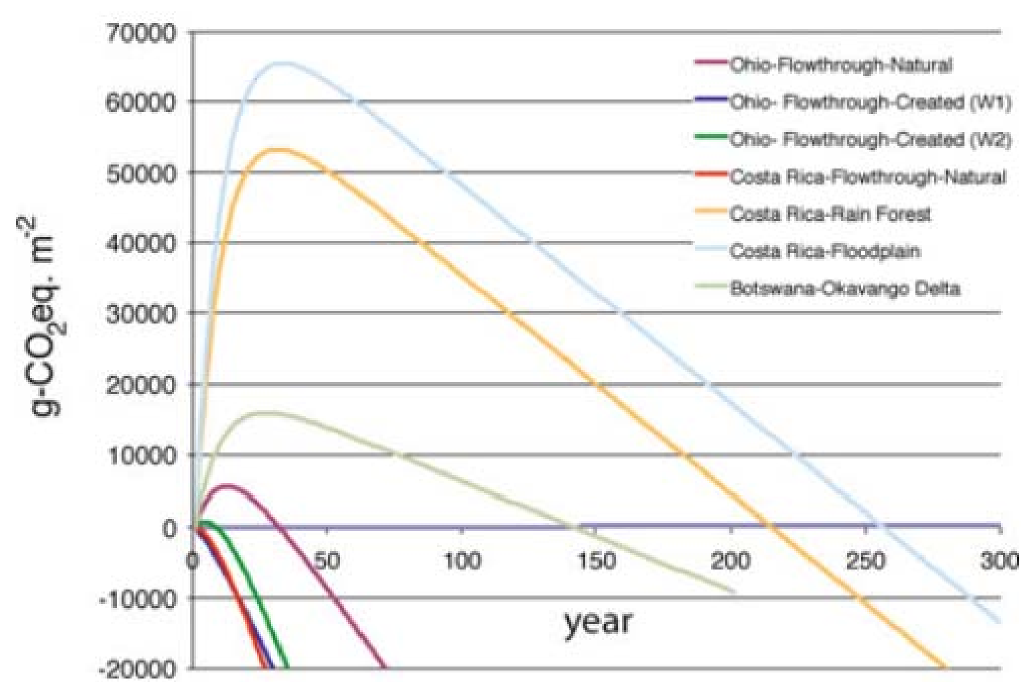
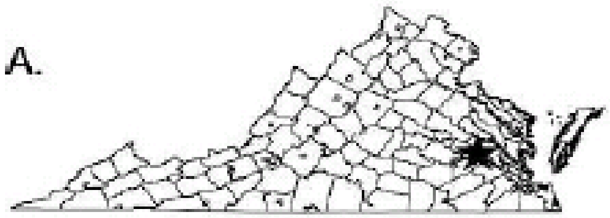


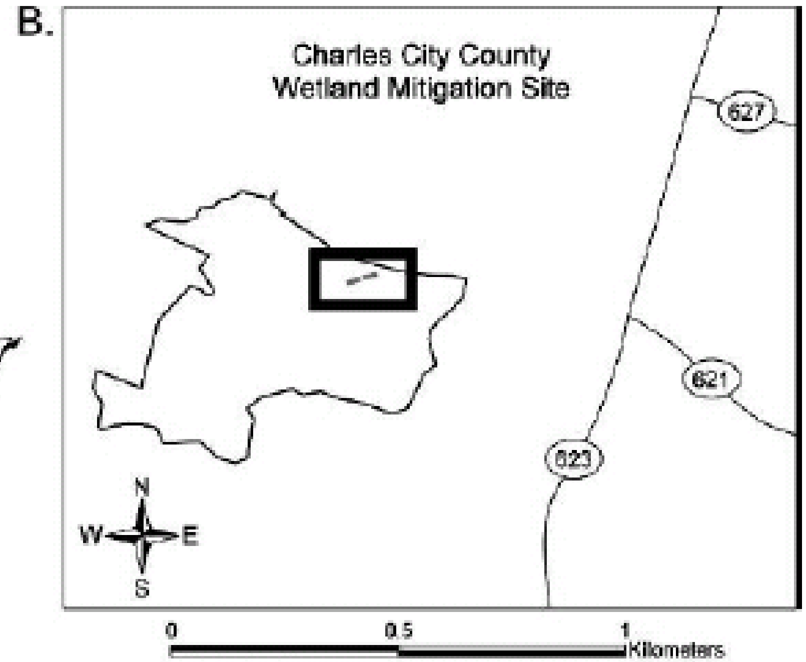
Fig. 2 Three-hundred year simulations of our atmospheric carbon budget model for the seven temperate and tropical wetlands from Ohio, Costa Rica, and Botswana described in this paper. The simulated amount, called CO_2-equivalent, is carbon dioxide plus 25 times methane. All wetlands eventually cause net decrease in CO_2-equivalent in the atmosphere (below the zero line) and several of the wetlands are net sinks from the start

Research Question

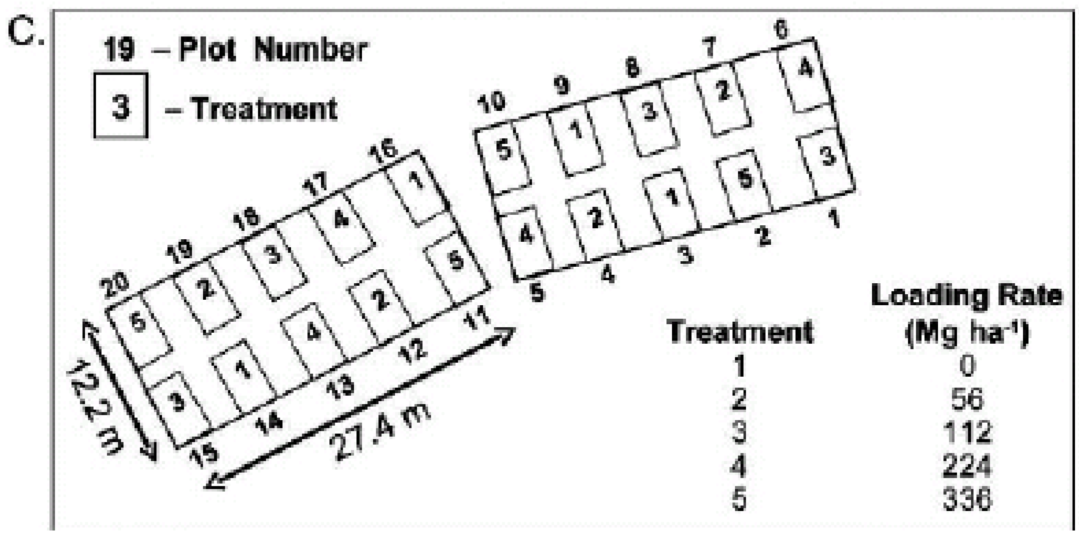
- **What is the effect of OM amendments on GHG emissions from a mitigation wetland?**

Study Site





Compost:
C:N – 44
TC – 36%



Bailey et al. 2007 ; Bruland et al 2009

Bailey (2006)

