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The role of suspended sediment in Everglades biogeochemistry and material redistribution

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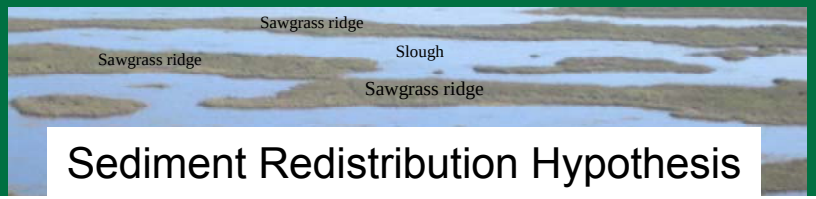
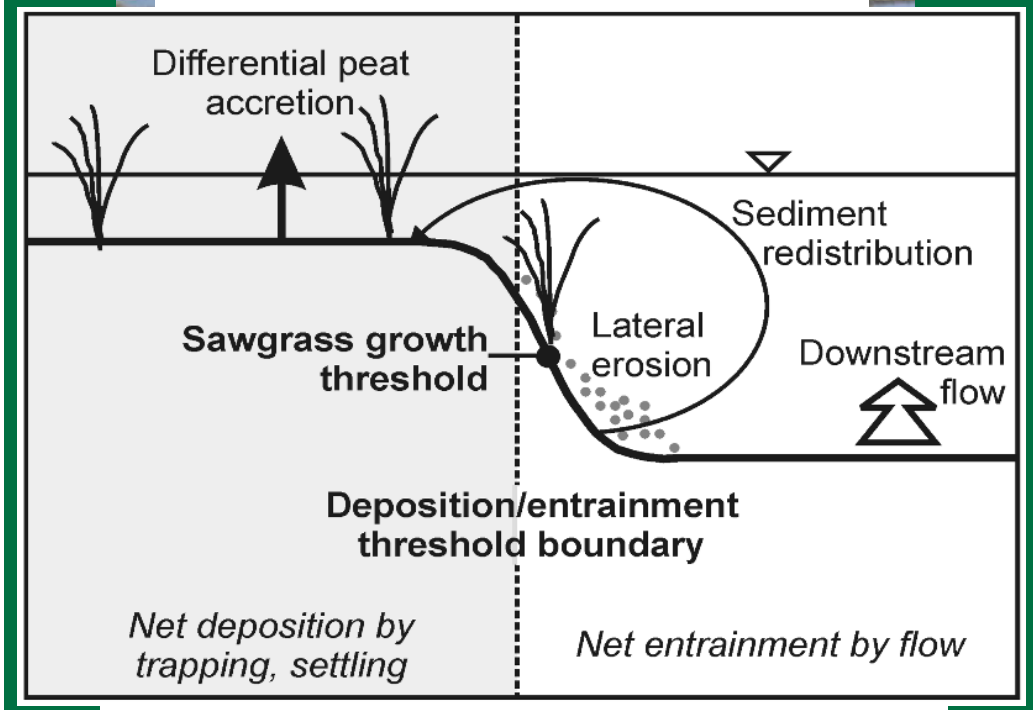
Potential importance of suspended sediment transport

Ridge and slough topography



Sediment Redistribution Hypothesis



Larsen *et al.* 2007. *Ecological Monographs*

SFWMD

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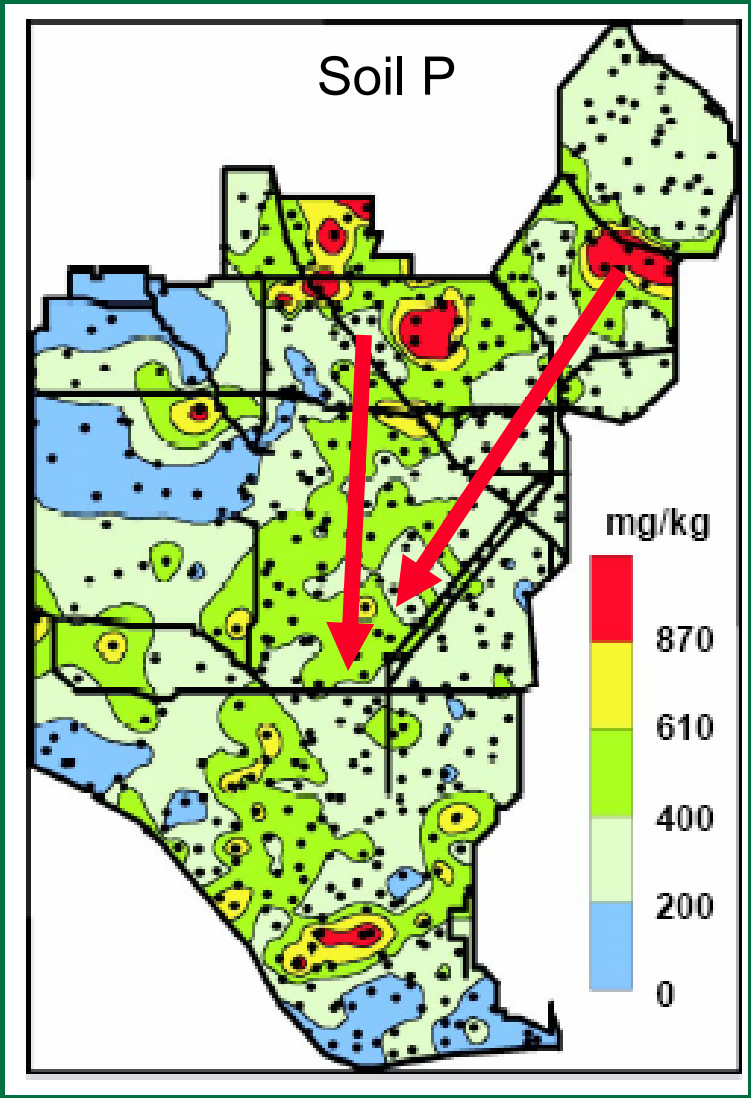
P transport



South Florida Ecosystem Assessment, EPA 2000

What suspended sediment?

