Greenhouse gas emissions dynamics in response to organic matter loading rates in a created freshwater wetland in southeastern Virginia

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Presentation Outline

1. Background on mitigation wetlands
2. Site description and research questions
3. Results and discussion
4. Methodological postscript

Wetland restoration policies and programs

- Clean Water Act – Section 404
  - 1977
- "No Net Loss"
  - 1989
- Wetlands Reserve Program
  - $2.1 Billion 1992-2007 (Ferris and Siikamäki, 2009)

News and Observer April 17, 2011

WASHED AWAY WASTING MILLIONS, PROTECTING DEVELOPMENT

State spends $140 million on faulty water projects

In 2005, the state rebuilt a section of Little Beaver Creek southwest of Apex as part of a $1.5 million stream restoration. Remnants of a tropical storm in 2006 caused major damage, prompting a planned $323,000 repair.

Typical wetland creation problems in Southeastern Virginia

- Soil compaction
- Low Soil Organic Matter

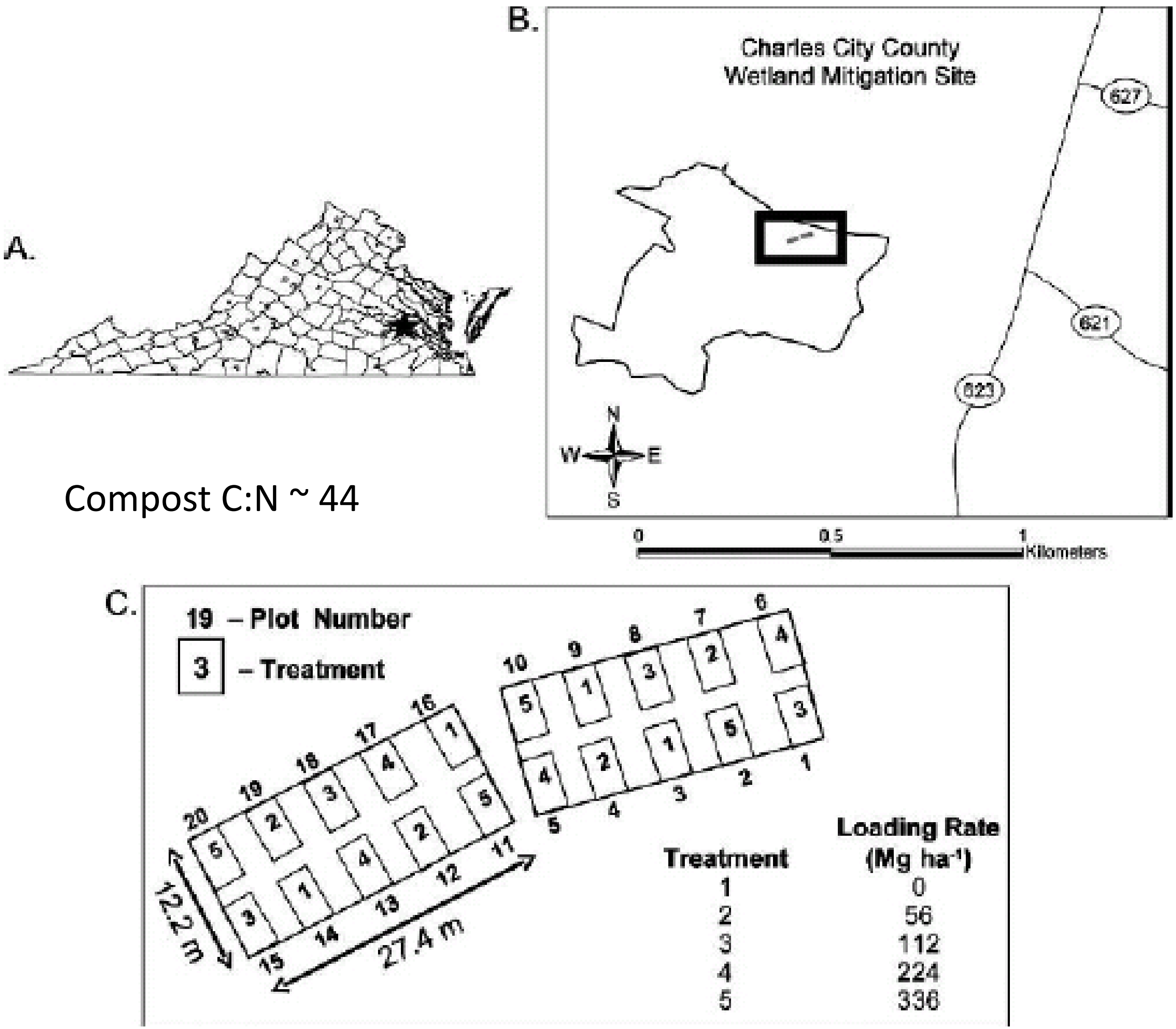
- Solution: Organic matter amendments

(Whittecar and Daniels, 1999)

Charles City County Wetland

Constructed: 1998
Organic Matter Amendment:2002
Tree Planting: 2004

(Daniels et al. 2005)