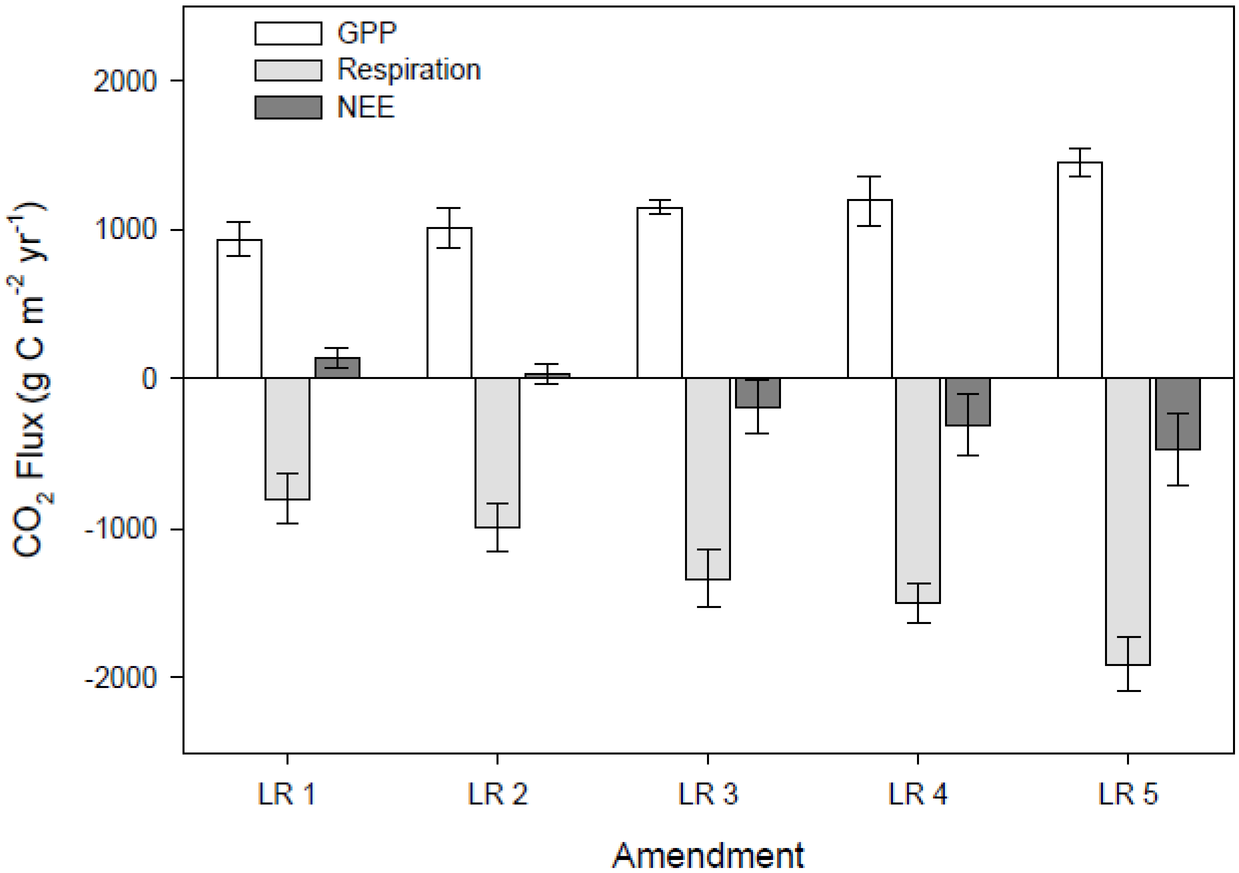
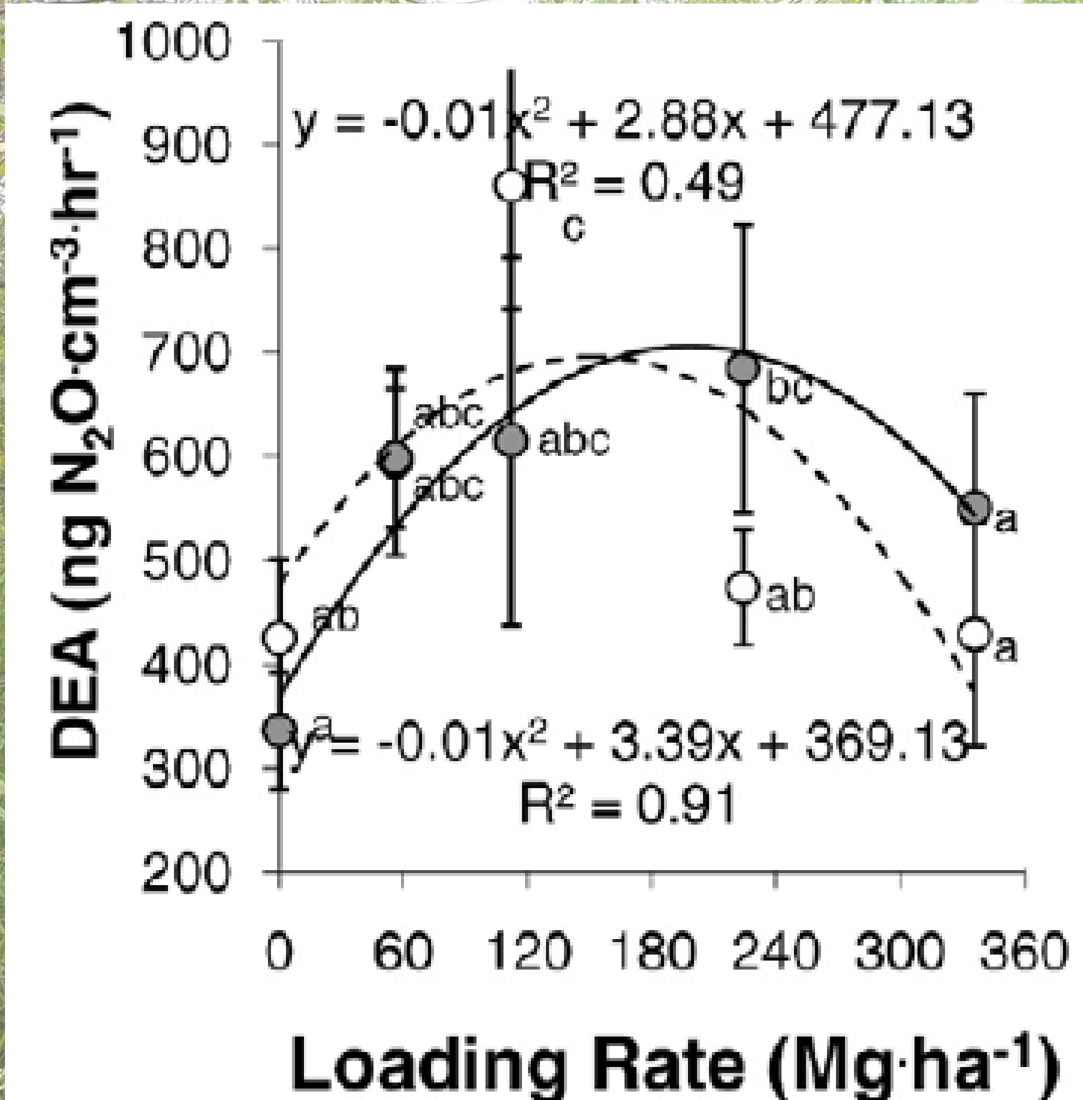


Figure 2. Annual gross primary production (GPP), respiration (R) and net ecosystem exchange (NEE) for each organic matter amendment treatment at the Charles City Mitigation site (CCW), Charles City Co. Virginia. Error bars represent ± one Standard Error (n = 4). LR 1 = 0 Mg ha^{-1}, LR 2 = 56 Mg ha^{-1}, LR 3 = 112 Mg ha^{-1}, LR 4 = 224 Mg ha^{-1}, LR 5 = 336 Mg ha^{-1}.

From Bailey (2006)