Clear water column of Everglades

Differential transport of P fractions

Retention of P forms in South Florida treatment wetlands:

Soluble Reactive P > Particulate P > Dissolved Organic P

Davis *et al.* 1981. *SFWMD*
DeBusk *et al.* 2004. *Ecological Engineering*
White *et al.* 2004. *Hydrological Processes*

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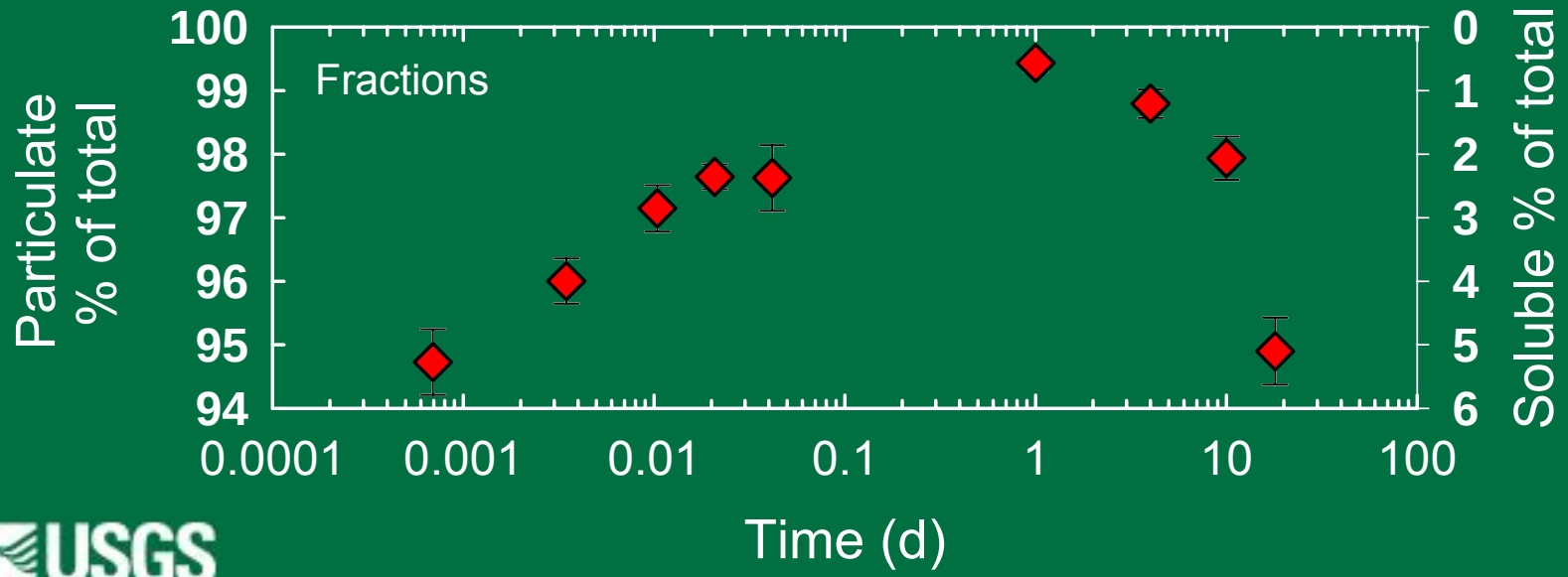
Surprising role of suspended sediment in P cycling

$^{32}PO_4$ added to 6 1-m^2 mesocosms

Initial P uptake by fine suspended particles (<100 µm)



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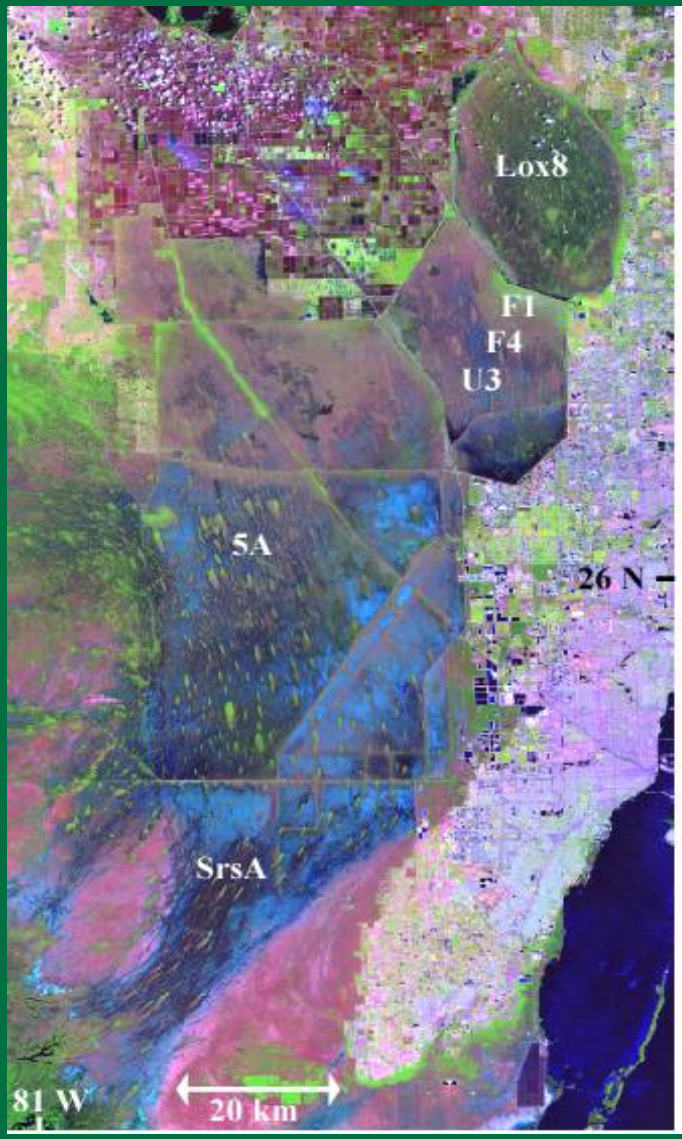
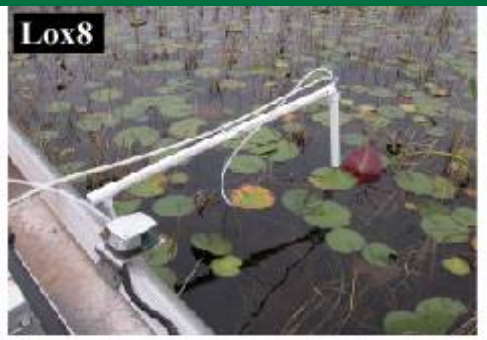
Noe *et al.* 2003. *Freshwater Biology*

