Feedbacks between Sediment and Vegetation Dynamics at Jug Bay Wetlands Sanctuary

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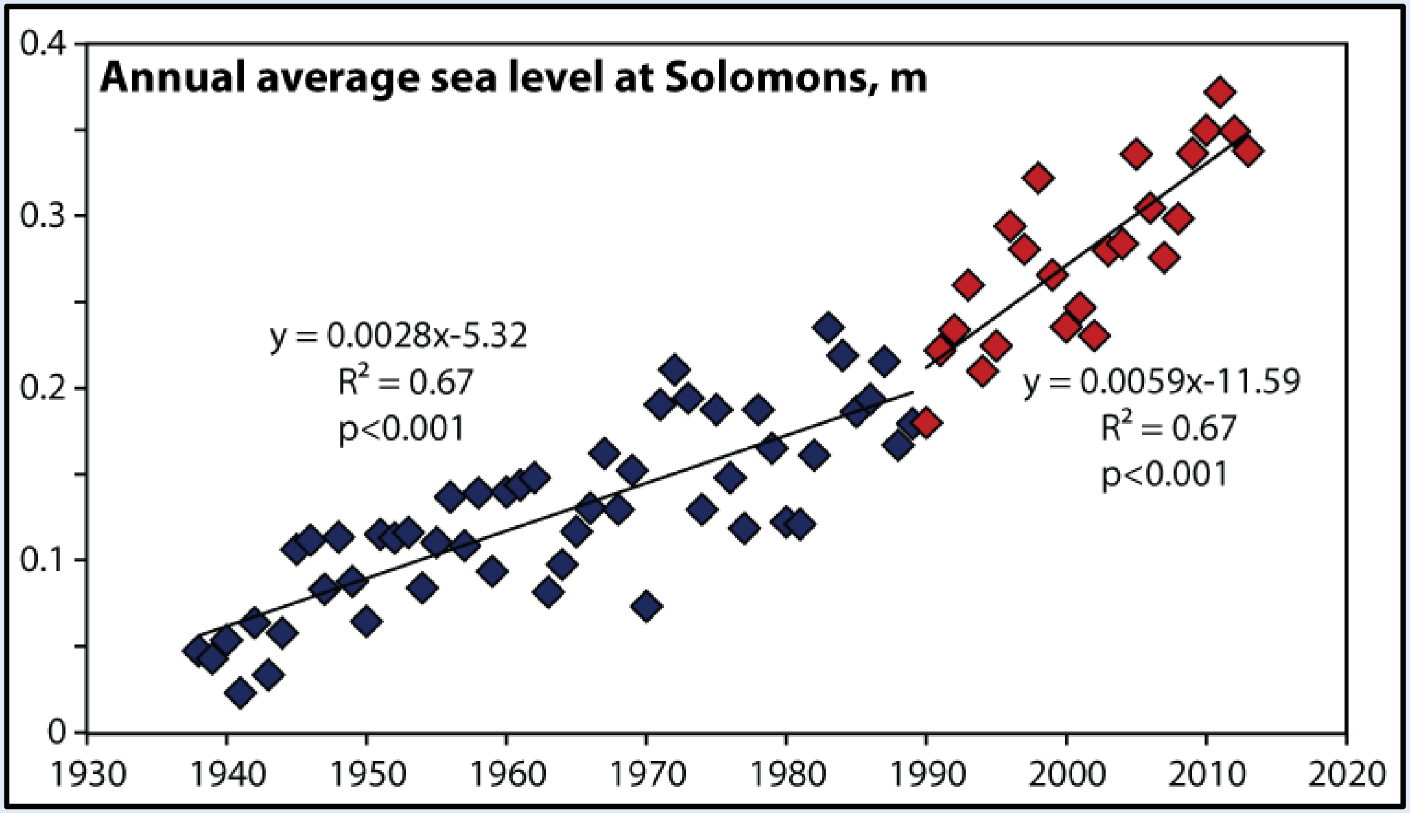
Motivation



Sea-level rise at Solomons

- Average rate since 1938: 3.7 mm/y
- Pre- and post-1990 values significantly ($p<0.001$) different

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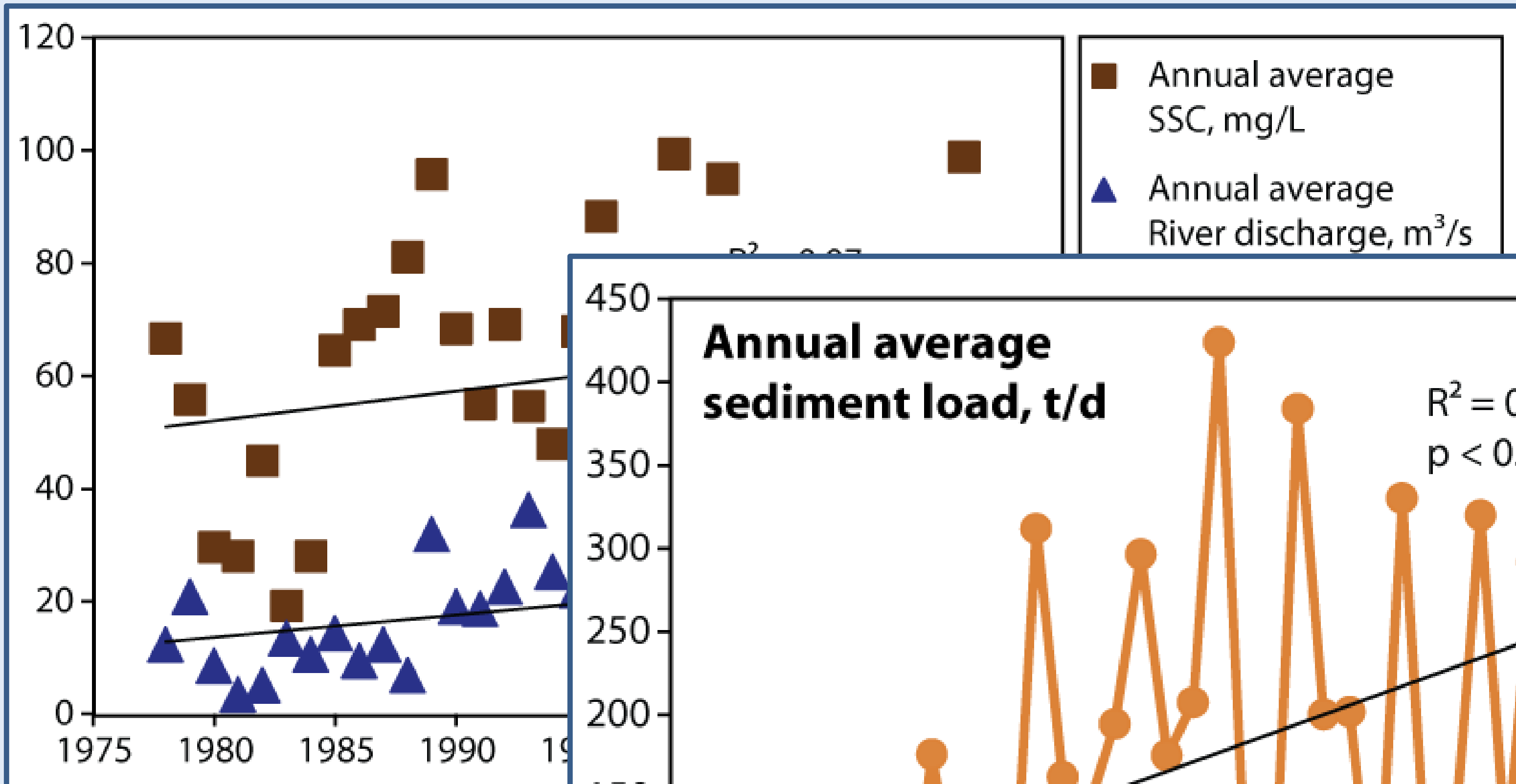