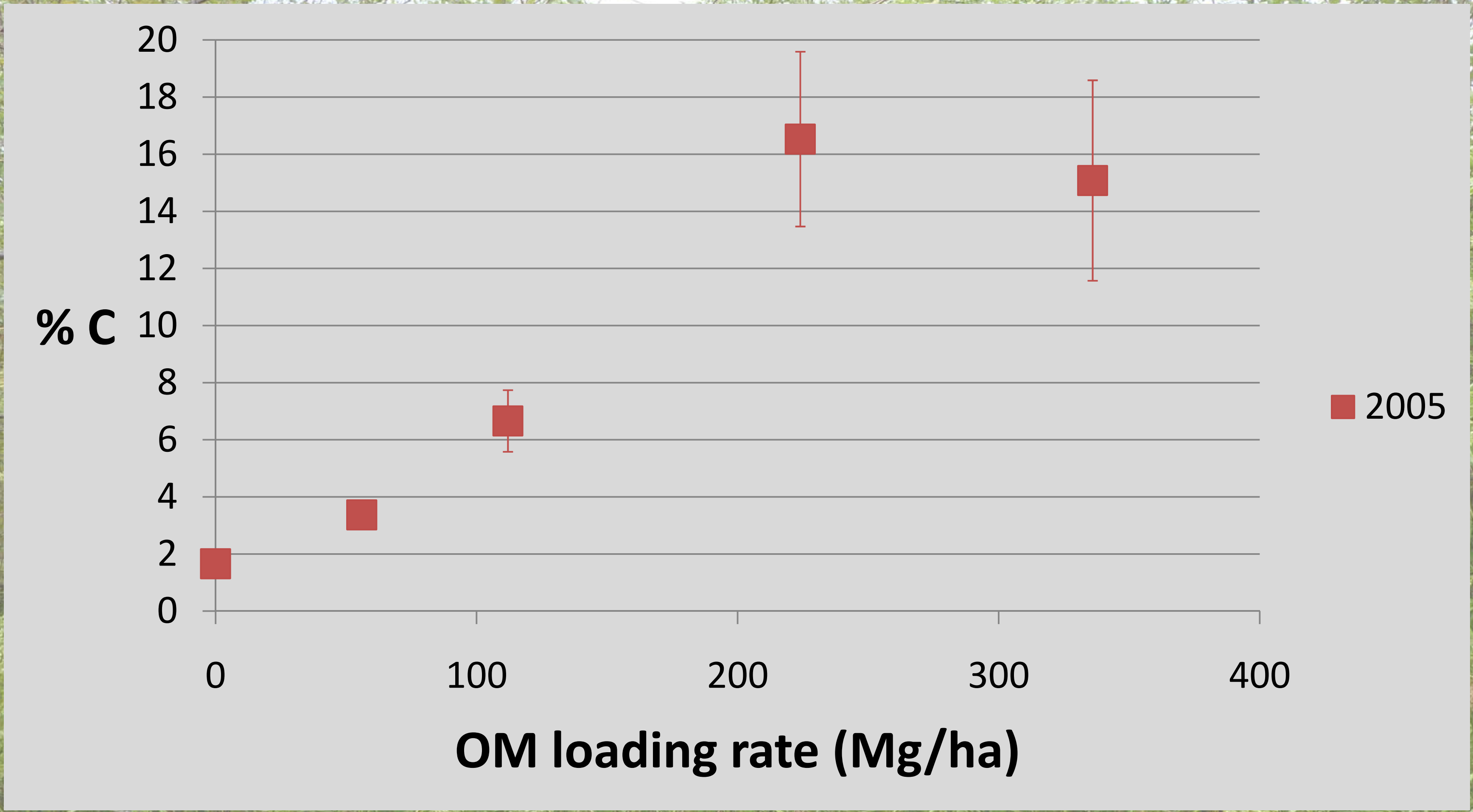
Bruland (2009)




Static chamber gas flux

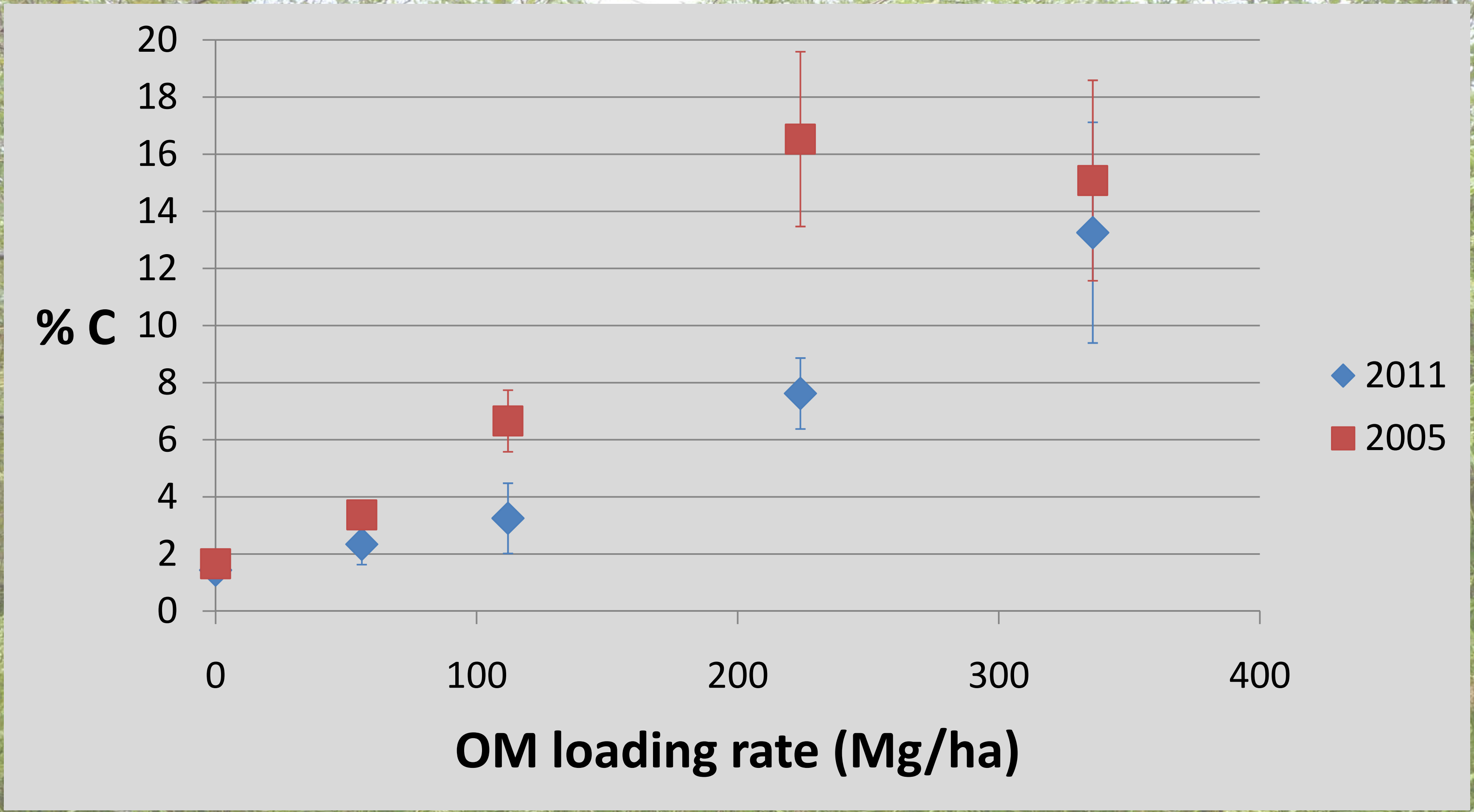

Leaf litter
Pore Water
Soil 0 – 20 cm

Total soil C top 10 cm



2005 data from Bailey et al 2007

Total soil C top 10 cm



2005 data from Bailey et al 2007

How much C lost?

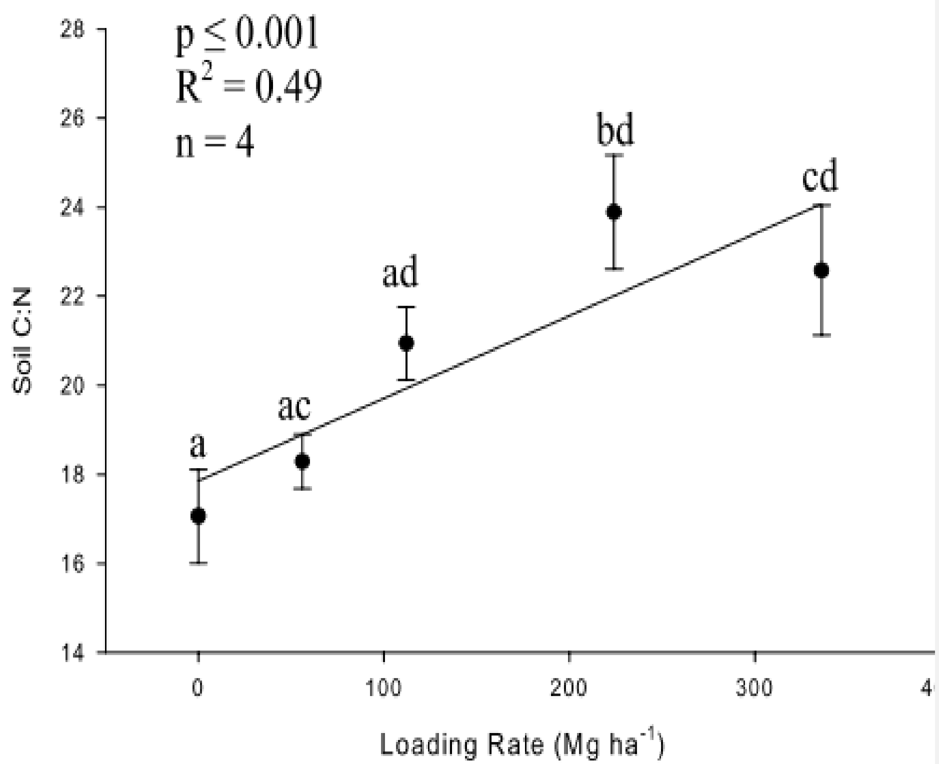
- A loss of 3.5% total soil C from top 10 cm corresponds to a loss of ~5kg C m^{-2}
- Annual litter fall ~0.4 kg C m^{-2}