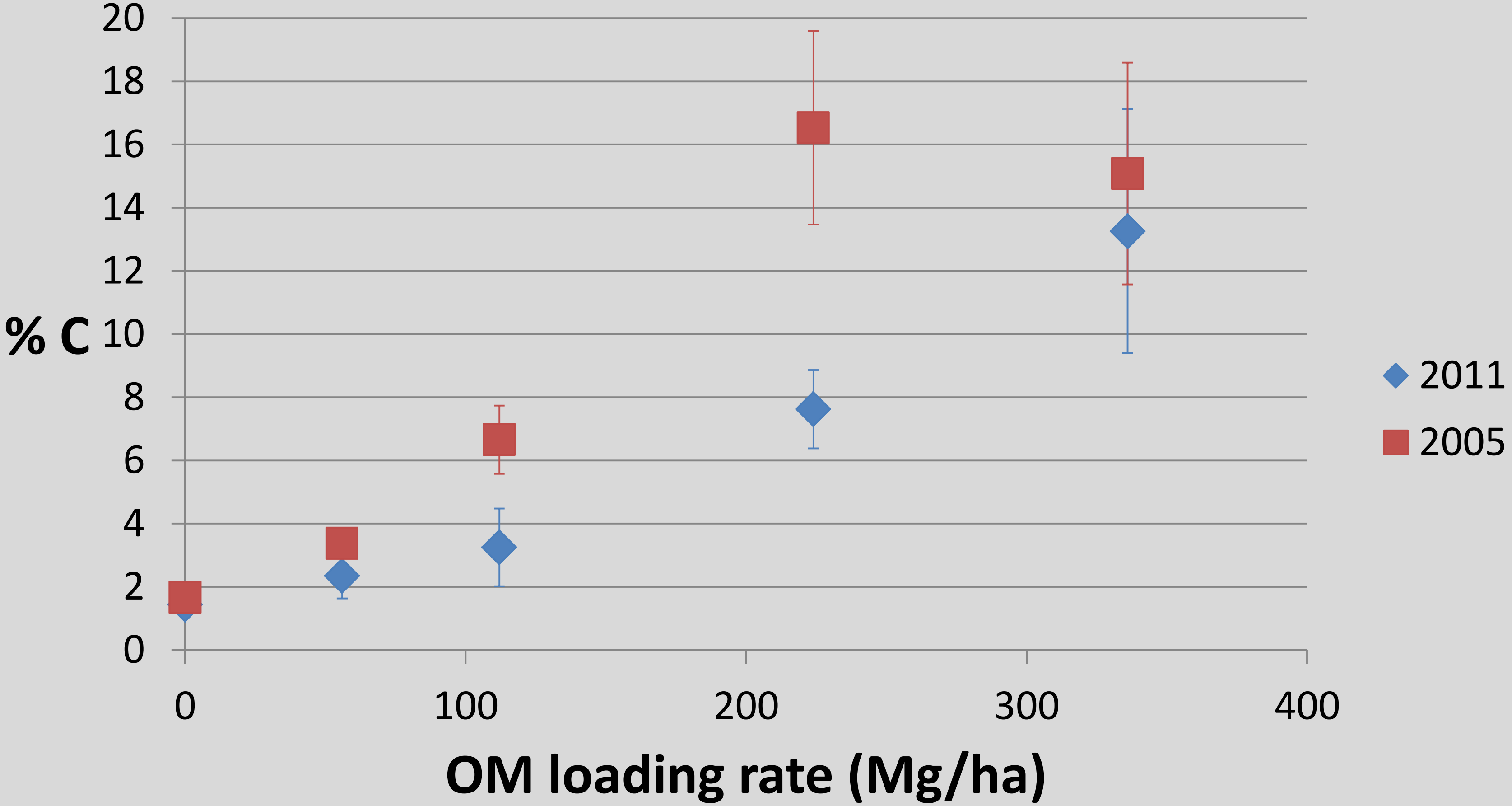
Compost C:N ~ 44

Bailey et al. 2007 ; Bruland et al 2009

Research Questions

- What is the fate of the organic matter that has been added to the Charles City County Wetland?
  - What effect do the different loading rates have of on biogenic trace gas emissions?

Total soil C top 10 cm



2005 data from Bailey et al 2007

Gas data summary

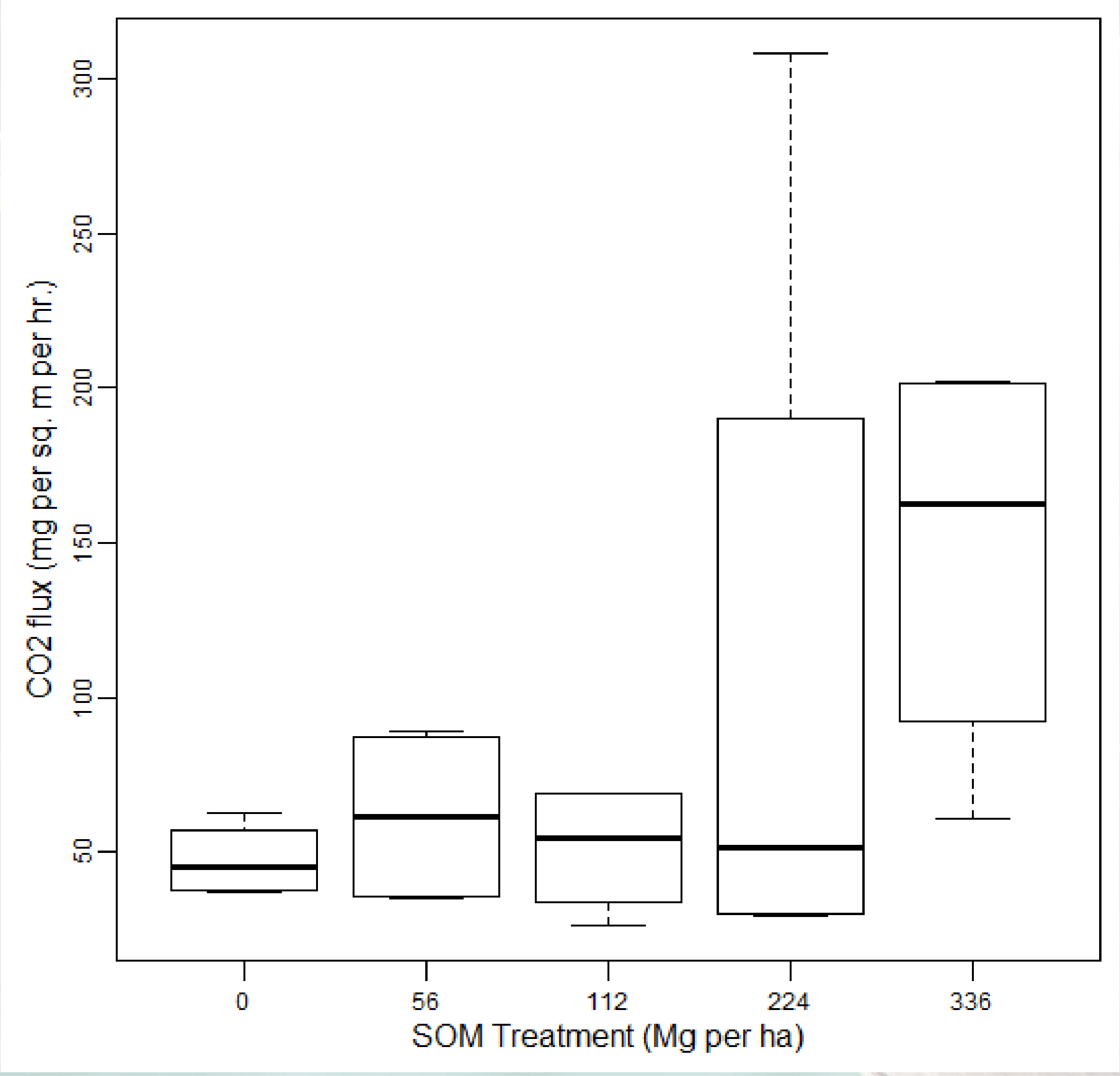
date	no. incubations	successful CH_4 incubations
9/2/2011	5	5
9/26/2011	15	3
10/21/2011	20	9
2/22/2012	27	8
5/7/2012	20	**20**

Other studies report 41 to 55 percent of methane incubations linear (Morse et al 2012; Nahlik and Mitsch 2010)