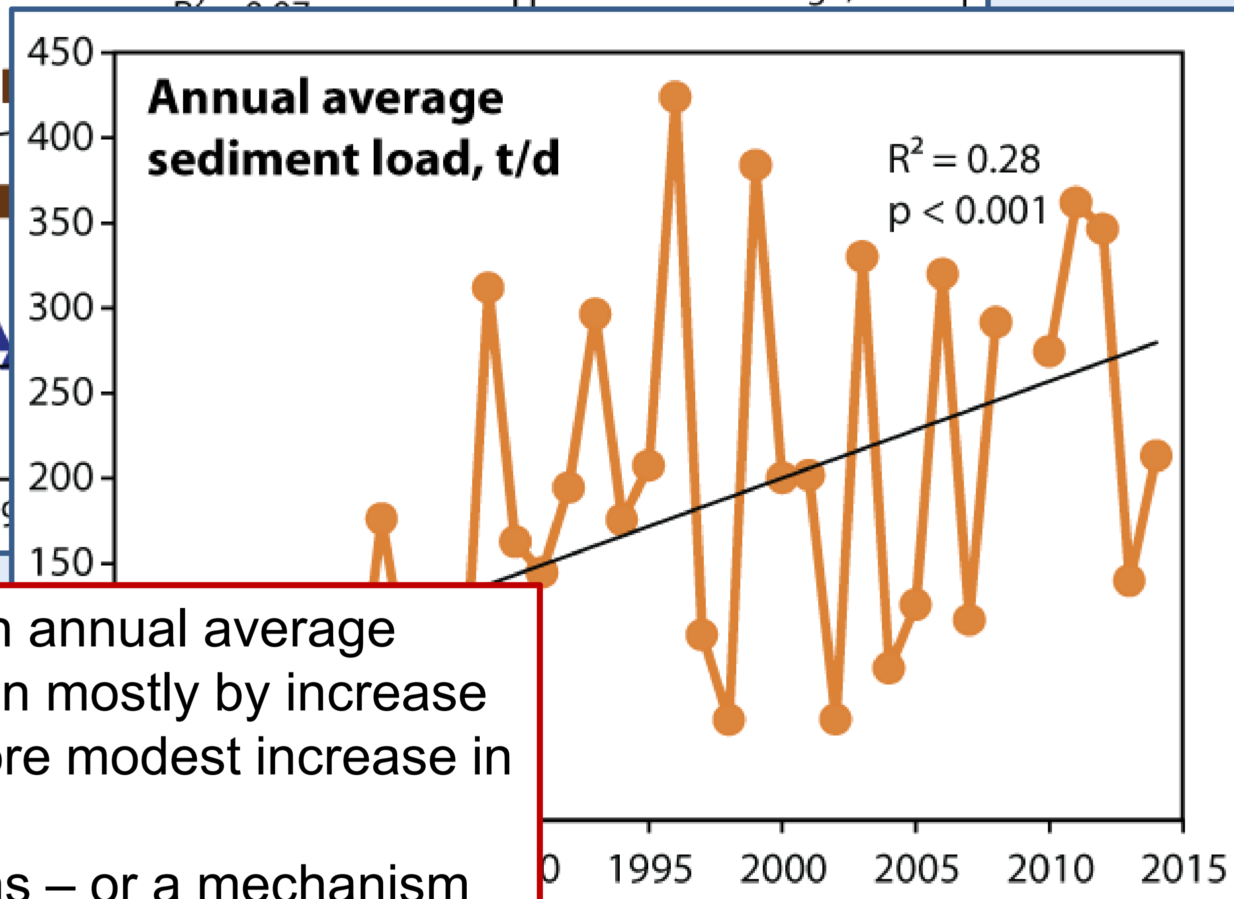

- Significant increase in annual average sediment load – driven mostly by increase in river discharge; more modest increase in SSC
- “Degrading” conditions – or a mechanism to counteract sea-level rise?