C:N

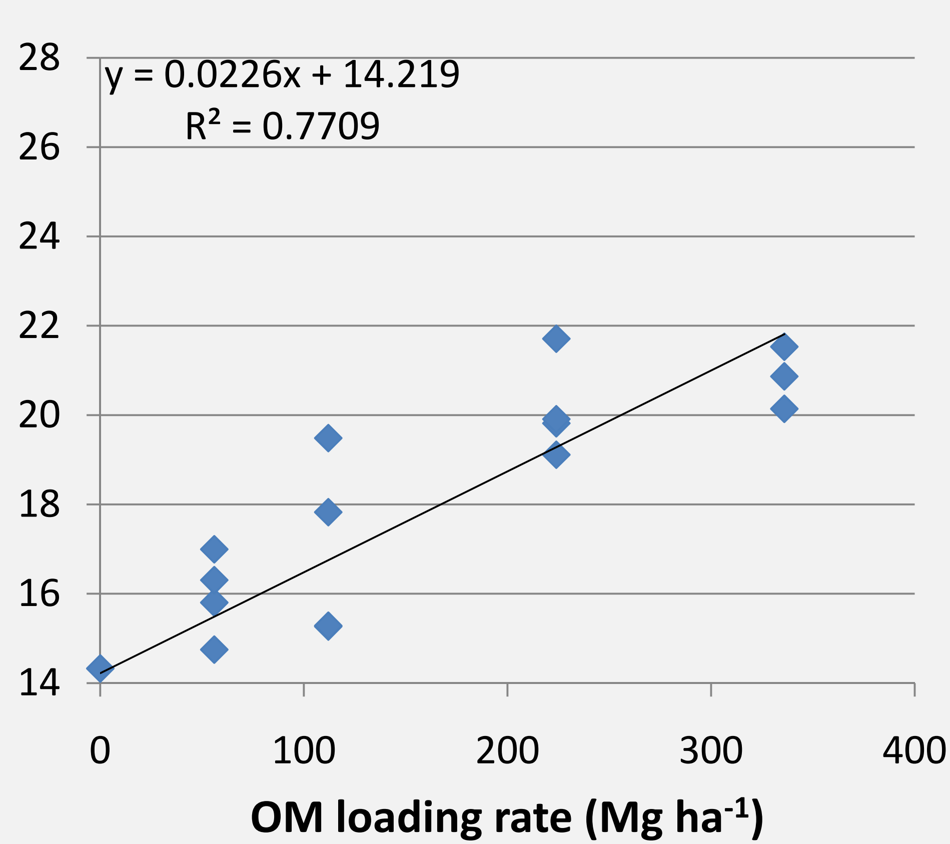
	C:N	source
Unamended soil	**14 - 15**	Bruland (2004)
Compost	**38 - 44**	Bruland (2004), Bailey (2005)
rye cover crops	37	Brady and Weil (1999)
Household compost	15	Brady and Weil (1999)
Sewage sludge	7	Brady and Weil (1999)
Range across OM gradient	**18 - 24**	Bailey (2005)
Range across OM gradient	**16 - 21**	This study (2011)

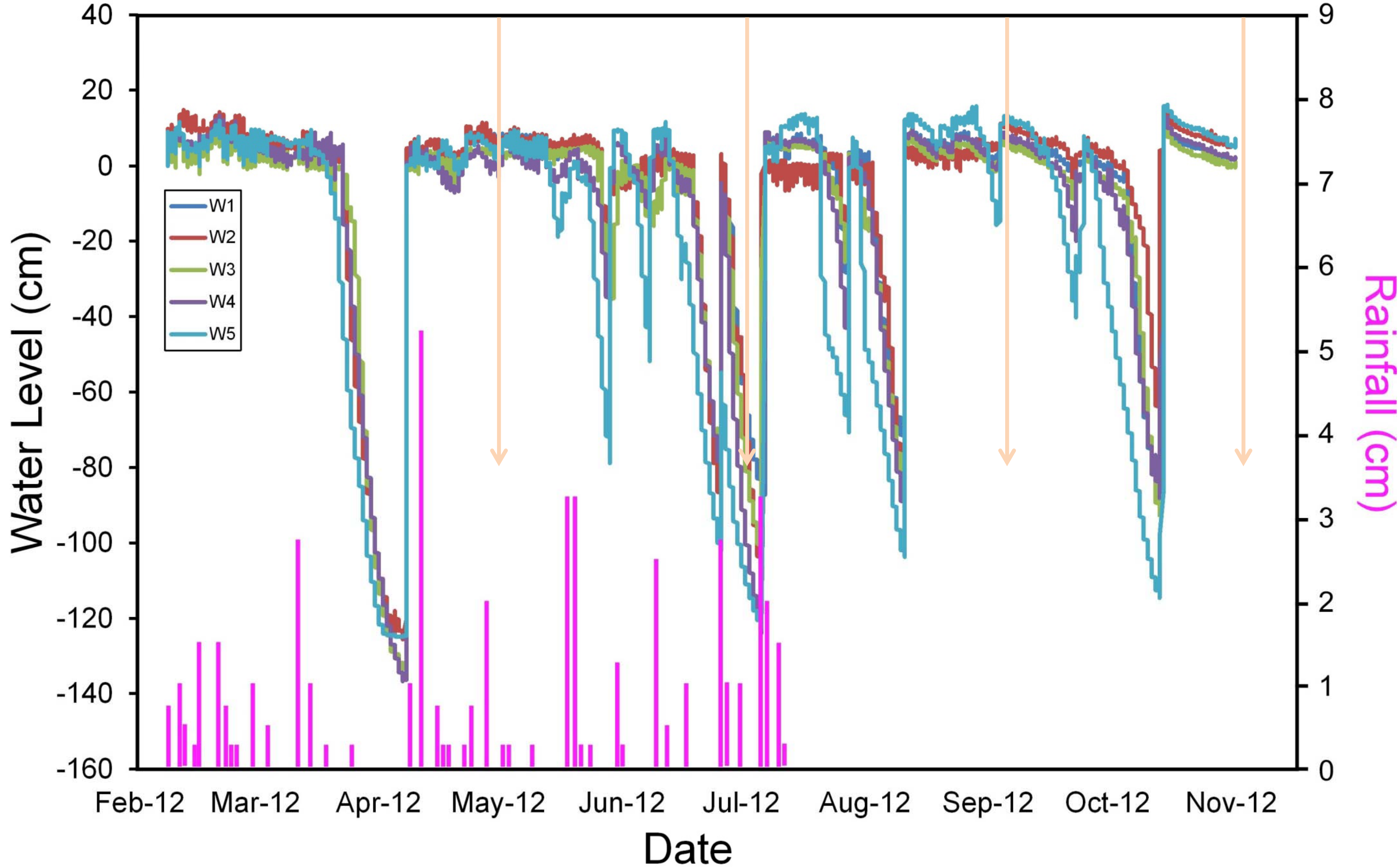
C:N 0 – 10 cm

2005 (from Bailey)