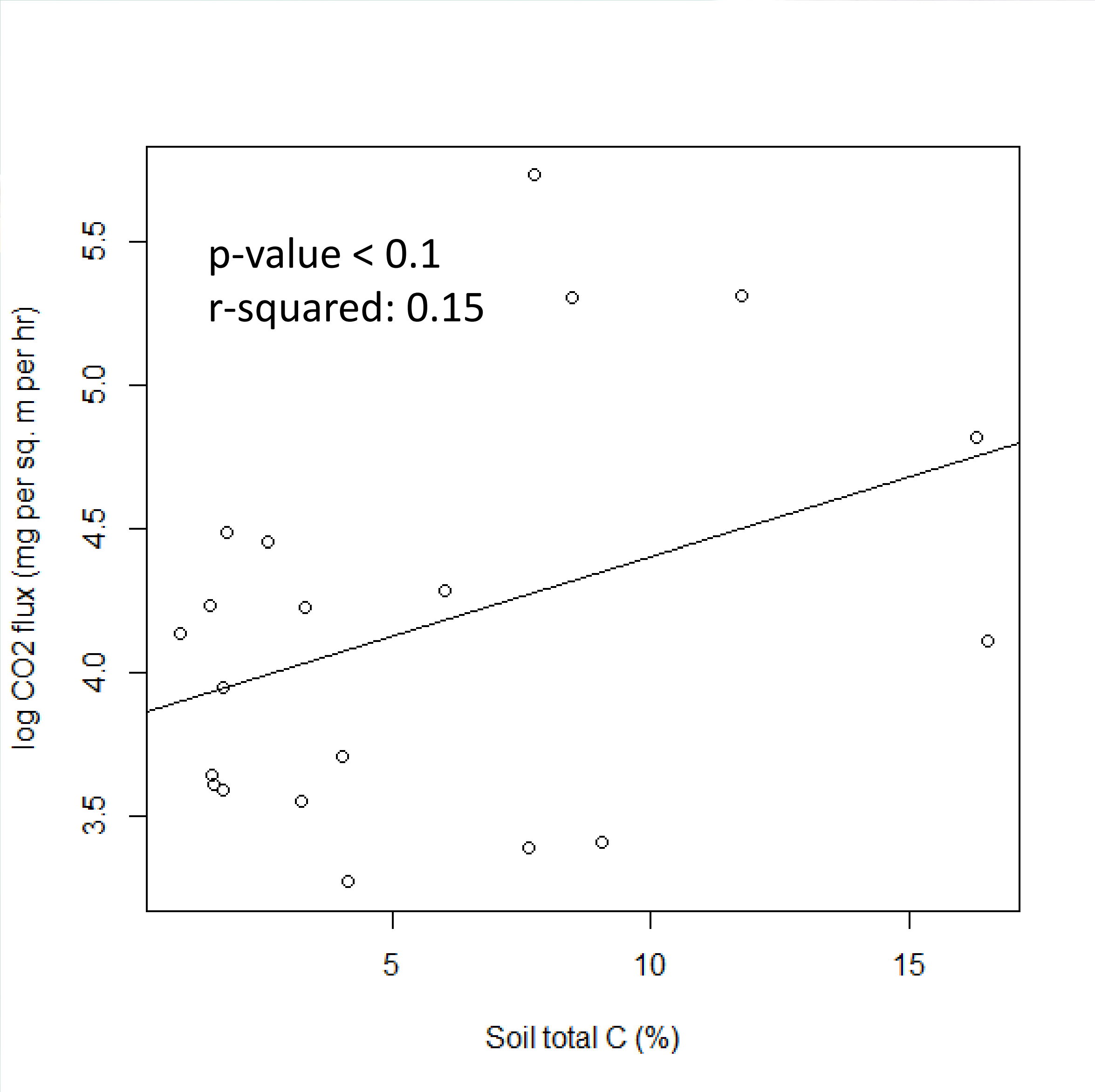
Results

- Plot CO_2 and CH_4 flux against:
  - OM treatment
  - Total soil C
- Model flux using other variables:
  - T
  - Soil Moisture
- Look at GWP by OM treatment

CO_2 flux as a function of OM loading rate (May 2012)



CO_2 flux as a function of soil C (May)

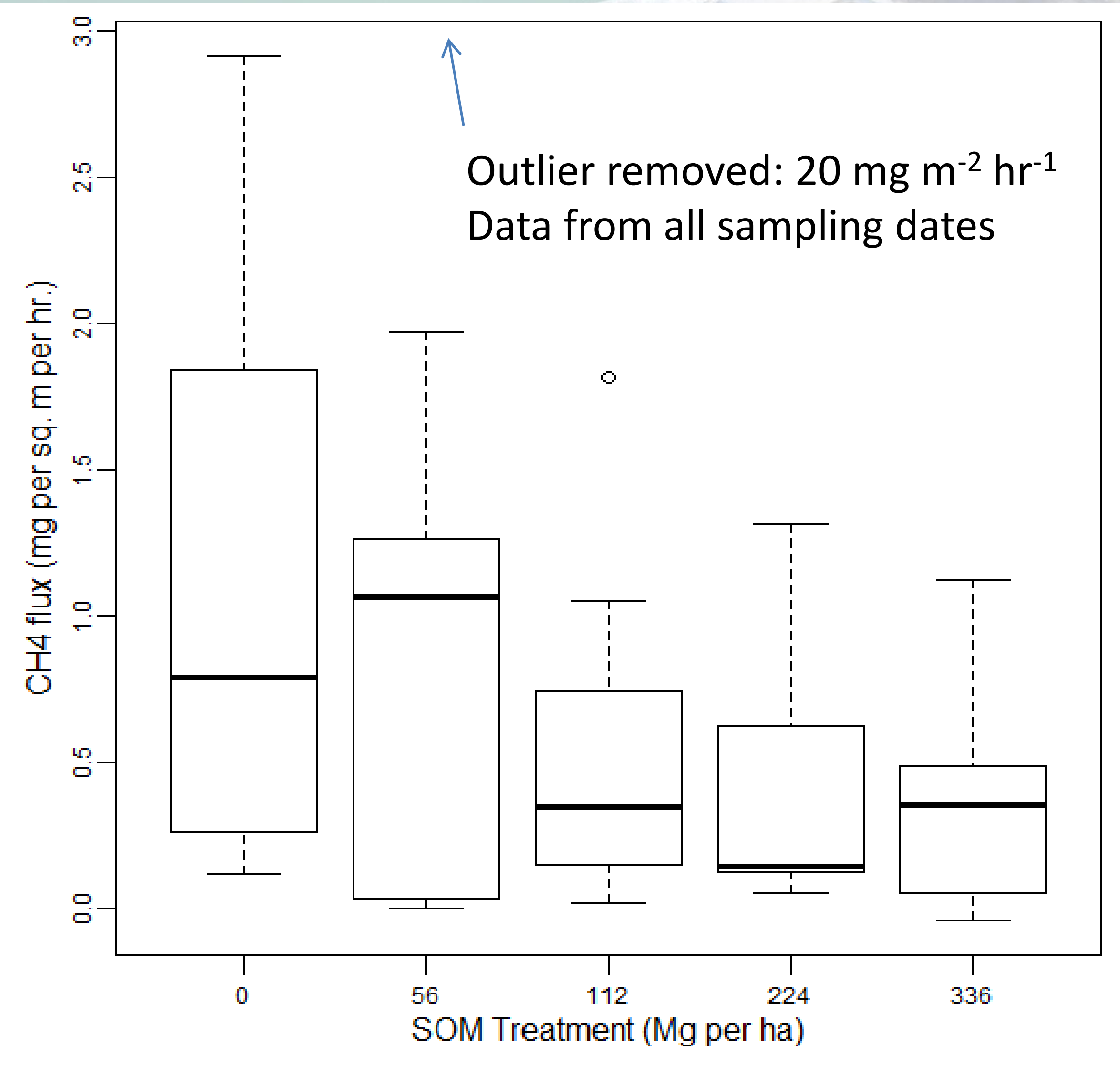


CO_2 Model: log CO_2 flux ~ Soil C + soil moisture + soil T (with interactions)