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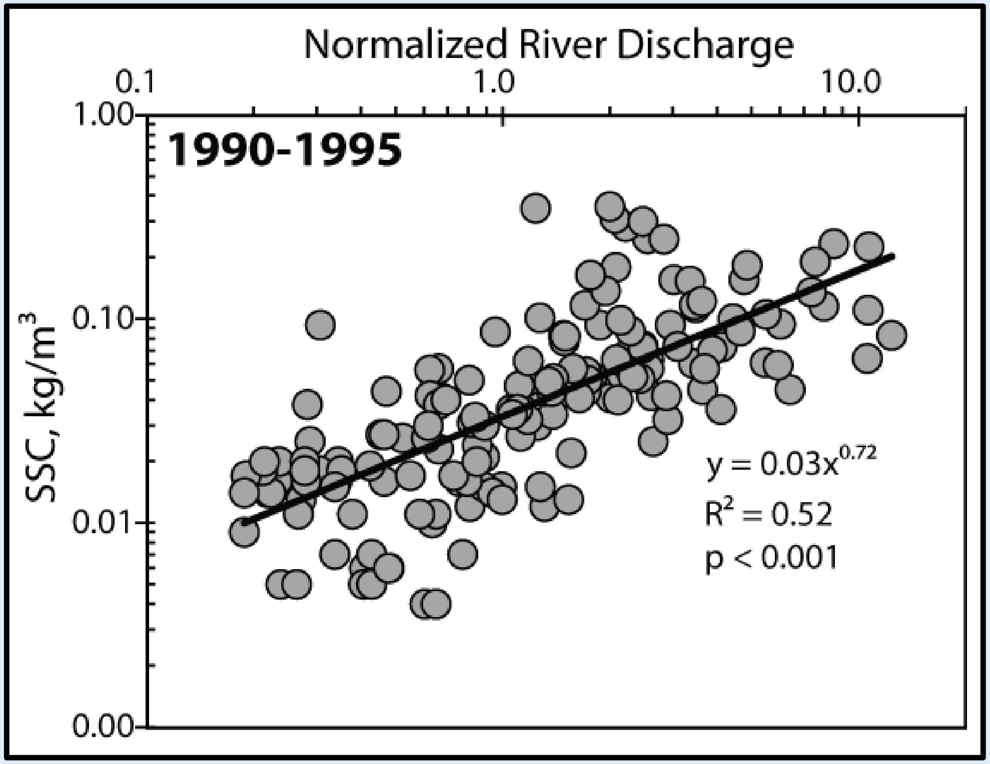
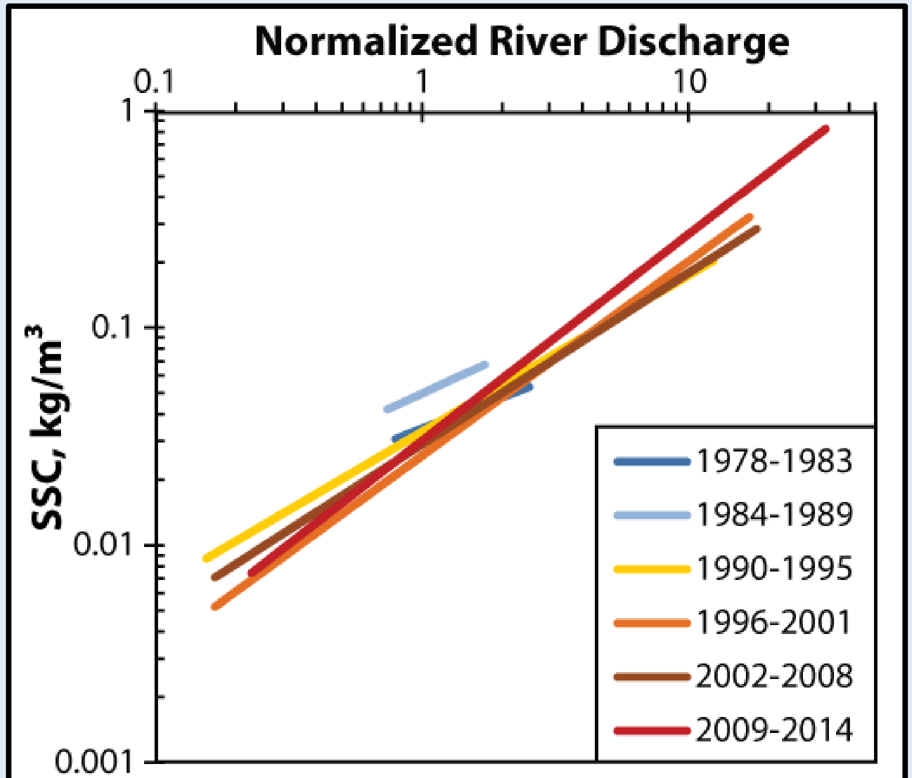
Sediment rating curves

Warrick, 2014:

$$C = \hat{a}\left(\frac{Q}{Q_{GM}}\right)^{b}$$

C = SSC (kg/m^3)
â = vertical offset parameter (kg/m^3); SSC of the middle of the sample distribution
b = rating parameter (unitless) from regression
Q_{GM} = geometric mean of *Q* (river discharge, m^3/s); uniform for all time intervals.





Warrick, J.A., 2014. Trend analyses with river sediment rating curves. Hydrological Processes
OI: 10.1002/hyp.10198

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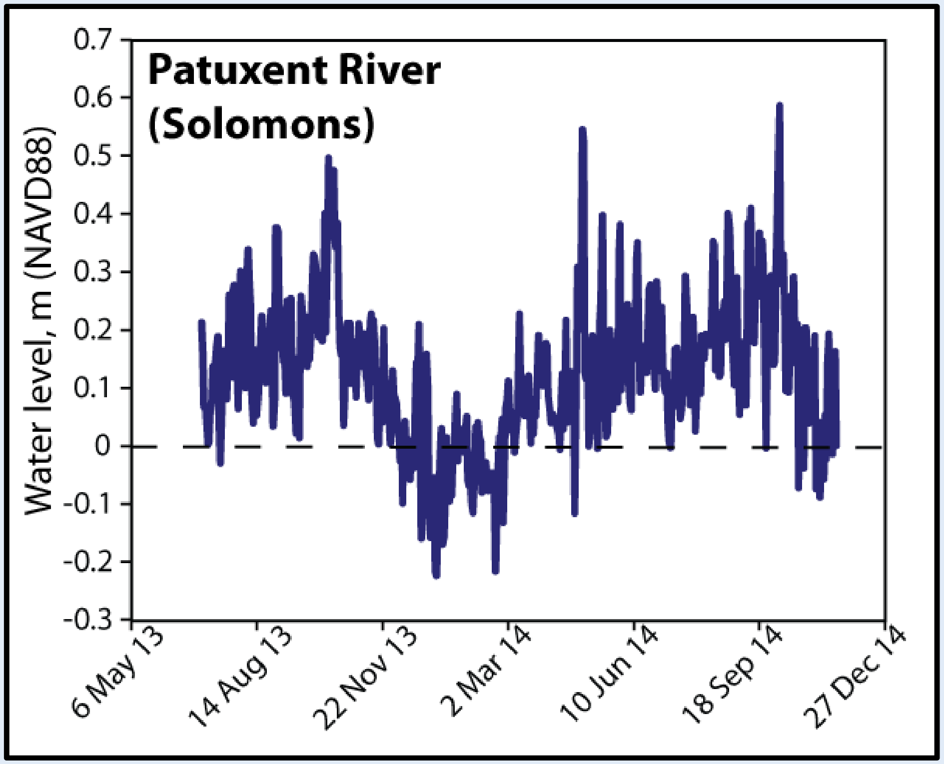
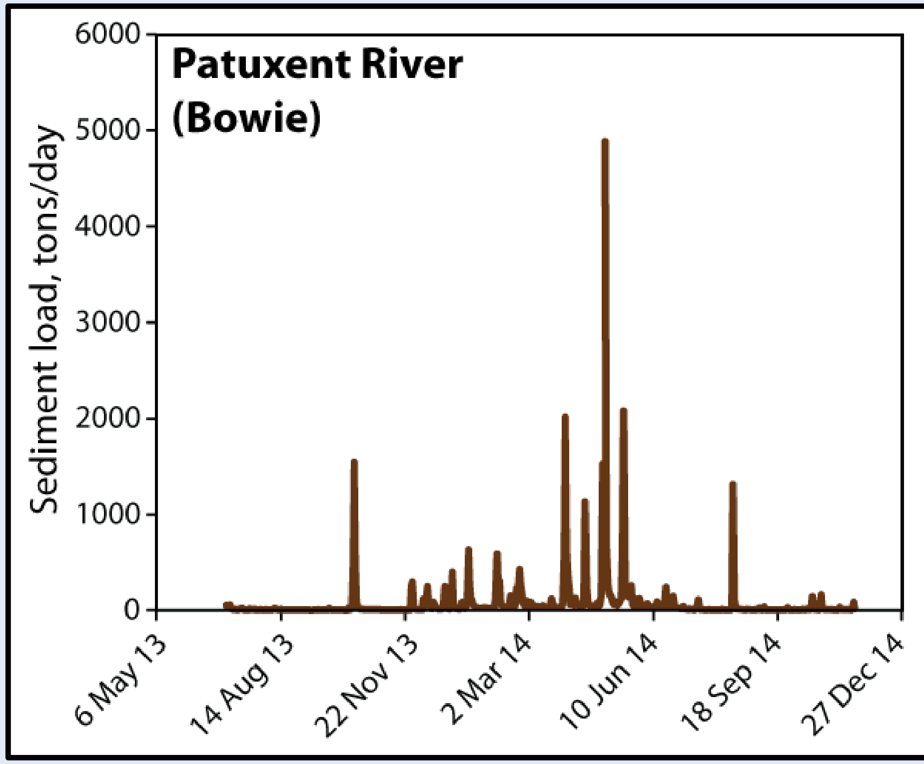
Sea level and sediment load