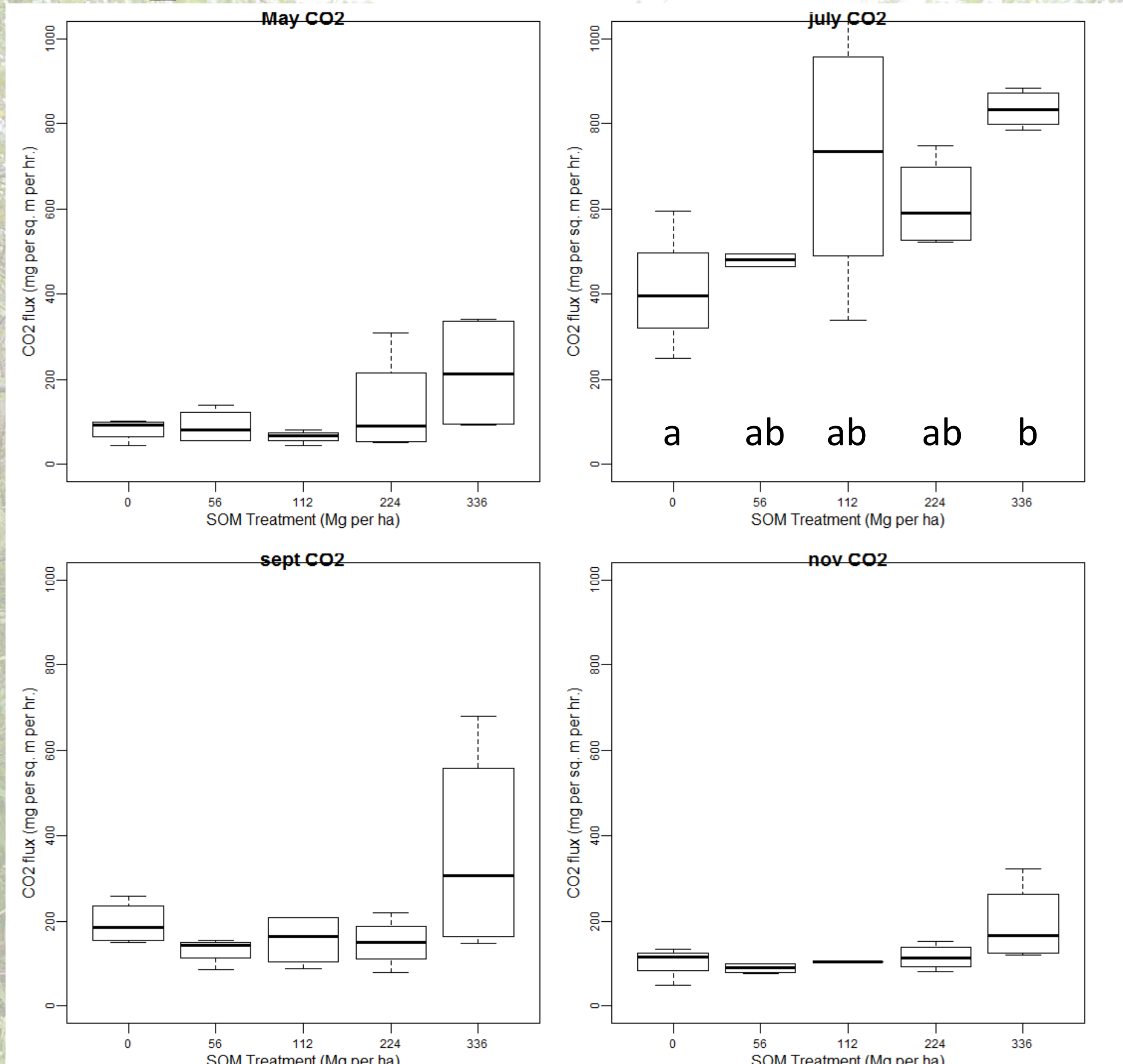
2011 (this study)





Water Level (cm)
Rainfall (cm)
Date
W1
W2
W3
W4
W5
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
9
8
7
6
5
4
3
2
1
0
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12