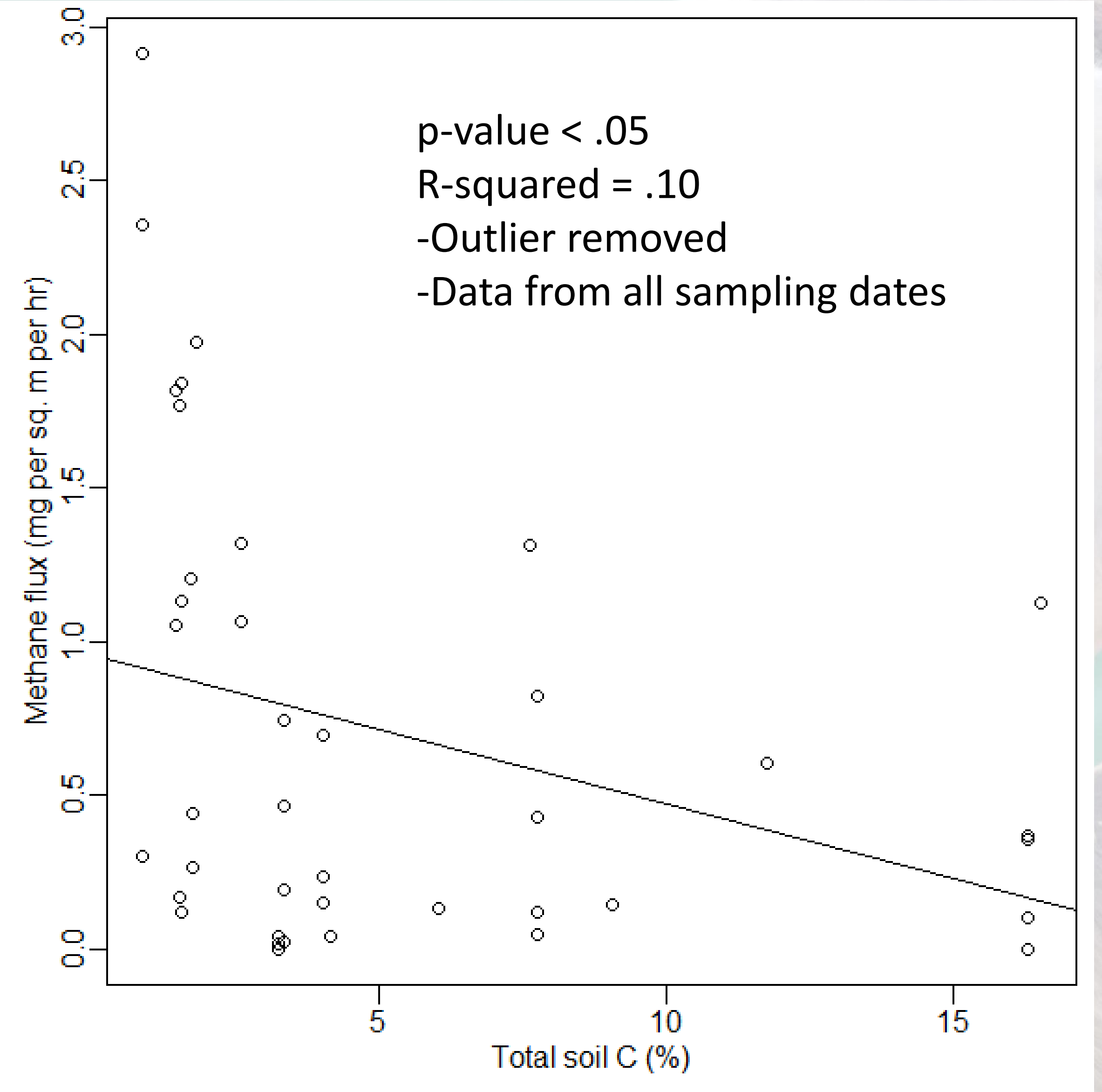
- Multiple r-squared: **.80**
- Adjusted r-squared: **.67**

	(p-values)
– Soil C	0.00194 **
– SVWC	0.01166 *
– Soil T	0.01148 *
– Soil C * SVWC	0.00201 **
– Soil C * Soil T	0.00205 **
– SVWC * Soil T	0.01185 *
– Soil C * SVWC * Soil T	0.00214 **

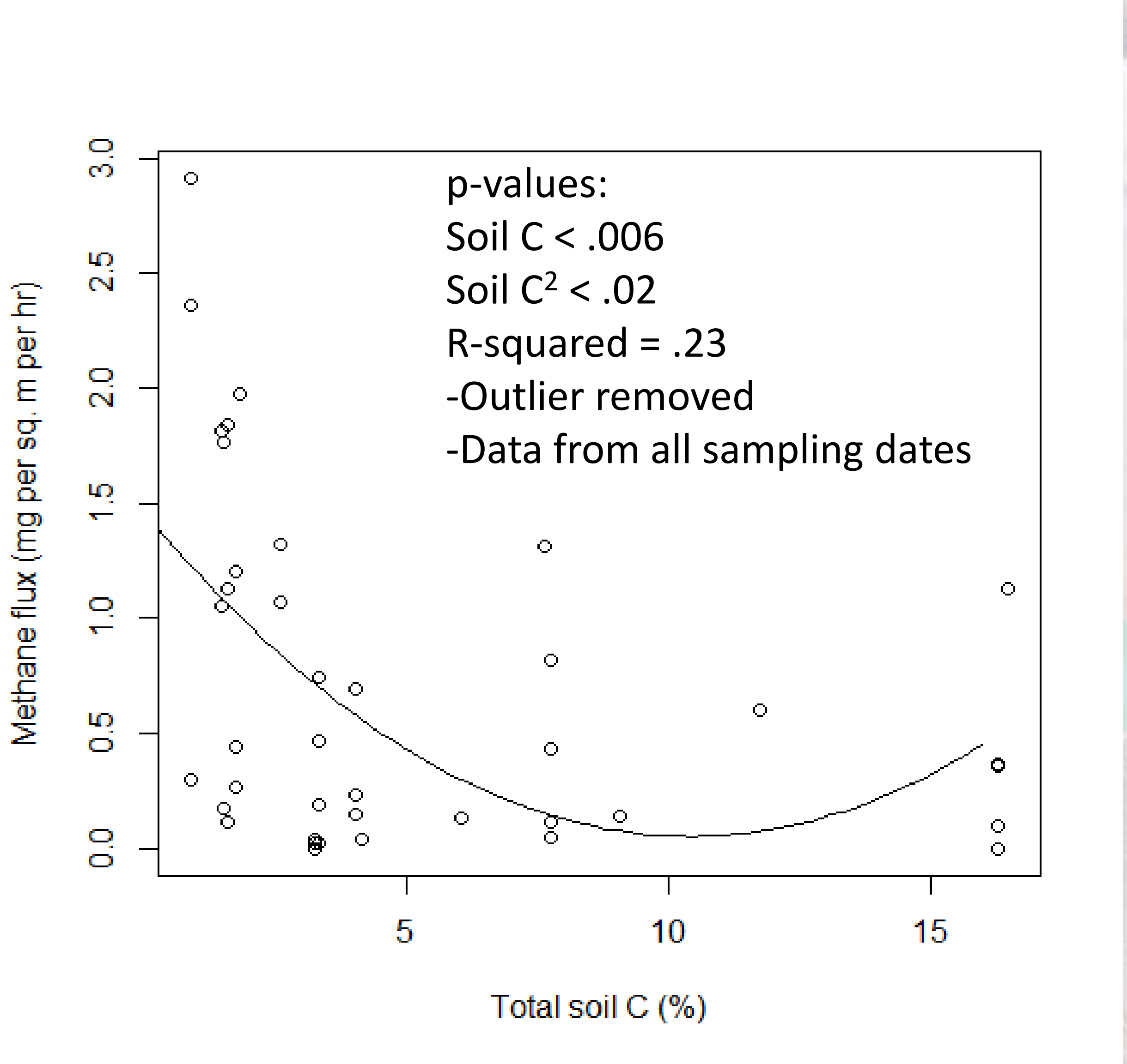
Methane flux as a function of OM loading rate