- Data not available at Solomons Oct 2013-April 2014; use average of last five years to fill gap
- Seasonal trend in water level
- Sediment load highly influenced by river discharge (spring freshet)

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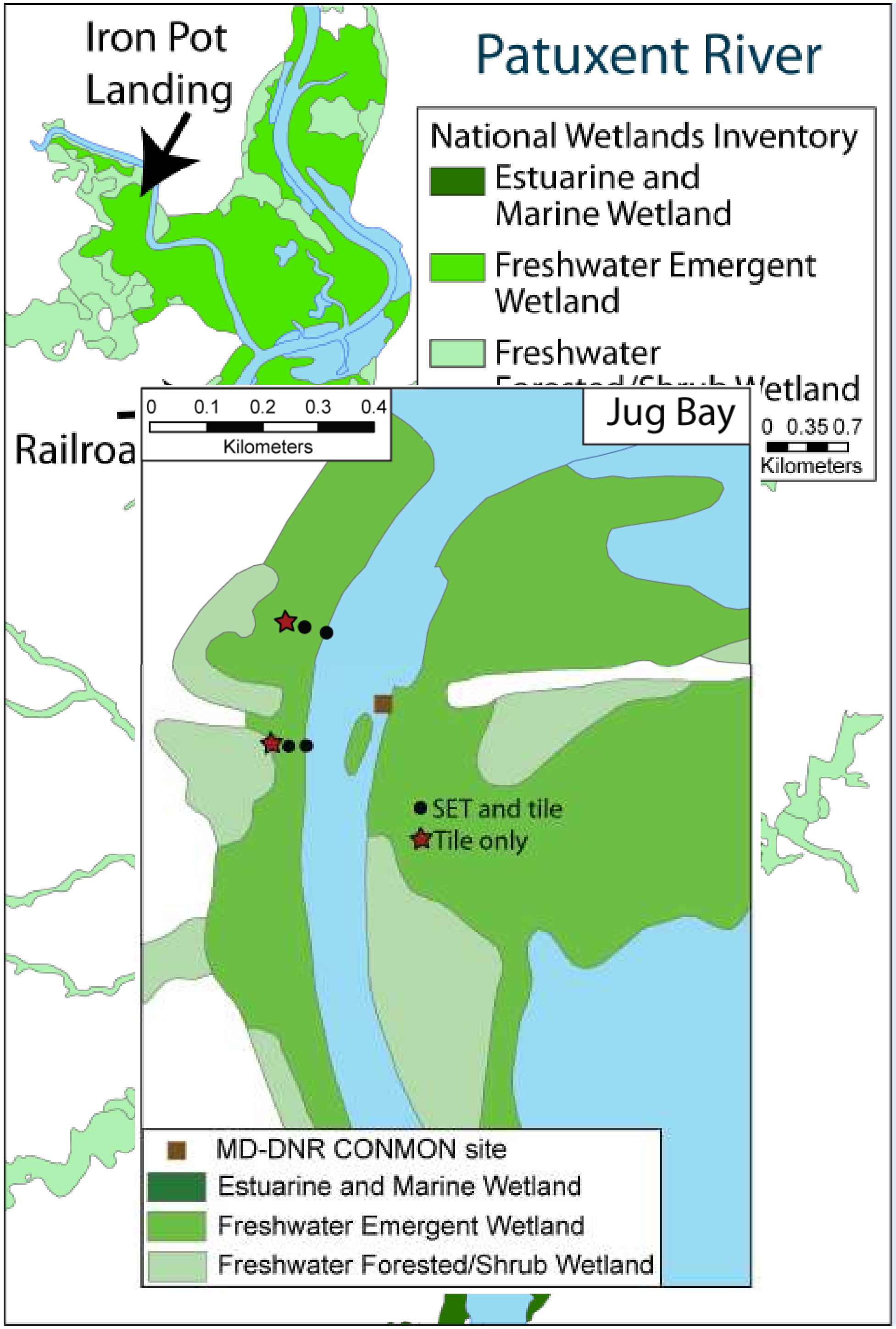

Methods

- 18 sites in 3 areas – low and high marsh
- 2014 RTK-GPS elevation survey
- Ceramic tiles deployed Sep 2013-Nov 2014 – sedimentation rates, organic content
- Vegetation surveys Sep 2013 and 2014 – species type, cover, stem counts

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Summary of physical drivers

	Sep 2013	Nov 2013	Apr 2014	Jun 2014	Sep 2014	Nov 2014	Average
Physical drivers							
Sea level (NAVD), m	0.15	0.21	0.02	0.17	0.17	0.16	0.15
SSC, kg/m^3	0.02	0.02	0.04	0.08	0.02	0.02	0.03
River discharge, m^3/s	5.71	8.45	17.60	31.49	9.22	6.93	13.23
Total sed load, tons	677.6	3119.8	15570.1	34596.5	1011.8	3138.6	9685.7

- **Sea level:** lowest April 2014; highest November 2013
- **SSC:** fairly similar, except for high in June 2014
- **River discharge:** highest June 2014; lowest September 2013
- **Sediment load:** highest in June 2014; lowest September 2013