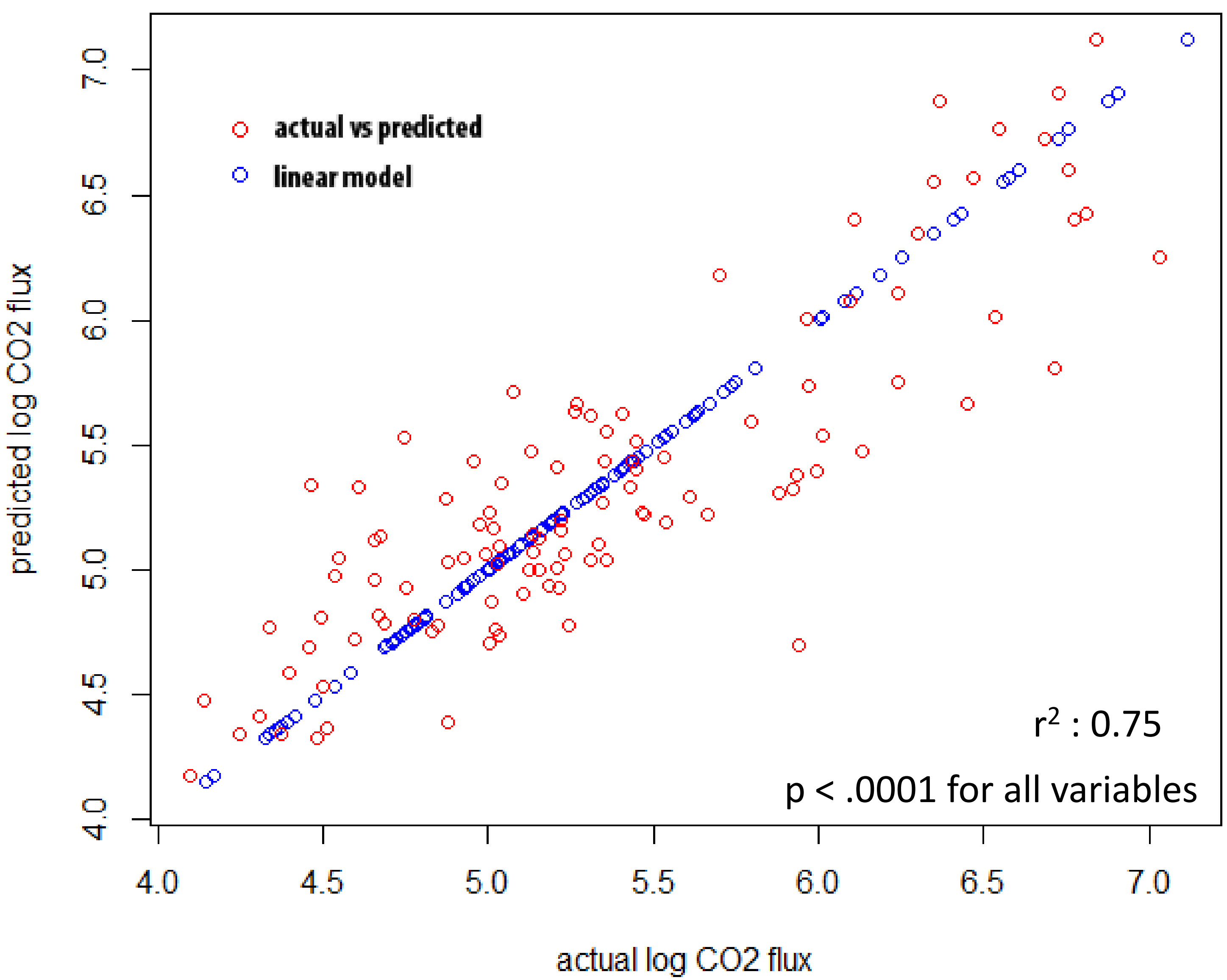
CO_2 flux by OM treatment



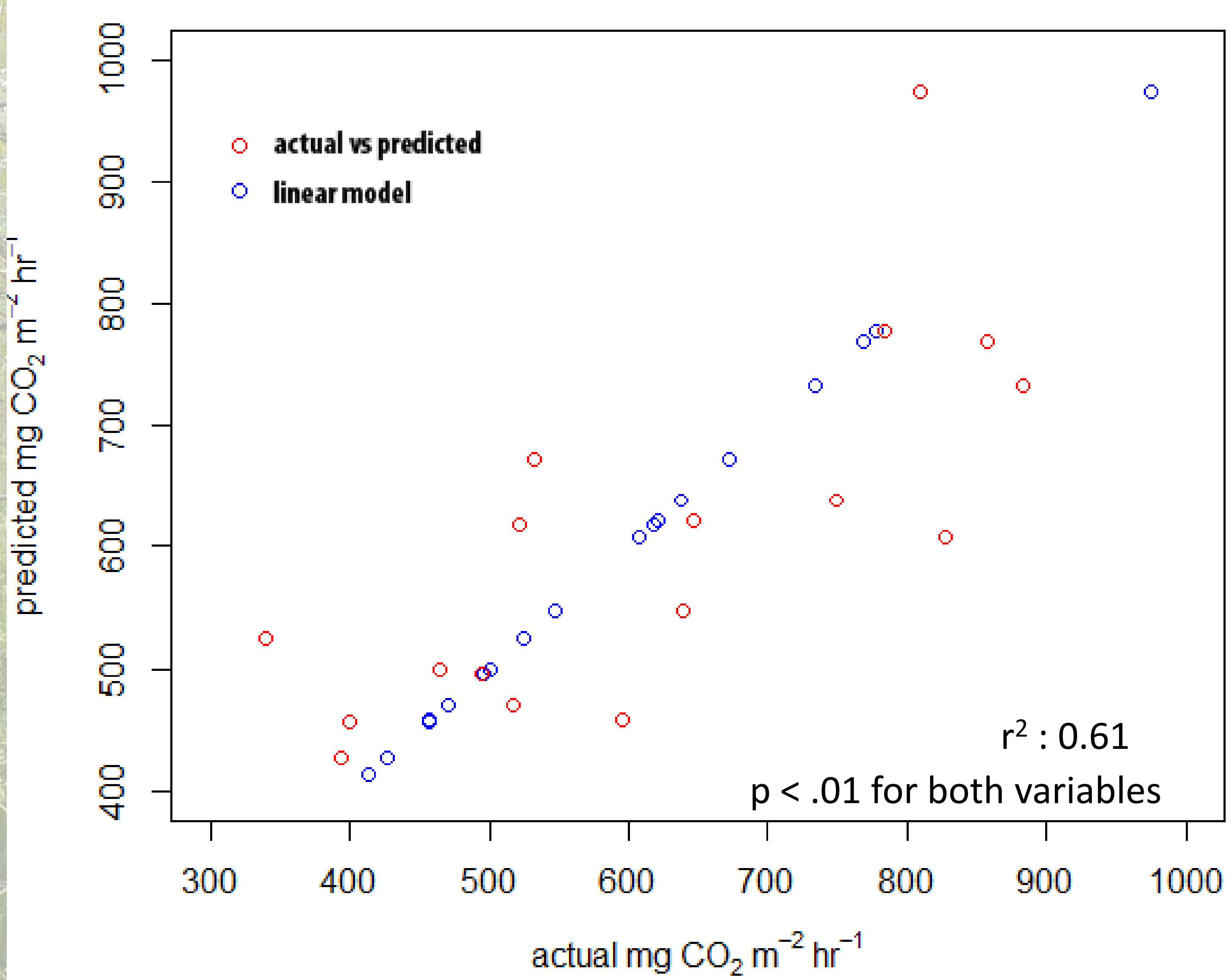
CO_2 flux by OM treatment

	linear regression		ANOVA
Month	p-value	Adj. r-squared	p-value
May	**0.028**	**0.20**	0.165
July	**0.004**	**0.38**	**0.039**
Sept	0.133	0.07	0.116
Nov	**0.009**	**0.35**	0.126

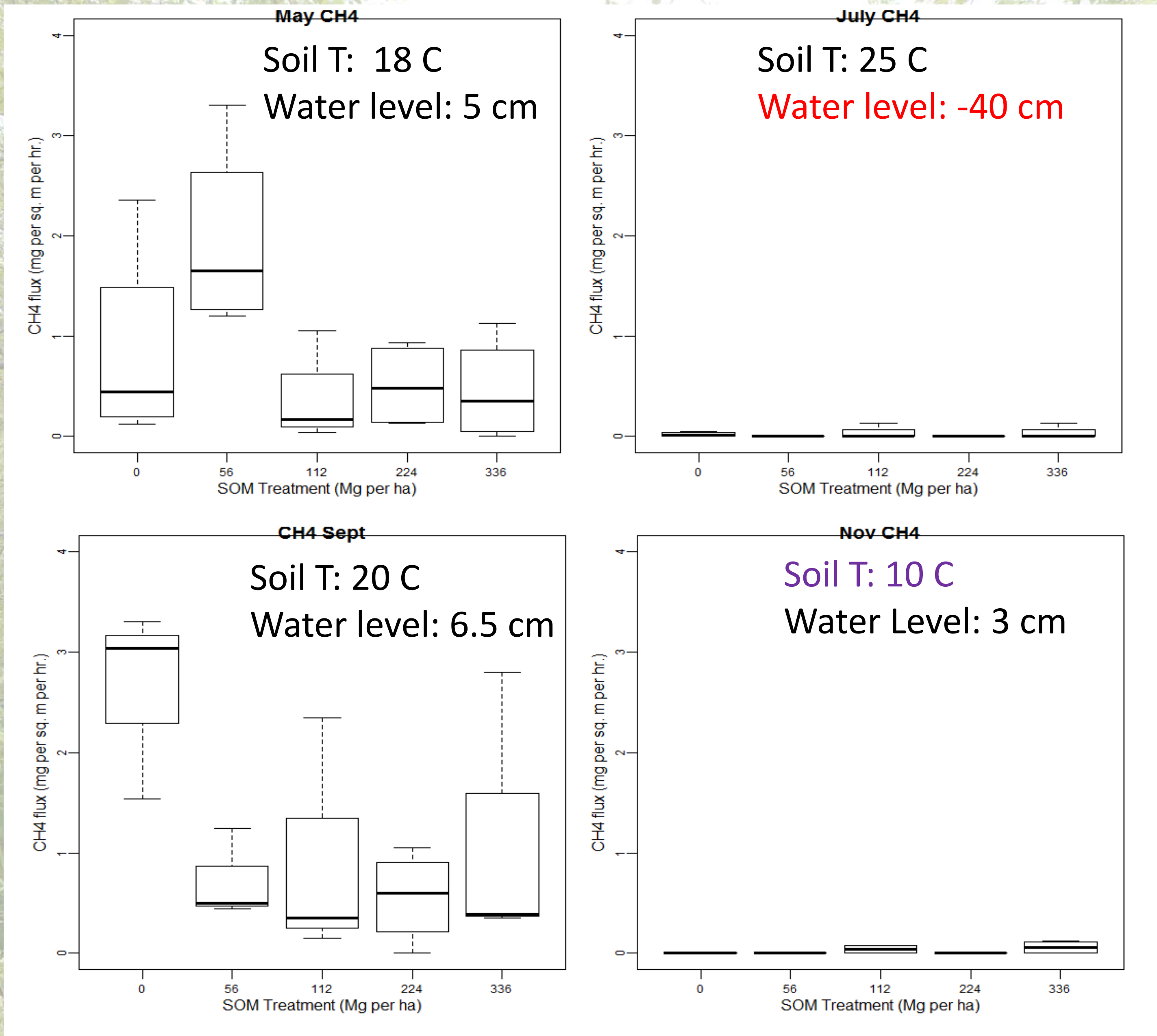
GLM - log CO2 flux ~ soil moisture, T, 0-5 cm TC - all months