Methane flux as a function of soil C



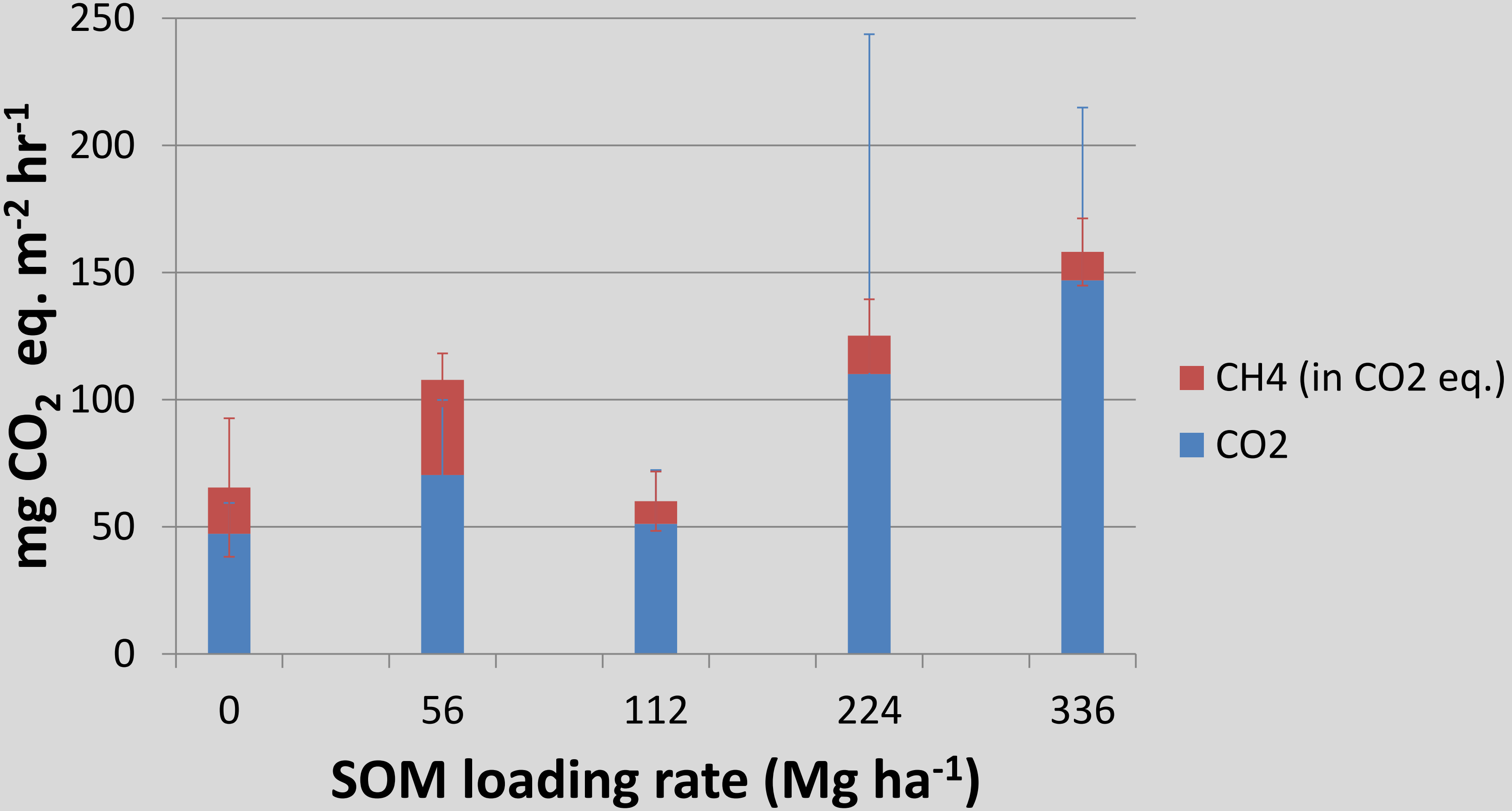
Methane flux as a function of soil C



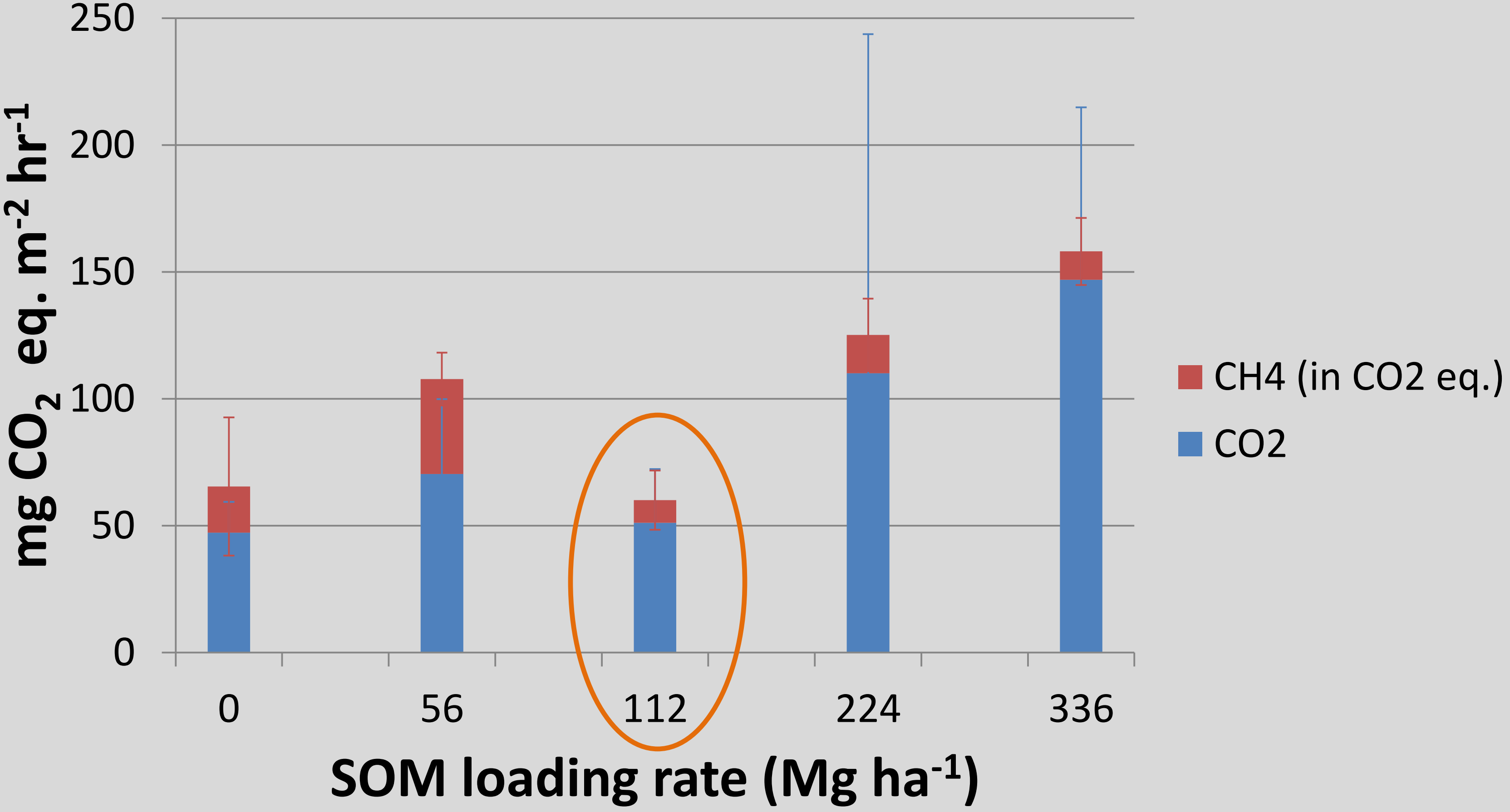
CH_4 Model?