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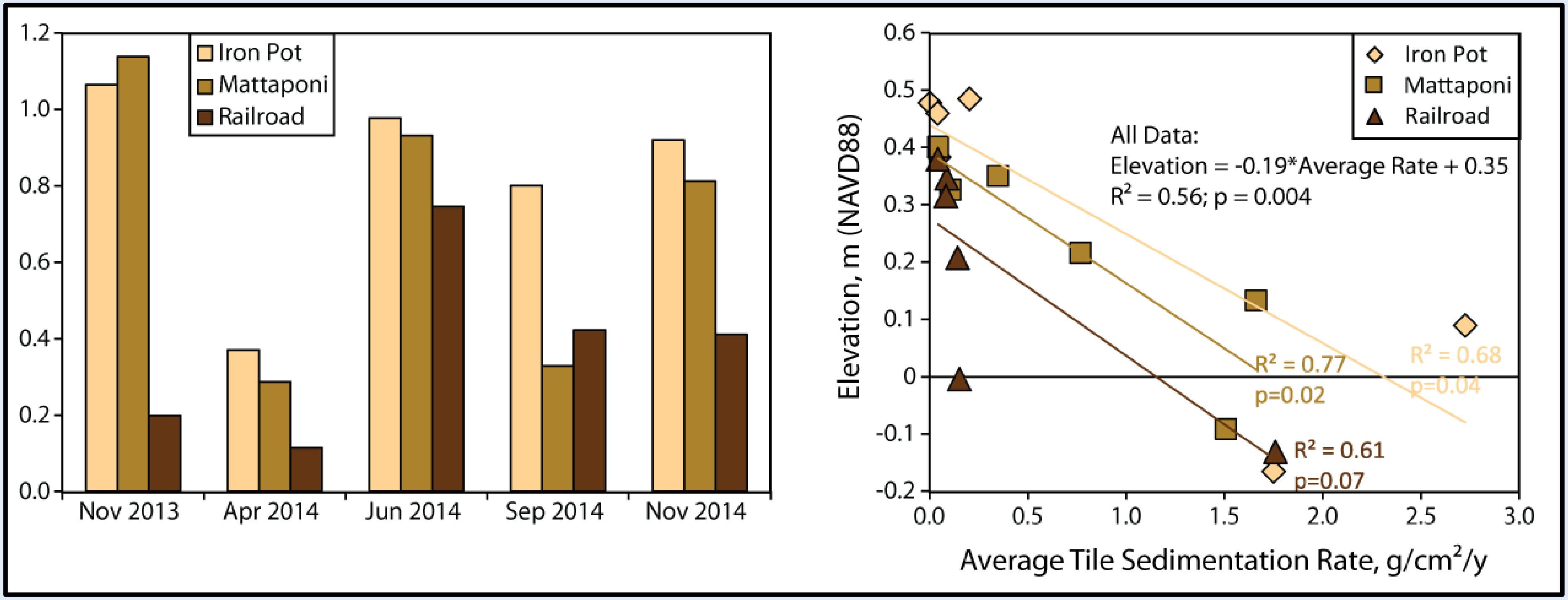
Sedimentation rates on tiles



- Highest in June 2014 and lowest in April 2014
- Highest near Iron Pot Landing and/or Mattaponi; lowest near the Railroad
- Differences among areas not significantly different (except Nov 2013)
- Rates were significantly negatively related to elevation

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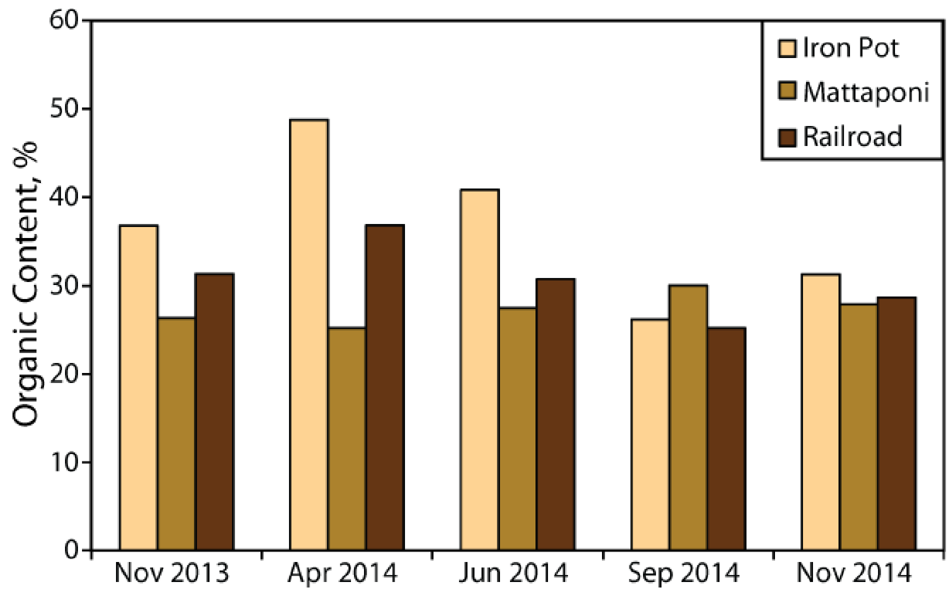
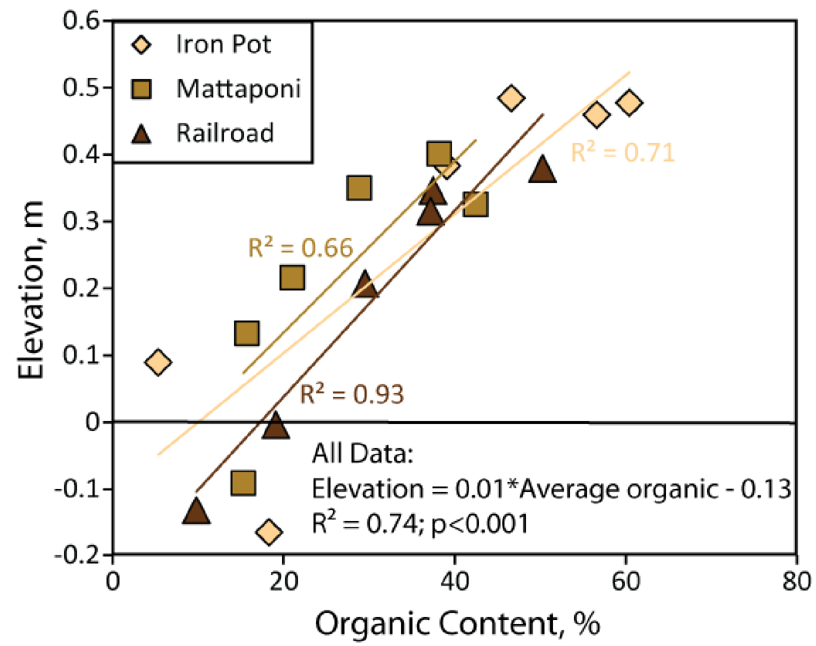
Organic content of tile sediments





- Highest in April 2014; lowest in September 2014
- Highest near Iron Pot Landing; lowest near Mattaponi (only significant difference in April 2014)
- Significantly positively related to elevation

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Summary (average of all areas)

	Sep 2013	Nov 2013	Apr 2014	Jun 2014	Sep 2014	Nov 14	Average
Sediment data							
Low marsh							
Tile rate, g/cm²/y		2.08	0.68	2.29	1.63	1.30	1.60
Tile org, %		15.13	18.10	11.34	12.22	12.37	13.83

- **Lowest rates and highest organic content in April 2014** – fluvial input and plant production low
- **Low marsh:** highest rates and lowest organic content June 2014 – fluvial supply during spring freshet dilutes plant contribution
- **High marsh:** highest rates November 2014; lowest organic content September 2014 – additional organic input from dieback?