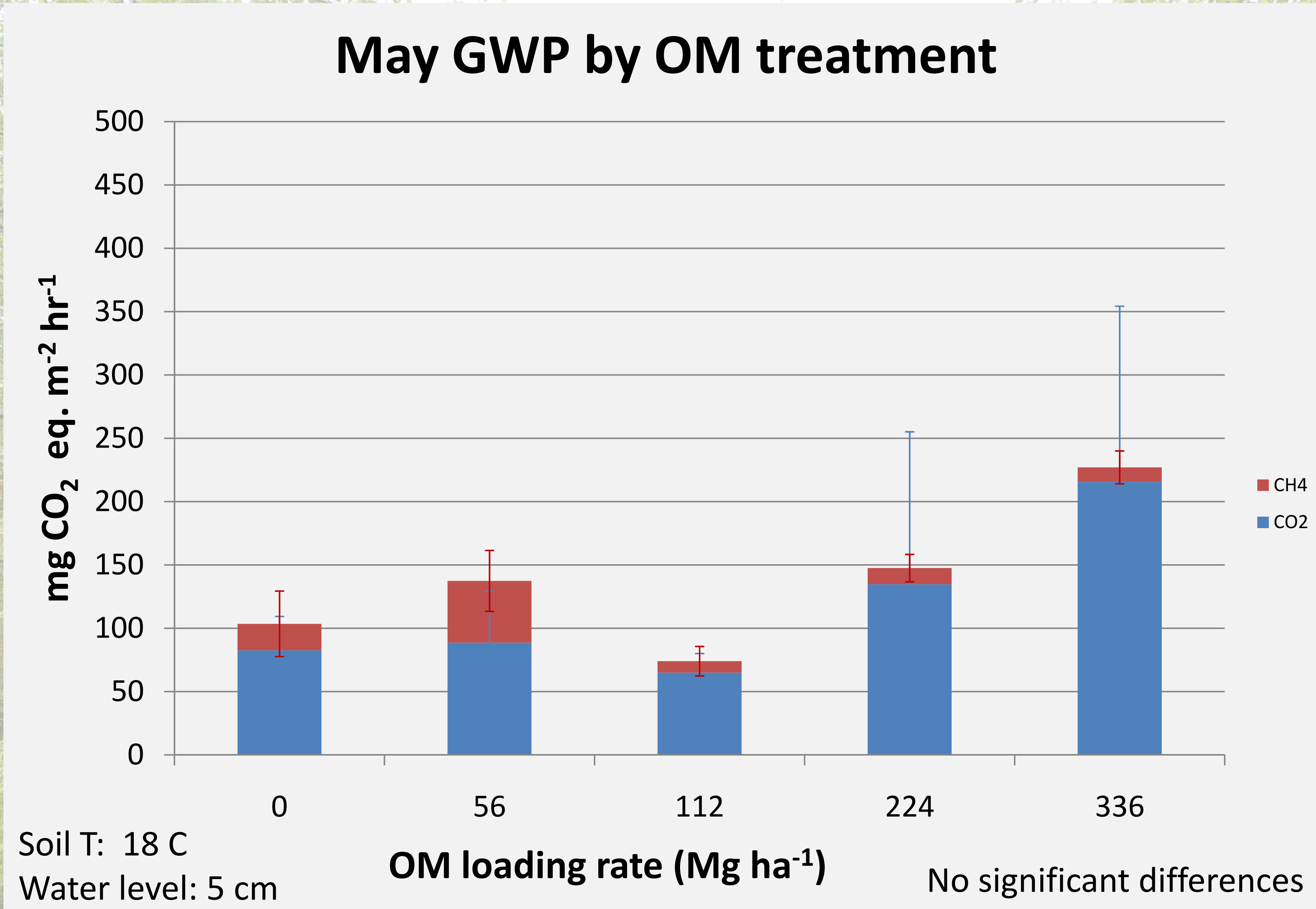


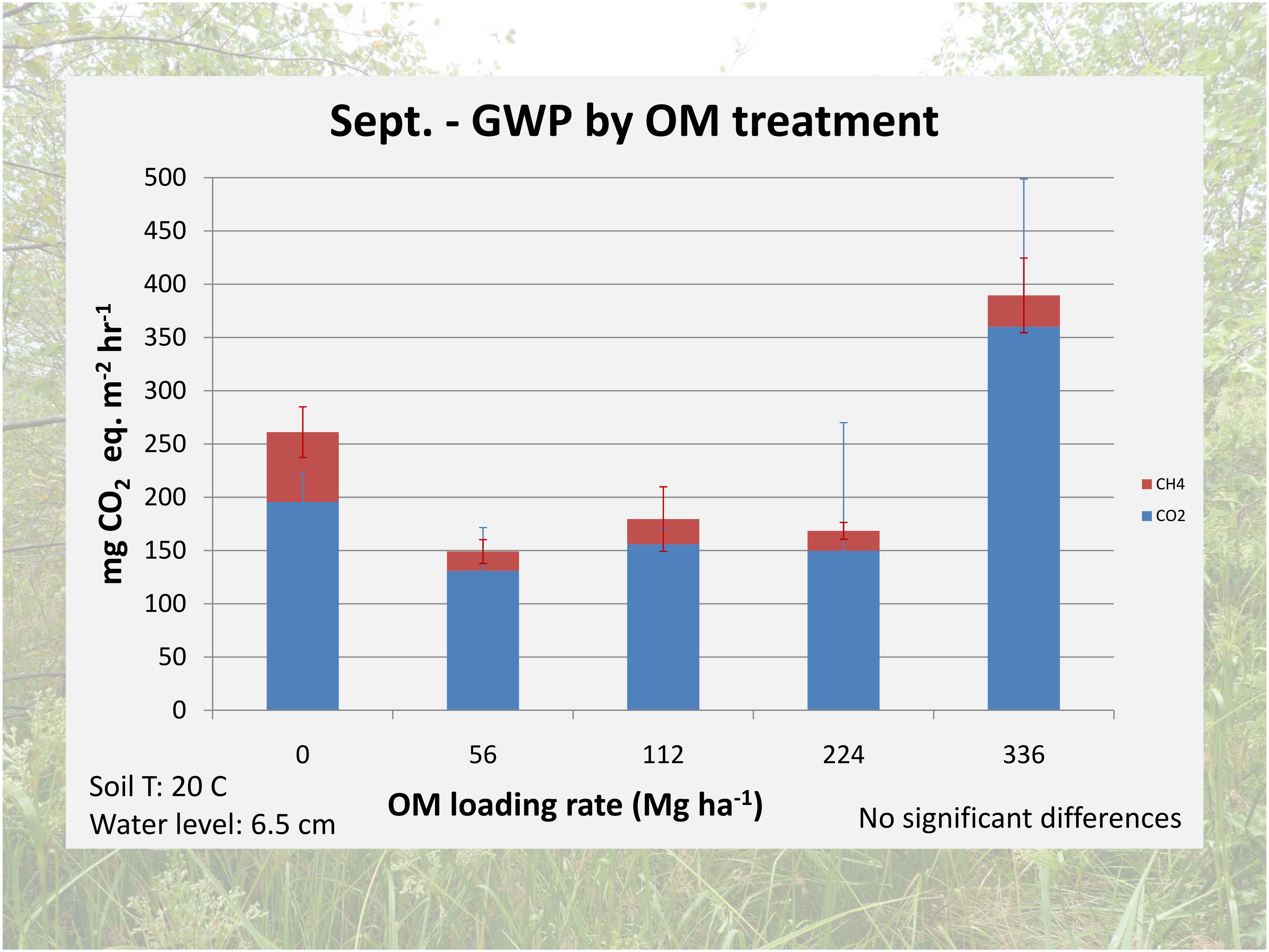
GLM - CO2 flux ~ 0-5 cm %C + 19-21 cm %N - July