Spatial patterns in suspended particle characteristics





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Fine (<100 µm) suspended sediment characteristics

Site	Total suspended sediment (mg L^{-1})	Total particulate P (µmol L^{-1})	Total particulate N (µmol L^{-1})	Percent particulate P	Percent particulate N	Particulate N:P (molar)
Lox8	2.71 ± 0.09	0.19 ± 0.01	6.8 ± 0.2	43 ± 2	7 ± 0	36 ± 3
F1	0.85 ± 0.12	0.31 ± 0.02	4.8 ± 0.7	25 ± 2	3 ± 0	15 ± 1
F4	1.19 ± 0.41	0.18 ± 0.00	3.2 ± 0.1	38 ± 0	2 ± 0	18 ± 0
U3	0.81 ± 0.11	0.10 ± 0.01	3.7 ± 0.2	27 ± 0	2 ± 0	38 ± 0
5A Slough	1.90 ± 0.27	0.09 ± 0.01	6.5 ± 0.5	31 ± 3	10 ± 0	69 ± 1
5A Cladium	2.15 ± 0.30	0.11 ± 0.01	7.0 ± 0.3	33 ± 3	10 ± 1	66 ± 1
SrsA	0.69 ± 0.14	0.05 ± 0.00	3.1 ± 0.2	20 ± 2	3 ± 0	65 ± 1

TSS was low (1.5 mg/L)

31% of P was particulate

Particulate P was more abundant and more labile with P enrichment

Geometric mean particle size:

Total Suspended Sediment = 11 µm
Particulate N = 6 µm
Particulate P = 3 µm

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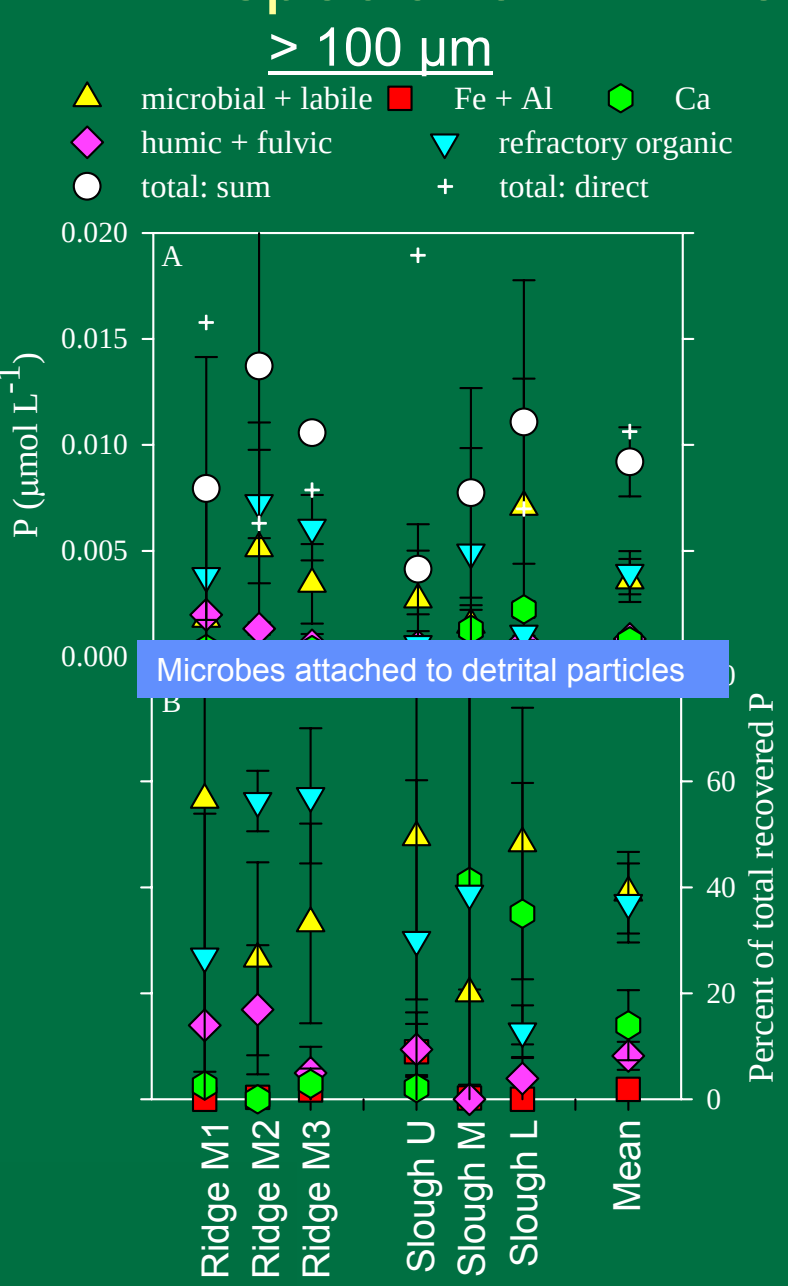
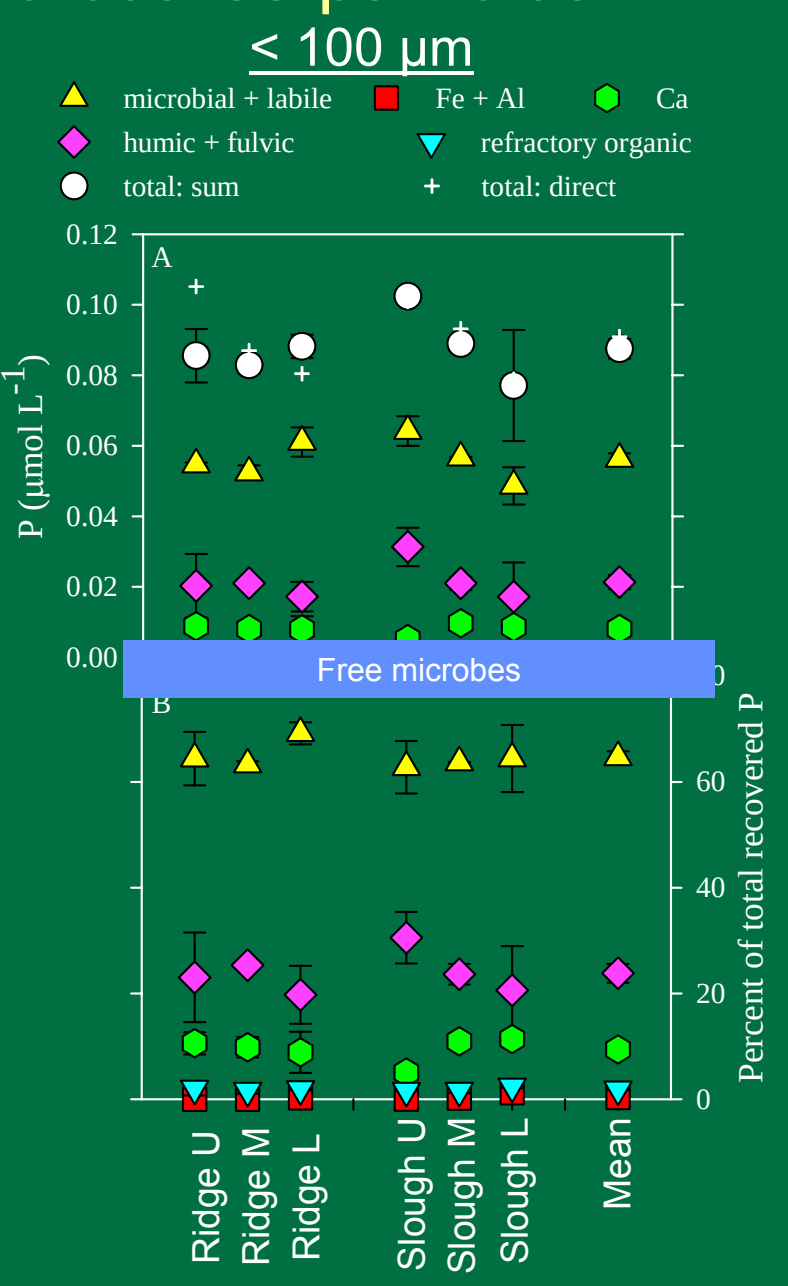
Noe *et al.* 2007. *Limnology & Oceanography*
See also Bazante *et al.* 2006. *Hydrological Processes*

P speciation in fine and coarse particles





Noe *et al.* 2008. *in review*

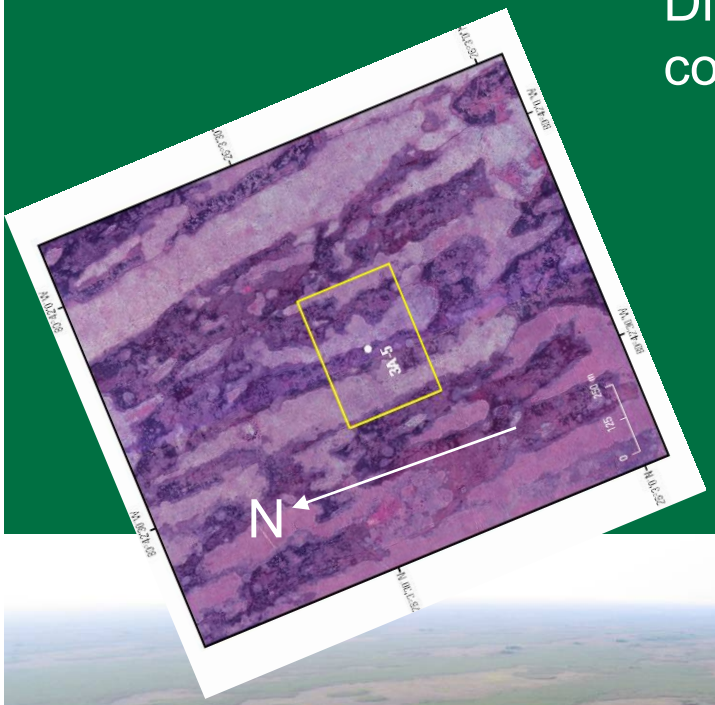
Noe *et al.* 2007. *Limnology & Oceanography*