- Soil Moisture and T are not significant predictors of CH_4 flux

Global Warming Potential by treatment

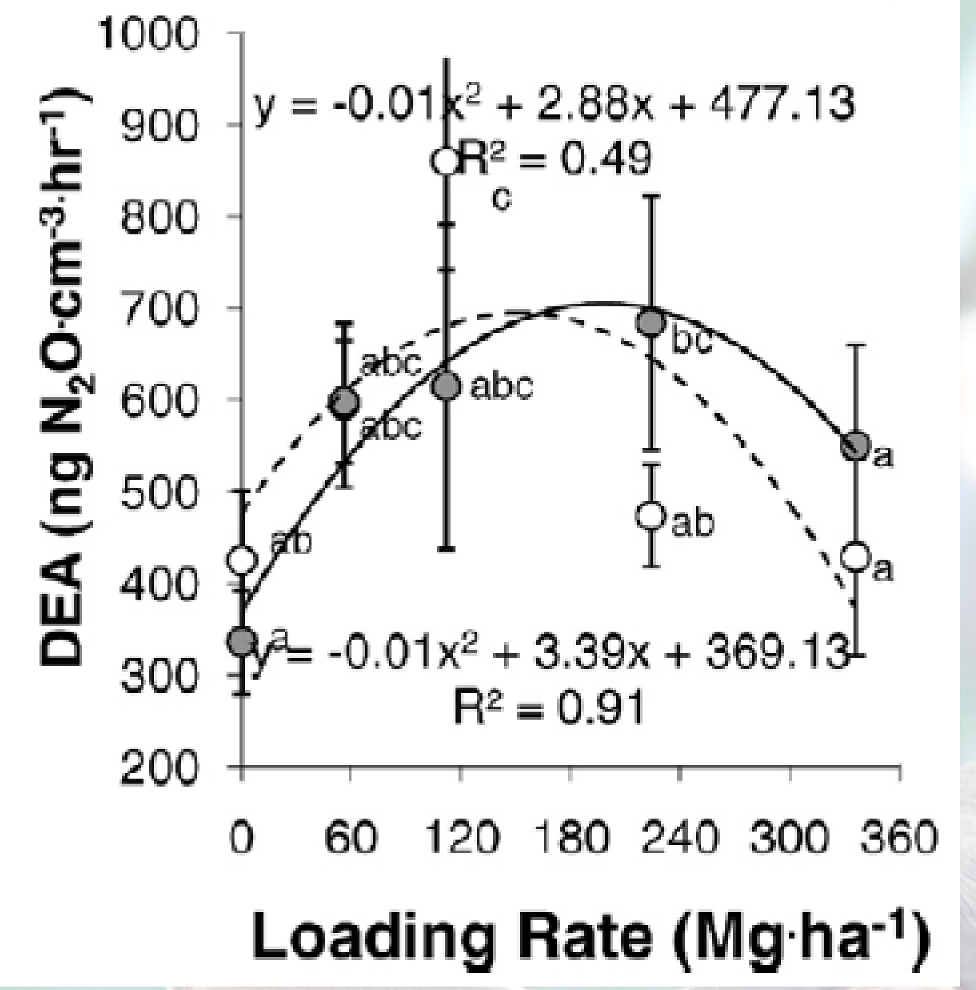


Global Warming Potential by treatment



A threshold?

- Bruland et al. (2009)



- Bailey et al. (2005) studied vegetation dynamics and reported: "…112 Mg ha^{-1} provided the maximum benefit…"

Conclusions

- CO_2 flux correlated with total soil C
  - dominates GWP
- N_2O flux rates below detection for 78% of samples
- CH_4 flux anti-correlated with soil C, but relationship weak
  - Bioavailability of C?
  - Soil Texture?
  - Tree roots?
- GWP minimum at intermediate SOM load?