Sedimentation rates: high marsh < low marsh
Organic content: low marsh < high marsh

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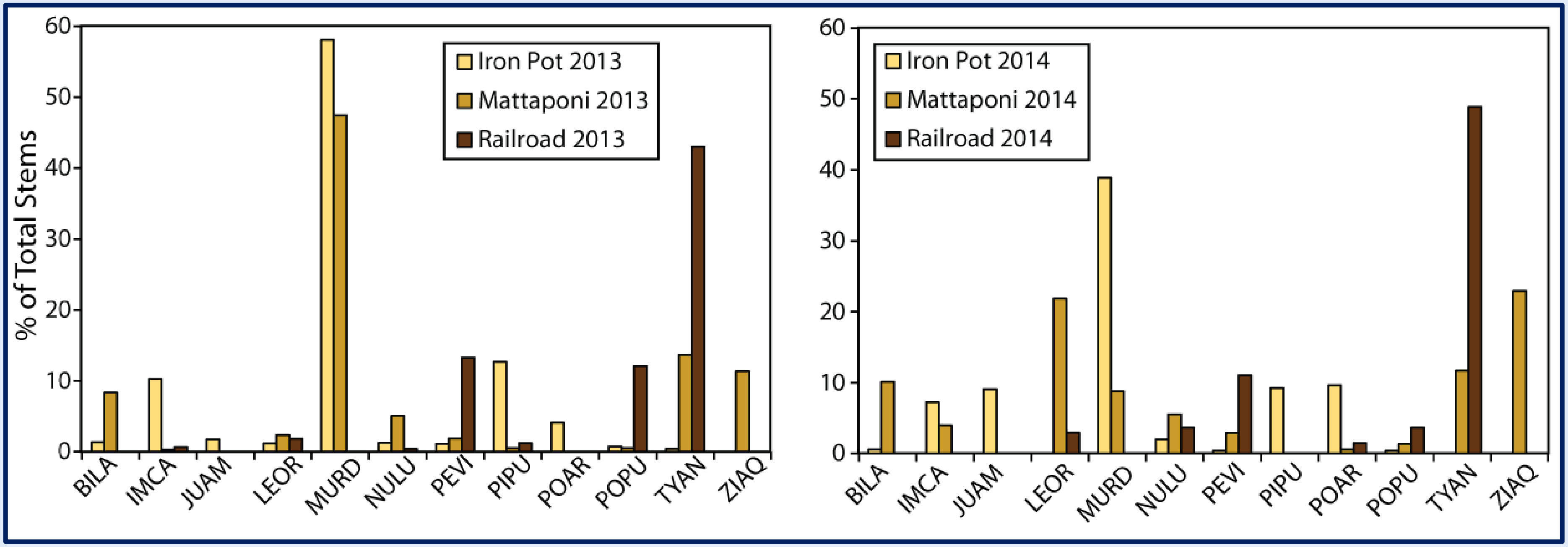
Vegetation data



BILA = *Bidens laevis*
IMCA = *Impatiens capensis*

PEVI = *Peltandra virginica*
PIPU = *Pilea pumila*

Dominant species:
Iron Pot Landing: *Murdannia keisak* (2013, 2014)
Mattaponi: *Murdannia keisak* (2013); *Zizania americanus* (2014)
Railroad: *Typha* species (2013 and 2014)

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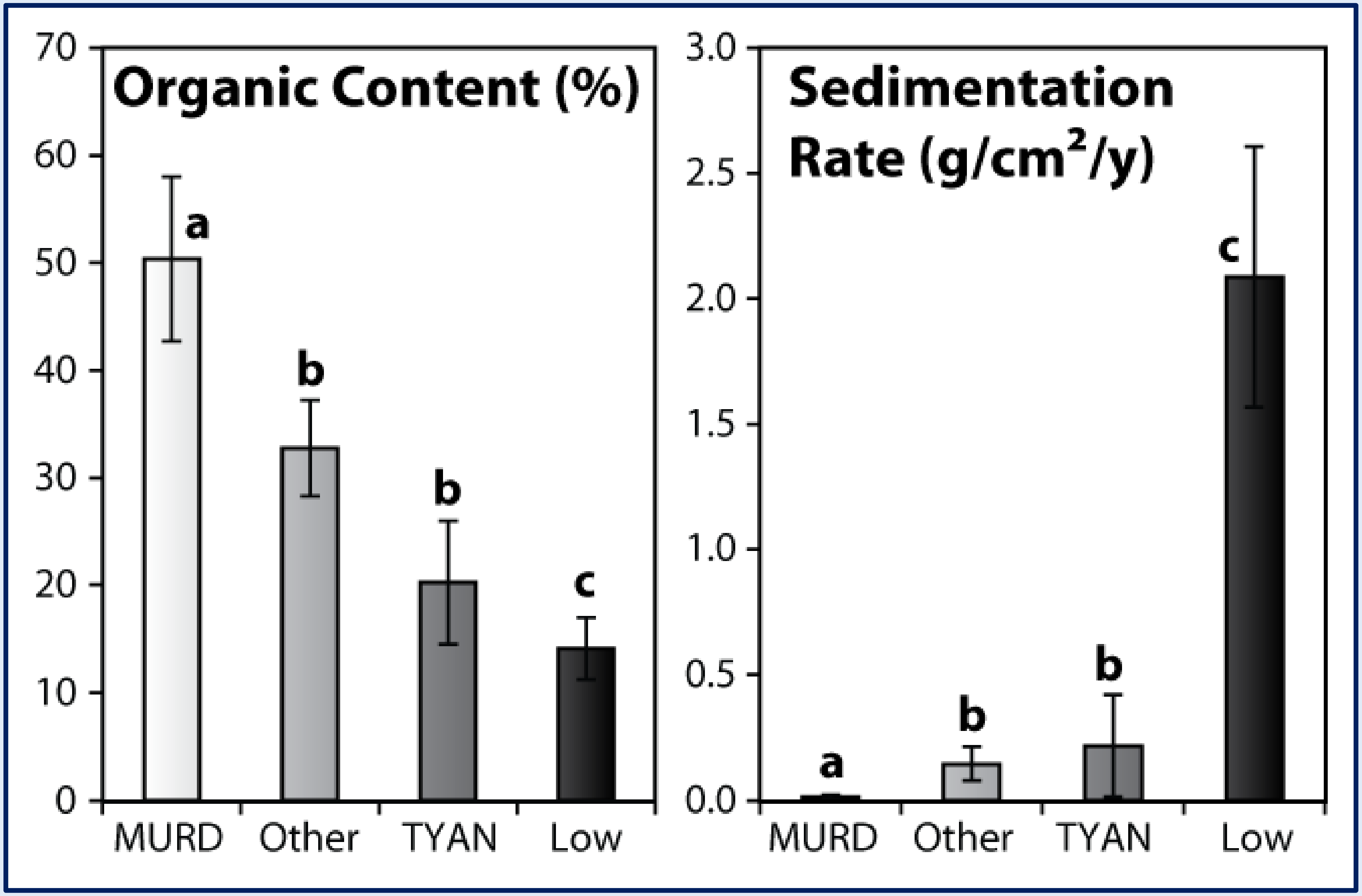
Sediment/vegetation synergy?