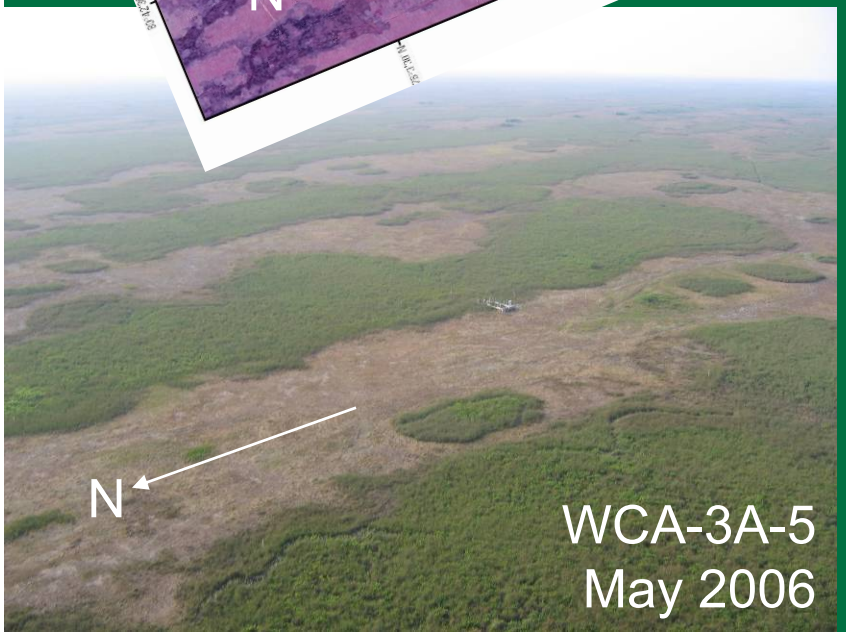
Ridge and Slough maintenance

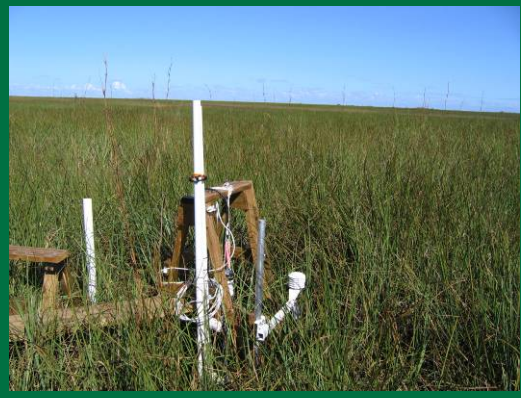
Hypothesis: Lower sediment concentrations in ridge (due to greater deposition and possibly filtration)

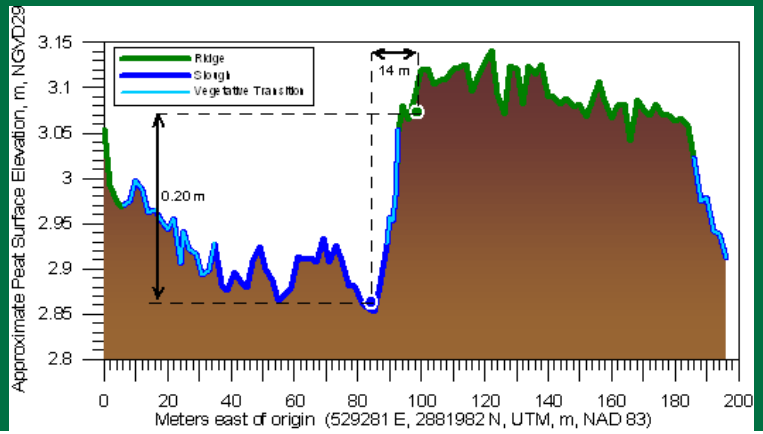
Directly sampled fine suspended particle (<100 µm) concentrations and P and N content

R/S (ridge, slough)
Depth (upper, middle, lower)
Time (through wet season)