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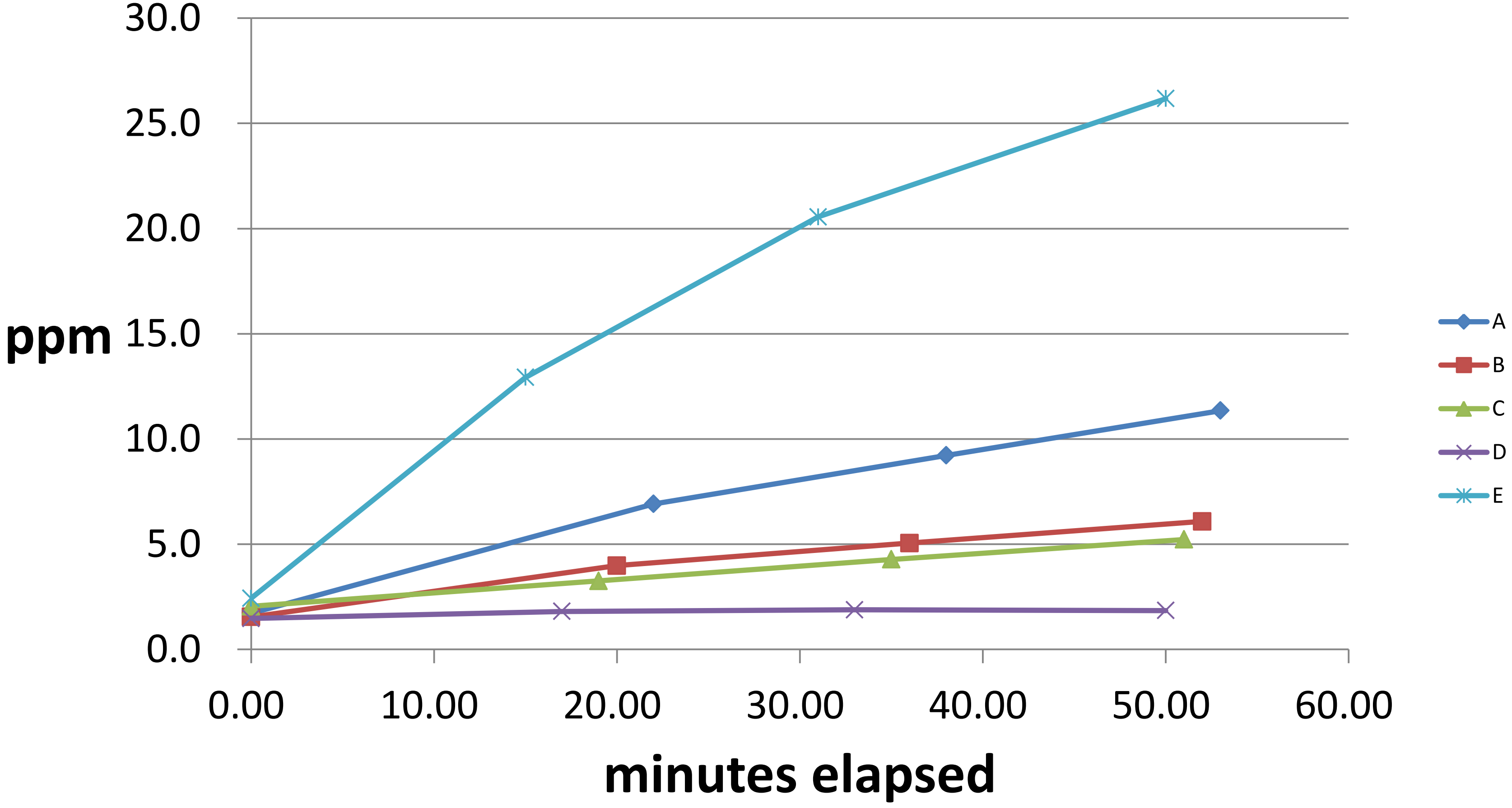
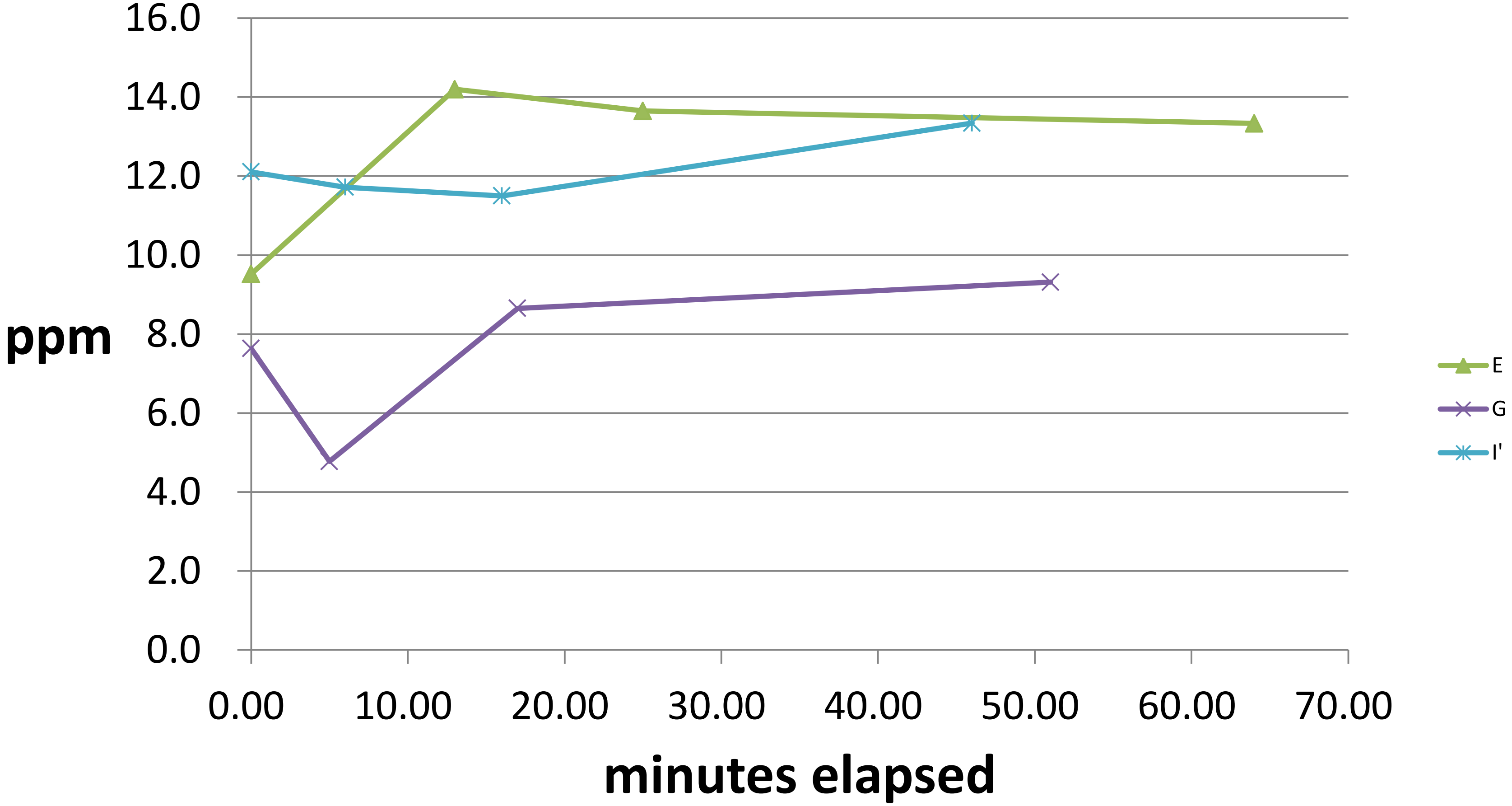
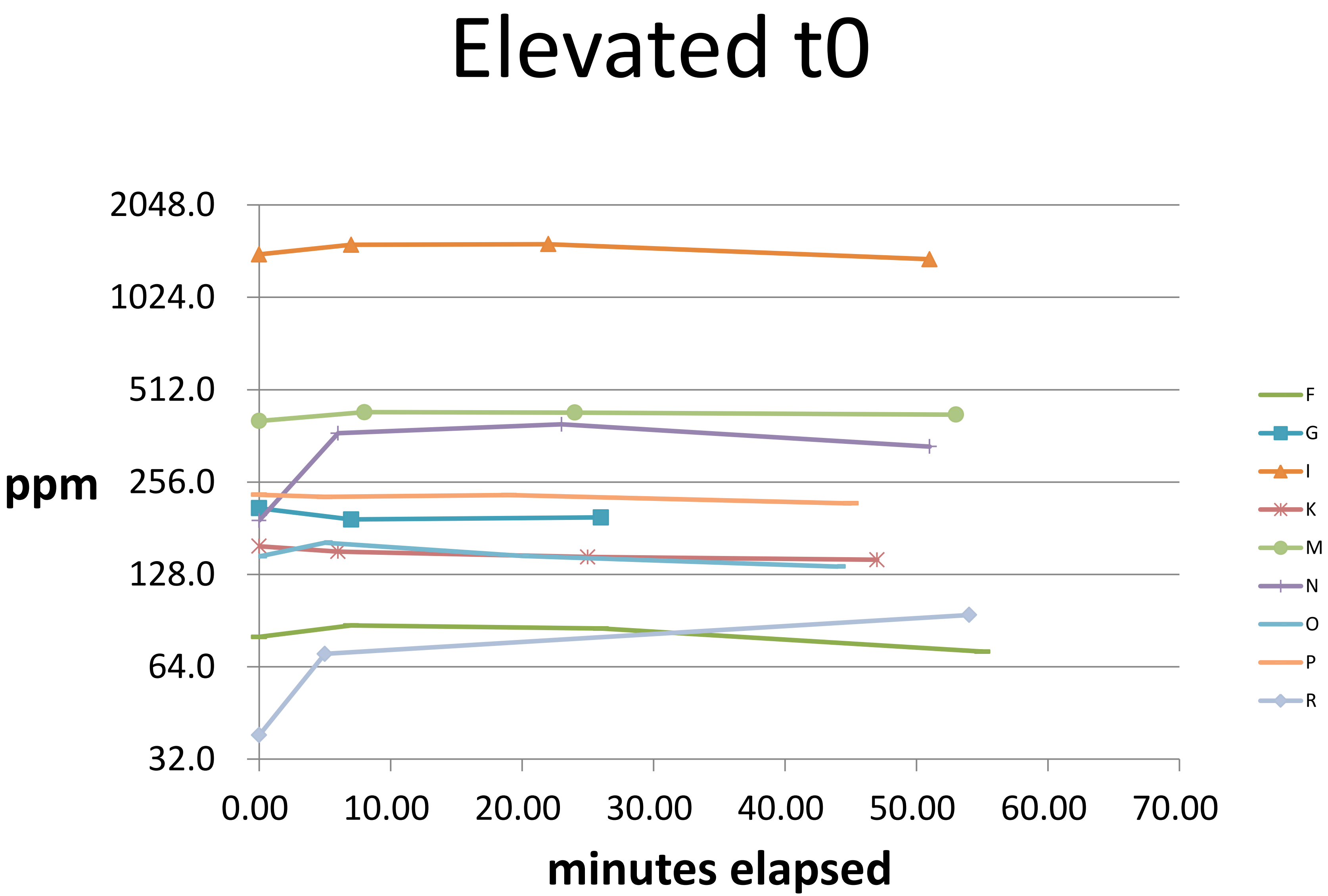
Good Curves