Railroad: consistently lower sedimentation rates; dominated by MURD
Iron Pot and Mattaponi: higher sedimentation rates; dominated by Typha

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Influences on sedimentation

	Organic	Elevation	Transect	P (all)	Adj r^2 (all)
Nov 2013	NA	P<0.001 (+ Low)	P=0.06 (- RRT)	<0.001	0.64
Apr 2014	P=0.002 (-)	P=0.08 (+ Low)	P=0.02 (- MT); P=0.006 (- RRT)	<0.001	0.76
Jun 2014	NA	P<0.001 (+ Low)	NA	<0.001	0.68
Sep 2014	NA	P=0.001 (+ Low)	NA	0.001	0.51
Nov 2014	P=0.001 (-)	NA	P=0.06 (-RRT)	0.004	0.55

- **Tile rates** generally predicted by elevation (+low) and location on RRT (-)
- **Organic content** plays role only in Apr (lowest fluvial input) and Nov 2014 (litter/dieback?)

Evaluating transect-scale variability

	Organic	Elevation	Depth	Turbidity	P (all)	Adj r^2 (all)
Iron Pot	NA	P<0.001 (+Low)	0.10	NA	0.001	0.82
Railroad	P<0.001	NA	NA	0.03	<0.001	0.83
Mattaponi	P=0.02	P=0.07 (+Low)	NA	NA	0.01	0.66

- **Depth** and **turbidity** influence tile sedimentation rates near Iron Pot Landing and the Railroad
- Higher **depth** (more flooding) and **turbidity** (more sediment) lead to higher rates
- Statistics start to break down as *n* gets smaller…

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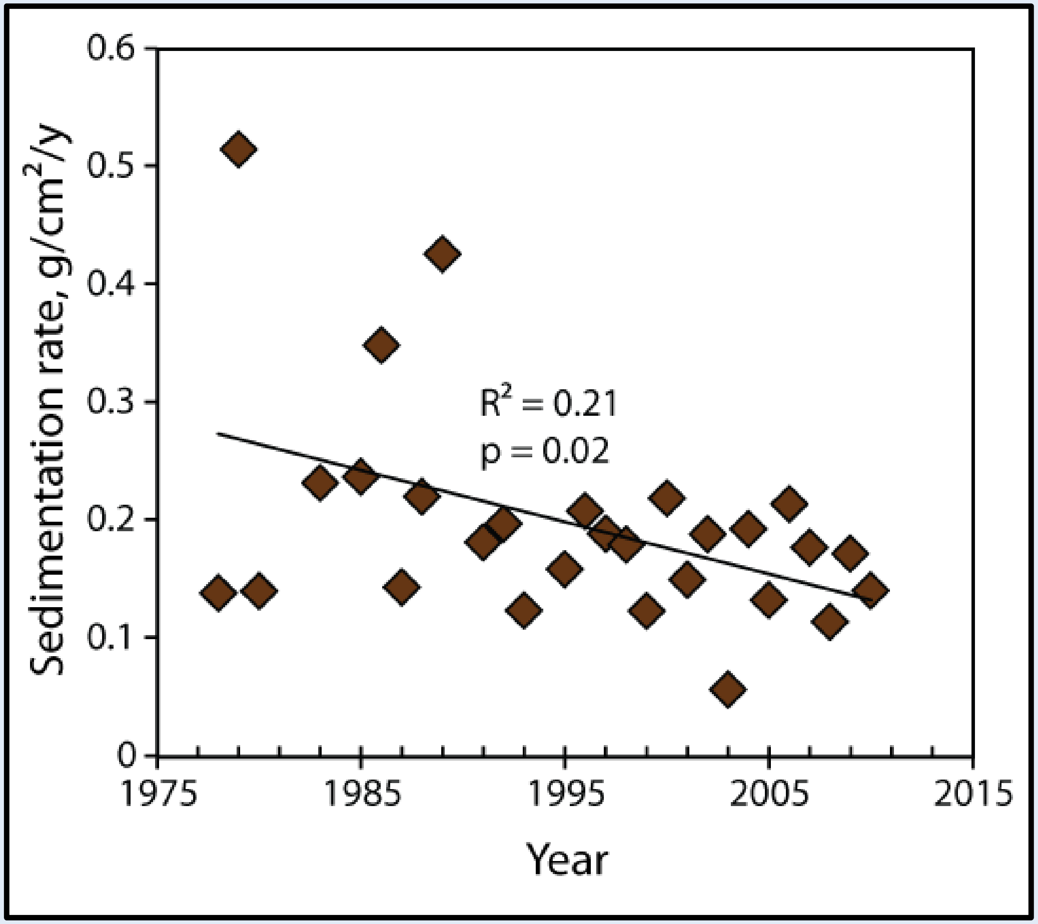
Insights from our work at Dyke Marsh



Data from Palinkas and Engelhardt, in revision (L&O):

- Peat cores (~60 cm) long taken on river/tidal-channel banks and in marsh interior
- Geochronology established with ^{210}Pb (half-life 22.3y) for each core
- Aggregate data of sedimentation rates since 1978; evaluate temporal trend, compare to record of SL and SSC

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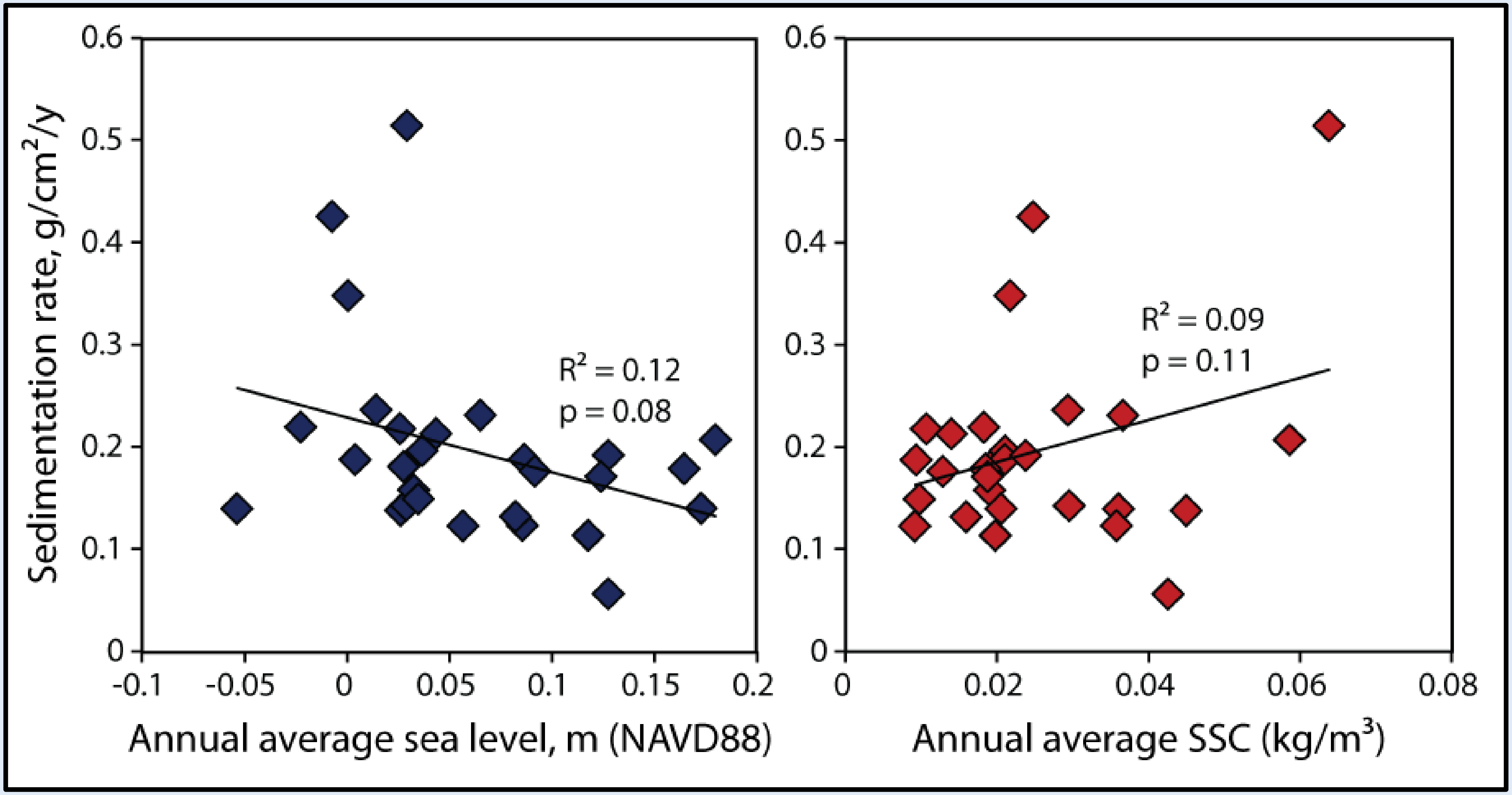