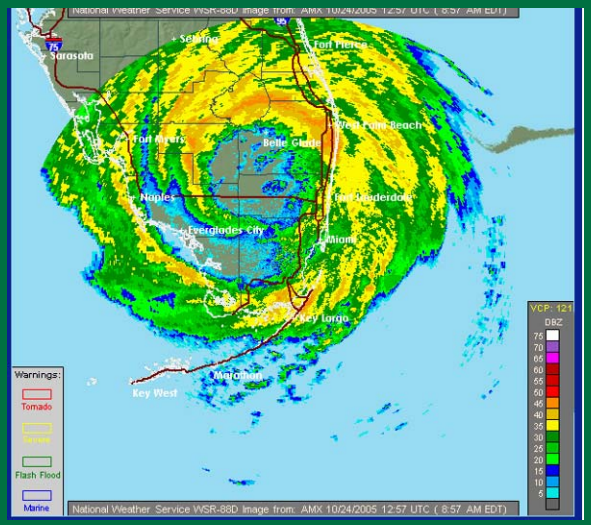




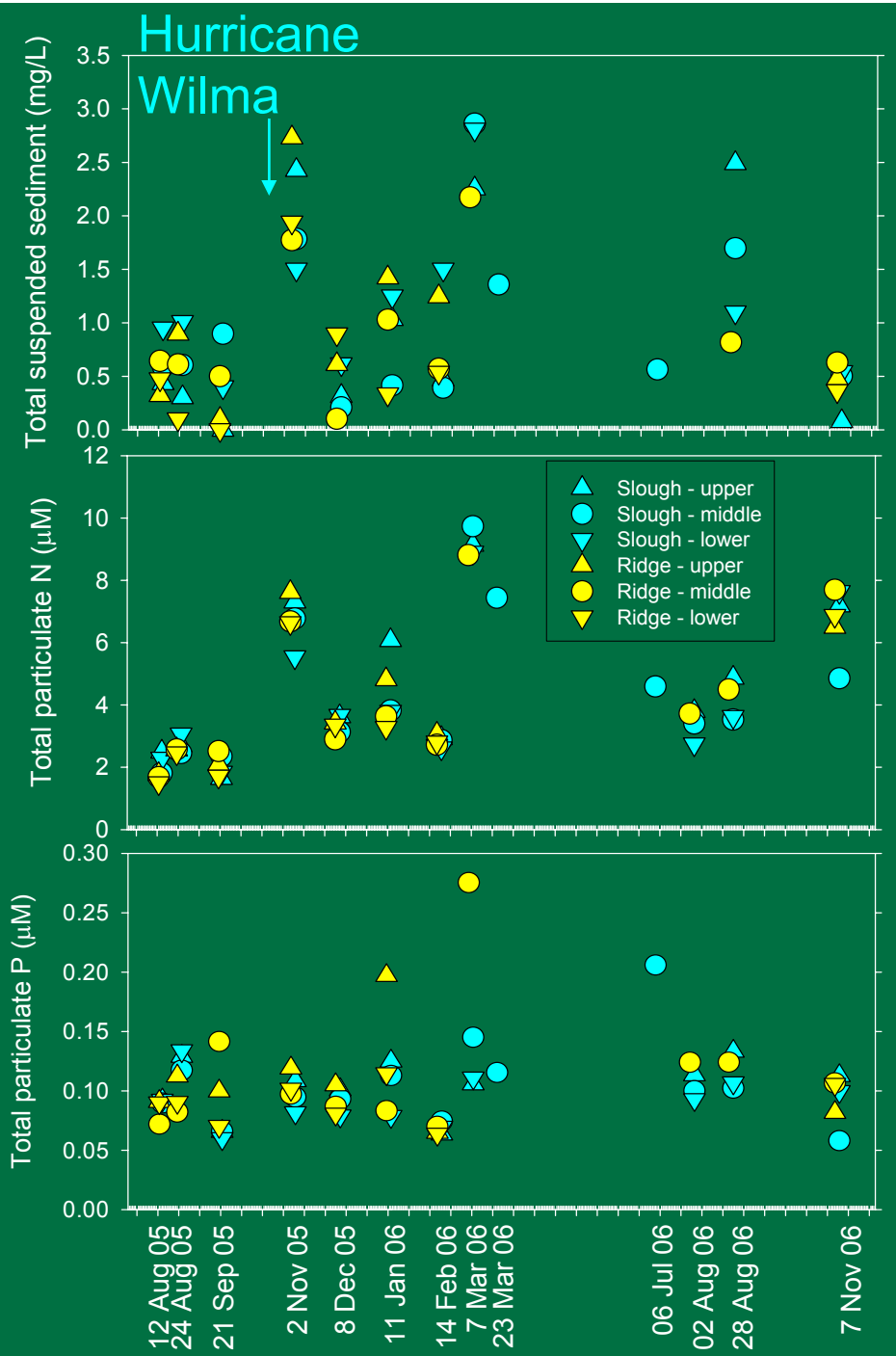


Fine particle concentrations

TSS: mean = 0.94 mg/L
R/S: *P* = 0.889



PP: mean = 0.10 µM
R/S: *P* = 0.370



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Noe *et al.* 2008. *in review*

Controls on suspended sediment abundance

Not water velocity

(no correlation, slow water velocity, and only small particles present)