Methane flux by OM treatment

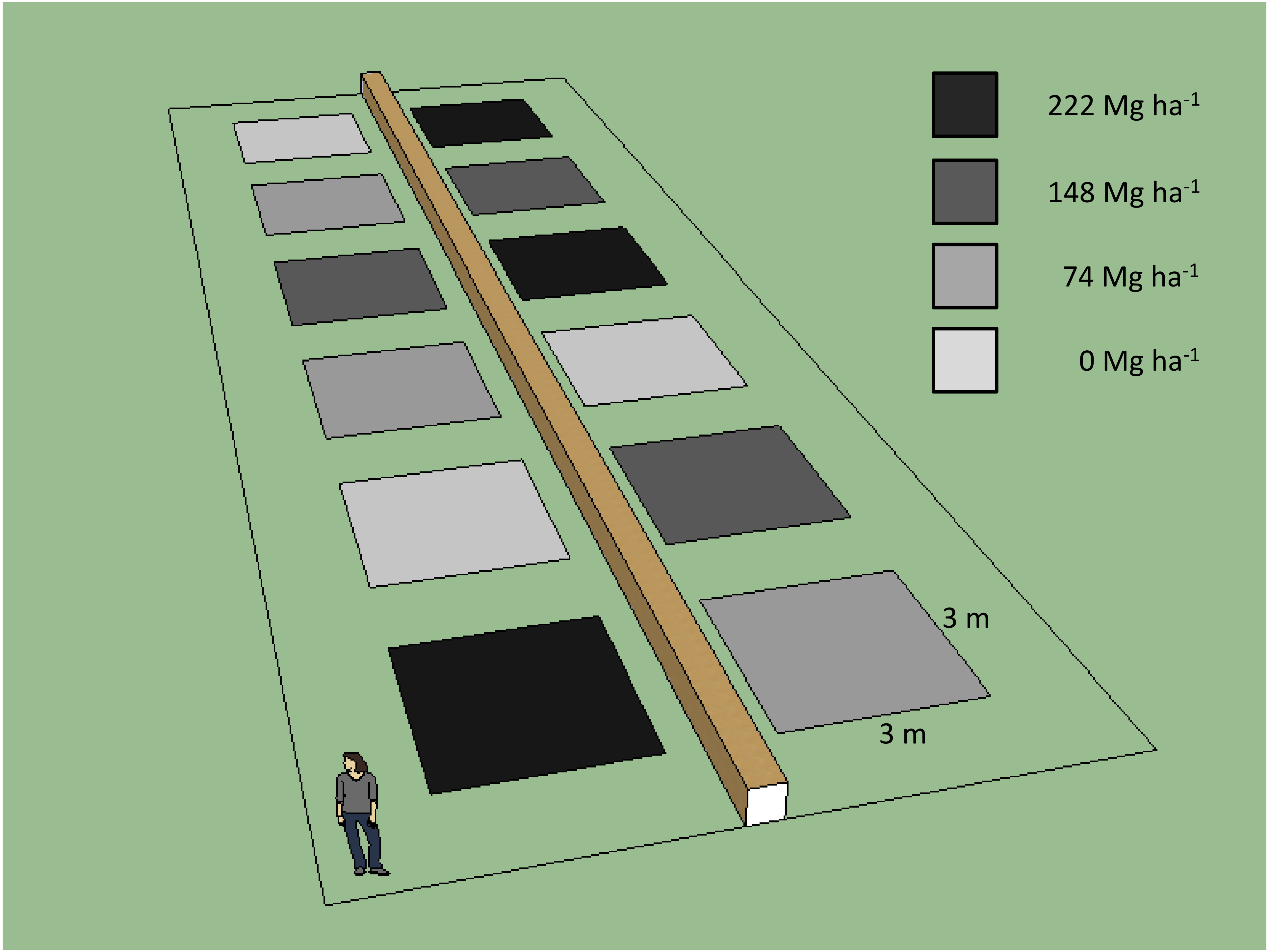



May GWP by OM treatment
mg CO2 eq. m-2 hr-1
500
450
400
350
300
250
200
150
100
50
0
0
56
112
224
336
CH4
CO2
Soil T: 18 C
Water level: 5 cm
OM loading rate (Mg ha-1)
No significant differences


Sept. - GWP by OM treatment
mg CO2 eq. m-2 hr-1
500
450
400
350
300
250
200
150
100
50
0
0
56
112
224
336
CH4
CO2
Soil T: 20 C
Water level: 6.5 cm
OM loading rate (Mg ha-1)
No significant differences

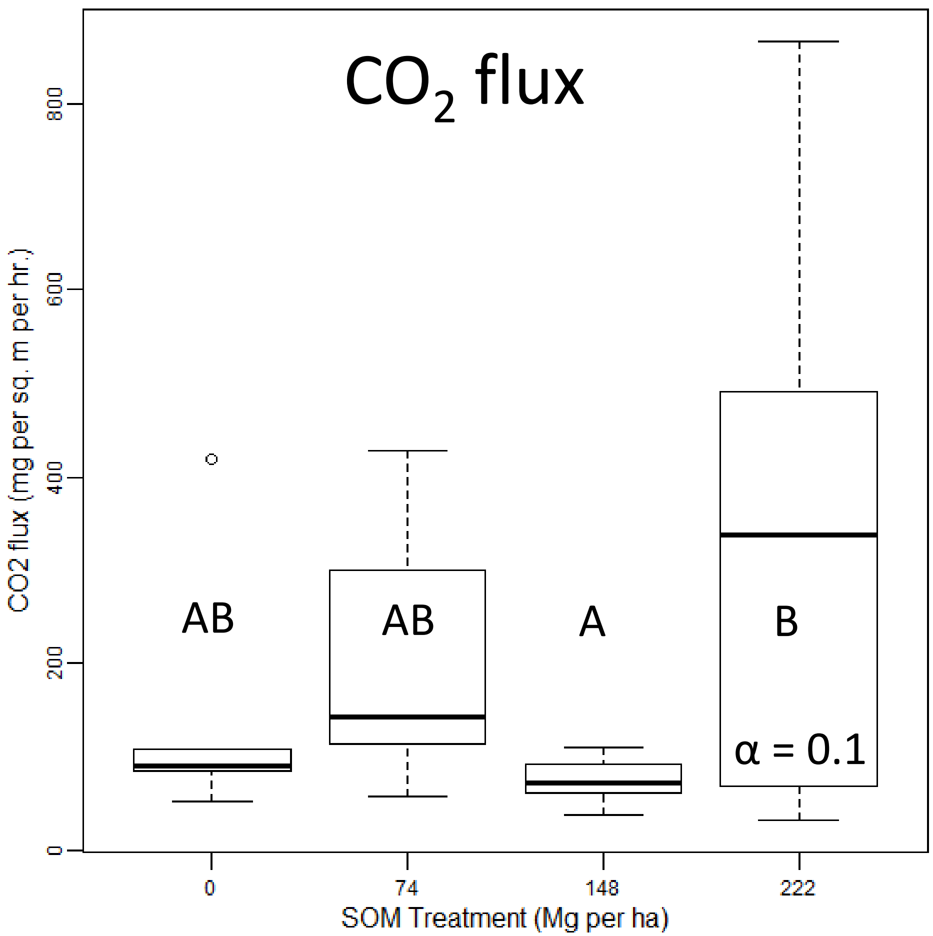
Conclusions

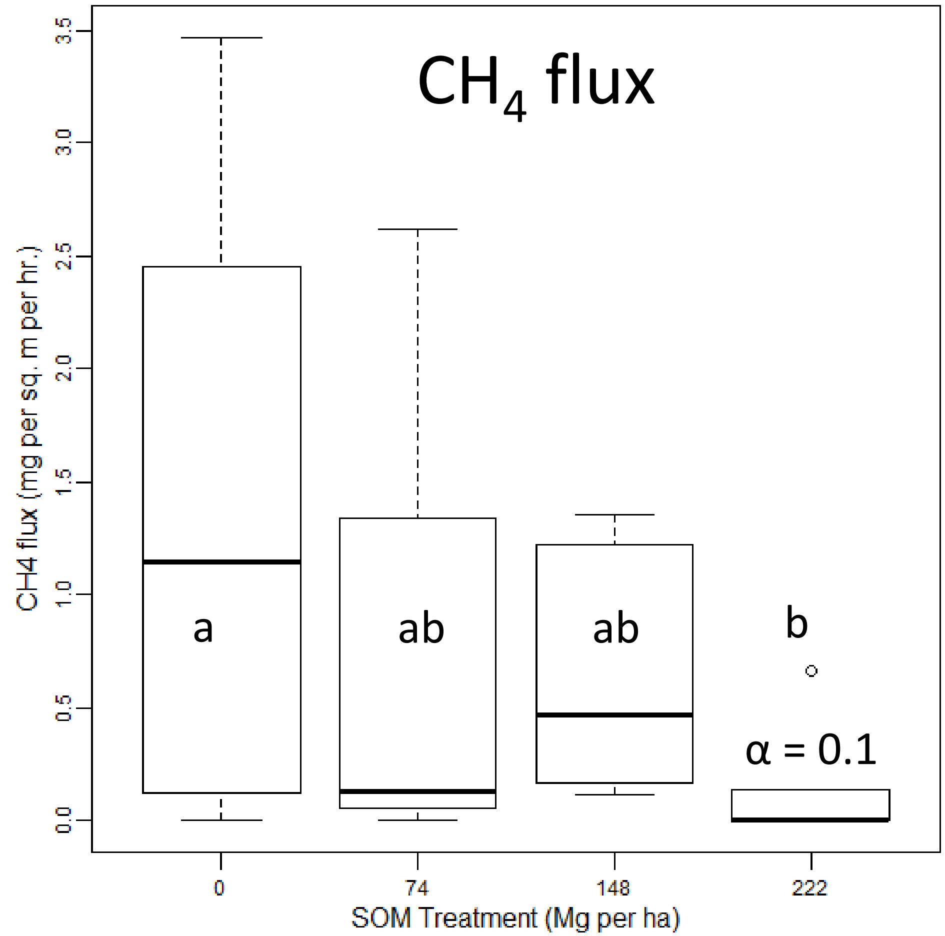
- Excess C from high OM amendments is emitted mainly as CO_2 not as methane
- Adding OM does not increase soil methane flux
- Adding moderate amounts of OM does not lead to enhanced GHG emissions
- Methane flux increases under flooding



222 Mg ha-1
148 Mg ha-1
74 Mg ha-1
0 Mg ha-1
3 m
3 m

Duke Forest Low Bench – Dec 2012





Acknowledgements

- The Peterson Family Foundation and WSSI
- The DU Wetland Center staff
  - Curt Richardson, Neal Flanagan, Hongjun Wang, Jonathon Bills, Wes Willis, Wyatt Hartman, Mengchi Ho
- The Bernhardt Lab
  - Emily Bernhardt, Ashley Helton, Medora Burke-Scoll, Anna Fedders, Ben Coleman
- Virginia Department of Transportation
- And
  - Dan Richter, Allan Bacon, Heide Winner, Eugene Yacobson, Mary Susan Sherman, Scott Sashy, Elizabeth Norment, Darmawan Prasadjo