Multiple linear regression:

Rate = -0.69*SL+2.35*SSC + 0.173

p = 0.03; adj r^2 *= 0.18*

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Polygonum arifolium

	2004	2005	2006	2007	2011	2012	2013	2014
DM1	■	■	■	■				
DM2	■	■	■	■				
DM3/SET7T	■	■	■	■				
DM4	■		■	■				
DM5				■				
DM6	■		■	■	■			
DM7	■			■		■		
DM8	■	■	■					
SET6/DM9						■		
DM10				■		■		
DM11								
DM12/SET4	■		■	■	■	■		
DM13	■		■	■		■		
DM14								
DM15/SET9p			■	■	■			■
DM16		■	■	■				■
DM17		■	■	■		■	■	
DM18								
DM19								
DM20	■			■				
DM21				■				
DM22/SET1								
DM23		■						
DM24				■				
DM25								
DM26	■			■		■	■	■
DM27				■				
DM28/SET2pp								
DM29/SET3	■	■	■	■	■			
DM30	■		■					
DM31	■		■	■				
DM32	■	■	■	■		■	■	■
DM33	■	■	■	■	■		■	■
DM34	■	■	■	■				
DM35	■	■	■	■		■		■
DM36	■		■	■				
DM37		■	■	■			■	■
DM38	■	■	■	■			■	■

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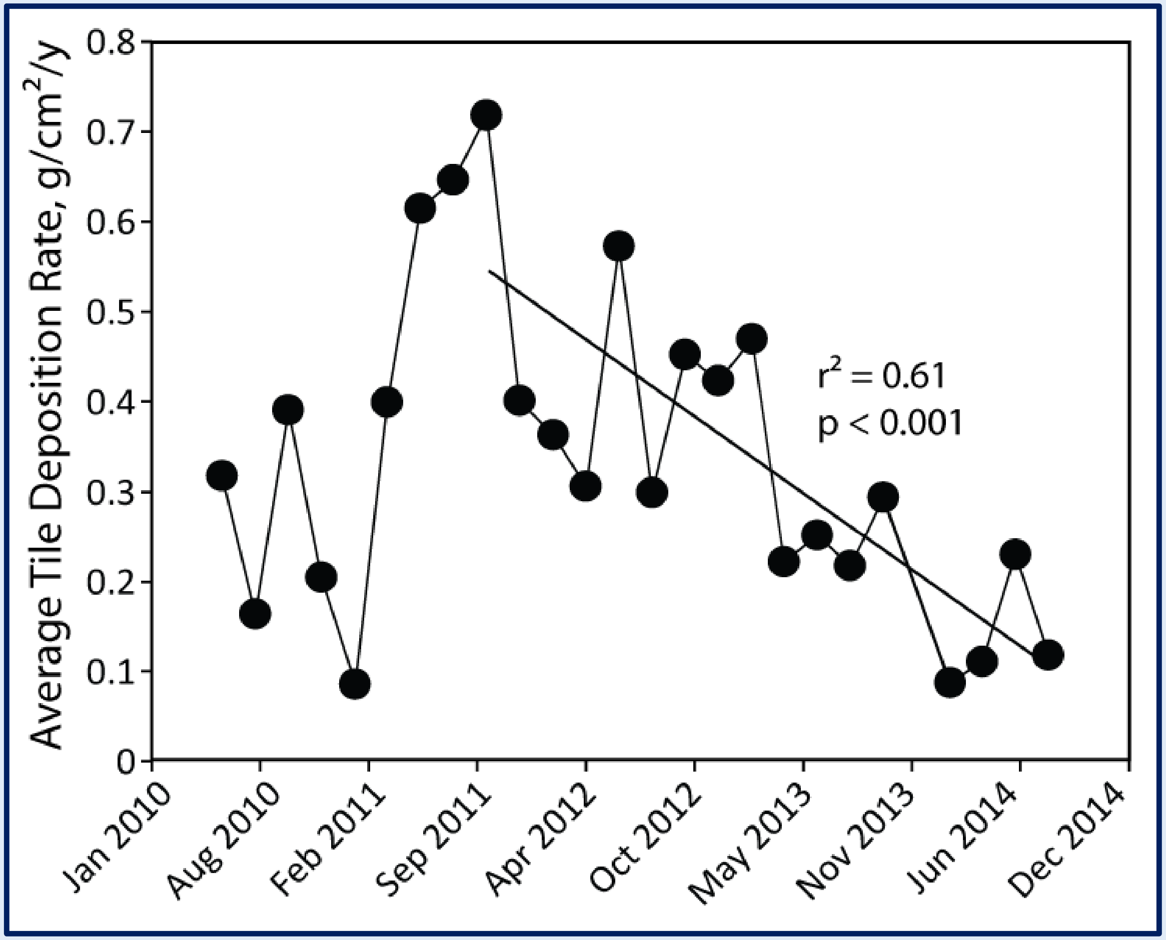
Time series of tile sedimentation rates at Dyke Marsh



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Summary, management implications, needs

Elevation and transect are dominant influences on the spatial variability of sedimentation within Jug Bay Wetland Sanctuary

Synergies exist between sediment and vegetation parameters – use to develop an "early warning system" for marsh vulnerability?

Depth and turbidity influence sedimentation along transects, but need much more data – finer-resolution sediment and monitoring data

Past response to changes in sea level and suspended-sediment concentrations can be examined with longer cores

Establishing continuous, long-term time series key for teasing apart long-term trends from interannual variability

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