Not vegetation

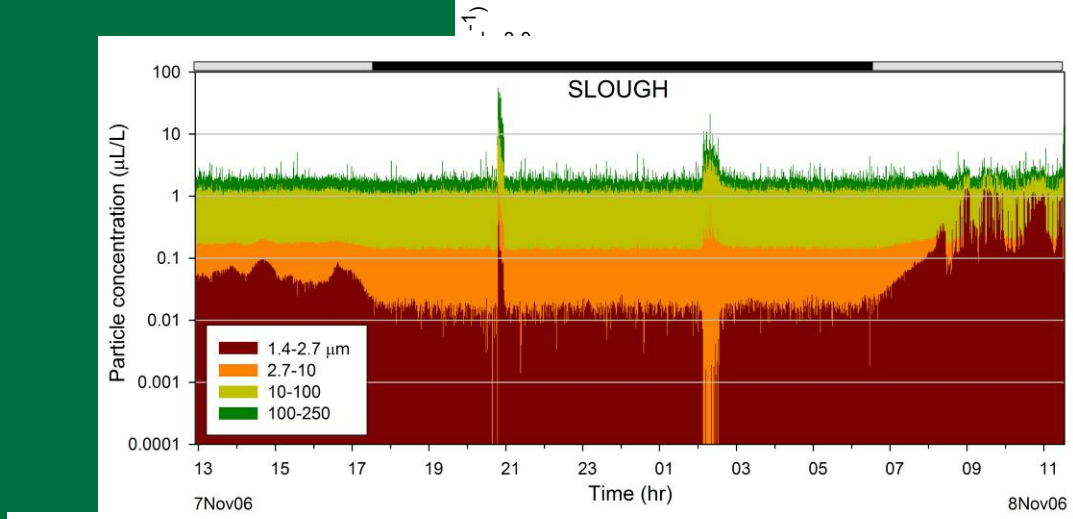
Sun

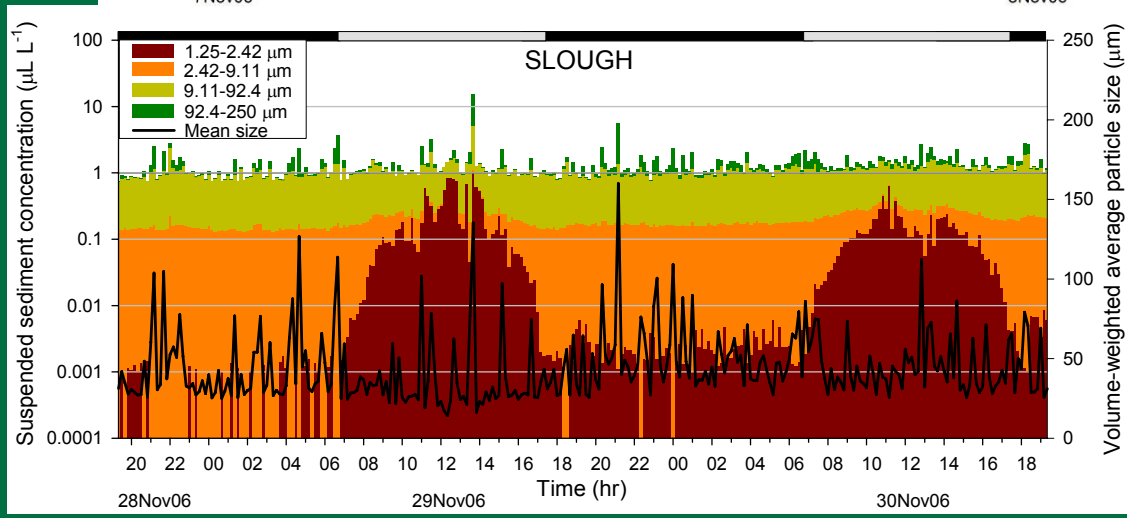
Wind and temperature of air and water

Bioturbation

Shallow water

Hurricanes





Noe *et al.* 2008. *in review*

Sources of suspended particles

EAA farm canals:
macrophytes and their detritus (Stuck *et al.* 2002)

STA treatment wetlands:
OM, plankton (Farve *et al.* 2004)
Periphyton, OM (Harris *et al.* 2007)

Everglades:
in situ production (periphyton?) (Leonard *et al.* 2006)
bacteria (Noe *et al.* 2007)
bacteria and periphyton, not floc (Noe *et al.* in review)

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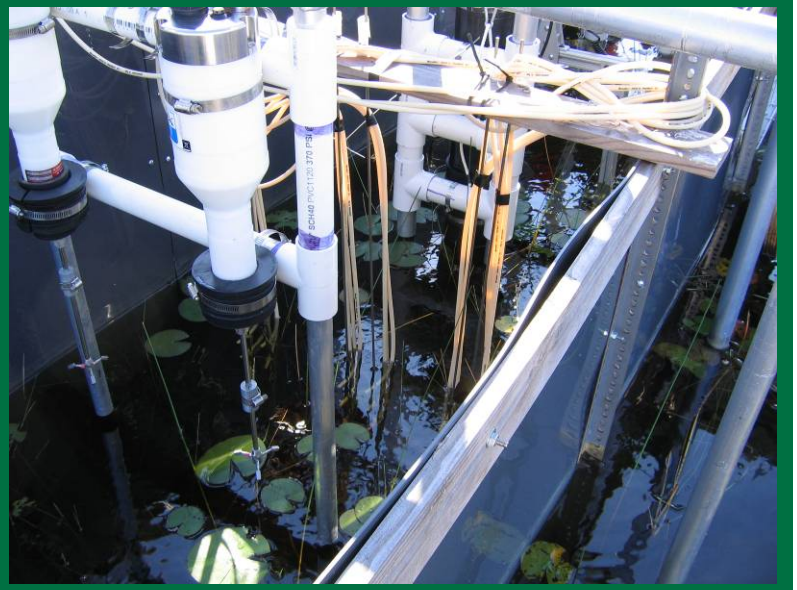
What flow velocity is needed to entrain sediment?



Flow enhancement in the field

cm/s: 0.3 1.7 3.2 5.3 5.7

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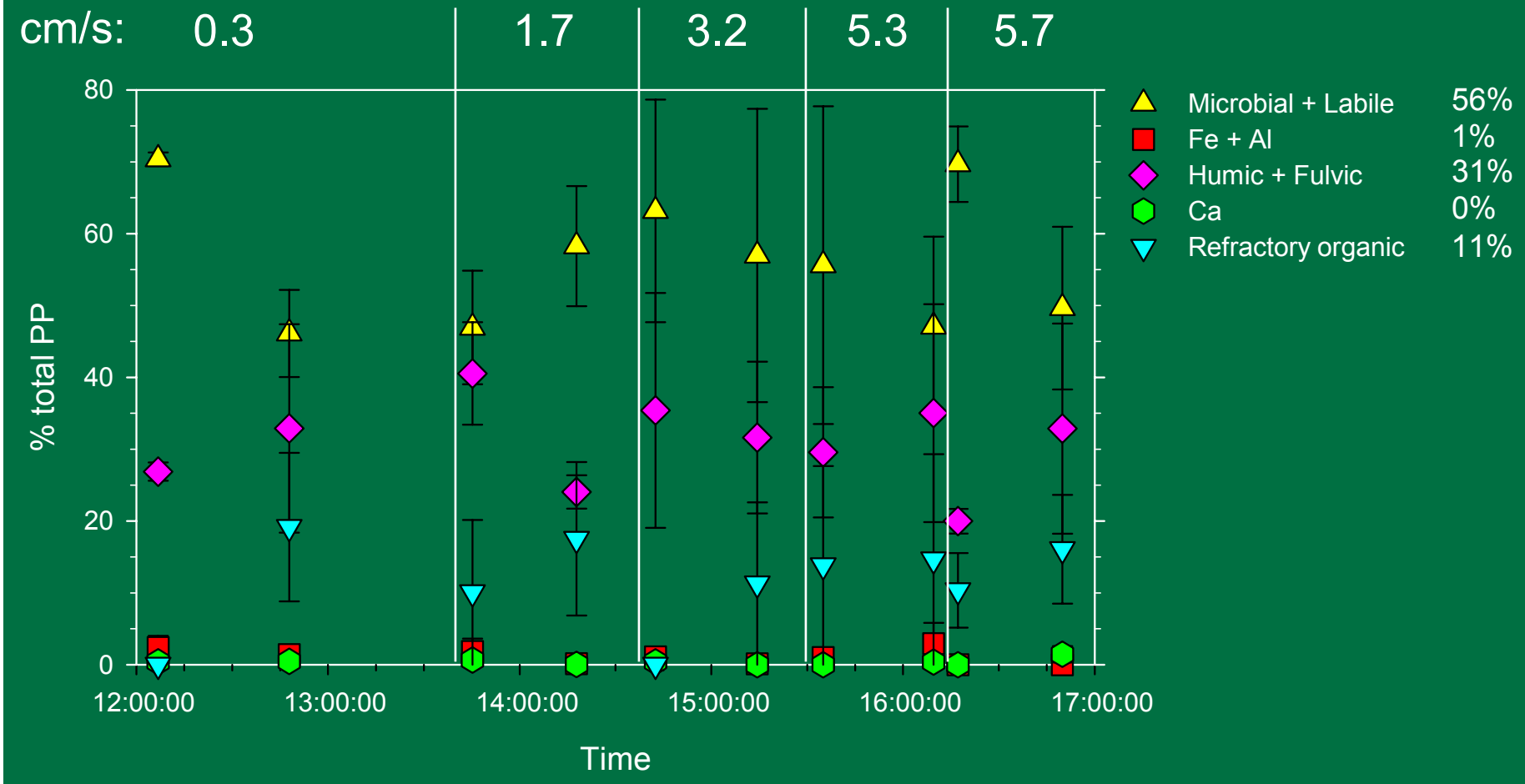
Total particulate P speciation