ppm
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
minutes elapsed
A
B
C
D
E

Bad Curves



16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
ppm
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
minutes elapsed
E
G
I'


Elevated t0
ppm
2048.0
1024.0
512.0
256.0
128.0
64.0
32.0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
minutes elapsed
F
G
I
K
M
N
O
P
R

Acknowledgements

- The Peterson Family Foundation
- The DU Wetland Center staff
  - Curt Richardson, Neal Flanagan, Hongjun Wang, Jonathon Bills, Wes Willis, Wyatt Hartman
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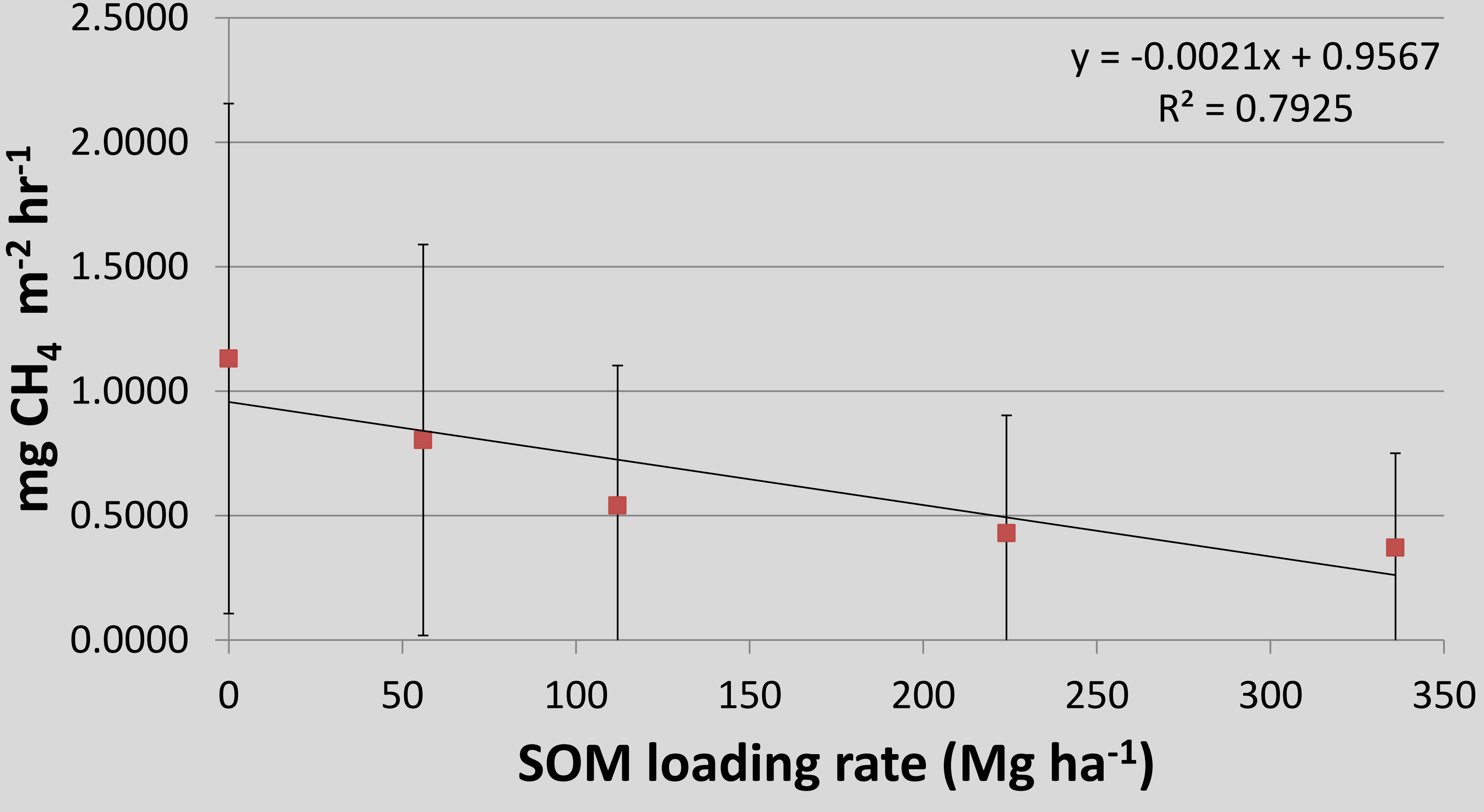
  - Dan Richter, Allan Bacon, Heide Winner, Eugene Yacobson, Mary Susan Sherman, Scott Sashy, Elizabeth Norment, Darmawan Prasadjo

CH_4 flux from freshwater wetlands

Source	ecosystem	Location	CH_4 flux (kg ha^{-1} yr^{-1})
This study	created WL	Virginia	31.5 to 131
Mander et al. (2008)	constructed WL	Estonia	6.81 to 204
Hendriks et al. (2007)	restored peatland	Netherlands	145 to 689
Altor and Mitsch (2006)	created riparian marsh	Ohio	307 to 934
Morse et al. (2012)	restored WL	North Carolina	0.7 to 197
This study	created WL	Virginia	-3 to 1816
Sovik and Klove (2007)	constructed WL	Norway	-5.84 to 9250
Gleason et al. (2009)	restored wet meadow	North Dakota	-6.18 to 1080

Methane flux as a function of OM loading rate (all data)



Elevation by OM treatments