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No change in particulate P concentrations or speciation at enhanced velocity

Flume fluxes

Velocity	Q (L/s)	LISST flux (µL/s)	TSS flux (mg/s)	PP flux (µmol/s)	microbial PP flux (µmol/s)	refractory PP flux (µmol/s)
Ambient	0.93	0.40	0.48	0.13	0.08	0.01
1	4.63	7.50	3.58	0.70	0.37	0.10
2	10.42	20.36	4.71	1.33	0.80	0.08
3	13.55	29.09	16.27	2.35	1.21	0.33
4	14.23	37.19	11.99	2.25	1.34	0.30

→ Enhanced velocity increased downstream fluxes

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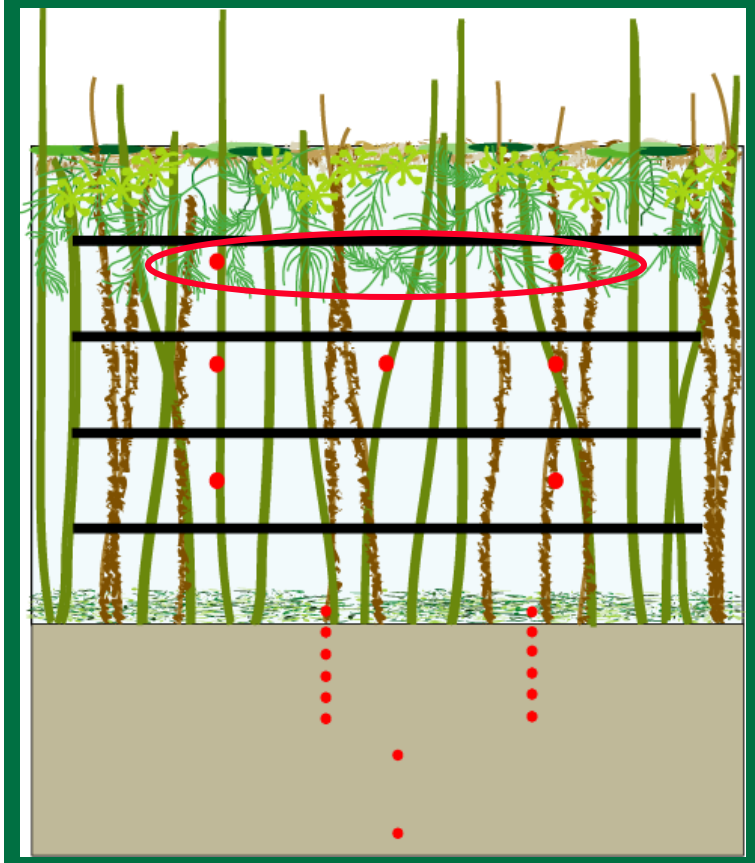
See talk by Jud Harvey:
Thur 2:20 @ Royal Palm VI-VII

Solute and particle transport: transport, dispersion, and interception



Slough:

Dual Br^- and TiO_2 (0.3 μm) injection

Efficient particle filtration by floating vegetation ($L_{1/2}$=1 m)

Different particle vs. solute transport

Ridge:

Fluorescing latex microspheres (1 μm)

Particle filtration: $L_{1/2}$=128 m

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Saiers *et al.* 2003. *Geophysical Research Letters*
Harvey *et al.* 2005. *Water Resources Research*
Huang *et al.* 2008. *Water Resources Research*

Conclusions

Suspended particles are critical to P cycling and transport … despite low TSS

P-rich particles are suspended bacteria, larger particles are more refractory and likely from a periphyton source

Particle interception rates and biogeochemical fate are key unknowns

Sediment and particulate nutrient redistribution between ridges and sloughs does not occur or rarely occurs in the Everglades

Sloughs are conduit for material transport (4X more than ridges)

Extreme flow events may be necessary to generate sediment transport

Restoration actions intended to increase sheetflow velocity will also transport more labile P downstream with sediment

Suspended particles must be incorporated into Everglades ecosystem models